CHOWCHILLA SUBBASIN

Sustainable Groundwater Management Act (SGMA)

Groundwater Sustainability Plan

APPENDIX 2. PLAN AREA AND BASIN SETTING

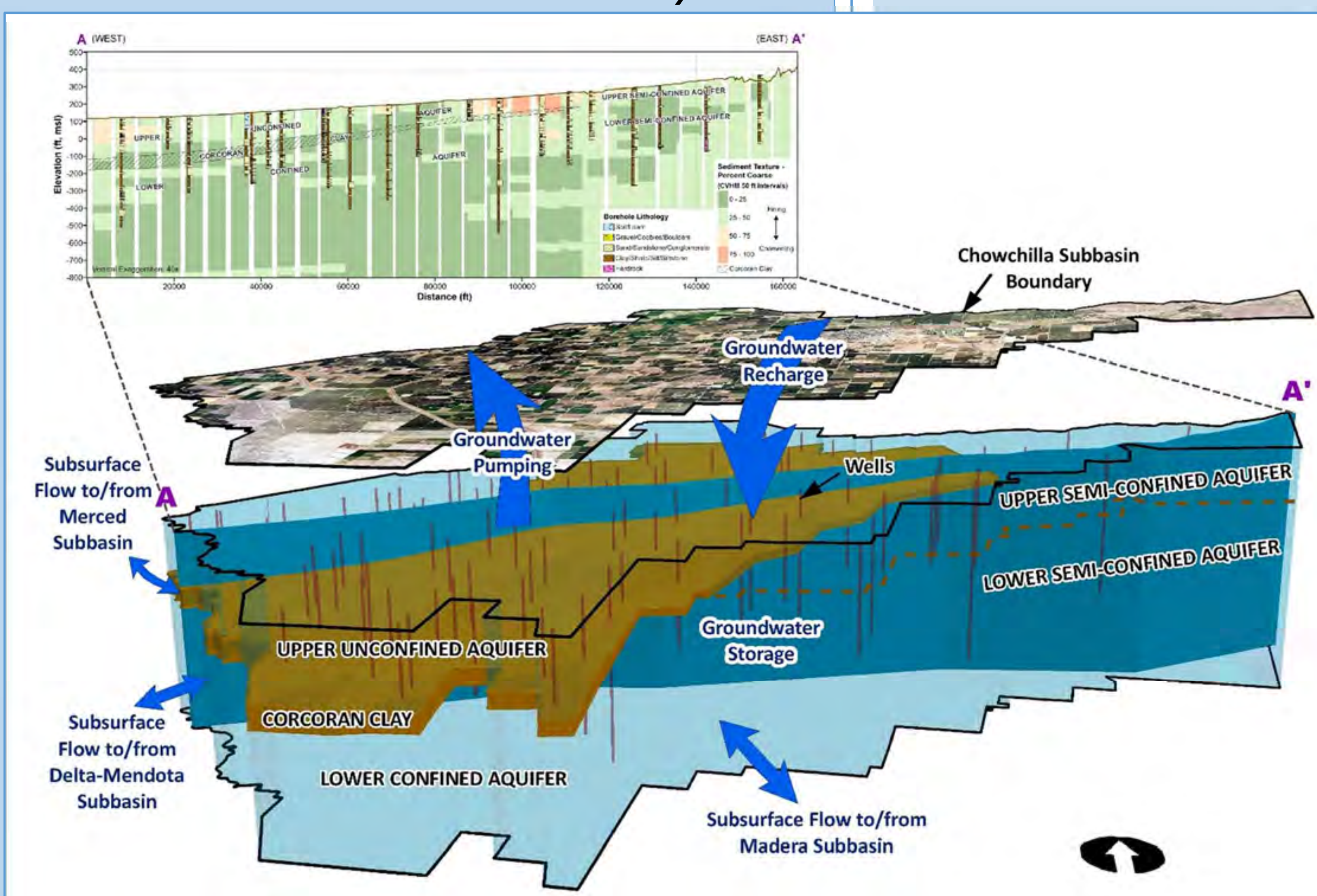
Technical Appendices 2.A. through 2.G.

January 2020

Revised July 2022

Prepared by

Davids Engineering, Inc (Revised GSP)
Luhdorff & Scalmanini (Revised GSP)
ERA Economics
Stillwater Sciences and
California State University, Sacramento



FINAL

Chowchilla Subbasin

Sustainable Groundwater Management Act

Groundwater Sustainability Plan

Technical Appendices 2.A. through 2.G.

January 2020
Revised July 2022

Prepared For

Chowchilla Subbasin GSP Advisory Committee

Prepared By

Davids Engineering, Inc
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APPENDIX 2. PLAN AREA AND BASIN SETTING

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APPENDIX 2.A. CHOWCHILLA SUBBASIN ANNUAL SPATIAL LAND USE

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020

GSP Team:

Davids Engineering, Inc
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To support GSP development, land use areas in the Chowchilla Subbasin were identified from available data in Madera and Merced Counties, which include the entire Chowchilla Subbasin.

Annual land use estimates were primarily based on spatially distributed land use information from DWR Land Use surveys for Madera County (1995, 2001, and 2011) and Merced County (1995, 2002, and 2012), and Land IQ[1] remote sensing-based land use identification for 2014. County Agriculture Commission land use areas were used to interpolate between years with available spatial land use information. Lands in the District were assigned to one of 17 land use classes.

The following five steps were used to develop the county-wide annual, spatial land use datasets.

1.) Developed spatial land use coverages for:
    Madera County: 1995, 2001, 2011, and 2014
    Merced County: 1995, 2002, 2012, and 2014,
    and made adjustments to the spatial coverage, including:
    a) Filled missing area from Land IQ coverage with 2011 DWR coverage (native, semi-agricultural, urban, and water account for 86% of the missing area in Madera County and 95% of missing area in Merced County)
    b) In Madera County: Used the water area from 2001 for the 1995 DWR survey (water surfaces were not included in the 1995 DWR survey).
2.) Calculated agricultural area:
    a) Assumed county data does not include idle land (county data has zero idle area in all years)
    b) Excluded idle land from DWR agricultural totals to be consistent with county totals
    c) Calculated the ratio of the DWR agricultural total area (not including idle lands) to county agricultural production area for years with DWR (or Land IQ) land use data
    d) Estimated agricultural area for missing years between the first and last available county data by interpolating the ratio calculated in step (c)
    e) Estimated agricultural area for missing years outside the available county data by extending the annual trend or estimating as equal to the nearest available county data
3.) Multiplied county agricultural acres for each crop by the ratio calculated in in step 2 (c) to adjust county agricultural areas for each crop scaling each crop area in each year by an estimate of the difference between the areas in the DWR land use surveys and County Commissioner reports. This procedure assumes DWR areas are the most accurate.
    a) Interpolated native, semi-agricultural, urban, and water land uses between DWR years.
    b) Calculated idle area as the remaining area (total DWR land use minus total cropped area)
4.) Reviewed calculated idle and crop area graphs and adjusted individual annual crop areas with abnormal area shifts based on professional judgement to eliminate calculated negative idle area.
    Madera County:
    a) 1996 adjustments--replaced high miscellaneous truck areas with interpolated values between 1995 and 1997
    b) 2002, 2003, 2004 and 2005 adjustments--replaced high areas for mixed pasture and alfalfa between 2001 and 2011 DWR areas by interpolating areas between 2001 and 2011.
    c) 2012 adjustments--replaced high miscellaneous deciduous, field and truck with interpolated value between 2011 and 2013
    Merced County:
    a) Almond acreage adjustments--interpolated years 2013 and 2015 using 2012 and 2014 land use coverages.
    b) Citrus and Subtropical acreage adjustments--interpolated between 2002 and 2015 using 2002, 2012, and 2014 land use surveys

[1] Land IQ is a firm that was contracted by DWR to use remote sensing methodologies to identify crops in fields.

   c) Grain and Hay Crops--interpolated years 2013 and 2015 using 2012 and 2014 land use coverages
   d) Grapes--interpolated between 1989 and 2015 using land use surveys
   e) Miscellaneous Field Crops--replaced low acreage in 1991 by interpolating between 1990 and 1992
   f) Miscellaneous Truck Crop--interpolated years 2006, 2009, 2010, 2013, and 2015 based on land use surveys
   g) Water--assumed acreage from 1995 DWR survey for 1989 through 1994

5.) Implemented the DWR Land Use interpolation tool to create annual spatial cropping data sets for 1989 through 2017.

Table A2.A-1 summarizes the land use sector and average acreage of each land use class in the Chowchilla Subbasin based on the above land use analysis.

Table A2.A-1. Average Land Use Acreages in Chowchilla Subbasin, 1989 to 2014.

Land Use Sector	Land Use Class	Acres
Agricultural	Alfalfa	22,743
	Almonds	26,296
	Citrus and Subtropical	65
	Corn (double crop)	17,325
	Grain and Hay Crops	5,642
	Grapes	9,976
	Idle	6,624
	Miscellaneous Deciduous	3,791
	Miscellaneous Field Crops	14,377
	Miscellaneous Truck Crops	1,537
	Mixed Pasture	6,424
	Pistachios	3,951
	Walnuts	315
Native Vegetation	Native	17,702
	Water	1,397
Urban	Urban	4,691
	Semi-agricultural	3,467
Total		146,323

References

DWR. 2011. “Madera County land use survey data.” State of California, Department of Water Resources. Available online: https://water.ca.gov/Programs/Water-Use-And-Efficiency/Land-And-Water-Use/Land-Use-Surveys. Also published in 1995 and 2001.

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Land IQ. 2014. “Statewide Crop Mapping 2014.” Land IQ, LLC, and State of California, Department of Water Resources. Available online: https://gis.water.ca.gov/app/CADWRLandUseViewer/.

Madera County. 2018. “Madera County Crop & Livestock Report.” Madera County Department of Agricultural Weights and Measures. Available Online: https://www.maderacounty.com/government/agricultural-commissioner-weights-and-measures/annual-crop-reports. Published annually.

Merced County. 2018. “Merced County Report on Agriculture.” Merced County Department of Agriculture. Available Online: https://www.co.merced.ca.us/151/Crop-Statistics-Reports. Published annually.

APPENDIX 2.B. ASSESSMENT OF GROUNDWATER DEPENDENT ECOSYSTEMS

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020

GSP Team:

Davids Engineering, Inc
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TECHNICAL APPENDIX ◦ NOVEMBER 2019

Assessment of Groundwater Dependent Ecosystems for the Chowchilla Subbasin Groundwater Sustainability Plan

PREPARED FOR

Groundwater Sustainability Plan
Chowchilla Subbasin

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1 GDE IDENTIFICATION

Groundwater dependent ecosystems (GDEs) are defined in California's Sustainable Groundwater Management Act (SGMA) as "ecological communities of species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface" (23 CCR § 351(m)). As described in The Nature Conservancy's guidance for GDE analysis (Rohde et al. 2018), a GDE's dependence on groundwater refers to reliance of GDE species and/or communities on groundwater for all or a portion of their water needs. In this section, we detail the information sources used, new information gathered, and methods applied to make determinations and to describe the conditions of GDEs identified in the Chowchilla Subbasin. We used Rohde et al. (2018) as well as the text of SGMA itself as primary guides.

1.1 GDE Mapping and Methods

We began the process of identifying the GDE units in the Chowchilla Subbasin using the California Department of Water Resources' (DWR) iGDE (GDE indicators) database, published online and referred to as the Natural Communities Commonly Associated with Groundwater dataset (Klausmeyer et al. 2018). We augmented these data with other relevant spatial vegetation data, aerial imagery, information on vegetation types, depth to groundwater, plant and animal species distributions in the area, plant species rooting depths, and field observations. Data analysis was conducted through a series of steps to augment, filter, classify and finalize the GDE units within the Chowchilla Subbasin.

1.1.1 Data sources

This section includes brief descriptions of the data and other information sources used to identify and aggregate potential GDEs into final GDE units.

Our starting point for GDE identification and analysis was the iGDE database (Klausmeyer et al. 2018). We downloaded the iGDE geodatabase from the DWR website (https://gis.water.ca.gov/app/NCDatasetViewer/#) and incorporated it into the project geographic information system (GIS) to create a preliminary map to serve as the primary basis for initial identification of potential GDEs. This data set is a combination of the best available data obtained from multiple publicly available sources:

- VegCAMP – Vegetation Classification and Mapping Program, California Department of Fish and Wildlife (CDFW 2018) – Areas mapped to the alliance level and with a minimum mapping unit (MMU) of 1.0 and 0.25 acres for natural uplands and wetlands/ riparian areas, respectively; mapped using 2012 imagery from the National Agriculture Imagery Program (NAIP) for the Southern San Joaquin Valley.
- NWI v2.0. – National Wetlands Inventory (Version 2.0), U.S. Fish and Wildlife Service (USFWS 2018); MMU = 0.5 acres.
- CalVeg – Landsat-based classification and assessment of visible ecological groupings, USDA Forest Service (March 2007) – vegetation mapping to the alliance level that is cross-walked to VegCAMP; MMU = 2.5 acres.

In addition, we added a more recent vegetation mapping source for the San Joaquin River riparian corridor, developed by Stillwater Sciences under contract with the Bureau of Reclamation for the San Joaquin River Restoration Program (Bureau of Reclamation 2014). This dataset represents an update to the Geographic Information Center's 2009 vegetation map, prepared for DWR's

Central Valley Flood Protection Program; this update used 2012 NAIP imagery and 2013 field observations. Vegetation was mapped to the alliance level with an MMU of 0.25 acres (Bureau of Reclamation 2014).

Klausmeyer et al. (2018) created the iGDE dataset as a starting point to identify potential GDEs across the state. Per the authors, this dataset requires careful review and refinement with local information since it was created at the state scale and broad decisions were made without consideration of local conditions. Thus, we reviewed all areas included in the iGDE dataset and scanned the full area of the Chowchilla Subbasin, using aerial imagery and existing vegetation mapping, to check for potential GDEs that might have been omitted or mischaracterized during creation of the statewide iGDE dataset.

To inform the assessment of GDE condition and potential effects (Sections 2 and 3), we obtained mapped plant community and wetland types detailed in the original VegCAMP, NWI, and CalVeg datasets as well as the San Joaquin River Riparian Vegetation dataset, the latter of which was available in-house. We evaluated and incorporated information on depth to groundwater and plant species rooting depth into this analysis to help inform subsequent assessment of potential sensitivity of vegetated GDEs to changes in groundwater. Published information on depth of rooting for riparian and wetland plant species was obtained in the form of a database (spreadsheet) collated and made publicly available online by TNC at The Nature Conservancy's Groundwater Resource Hub (https://groundwaterresourcehub.org/gde-tools/gde-rooting-depths-database-for-gdes/). Where data were missing, Stillwater's vegetation ecologists conducted literature searches to update this database for phreatophyte species occurring within the Chowchilla Subbasin. Depth to groundwater in the regional aquifer was estimated and mapped by LSCE based on existing well data, as described in Section 2.2.2 of this Groundwater Sustainability Plan (GSP) and provided as a geodatabase. Information on hydrogeology was used to better understand the distribution of other perched/mounded groundwater in the subbasin (Davids Engineering and LSCE 2017).

1.1.2 Procedure

In general, we followed the steps for defining and mapping GDEs outlined in Rohde et al. (2018). Throughout this process, we applied a decision tree to determine when species or biological communities were considered groundwater dependent based on definitions found in SGMA and Rohde et al. (2018). This decision tree, created to systematically and consistently address the range of conditions encountered, is summarized below, where the term 'unit' refers to an area with consistent vegetation and hydrology:

The unit is a GDE if groundwater is:

1. An important hydrologic input to the unit during some time of the year, AND
2. Important to survival and/or natural history of inhabiting species, AND
3. Associated with:
    a. A perched/mounded[1] unconfined aquifer, OR
    b. A regional aquifer used as a regionally important source of groundwater.

[1] The degree to which the shallow groundwater is perched or mounded atop shallow clay layers. Mounding is often pronounced underneath rivers which are often the source of the mounded water.

The unit is not a GDE if its hydrologic regime is primarily controlled by:

1. Surface discharge or drainage from an upslope human-made structure(s), such as irrigation canal, irrigated fields, reservoir, cattle pond, water treatment pond/facility.
2. Precipitation inputs directly to the unit surface. This excludes vernal pools from being GDEs where units are hydrologically supplied by direct precipitation and very local shallow subsurface flows from the immediately surrounding area.

For the Chowchilla Subbasin, shallow groundwater is perched/mounded above shallow clay layers rather than the regional aquifer. Specifics on these steps, as applied to the Chowchilla Subbasin, are provided below.

1.1.2.1 Identify communities supporting phreatophytic vegetation

After obtaining the relevant spatial data described above, we overlaid and evaluated these data in GIS to select the most recent and highest quality vegetation and water body mapping information. In this case, consistent with Klausmeyer et al. (2018), we prioritized the most recent and highest resolution mapping over earlier and coarser scale mapping information. Thus, the order of priority, from first to last, was: San Joaquin River Riparian (Bureau of Reclamation 2014), VegCAMP, NWI v2.0, CalVeg. The highest priority mapped vegetation type polygons that overlapped with the iGDE polygons were summarized by vegetation type and total acreage. These vegetation types were reviewed by one of our experienced wetland and riparian ecologists to remove vegetation types adapted to well drained, upland conditions (i.e., those not considered phreatophytes[2]) from the working GIS layer, such as blue oak woodland (*Quercus douglasii*).

1.1.2.2 Identify potential GDEs based on potential hydrologic connection to groundwater

GDEs rely on shallow groundwater in the Chowchilla Subbasin. For much of the subbasin, the regional aquifer is very deep, and the shallow groundwater that GDEs rely on is perched or mounded atop shallow clay layers. Because the potential hydrologic connection between the shallow groundwater and deep groundwater is often unknown, we conservatively assumed that shallow groundwater could potentially be influenced by pumping. We removed iGDEs without a potential hydrological connection to groundwater from the original dataset using spatially extrapolated or interpolated empirical measurements of depth to groundwater (DTW) for winter/spring of water years 2014 and 2016. DTW mapping for 2015 was not used due to limitations resulting from few available water level measurements. The 2014 and 2016 DTW data were the most accurate and recent DTW data available for the Chowchilla Subbasin. While the 2016 data represent conditions after the 2015 SGMA baseline, the use of shallow groundwater data from both years was deemed appropriate because it provided a more conservative (i.e., more inclusive) indicator of potential GDEs than the use of a data from a single year.

A DTW of 30 feet was used as one of the primary criteria in the initial screening of potential GDEs. The use of a 30-foot DTW criterion to screen potential GDEs corresponds to the maximum rooting depth of valley oak, *Quercus lobata* (Lewis and Burgy 1964), one of the species that compose iGDEs in the subbasin and is consistent with guidance provided by The Nature Conservancy (Rohde et al. 2018) for identifying GDEs. Potential GDEs were retained for

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[2] A phreatophyte is a deep-rooted plant that obtains its water from the phreatic zone (zone of saturation) or the capillary fringe above the phreatic zone (Rohde et al. 2018). Phreatophytes grow where precipitation is insufficient for their persistence and groundwater is therefore required for long-term survival (Naumberg et al. 2005). Phreatophytes are often, but not always, found in riparian areas and wetlands.

further analysis if the underlying DTW in either winter/spring 2014 or winter/spring 2016 was equal to or shallower than 30 feet. In addition, we evaluated DTW under the San Joaquin and Chowchilla rivers during 2014 and 2016 in relation to river flow to assess the potential connection between surface flow and groundwater levels. If there was evidence that the surface water was connected to groundwater (i.e., a gaining stream), that reach would be eligible for inclusion as a potential GDE. Because the vast majority of rivers in the subbasin are not perennial and all are in a net-losing hydrological condition (i.e., losing water to the groundwater system), this criterion excluded most of the smaller river channels and associated terrestrial vegetation from consideration as GDEs. Thus, we generated a draft map of the potential GDEs that occur in areas where DTW was less than or equal to 30 feet in either water year 2014 or 2016. We used 2012 geospatial vernal pool mapping data (Witham et al. 2014) in combination with aerial photographic analysis to identify vernal pools mapped in the iGDE data set and remove them from the working GIS layer and draft map. Other surface water features such as stock ponds that we determined were not connected to groundwater were removed based on review of aerial photographs and other available information.

1.1.2.3 Refine potential GDE map

We reviewed for accuracy the mapped vegetation cover in remaining polygons identified as potential GDEs using visual analysis of Google Earth and NAIP imagery. These potential GDE polygons were primarily those dominated by terrestrial vegetation (i.e., vegetated potential GDEs). We removed from the potential GDE map those areas that had, since vegetation mapping occurred, changed land use from natural vegetation to developed uses (urban, roads, or agriculture). During this heads-up review of the potential GDEs, areas supporting riparian or wetland vegetation that were not in the original iGDE geodatabase, but were included in other high-quality datasets (e.g., VegCAMP or San Joaquin River Riparian mapping [Bureau of Reclamation 2014]) and have the potential to be hydrologically linked to groundwater (i.e., located in an area where the depth to water is less than or equal to 30 feet or along a gaining river or stream reach), were added to the potential GDE geodatabase and map. Polygons on the potential GDE map were labeled and color-coded as “kept,” “added” or “removed” from the original iGDE data set according to the above described criteria (Figure A2.B-1).

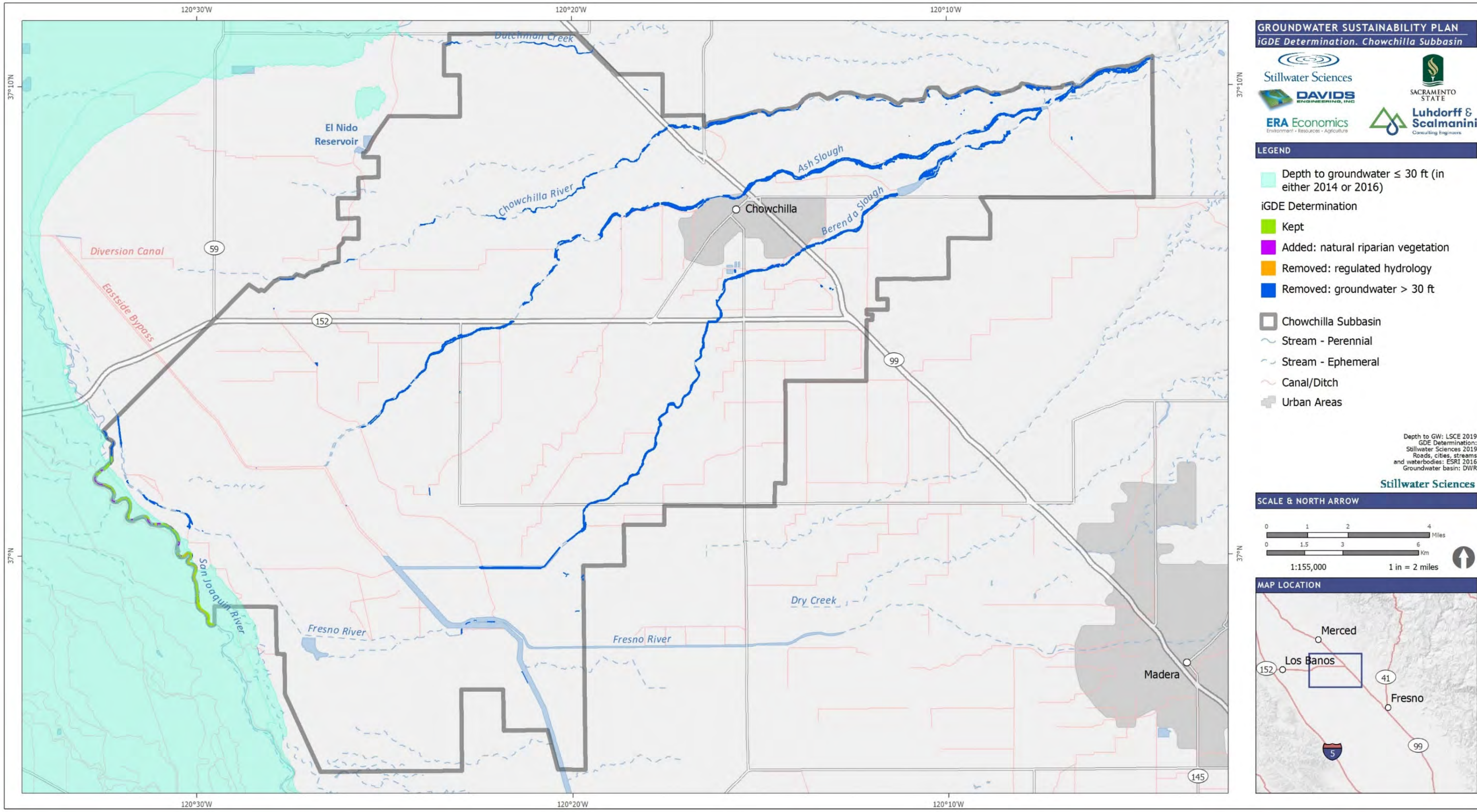

Figure A2.B-1. Potential GDEs in the Chowchilla Subbasin, showing iGDE polygons kept, added, or removed from the DWR Natural Communities Commonly Associated with Groundwater dataset.

1.1.2.4 Identify potentially associated sensitive species and community types

Stillwater Sciences' ecologists queried existing databases on regional and local occurrences and spatial distributions of special-status species. Databases accessed include CNDDB (2019), CNPS (2019), and eBird (2019). Spatial database queries were centered on the potential GDEs plus a 5-mile buffer. Stillwater's ecologists reviewed the database query results and identified species and community types with the potential to occur within or to be associated with the vegetation and aquatic communities in or immediately adjacent to the potential GDEs. Stillwater's ecologists then consolidated a list of these sensitive species and community types, along with summaries of habitat preferences and any known occurrence reports, for field review.

1.1.2.5 Ground truth vegetation type and condition in field surveys

On May 1, 2019, two Stillwater Sciences biologists, one with expertise in vegetation and the other in wildlife, performed a reconnaissance level survey of portions of the areas mapped as potential GDEs. The Stillwater team loaded spatial data on potential GDE locations, sensitive species occurrences, and DTW estimates onto a GPS equipped field tablet. The field crew also brought field maps and other information on potential special-status species to the field and visited a subset of the potential GDEs, selected to represent the range of potential GDE vegetation and hydrologic types in the subbasin. At each site, the field biologists recorded dominant vegetation types and plant species, estimates of percent cover for native and non-native plants by vegetation layer, indications of hydrologic connectivity with surface and/or groundwater, and indications of site alteration (e.g., cattle use, human disturbance, land use changes). Based on field observations, the field crew confirmed or refined mapped vegetation types, qualitatively evaluated the ecological condition, and qualitatively assessed habitat conditions for sensitive species at each representative site. The field crew recorded notes on the ecological conditions of each site visited, such as information on the proportion of live vs. senescent canopy, evidence of native species recruitment, and vegetation density. Habitat conditions for each species were assessed by comparing each species' habitat preferences (e.g., large trees, open water or herbaceous cover, etc.) to conditions present at the site. The field crew also recorded observations to help inform or verify potential linkages to groundwater, such as indications of standing water, water emerging from the ground, or flowing into or off of the site from a contributing area.

1.1.2.6 Refine vegetation and aquifer association for potential GDEs

We updated our geodatabase with field refinements in mapped vegetation types and extents, as well as location and extent of newly observed potential GDEs identified within the subbasin during the site survey. We then assigned the potential GDE units to aquifers based on DTW data and field observations.

1.1.2.7 Document changes to iGDE map and create final GDE map

We consolidated the remaining GDE polygons by type (e.g., vegetated, riparian) and proximity to one another, giving each grouping a descriptive name. Changes made to the original iGDE map were recorded as they were made, based on desktop or field observation of changes in vegetation type or land use, indications of no hydrologic linkage to groundwater, or areas where the hydrologic regime is dominated by human intervention, including canals. The final GDE map (Figure A2.B-2) shows these consolidated GDEs, grouped into GDE units, each with a unique color and name. A single unit, the San Joaquin River Riparian GDE Unit, occurs in the Chowchilla Subbasin. Figure A2.B-3 shows the GDE unit in greater detail.

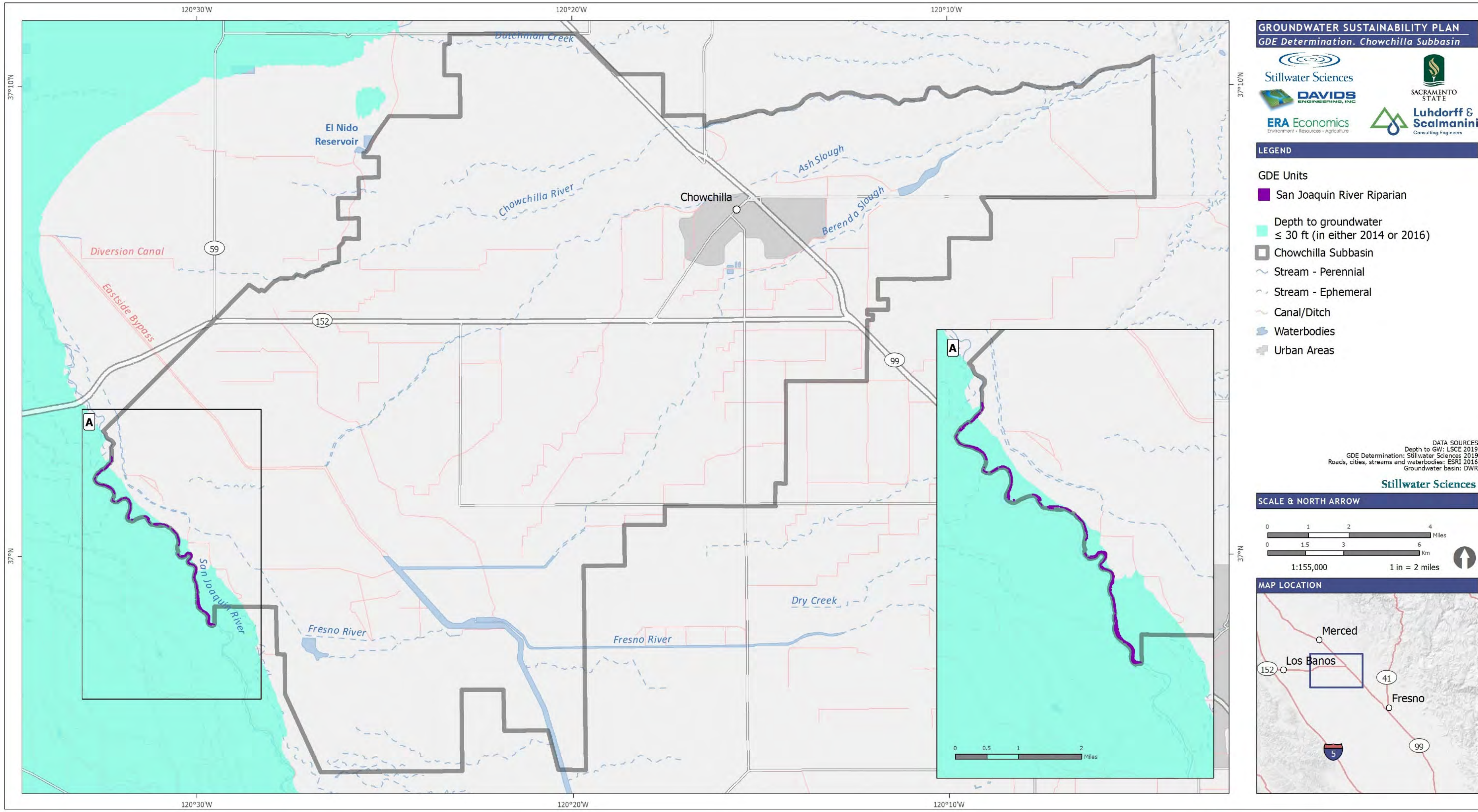

Figure A2.B-2. GDE units and depth to groundwater in the Chowchilla Subbasin.

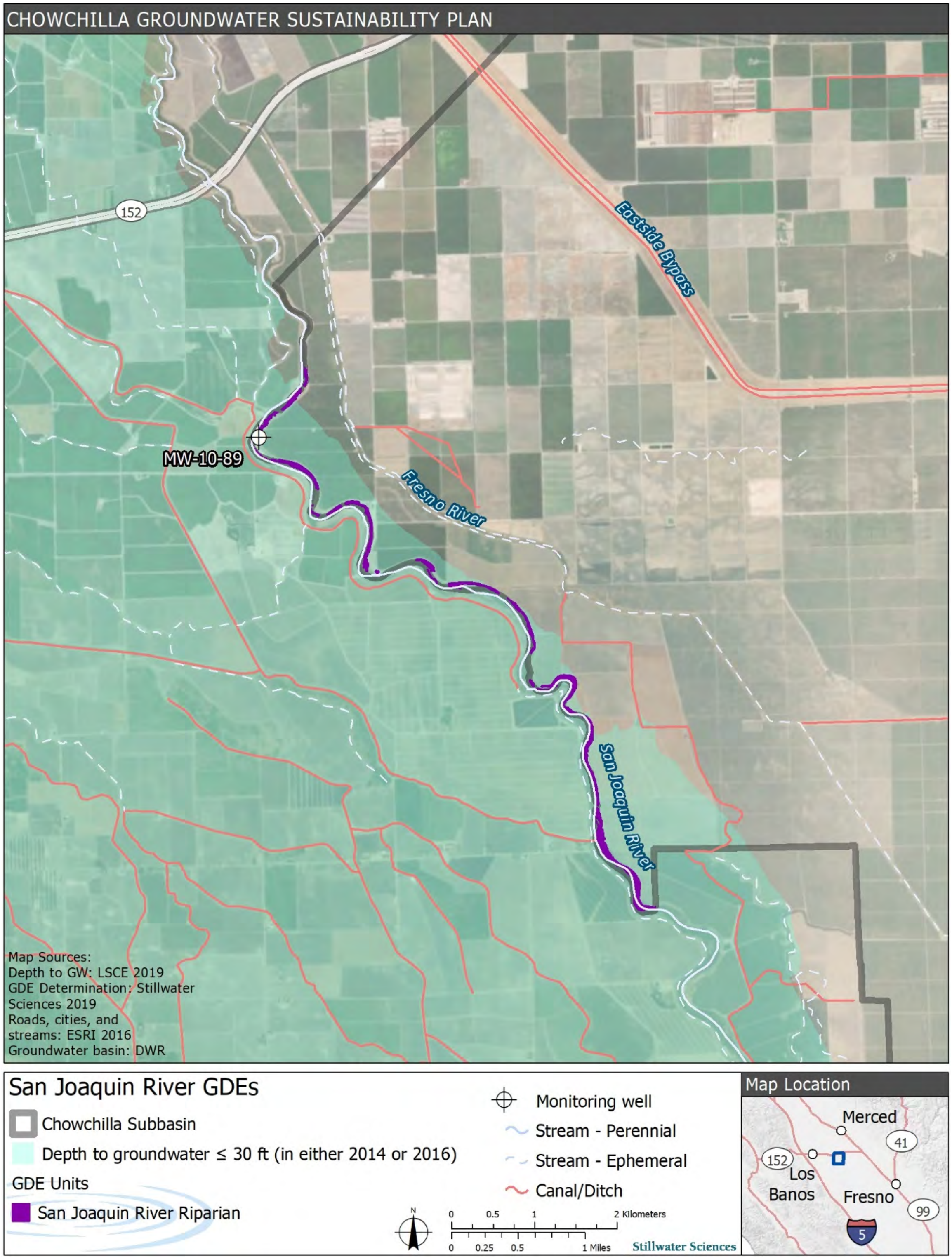

Figure A2.B-3. San Joaquin River Riparian GDE Unit, and the location of the San Joaquin River Restoration Program (SJRRP) monitoring well MW-10-89.

2 GDE CONDITION

In this section we characterize the San Joaquin River Riparian GDE Unit based on its hydrologic and ecological conditions and assign a relative ecological value to the unit by evaluating its ecological assets and their vulnerability to changes in groundwater (Rohde et al. 2018).

2.1 Hydrologic Conditions

The San Joaquin River Riparian GDE Unit is located along the western boundary of the Chowchilla Subbasin. Flows in this reach of the San Joaquin River are largely controlled by releases from Friant Dam and Mendota Pool. The unit is underlain by interbedded sands and silt/clays and the Corcoran Clay is over 200 feet below the ground surface (see Chapter 2.2.1 of this GSP).

Groundwater was less than 30 feet deep in 2014 and 2016 under the GDE unit (Figure A2.B-3). This is too deep for the surface flow of the San Joaquin River to be continuously connected to groundwater, but within the maximum rooting depth of riparian plants. The groundwater may connect to the river during sustained high flows in the San Joaquin River. Groundwater perched/mounded atop the upper clay likely originates from infiltration of surface water, agricultural runoff and infiltration, and potentially leakage from the canals in close proximity to the channel. Underneath the San Joaquin River, the groundwater is perched or mounded atop the shallow clay but there is no unsaturated zone below the perched/mounded aquifer. It is therefore possible that changes to the regional aquifer could affect the shallower perched/mounded aquifer that maintains the GDE, but this connection is unknown. Simulations using C2VSIM, a groundwater-surface water modeling system designed by DWR for the entire Central Valley, suggest the San Joaquin River in this reach was a gaining stream, on average from the 1920s through 2000 (TNC 2014). The average element size for the C2VSIM modeling was 0.64 mi^2, a much coarser grid than used for the modeling conducted as part of this GSP, and hence the C2VSIM model has a much larger uncertainty in its results.

Flows in the San Joaquin River changed following the San Joaquin River Restoration Settlement Agreement in 2006. Prior to the settlement minimum releases from Friant Dam were required to deliver 5 cfs to Gravelly Ford, located upstream in the Madera Subbasin. Interim flow releases from Friant Dam began in October 2009, and restoration flows began January 1, 2014, but were curtailed during critically dry conditions from March 2014–February 2016. Restoration flows in the San Joaquin River were reinitiated in 2016.

To determine hydrologic conditions, groundwater depth was modeled at San Joaquin River Restoration Program (SJRRP) monitoring well SJRRP_MW-10-89. The historical condition (1988–2015) is illustrated in Figure A2.B-4. This well is located adjacent to the river within 50 feet of the GDE unit (Figure A2.B-3). Two other shallow SJRRP wells, SJRRP_MW-11-161 and SJRRP_MW-11-163, which are located approximately 1,800 feet upstream of Sack Dam (and approximately 5 miles upstream of SJRRP MW-10-89), are ¼ mile east of the San Joaquin River Riparian GDE. These more distal wells can be used to assess groundwater changes near the upstream end of the GDE.

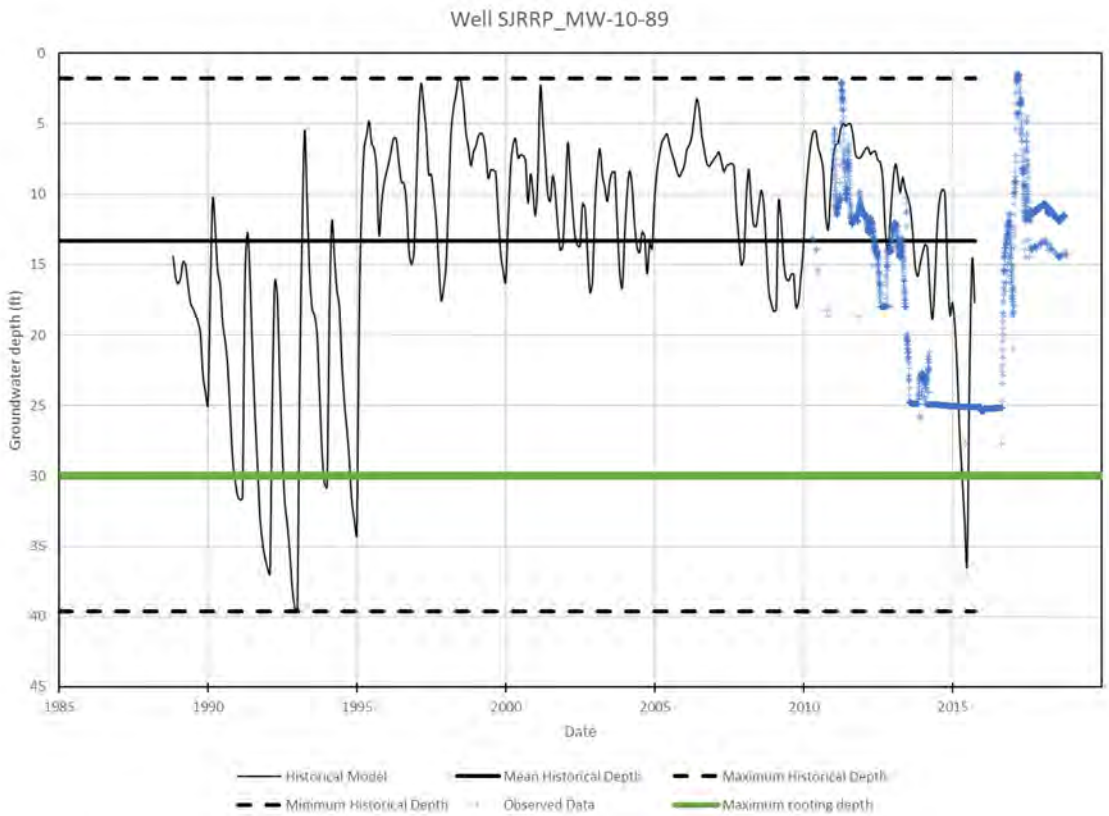

Figure A2.B-4. Modeled and observed groundwater elevations from well SJRRP_MW-10-89 located at the northwest section of the San Joaquin River Riparian GDE Unit.

Figure A2.B-4 shows the modeled depth for the finer-scale modeling results for 1988–2015 conducted as part of this GSP (black lines), groundwater depth measurements (blue plus symbols), the mean groundwater depth for 1988–2015 (horizontal solid line), and the minimum and maximum modeled depths for 1988–2015 (dashed horizontal lines) for SJRRP_MW-10-89. The model results are linked to known hydrologic inputs from 1988–2015 and observed data recorded from April 2010–October 2018 for the SJRRP_MW-10-89 well. Because the well is screened from 10 to 25 feet below the ground surface, the persistent water depths near 25 feet from 2013–2016 (Figure A2.B-4) indicate that water depth was at least 25 feet deep, but the actual depth is unknown. The SJRRP restoration flows in the San Joaquin River are likely critical to maintaining shallow groundwater elevations associated with the GDE unit. With the exception of the dry period from 2013–2016 (when the observations do not reflect changes in groundwater level because the groundwater depth exceeded 25 feet), the model does a reasonable job capturing the timing of changes in groundwater level. The magnitudes of change differ by generally about 5 feet but the model results were at least 15 feet higher than the observations in 2014. The model does a much better job representing the 2012–2016 period in wells SJRRP_MW-11-161 and SJRRP_MW-11-163. From October 1988–December 1994 the shallow groundwater was very deep and highly variable. To some degree this is due to the drought during this period in combination with the lack of interim or restoration flow releases from Friant Dam prior to 2009.

The minimum modeled groundwater depth was 36.2 feet during the drought in November 1992. The deep groundwater depths prior to 1995 were due to a combination of drought conditions in the subbasin and very low flow releases to the San Joaquin River. The mean modeled groundwater depth form 1989–2015 was 7.9 feet and the groundwater depth ranged from 1.8–39.6 feet. Over this period, the groundwater depth exceeded 30 feet (the maximum depth at which GDE connection to groundwater is likely) for 22 months (6.8% of the monthly data). The shallowest well depths indicate that the surface water may be temporarily connected with the perched/mounded groundwater beneath the well. Because the groundwater inputs are dependent on inflow from the San Joaquin River, groundwater elevations decline during low flow periods and increase during high flows.

2.2 Ecological Conditions

The San Joaquin River Riparian GDE Unit is located along the San Joaquin River on the western margin of the Chowchilla Subbasin (Figures A2.B-2 and A2.B-3) and is composed of a mix of riparian forest, shrub, and herbaceous habitat types totaling approximately 70 acres. Analysis of existing vegetation mapping data (Klausmeyer et al. 2018), color aerial imagery (ESRI 2017), and May 2019 field reconnaissance conducted in representative portions of the unit determined the quality of riparian habitat in this unit to be generally good but with habitat patches ranging from somewhat degraded to excellent quality. The width, complexity, and relative percentage of native vegetation in the riparian corridor varied along the length of the San Joaquin River in this unit, as observed during the May 2019 field survey and past surveys of the area by Stillwater Sciences' ecologists, as well as review of aerial imagery. The riverine, aquatic habitat of the San Joaquin River is not contained within the GDE unit because, although surface flows in the San Joaquin River likely contribute to shallow groundwater in the unit via infiltration (see Section 2.2.2.5 of this GSP), available hydrologic data indicates no substantial groundwater contribution to the surface flow in the river (i.e., this reach of the San Joaquin River does not gain but rather loses water to the groundwater system). However, the riparian vegetation community of the San Joaquin River Riparian GDE Unit fulfills several essential ecosystem functions or provides important habitat elements, such as large wood and riparian shade, on which both semi-aquatic species of the GDE unit and aquatic species of the San Joaquin River depend for completing essential life behaviors. The Water Quality Control Plan (Basin Plan) for the San Joaquin River Basin (CRWQCB 2018) identifies the San Joaquin River adjacent to the GDE unit as having the following beneficial uses for fish and wildlife:

- Warm freshwater habitat (WARM);
- Warm and cold migration habitat (MIGR);
- Warmwater spawning habitat (SPWN); and
- Wildlife habitat (WILD).

Designated fish and wildlife beneficial uses of other surface water bodies in the Chowchilla Subbasin, including the Fresno River and Chowchilla River, are limited to warm freshwater habitat (WARM) and wildlife habitat (WILD). The Basin Plan also lists coldwater spawning habitat (SPWN) for salmon and trout as a potential beneficial use for this portion of the San Joaquin River. Because certain special-status aquatic species and habitat elements present in the San Joaquin River may rely in part on inputs and functions provided by vegetation in the GDE unit, these contributions are considered beneficial uses warranting consideration under SGMA. Accordingly, certain special-status species and their habitat in the San Joaquin River are included in the analyses of potential effects on the San Joaquin River Riparian GDE Unit presented below.

The reconnaissance-level biological assessment of representative portions of the San Joaquin River Riparian GDE Unit conducted in May 2019 identified areas of mature riparian forest with a stratified canopy and moderately open understory, overhanging vegetation along the riverbank, and downed wood (Figure A2.B-5). Vegetation at the site provided over 90% native cover in the shrub and tree layer and 15–25% native cover in the herbaceous ground cover, with the balance occupied by non-native species. Dominant vegetation included Fremont cottonwood (*Populus fremontii*) and Goodding's willow (*Salix gooddingii*) in the overstory and narrow-leaved willow (*Salix exigua*) in the shrub layer, interspersed with herbaceous ground cover dominated by European grasses and emergent vegetation (tules, cattails) lining the channel edge. Wildlife observed within the San Joaquin River Riparian GDE Unit included white-faced ibis, barn swallow, ash-throated flycatcher, Canada goose, spotted towhee, and house wren.

Figure A2.B-5. High-quality riparian habitat in the San Joaquin River Riparian GDE Unit. Photo taken May 1, 2019 by Stillwater Sciences.

The potential for special-status species and their habitat to occur in the San Joaquin River Riparian GDE Unit was determined by querying databases on regional and local occurrences and spatial distributions of special-status species, including CNDDB (2019), CNPS (2019), and eBird (2019). Spatial database queries were centered on the potential GDE plus a 5-mi buffer. Database query results of local and regional occurrences were combined with known habitat requirements of identified special-status species to develop a list of special-status species that satisfy one or more of the following criteria: (1) known to occur in the region and suitable habitat present in the GDE unit, (2) documented occurrence within the GDE Unit, and (3) directly observed during the May 1, 2019 reconnaissance survey (Table A2.B-1).

This GDE unit does not contain or overlap any critical habitat for federally listed species (USFWS 2019, NMFS 2016) but the adjacent San Joaquin River contains Essential Fish Habitat (EFH) for Chinook salmon which is partially dependent on riparian inputs to provide important salmon habitat elements including shade, overhead cover, nutrients, and woody material for instream cover and habitat complexity (PFMC 2014). The PG&E San Joaquin Valley Operations and Maintenance Habitat Conservation Plan (Jones & Stokes 2006) includes covered lands within the San Joaquin River Riparian GDE Unit and covers some of the same species identified in our queries as potentially occurring within the unit. However, the queries and field reconnaissance we conducted for this analysis provide more recent and site-specific data on the presence or potential for special status species to occur in the GDE unit, as well as the overall ecological value, ecological condition trend, and vulnerability to future groundwater changes. Therefore, the information contained in the PG&E Habitat Conservation Plan was not incorporated into our analysis. The unit does not include any known protected lands (CPAD 2019).

2.3 Ecological Value

The San Joaquin River Riparian GDE Unit was determined to have **high ecological value** because of: (1) the known occurrence and presence of suitable habitat for several special-status species (Table A2.B-1); and (2) the vulnerability of these species and their habitat to changes in groundwater levels (Rohde et al. 2018). The unit's high ecological value is also related to its contributions to the ecological function of adjacent riverine habitat that supports special-status salmonids and other species.

Table A2.B-1. Special-status species with known occurrence, or presence of suitable habitat in the San Joaquin River Riparian GDE Unit.

Common name ***Scientific name***	**Status**[1]	**Association with GDE Unit**	**Source**	**Habitat and occurrence**
Birds				
Bald eagle *Haliaeetus leucocephalus*	FD, SFP	Likely	regional occurrence (CNDDB, eBird)	moderately suitable perching and limited nesting habitat; many documented occurrences in region; suitable foraging habitat in adjacent San Joaquin River
Swainson's hawk *Buteo swainsoni*	ST	Likely	regional occurrence (CNDDB, eBird)	highly suitable nest trees and nearby foraging habitat; many documented occurrences in Madera County
Western yellow-billed cuckoo *Coccyzus americanus occidentalis*	FT, SE	Unlikely	regional occurrence (CNDDB, eBird)	although rare, species is known or believed to occur in Madera County (USFWS 2019); moderately suitable nesting and foraging habitat present
Mammals				
Pallid bat *Antrozous pallidas*	SSC	Likely	regional occurrence (CNDDB, eBird)	suitable foraging habitat and numerous large trees for roosting; small structures moderately suitable for roosting in the vicinity
Western red bat *Lasiurus blossevillii*	SSC	Likely	regional occurrence (CNDDB, eBird)	suitable foraging habitat and numerous large trees for roosting
Amphibians and reptiles				
Western pond turtle *Emys marmorata*	SSC	Nesting stage likely; foraging may occur in adjacent San Joaquin River)	regional occurrence (CNDDB)	suitable nesting habitat
Fish				
Central Valley Spring-Run Chinook Salmon *Oncorhynchus tshawytscha*	FT	Not in GDE Unit but occupies adjacent San Joaquin River	known occurrence in San Joaquin River[2]	Suitable habitat present (migration, rearing); species known to occur in San Joaquin River and is sustained by San Joaquin River Restoration Program
Central Valley Steelhead *Oncorhynchus mykiss*	FT	Not in GDE Unit but likely in adjacent San Joaquin River	local/regional occurrence in San Joaquin River (CNDDB, NMFS)	Suitable habitat present (migration, rearing); species known to occur in San Joaquin River
Hardhead *Mylopharodon conocephalus*	SSC	Not in GDE Unit but likely in adjacent San Joaquin River	local/regional occurrence in San Joaquin River (CNDDB)	Suitable habitat present; species known to occur in San Joaquin River
Plants				
Sanford's arrowhead *Sagittaria sanfordii*	1B.2, S3, G3, not state or federally listed	Likely	regional occurrence (CNDDB)	Emergent vegetation along backwater areas of channel edge could support this species.
California satintail *Imperata brevifolia*	2B.1, S3, G4, not state or federally listed	Likely	regional occurrence (CNDDB)	Occurs on stream banks and floodplains and therefore could be supported along these banks of the San Joaquin.
Brittlescale *Atriplex depressa*	1B.2, S2, G2, not state or federally listed	Likely	local occurrence (CNDDB)	Meadows, seeps, playas, vernal pools, alkaline soil, perennial grasslands, and backwater/oxbow depressions with saline soil could support this species; all CNDDB observations within buffer area are in grasslands and/or vernal pool areas; none in riparian corridor
Heartscale *Atriplex cordulata var. cordulata*	1B.2, S2, G3, not state or federally listed	Likely	local occurrence (CNDDB)	Found on saline or alkaline soils; occurs in annual grasslands, seeps, and backwater/oxbow depressions with saline soil; all CNDDB observations within buffer area are in grasslands and/or vernal pool areas; none in riparian corridor
Munz's tidy-tips *Layia munzii*	1B.2	Unlikely	local occurrence (CNDDB)	Chenopod scrub, grasslands, found on alkaline clay soils; last reported in area in 1941
Palmate-bracted bird's-beak *Chloropyron palmatum*	1B.1, FE, SE,	Likely	local occurrence (CNDDB)	Chenopod Scrub, alkaline soils, found in alkaline flats but multiple semi-recent sightings in the vicinity

Common name ***Scientific name***	**Status**[1]	**Association with GDE Unit**	**Source**	**Habitat and occurrence**
Spiny-sepaled button-celery *Eryngium spinosepalum*	1B.2, S2, G2, not state or federally listed	Likely	local occurrence (CNDDB)	Valley grassland, freshwater wetlands, wetland-riparian, vernal pools. Many CNDDB observations within buffer area are in grasslands such as those along San Joaquin riparian corridor
California alkali grass *Puccinellia simplex*	1B.2, S2, G3, not state or federally listed	Likely	local occurrence (CNDDB)	Valley grassland, wetland-riparian, Meadows, seeps, vernal pools, vernally mesic, sinks, lake margins however most CNDDB sightings are on alkali soils and/or vernal pools
Valley Sacaton Grassland	S1.1, G1	Likely	local occurrence (CNDDB)	Alkali-saline soil, and wetland found along riparian zones in California and southwest
Sycamore Alluvial Woodland	S1.1, G1	Likely	Regional occurrence (CNDDB)	Riparian, floodplain, and wetland

[1] Status codes:

G = Global

Federal
FT = Listed as threatened under the federal Endangered Species Act
FD = Federally delisted

State
S = Sensitive
SE = Listed as Endangered under the California Endangered Species Act
ST = Listed as Threatened under the California Endangered Species Act
SSC = CDFW species of special concern
SFP = CDFW fully protected species

Global Rank
1 Critically Imperiled—At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.
2 Imperiled—At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.
3 Vulnerable — At moderate risk of extinction or elimination due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.
4 Apparently Secure — Uncommon but not rare; some cause for long-term concern due to declines or other factors.

California Rare Plant Rank
1B Plants rare, threatened, or endangered in California and elsewhere
2B Plants rare, threatened, or endangered in California, but more common elsewhere
3 More information needed about this plant, a review list
4 Plants of limited distribution, a watch list
CBR Considered but rejected

CRPR Threat Ranks:
0.1 Seriously threatened in California (high degree/immediacy of threat)
0.2 Fairly threatened in California (moderate degree/immediacy of threat)
0.3 Not very threatened in California (low degree/immediacy of threats or no current threats known)

[2] San Joaquin River Restoration Program. 2017. Fisheries Framework: Spring-run and Fall-run Chinook Salmon. June 2017. http://www.restoresjr.net/?wpfb_dl=1055

3 POTENTIAL EFFECTS ON GDEs

This section presents the methods and results of our analysis to identify how groundwater management could affect GDEs in the Chowchilla Subbasin. Adverse effects (impacts) on GDEs are considered undesirable results under SGMA (State of California 2014). The analysis is based on the hydrologic conditions affecting GDEs and their susceptibility to changing groundwater conditions, trends in biological condition of the GDEs, and anticipated conditions or management actions likely to affect GDEs in the future.

3.1 Summary

This section provides a summary of potential effects for the San Joaquin River Riparian GDE Unit. The methods used to determine the GDE unit's current ecological condition and its susceptibility to changing groundwater conditions are described in Section 3.2 below. The analyses and rationale for these assessments are described in Sections 3.3, 3.4, and 3.5.

The San Joaquin River Riparian GDE Unit is characterized as having high ecological value with moderate susceptibility to changing groundwater conditions. The perched/mounded shallow groundwater associated with this unit has a potential connection with the regional aquifer and could be affected by groundwater pumping. Reconnaissance level biological assessment, aerial photograph analysis, and NDVI/NDMI data indicate the ecosystem structure and functions of the San Joaquin River Riparian GDE Unit are relatively intact and within the range of natural variability (Biological Condition Gradient Level 2 – Minimal Changes) and adverse impacts are not likely occurring in the unit as a result of current groundwater management (Table A2.B-2).

Projected future trends in depth to water indicate a modest decline in the average groundwater depth in the unit and an increase in the frequency and duration with which groundwater depth is expected to exceed historical lows. Adverse impacts related to future groundwater management are therefore possible.

Table A2.B-2. Summary of ecological value, susceptibility, and condition gradient in the San Joaquin River Riparian GDE Unit.

Ecological value	Rationale
High	1. Presence of special-status species 2. Vulnerability of special-status species and their habitat to changes in groundwater
Susceptibility to changing groundwater conditions	**Rationale**
Moderate	Current groundwater conditions (since 2015) are within the baseline range (1988–2015) but future changes in groundwater conditions may cause it to fall outside the baseline range.
Biological condition gradient	**Rationale**
Level 2—Minimal Changes	1. No change observed in NDVI/NDMI trends over the period 1985–2018 2. Relatively intact biotic structure and function as deduced from reconnaissance level assessment of riparian vegetation community condition 3. Suitable habitat present for those special-status species with likelihood to occur

3.2 Methods

SGMA describes six groundwater conditions that could cause undesirable results, including adverse impacts on GDEs. These are (1) chronic lowering of groundwater levels, (2) reduction of groundwater storage, (3) seawater intrusion, (4) degraded water quality, (5) land subsidence, and (6) depletions of interconnected surface water. Rohde et al. (2018) identify chronic lowering of groundwater levels, degraded water quality, and depletions of interconnected surface water as the most likely conditions to have direct effects on GDEs, potentially leading to an undesirable result. Following this guidance and based on available information for the Chowchilla Subbasin, we have eliminated reduction of groundwater storage, seawater intrusion (the subbasin is not located near or hydrologically connected to the ocean), and land subsidence from consideration. Current evidence indicates that groundwater pumping from the regional aquifer is unlikely to affect surface water flows in the subbasin, thus depletion of interconnected surface water is considered unlikely. The San Joaquin River is adjacent to, but not a part of, the San Joaquin River Riparian GDE Unit and is in a net-losing condition, with surface flow likely contributing directly to the shallow groundwater system that supports the vegetation in the unit. However, the shallow groundwater system adjacent to and disconnected from the San Joaquin River, which supports the GDE unit, does have at least the potential (albeit quite muted) to be affected by regional groundwater pumping.

This section evaluates the potential for chronic lowering of groundwater levels and degraded groundwater quality to cause direct effects on GDEs compared to baseline conditions), with a focus on effects related to groundwater levels. First, we identified baseline hydrologic conditions for the GDE unit using available information (see Section 2.2.2 of this GSP). The primary baseline hydrological condition metric used for our analysis was depth to groundwater. Next, we determined each GDE unit's susceptibility to changing groundwater conditions using available hydrologic data and the GDE susceptibility classifications (Rohde et al. 2018) summarized in Table A2.B-3.

Table A2.B-3. Susceptibility classifications developed for evaluation of a GDE's susceptibility to changing groundwater conditions (Rohde et al. 2018).

Susceptibility classifications	
High Susceptibility	Current groundwater conditions for the selected hydrologic data fall outside the baseline range.
Moderate Susceptibility	Current groundwater conditions for the selected hydrologic data fall within the baseline range but future changes in groundwater conditions are likely to cause it to fall outside the baseline range. The future conditions could be due to planned or anticipated activities that increase or shift groundwater production, causing a potential effect on a GDE.
Low Susceptibility	Current groundwater conditions for the selected hydrologic data fall within the baseline range and no future changes in groundwater conditions are likely to cause the hydrologic data to fall outside the baseline range.

We used these susceptibility classifications to trigger further evaluation of potential effects on GDEs by integrating existing biological data, field reconnaissance assessments, and aerial photography analysis. If we determined a GDE unit to have moderate or high susceptibility to changing groundwater conditions, we used biological information to assess whether evidence exists of a biological response to changing groundwater levels or degraded water quality. The biological response analysis consisted of a combined approach of reconnaissance-level biological assessments in representative areas of each GDE unit, and quantitative trend analysis of Normalized Difference Vegetation Index (NDVI) and Normalized Difference Moisture Index (NDMI) data for individual vegetation polygons within the GDE unit (Klausmeyer et al. 2019). The polygons correspond to different GDE mapping units (i.e., different species compositions) and the size of the GDE polygons varied.

NDVI, which estimates vegetation greenness, and NDMI, which estimates vegetation moisture, were generated from surface reflectance corrected multispectral Landsat imagery corresponding to the period July 9 to September 7 of each year, which represents the period when GDE species are most likely to use groundwater (see Klausmeyer et al. 2019 for further description of methods). Vegetation with higher NDVI values indicate increased density of chlorophyll and photosynthetic capacity in the canopy, an indicator of vigorous, growing vegetation. Similarly, high NDMI values indicate that the vegetation canopy has high water content and is therefore not drought stressed. These indices are both commonly used proxies for vegetation health in analyses of temporal trends in health of groundwater dependent vegetation (Rouse et al. 1974, Jiang et al. 2006; as cited in Klausmeyer et al. 2019). NDVI and NDMI trend analysis included compilation of NDVI and NDMI trend data from 1985 to 2018 for all delineated GDE polygons from the GDE Pulse Interactive Map (TNC 2019) that are within the GDE unit boundary. These data were used to calculate mean NDVI and NDMI, and 95% confidence intervals, by year for the GDE unit as a whole, and then change in mean NDVI/NDMI was visually inspected to identify increasing, decreasing, or no change in temporal trends over the period 1985 to 2018. Negligible changes were identified as those that failed to exceed the level of uncertainty in mean values as indicated by 95% confidence intervals.

To examine the effect of variable precipitation on NDVI/NDMI, annual precipitation data for each GDE was downloaded from the GDE Pulse Interactive Map (TNC 2019), and multiple linear regression analysis was used to evaluate potential relationships between precipitation and vegetation health. A weak correlation was interpreted as a weak coupling between precipitation and NDVI/NDMI, suggesting a comparatively stronger influence of groundwater conditions on NDVI/NDMI. We also evaluated the effect of surface water flows on NDVI/NDMI using the San Joaquin Valley Index (SJVI), which is calculated by DWR and is a function of San Joaquin flow into Millerton Reservoir, Merced River flow into Lake McClure, Tuolumne River flow to New Don Pedro Reservoir, and Stanislaus River flow into New Melones Reservoir (CDEC 2019). The index is used to determine water year type and flow releases in the San Joaquin River and its major tributaries. Because the SJVI is used to determine flow releases into the San Joaquin Valley and includes the previous year's hydrologic condition, it is a good proxy for hydrologic conditions experienced by GDEs located along San Joaquin Valley rivers.

Reconnaissance level biological assessments were used to determine the overall condition of riparian vegetation within the GDE unit, assess evidence of recent riparian tree recruitment, and detect biological indications of degraded water quality. Field observations were augmented with analysis of recent (2017 and 2018) aerial photographs to assess the degree to which field observations were consistent with trends detected in aerial photographs as well as spatial variability across the GDE unit.

These field-based, and remotely sensed biological data sources were used to determine any apparent trends in biological condition of the vegetation composing the GDE unit. These trends were evaluated over the period 1985–2018 (NDVI/NDMI) and 2017–2019 (using field-based and aerial photograph analyses) within the Biological Condition Gradient classification scheme (USEPA 2016) (Table A2.B-4). To assess impacts to GDEs, minimal or evident changes (Levels 2 and 3) were considered to indicate the potential for impacts due to changing groundwater conditions, with further data collection and analysis (i.e., monitoring) needed to evaluate the connection between impacts and groundwater management, if any. Moderate to severe changes (Levels 4–6), if detected, were considered to indicate adverse impacts to GDEs and therefore undesirable results in the subbasin.

Table A2.B-4. Classifications of the Biological Condition Gradient, a conceptual framework developed for interpretation of biological responses to effects of water quality stressors (USEPA 2016).

Biological condition gradient classifications	
Level 1—Natural or Native Condition	Native structural, functional, and taxonomic integrity is preserved. Ecosystem function is preserved within the range of natural variability. Functions are processes required for the normal performance of a biological system and may be applied to any level of biological organization.
Level 2—Minimal Changes	Minimal changes in the structure of the biotic community and minimal changes in ecosystem function. Most native taxa are maintained with some changes in biomass and/or abundance. Ecosystem functions are fully maintained within the range of natural variability.
Level 3—Evident Changes	Evident changes in the structure of the biotic community and minimal changes in ecosystem function. Evident changes in the structure due to loss of some highly sensitive native taxa; shifts in relative abundance of taxa, but sensitive ubiquitous taxa are common and relatively abundant. Ecosystem functions are fully maintained through redundant attributes of the system.
Level 4—Moderate Changes	Moderate changes in the structure of the biotic community with minimal changes in ecosystem function. Moderate changes in the structure due to the replacement of some intermediate sensitive taxa by more tolerant taxa, but reproducing populations of some sensitive taxa are maintained; overall balanced distribution of all expected major groups. Ecosystem functions largely maintained through redundant attributes.
Level 5—Major Changes	Major changes in the structure of the biotic community and moderate changes in ecosystem function. Sensitive taxa are markedly diminished or missing; organism condition shows signs of physiological stress. Ecosystem function shows reduced complexity and redundancy.
Level 6—Severe Changes	Severe changes in the structure of the biotic community and major loss of ecosystem function. Extreme changes in structure, wholesale changes in taxonomic composition, extreme alterations from normal densities and distributions, and organism condition is often poor. Ecosystem functions are severely altered.

3.3 Hydrologic Data

3.3.1 Baseline conditions

The baseline hydrologic conditions for the San Joaquin River Riparian GDE were assessed using the modeled period from October 1988 to September 2015 (water years 1989–2015). Because the shallow groundwater elevations are tied to flows in the San Joaquin River, changes to the operations of Friant Dam have the potential to alter shallow groundwater levels. In particular, SJRRP interim flow releases beginning in 2009 and restoration flow releases beginning in 2014, and from 2017 to present, will likely help to maintain shallower groundwater elevations in the GDE compared with the scant flow releases in the San Joaquin River prior to 2009. Nevertheless, we use the entire 1988–2015 period as the baseline condition because it incorporates two droughts, which are most likely to impact the health of the GDE. Moreover, releases from Friant Dam generally aid the GDE, but have been curtailed during critically dry years typical of droughts.

The minimum modeled groundwater depth for 1988–2015 is an inverse function of the SJVI (Figure A2.B-6), which is integrates runoff in the San Joaquin Basin for a given water year and hydrologic conditions the previous year. Low values of the SJVI are correlated with drier conditions and higher values reflect wetter conditions. Groundwater is deepest for San SJVI values less than 2.1, which correspond to critically dry water years. Modeled groundwater depths were more variable.

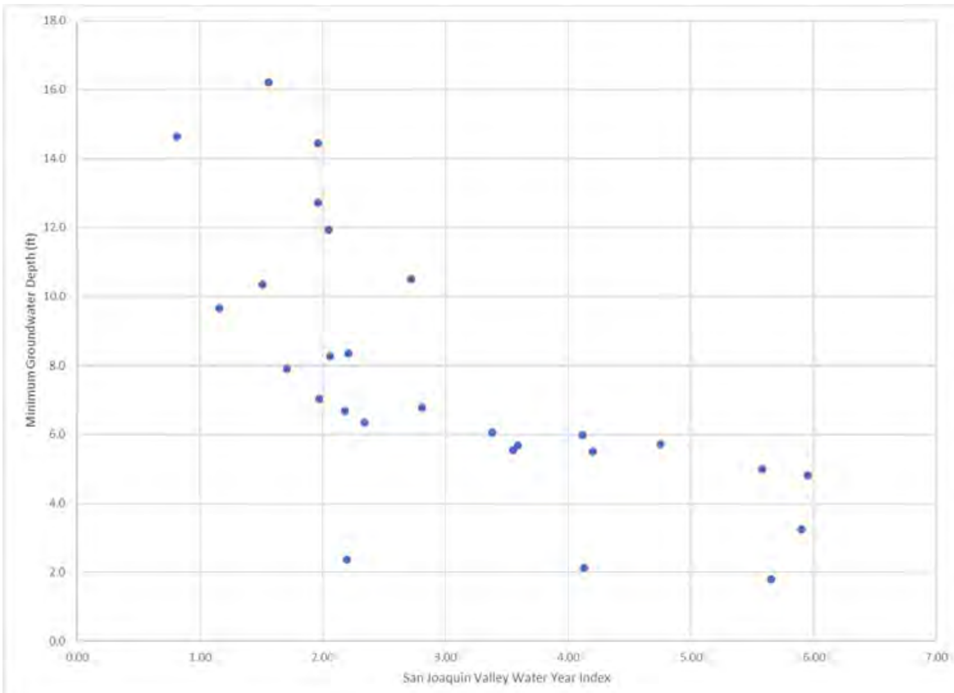

Figure A2.B-6. Minimum modeled groundwater depth for well SJRRP_MW-10-89 relative to San Joaquin Valley water year index, 1988-2015.

Groundwater quality data is available for multiple wells and constituents near the San Joaquin River Riparian GDE Unit (see Chapter 2.2.2.3 of this GSP). Maximum total dissolved solids (TDS) concentrations in the shallow groundwater of the GDE unit is elevated (>1,000 mg/L) at some locations, but other nearby wells indicate much lower values from 251–500 mg/L. High TDS conditions may be a result of naturally-occurring salinity in the groundwater system, especially in Coast Range-sourced sediments, which have marine origin. Other constituents, including nitrate, fall below applicable thresholds for environmental protection and human health at wells near the GDE unit.

The hydrologic baseline for the San Joaquin River Riparian GDE Unit is represented by the period from 1988–2015. This period experienced two droughts during which shallow groundwater depths likely were below the maximum rooting depth of riparian plants, but groundwater levels recovered once flows increased. There was no trend in shallow groundwater levels near the San Joaquin River Riparian GDE during the hydrologic baseline, rather the groundwater responded to surface hydrologic conditions, with monitoring and modeling results showing the groundwater very close to the ground surface during wet periods. While the San Joaquin River may be hydrologically connected to the groundwater during high flow events, this connection is likely very short-lived and likely reflects high runoff in the San Joaquin Basin. Since its construction in 1942, Friant Dam has diverted San Joaquin River water for agriculture. Operations were altered starting in 2009 to increase surface water flows for restoration and may help to maintain shallow groundwater elevations.

3.3.2 Susceptibility to potential effects

Future groundwater conditions were simulated by others for purposes of this GSP using MCSim, the same groundwater model used to assess the historical period shown in Figure A2.B-4. The future modeling was developed for use in GSP analyses assuming that the GSA will implement groundwater recharge projects, decrease groundwater demand, and to a lesser extent replace groundwater use with surface water use. As discussed in Chapter 3 of this GSP, the climate data used to model the first 20 years after implementation included a series of wet, average, and dry years that reflected the long-term historical average hydrologic conditions for the subbasin, but does not include a continuous series of dry or wet years. Following the implementation period (i.e., 2020–2040), historical hydrology from 1965–2015 is used for 2041–2090 and includes groupings of wet years and dry years (i.e., short- and longer-term droughts). Climate change was incorporated into the model following DWR guidelines (e.g., DWR 2018). In addition, model projections include a 10-year drought from 2060–2070 that is longer than the droughts experienced in the Chowchilla Subbasin during the historical modeling period, to explore the effects of a severe drought on groundwater sustainability.

Figure A2.B-7 shows the simulated and observed groundwater elevations for well SJRRP MW-10-89 from 1988–2090. The observed and simulated groundwater elevations for the historical (baseline) period (1988–2015) are identical to Figure A2.B-4, but Figure A2.B-7 includes the future simulation described above. Relative to the modeled baseline (1988–2015), the mean simulated shallow groundwater depth from 2020–2090 declines by 1.6 feet, from 13.3 in the baseline period to 14.9 ft in the implementation and sustainability periods (Figure A2.B-7 and Table A2.B-5). For the implementation period (2020–2040), which does not include the simulated 2060–2070 drought, the mean modeled groundwater elevation was 14.2 feet, between the 1988–2015 mean depth and the 2020–2090 mean depth. The range of simulated groundwater depth also increased as the minimum depth was closer to the surface (from 1.8 to 0.7 feet) and the maximum depth increases from 39.6 to 47.1 feet. As a consequence, the standard deviation of depth increases from 7.9 to 8.3 feet for the baseline and future conditions, respectively (Table A2.B-5). The fraction of months with groundwater depth greater than 30 feet increased from 6.8% for the baseline period to 9.2% for the implementation and sustainability periods (2020–2090).

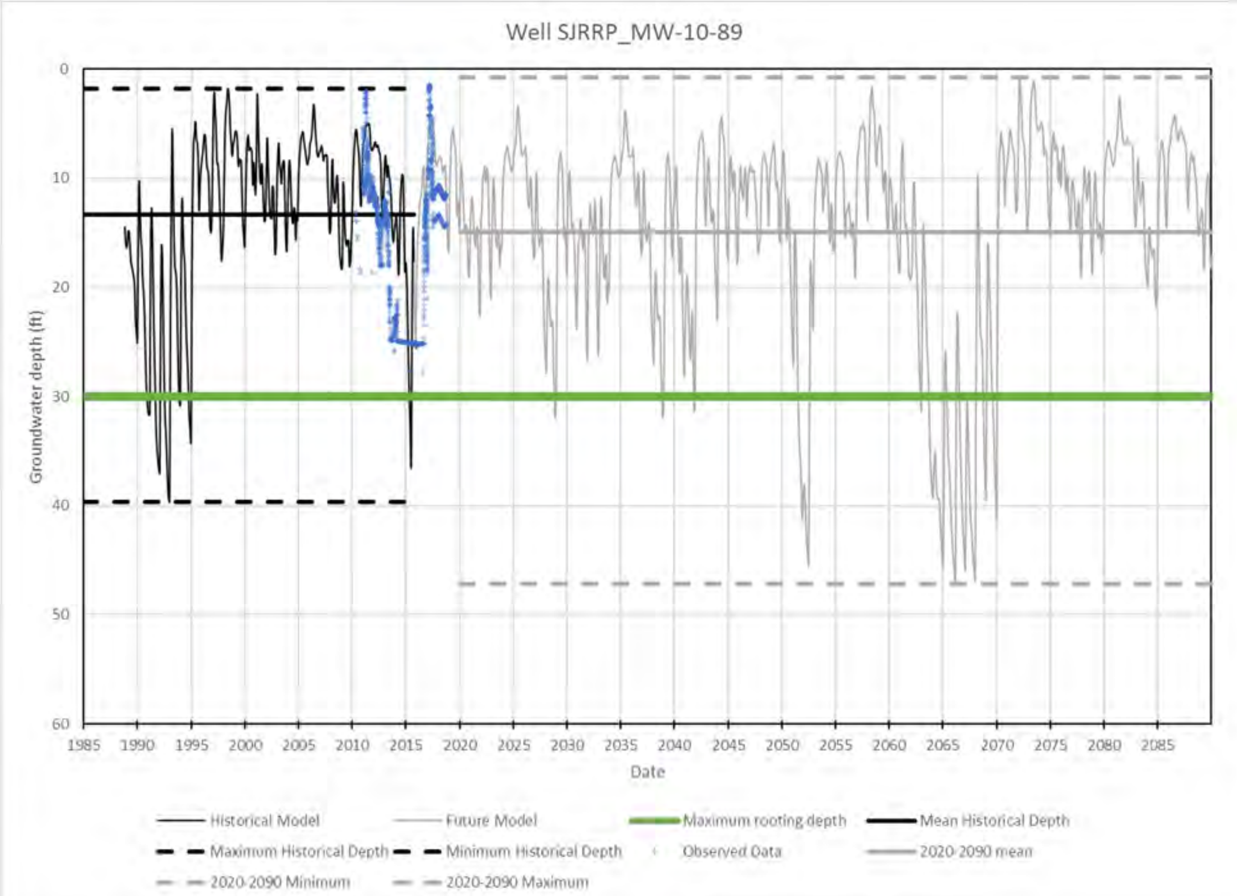

Figure A2.B-7. Simulated historical (black line 1988–2015) and modeled projected (grey line 2016–2090) monthly groundwater depth for well SJRRP_MW-10-89. Observed data (blue plus signs) were recorded hourly. The solid horizontal lines represent the mean modeled groundwater depth for the historical (black) and projected post-implementation (2020-2090) (grey) periods, while the horizontal dashed lines represent the maximum and minimum groundwater depth for the historical (black) and projected (grey) periods. The horizontal green line represents the maximum depth (30 feet) at which phreatophytic plants can access groundwater.

Table A2.B-5. Statistics of monthly modeled well depth for the SJRRP_MW-10-89 well.

Date range	Number of months	Mean depth (ft)	Standard deviation (ft)	Maximum depth (ft)	Minimum depth (ft)	Days depth>30 ft	% of days where depth>30 ft
1988–2015	324	13.3	7.9	39.6	1.8	22	6.8
2020–2090	849	14.9	9.3	47.1	0.7	78	9.2

During the implementation and sustainability periods, groundwater elevations are projected to show significant seasonal variation. On average, the groundwater depth varies by 12.0 feet within a water year from 1988–2015 and 12.2 feet from 2020–2090 (Figure A2.B-7). The simulated maximum groundwater elevation change was 34.1 feet in 1988–2015 and 37.2 feet from 2020–2090, while the minimum variation in monthly water elevations within a year was 4.0 feet for both the historical and future periods. Seasonal variation in groundwater depth is typically highest during the wettest or driest years. During the wettest years, the minimum groundwater depths are very shallow, while during the driest years, the maximum depths are very deep. Both the observed and model data show that shallow groundwater at well SJRRP_MW-10-89 can decline significantly during droughts but responds very quickly once San Joaquin River discharge increases. This response pattern is illustrated in Figures A2.B-6 and A2.B-7.

Combined, annual trends in depth to water during the observed and projected time periods indicate relatively stable groundwater conditions in the San Joaquin River Riparian GDE Unit. The small drop in mean groundwater depth is unlikely to have an adverse effect on the GDE, but the potential for more severe and longer-lived droughts may cause a decline in the health and extent of the San Joaquin River Riparian GDE. Groundwater modeling, however, provides evidence for an increase in the portion of months where depth to water exceeds the 30-foot rooting depth criterion (Section 1). The San Joaquin River Riparian GDE has persisted through droughts before, but the degree to which a threshold exists where the GDE is unable to recover is not known. If it exists, such a threshold effect could include replacement of native vegetation with more xeric non-native species or a reduced extent of the GDE. Either of these outcomes would have associated impacts to species relying on riparian vegetation for habitat and other ecological functions. As a result, the San Joaquin River Riparian GDE Unit was determined to be **moderately susceptible** (Table A2.B-3) to groundwater conditions falling outside the baseline range.

3.4 Biological Data

Average summer NDVI and NDMI for the period 1985–2018 indicate little to no overall change and modest fluctuations in both indices in the San Joaquin River Riparian GDE Unit (Figures A2.B-8 andA2.B-9). NDVI for individual, mapped polygons ranges from approximately 0.10 to 0.70, and mean NDVI for all polygons was lowest in 1992 (0.36) and highest in 2018 (0.54) (Figure A2.B-8). Change in NDVI between 1985 and 2018 showed a negligible increase (0.09) for mean NDVI. NDVI tends to decline during drier periods as indicated by the SJVI. For example, mean NDVI declined from 0.44 to 0.36 from 1985–1992 (Figure A2.B-8). A similar trend occurred from 2007–2010 and 2012–2016. In contrast, NDVI tends to increase during the wettest years. NDMI for individual, mapped polygons shows a similar trend to NDVI but with values ranging from approximately -0.2 to 0.45 (Figure A2.B-9). Mean NDMI for all polygons was also lowest in 1992 (-0.005), and highest in 2018 (0.17). Like NDVI, mean NDMI also showed a negligible increase (0.08) between 1985 and 2018. While there were interannual fluctuations in both NDVI and NDMI, lack of any long-term trend in either of these indicators of vegetation health suggests that the vegetation health in the San Joaquin River Riparian GDE has been stable throughout this period. Other factors may also influence NDVI and NDMI, including channel migration and erosion/deposition of sediment during floods.

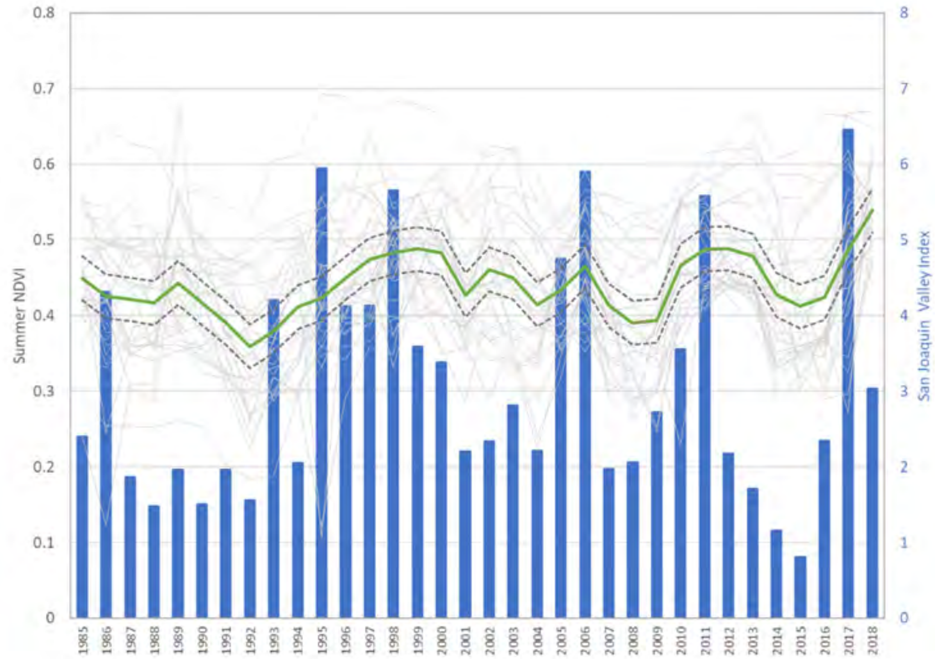

Figure A2.B-8. Summer NDVI for all GDE polygons identified in the GDE Pulse Interactive Map comprising the San Joaquin River Riparian GDE Unit from 1985–2018 (light grey lines). Mean NDVI (green line), and 95% confidence intervals of the mean NDVI (dashed black lines). The blue bars show the San Joaquin Valley Index, with low values corresponding to drier years and high values corresponding to wetter years.

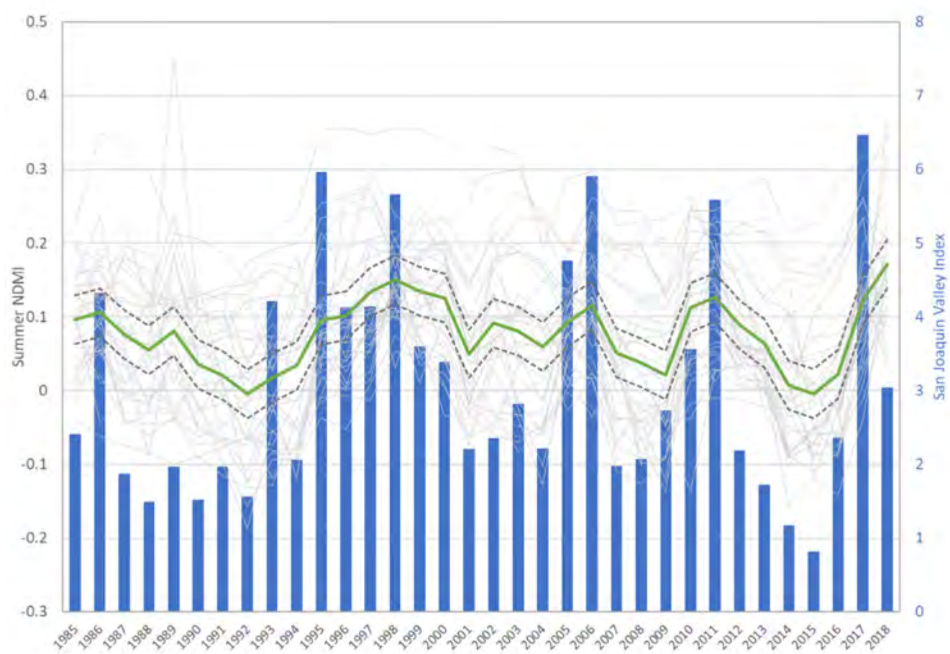

Figure A2.B-9. Summer NDMI for all GDE polygons identified in the GDE Pulse Interactive Map comprising the San Joaquin River Riparian GDE Unit from 1985–2018 (light grey lines). Mean NDMI (green line), and 95% confidence intervals of the mean NDMI (dashed black lines). The blue bars show the San Joaquin Valley Index, with low values corresponding to drier years and high values corresponding to wetter years.

Multiple linear regression was used to assess the effect of year, and annual precipitation on NDVI/NDMI. Annual precipitation was not a statistically significant predictor variable of mean NDVI ($p = 0.35$), and explained little, if any, of the variation in NDVI ($R^2 = 0.03$). Conversely, annual precipitation was a statistically significant predictor variable of mean NDMI ($p = 0.01$), but still showed little explanatory power of the variation in NDMI ($R^2 = 0.18$)

A reconnaissance field assessment of the San Joaquin River Riparian GDE Unit documented presence of recent riparian tree recruitment at representative sites in May 2019 as part of this study and also in 2013 as documented in Bureau of Reclamation (2014). The riparian vegetation observed in May 2019 appeared very healthy, with dense, green canopies at multiple layers with evidence of recent growth and saplings less than five years of age indicating recent recruitment of native riparian trees. Analysis of recent satellite imagery corroborates these field observations.

3.5 Potential Effects

Reconnaissance level biological assessments, aerial photograph analysis, and NDVI/NDMI data indicate adverse impacts are not likely occurring in the San Joaquin River Riparian GDE Unit as a result of changes in groundwater levels or degraded groundwater quality. However, detection of some types of adverse impacts may be precluded by insufficient data on the extent to which groundwater management may be influencing shallow groundwater underlying the GDE unit, and the potential for concomitant effects on riparian vegetation dynamics and habitat for special status species.

Groundwater in the San Joaquin River Riparian GDE Unit is tightly coupled with surface flow and runoff, and is generally maintained at depths within the maximum rooting depth of riparian species present in the unit (see Section 2.2.2 of this GSP). In the Chowchilla Subbasin, the San Joaquin River flows adjacent to the San Joaquin River Riparian GDE Unit and is in a net-losing condition, with surface flow likely contributing directly to the shallow groundwater system that supports the vegetation in the unit. Evidence of recent riparian tree recruitment (within 5 years) observed in the San Joaquin River Riparian GDE Unit, along with high-density, healthy vegetation at multiple layers, and the presence of these attributes throughout the unit suggests that baseline groundwater levels (i.e., those occurring since 1988 are sufficient to maintain ecosystem functions essential for the survival and reproduction of riparian plant species. In addition, trends in NDVI/NDMI show little to no change in overall vegetation health within the unit, and although past fluctuations in these indices appear correlated with periods of drought in the San Joaquin Basin (e.g., 2012–2016), both indices have rebounded following 2107 which was a wet water year. Based on these recent historical response patterns, it appears the dominant native vegetation composing the San Joaquin River Riparian GDE Unit is sufficiently resilient to maintain ecosystem integrity and function in the face of predicted fluctuations in groundwater conditions around the recent historical baseline level. The observed vegetation response following the 2012–2016 drought suggests that the ecological integrity of the GDE Unit would be maintained following periods of drought predicted to occur within the next 30–50 years, although adverse impacts ranging from short-term (e.g., water stress) to prolonged (reduced growth and recruitment, habitat loss) are possible (Rohde et al. 2018). The extent to which the late-1980s-early1990s drought impacted the GDE is not known, but we observed several cottonwood and oak trees in the GDE unit that likely pre-date that drought.

Riparian vegetation condition and NDVI/NDMI trends within the GDE unit also indicate groundwater quality is not limiting ecosystem functions essential for the survival and reproduction of riparian plant species. Rohde et al. (2018) list declining NDVI/NDMI, reduced tree canopy and understory, shifts in vegetation type, tree mortality, and habitat fragmentation as indicators of adverse impacts; however, none of these was detected within the GDE unit. Because the NDVI assessment was confined to the GDEs mostly mapped in 2014, our analysis does not account for potential reduction in the extent of riparian vegetation (and hence a reduction in the area of the polygons) prior to the vegetation mapping.

The response of perennial, resident wildlife and vegetation species, including those with protected status, and overall species composition to groundwater dynamics in the San Joaquin River Riparian GDE Unit is not well understood because population dynamics during the baseline period are not known. Many of these species survived the droughts in the early 1990s and the mid-2010s, but the effects on the species and their susceptibility to future changes are unknown. Appropriate data for evaluating these relationships is not readily available but, if obtained, could provide insight to additional interactions between groundwater conditions and biological responses, leading to a more complete evaluation of potential adverse impacts. Recommendations for monitoring to provide additional data for this purpose are included below in Section 5.

4 SUSTAINABLE MANAGEMENT CRITERIA

Sustainable management criteria for the Chowchilla Subbasin were developed using information from stakeholder and public input, correspondence with the GSAs, public meetings, hydrogeologic analysis, and meetings with GSA technical experts. The sustainable management criteria and methods used to establish them are described in Chapter 3 of this GSP.

4.1 Sustainability Goal

The sustainability goal developed for the Chowchilla GSP is expected to maintain the ecological integrity and function of the San Joaquin River Riparian GDE Unit. This includes maintenance of riparian habitat conditions for special-status species and other native species in the unit or those likely to occur, and provision of important ecosystem support functions for Central Valley spring-run Chinook salmon, Central Valley steelhead, and other special-status species and native aquatic species in the adjacent San Joaquin River. The GSP's sustainability goal would be achieved by implementing a package of projects and management actions that will, by 2040, balance long-term groundwater system inflows with outflows based on a 50-year period representative of average historical hydrologic conditions.

4.2 Minimum Thresholds for Sustainability Indicators

Minimum thresholds for the applicable sustainability indicators are described in Section 3.3 of this GSP. The minimum thresholds for chronic lowering of groundwater levels, the sustainability indicator most likely to affect GDEs in the subbasin, are based on selection of representative monitoring sites from among existing production and monitoring wells located throughout the subbasin and screened in both the Upper and Lower Aquifers. Of the representative monitoring sites for the subbasin, three are located in the Upper Aquifer and in close proximity to the San Joaquin River Riparian GDE Unit and one, SJRRP_MW-10-89, is considered to best represent shallow groundwater conditions potentially affecting the GDE unit. The proposed minimum threshold for groundwater levels in this well is 48 feet below ground surface (Section 3.3 of this GSP). Although the minimum threshold depth is greater than the 30-foot maximum rooting depth of the dominant native woody riparian plant species composing the GDE, modeled historical lows also show depths to water exceeding 30 feet. This is an indication that the dominant vegetation in the GDE unit is able to survive short-term declines in water levels, possibly due in part to the presence of a capillary fringe above the water table. The modeled future exceedances of the 30-foot rooting depth threshold (i.e., depth to water approaching each well's minimum threshold for this sustainability indicator) are projected to be of relatively short duration (1–5 years) and to occur only once or twice during the 70 years that include the 20-year implementation period and the 50-year sustainability period. If these projected reductions in groundwater levels occur, effects on GDEs could include short-term adverse impacts such as water stress and could also lead to longer-term impacts such as reduced growth and recruitment, and potential branch dieback or some tree mortality resulting in some loss of vegetation structure, ecological function, and habitat for special-status species. However, given their relatively low projected frequency and short duration, coupled with the inherent uncertainty in model projections and response of the GDE to the recent multi-year drought, longer-term impacts are unlikely. Historical model results for well SJRRP_MW-10-89 reflect shallow groundwater conditions under which the GDE vegetation currently composing the unit has persisted since 1985 with no apparent adverse effects, suggesting that similar conditions in the future (and possibly deeper water levels) would continue to support the GDEs. In addition, restoration flows in the San Joaquin River under the SJRRP are expected to provide continued hydrologic inputs contributing to long-term support of the San Joaquin River Riparian GDE unit.

Based on this information, the native vegetation communities composing the San Joaquin River Riparian GDE are expected to be maintained in good health by sustainable groundwater management in the Chowchilla Subbasin and therefore resilient to short-term adverse impacts, thus the minimum thresholds are not expected to cause substantial adverse impacts to GDEs.

4.3 Measurable Objectives and Interim Milestones

Measurable objectives and interim milestones for the applicable sustainability indicators are described in Section 3.3 of this GSP. Measurable objectives and interim milestones for groundwater levels, the sustainability indicator most likely to affect GDEs in the subbasin, are proposed for representative monitoring sites in the subbasin including well SJRRP_MW-10-89, which best represents groundwater conditions associated with the San Joaquin River Riparian GDE Unit. The proposed measurable objectives and interim milestones for groundwater levels in these three wells range from 8–14 ft below ground surface (Section 3.3 of this GSP). The groundwater level objectives and milestones are well within the range of maximum vegetation rooting depth and are expected to maintain or increase the spatial extent of the GDE unit, with no net loss of native plant species dominance. These characteristics can be assessed through monitoring to measure the areal extent of the vegetated GDE unit and the ecological condition of phreatophytic vegetation.

5 GDE MONITORING

Data on San Joaquin River riparian forest condition and extent, as well as surface water and shallow groundwater hydrology of the San Joaquin River, are among the types of information that have been collected, analyzed, and reported under the auspices of the SJRRP. The SJRRP is currently monitoring shallow groundwater in several wells along the San Joaquin River in the Chowchilla Subbasin. However, the ecological characteristics and hydrologic dependencies of the San Joaquin River Riparian GDE unit are not currently the subject of regular, systematic monitoring as part of any known program. Actions to improve the existing monitoring network may be warranted so that GDE conditions can be thoroughly documented and impacts to GDEs can be detected. Biological data should be collected with sufficient spatial and temporal coverage to adequately characterize the GDE's reliance on groundwater and, together with evaluation of associated hydrologic data, to monitor the response of GDEs to groundwater management, including projects and management actions proposed to be implemented under this GSP (Section 6).

The San Joaquin River Riparian GDE is moderately susceptible to changing groundwater conditions and has high ecological value, thus the following types of monitoring recommended by Rohde et al. (2018) should be considered:

- Annual desktop monitoring using simple biological indicators such as remote sensing indexes (NDVI/NDMI) and aerial photograph analysis to monitor changes in vegetation condition, growth, and the spatial extent of the GDE.
- Biological surveys (e.g., vegetation transects) conducted at regular intervals (minimum every 5 years or more frequently if needed based on the desktop surveys or biological surveys that indicate the GDE condition or extent has declined) to document baseline biological conditions and changes corresponding to GSP implementation and groundwater management.

Biological monitoring data should be evaluated as part of an adaptive management framework to facilitate improvements in the monitoring program and refinement of projects and management actions or implementation of new actions to avoid adverse impacts to GDEs.

6 PROJECTS AND MANAGEMENT ACTIONS

Implementation of the GSP will require the Chowchilla Subbasin to be operated within its sustainable yield by 2040. To ensure the subbasin meets its sustainability goal by 2040, the GSAs have proposed projects and management actions to address undesirable results (see Chapters 3 and 4 of this GSP). To achieve this, GSAs may implement projects to increase groundwater recharge, reduce groundwater pumping, or both.

Because no undesirable results were identified for the San Joaquin River Riparian GDE Unit under baseline, existing, or projected future with-project conditions, no GDE-specific projects or management actions were developed for this GSP. Effects on GDEs resulting from increased groundwater recharge and reduced groundwater pumping are expected to be beneficial, as groundwater levels accessed by vegetation in the San Joaquin River Riparian GDE Unit are expected to remain relatively similar to historical and recent baseline conditions, thus maintaining an accessible and reliable water source.

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APPENDIX 2.C. NOTICE AND COMMUNICATION

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020

GSP Team:

Davids Engineering, Inc
Luhdorff & Scalmanini
ERA Economics
Stillwater Sciences and
California State University, Sacramento

2.C. Notice and Communication

APPENDIX 2.C. NOTICE AND COMMUNICATION

2.C.a. Chowchilla Subbasin Stakeholders Communication and Engagement Plan

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020

GSP Team:

Davids Engineering, Inc
Luhdorff & Scalmanini
ERA Economics
Stillwater Sciences and
California State University, Sacramento

Chowchilla Subbasin

Communication and Engagement Plan

August 2019

Prepared by the
California State University Sacramento
College of Continuing Education
Consensus and Collaboration Program

Contents

Chowchilla Subbasin Stakeholder Communication and Engagement Plan
August 2019

Purpose

The purpose of this Communication and Engagement Plan is to assist Chowchilla Subbasin Groundwater Sustainability Agencies (GSAs) in their efforts to develop general and strategic communications to engage stakeholders in groundwater management activities.

Overview and Background

California's Sustainable Groundwater Management Act (SGMA) of 2014 requires broad and diverse stakeholder involvement in GSA activities and the development and implementation of Groundwater Sustainability Plans (GSP) for groundwater basins around the state, including the Chowchilla Subbasin (Subbasin). The intent of SGMA is to ensure successful, sustainable management of groundwater resources at the local level. Success will require cooperation by all stakeholders, and cooperation is far more likely if stakeholders have consistent messaging of valid information and are provided with opportunities to help shape the path forward.

Chowchilla Subbasin

The Chowchilla Subbasin has been identified by the California Department of Water Resources (DWR) as a high-priority and critically-overdrafted subbasin with conditions of historical groundwater level declines, land subsidence, and groundwater quality degradation. The area has a substantial agricultural community heavily reliant on groundwater. Nearly 79 percent of the Subbasin is designated as part of a severely disadvantaged community (SDAC) and approximately 30 percent of the Subbasin (primarily in the northern and southern central parts of the Subbasins and also around the City of Chowchilla) is designated as part of a DAC.

Subbasin Governance

Four GSAs have formed to ensure local control of groundwater management in the Subbasin: Chowchilla Water District, Madera County, Merced County and Triangle T Water District. The GSAs are developing a single GSP for the Subbasin. The four GSAs together with other local agencies have developed a set of six guiding principles as a foundation for developing the GSA for the entire Subbasin. The other local agencies include the City of Chowchilla, Clayton Water District and Sierra Vista Mutual Water Company. The Chowchilla Water District, County of Madera, County of Merced, Triangle T Water District and Sierra Vista Mutual Water Company entered into a Memorandum of Understanding with respect to the preparation of the GSP for the Subbasin.

The Chowchilla Subbasin GSP Advisory Committee (Advisory Committee) was formed in 2018 to bring together local agencies and related parties vested with the authority and/or ability to support implementation of SGMA in the Subbasin. Representatives from Merced County, Merced Irrigation District, Madera County, CWD, Madera Farm Bureau, Triangle T Water District, Clayton Water District and City of Chowchilla regularly attend the Advisory Committee meetings. The Advisory Committee has been meeting approximately monthly since its formation.

The GSAs agreed to hire a professional facilitator from California State University, Sacramento, to provide third-party facilitation support for GSP development and implementation, particularly to advance the GSAs' stakeholder engagement efforts.

Communication and Engagement Plan

The purpose of the Communication and Engagement Plan (Plan) is:

- To provide GSAs, community leaders, and other beneficial users a roadmap to follow to ensure consistent messaging of SGMA requirements and related Chowchilla Subbasin information and data.
- To provide a roadmap to GSAs and community leaders to follow to ensure stakeholders have meaningful input into GSA decision-making, including GSP development.
- Ensure the roadmap demonstrates a process that is widely seen by stakeholders as fair and respectful to the range of interested parties.
- To make transparent to stakeholders their opportunities to contribute to the development of a GSP that can effectively address groundwater management within the Chowchilla Subbasin.

Communication Plan Goals

The Plan seeks to accomplish the following goals:

1. Educate stakeholders about:
    a. SGMA and its requirements.
    b. Individual GSAs within the Subbasin as management units.
    c. Potential changes to current groundwater management under SGMA.
    d. How stakeholders will be represented in their respective GSAs.
2. Communicate important SGMA deadlines and dates.
3. Coordinate outreach and engagement activities between GSAs to ensure efficiencies and to support stakeholders in GSP development.
4. Articulate strategies and channels for gaining ongoing stakeholder input and feedback to inform GSP design and development.
5. Encourage stakeholder engagement by communicating dedicated SGMA outreach strategies and channels, including meeting and workshop dates and content, as opportunities for stakeholders to provide input in the GSA decision-making process and GPS planning process.

Major Audiences

A Chowchilla Subbasin stakeholder is a "beneficial user" as described by SGMA. Under the requirements of SGMA, all beneficial uses and users of groundwater must be considered in the development of GSPs, and GSAs must encourage the active involvement of diverse social, cultural, and economic elements of the population. Beneficial users, therefore, are any stakeholder who has an interest in groundwater use and management in the Chowchilla Subbasin community. Their interest may be GSA activities, GSP development and implementation, and/or water access and management in general.

To assist in determining who the specific SGMA stakeholders and beneficial users are, DWR has issued a Stakeholder Engagement Chart (Table 1) for GSP Development in their 2017 *GSP Stakeholder Communication and Engagement Guidance Document*. This table was modified to fit the circumstances and stakeholders of the Chowchilla Subbasin, and will continue to be updated during the planning process.

Table 1: Stakeholder Engagement Chart for GSP Development

Category of Interest	Examples of Stakeholder Groups	Engagement purpose
General Public	• Citizens groups • Community leaders	Inform to improve public awareness of sustainable groundwater management
Land Use	• Municipalities (City, County planning departments): City of Chowchilla • Regional land use agencies	Consult and involve to ensure land use policies are supporting GSPs
Private users	• Private pumpers • Domestic users • School systems: Chowchilla Elementary School District • Hospitals: Chowchilla Memorial Health Care District	Inform and involve to avoid negative impact to these users
Urban/ Agriculture users	• Water agencies • Irrigation districts • Mutual water companies • Resource conservation districts: Chowchilla Red Top RCD • Farm Bureau: Merced Farm Bureau, Madera County Farm Bureau	Collaborate to ensure sustainable management of groundwater
Industrial users	• Commercial and industrial self-supplier • Local trade association or group	Inform and involve to avoid negative impact to these users
Environmental and Ecosystem	• Federal and State agencies - CDFW • Environmental groups	Inform and involve to sustain a vital ecosystem
Economic Development	• Chambers of commerce: Chowchilla District Chamber of Commerce • Business groups/associations • Elected officials (Board of Supervisors, City Council) • State Assembly members • State Senators	Inform and involve to support a stable economy
Human right to water	• Disadvantaged Communities • Small community systems • Environmental Justice Groups: Leadership Council for Justice and Accountability, Self-Help Enterprises, Community Water Center	Inform and involve to provide a safe and secure groundwater supplies to all communities reliant on groundwater
Tribes	• Federally Recognized Tribes and non-federally recognized Tribes with Lands or potential interests in Chowchilla Subbasin	Inform, involve and consult with tribal government
Federal lands	• Bureau of Reclamation (USBR) • Bureau of Land Management	Inform, involve and collaborate to ensure basin sustainability
Integrated Water Management	• Regional water management groups (IRWM regions) • Flood agencies	Inform, involve and collaborate to improve regional sustainability

Key Messages

As GSAs begin the process of reaching out to stakeholders to inform and engage them in groundwater management issues and items, it is critical that GSAs share clear and consistent key messages to avoid confusion and misunderstanding. Key messages are as follows:

1. Four GSAs have formed to ensure local control of groundwater management in the Chowchilla Subbasin:
    a. Chowchilla Water District
    b. Madera County
    c. Merced County
    d. Triangle T Water District
2. Management elements include GSP decision-making, funding, implementation and enforcement.
3. GSAs are committed to proactively and sustainably manage groundwater in the Subbasin.
4. GSAs shall ensure compliance with SGMA to prevent State intervention.
5. GSAs seek to coordinate efforts in managing their respective portion of the Subbasin to achieve compliance with SGMA.
6. GSAs will develop a single GSP for the Subbasin.
7. GSAs are committed to proactive and transparent outreach and engagement with stakeholders and Subbasin community members during the GSP planning process, implementation and beyond.

Decision-Making

Decision-making and communication about said decision-making will comply with all requirements of Section 354.10 of the State's GSP regulations.

Recommended Communication Strategies and Mechanisms

GSAs representatives and staff will engage with Subbasin beneficial users, and will be responsible to track the needs of their local communities. GSAs will consider stakeholder input gathered from outreach efforts as they move through GSP development and implementation processes. Three sets of strategies are important to consider when planning outreach and engagement activities, included in the following categories:

- SGMA-required: the law requires GSAs to undertake specific types of outreach and engagement activities.
- Essential strategies centrally communicated at the Subbasin and GSA Management Area level (if Management Areas are deemed appropriate by the GSAs): activities proven to successfully engage stakeholders.
- Secondary strategies locally communicated at the GSA Management Area and beneficial user level: activities that will enhance engagement efforts on a local and as needed basis.

SGMA-Required Strategies

SGMA strongly encourages broad stakeholder engagement in development and implementation of GSPs. According to SGMA:

- "The groundwater sustainability agency shall encourage the active involvement of diverse social, cultural, and economic elements of the population within the groundwater basin prior to and during the development and implementation of the groundwater sustainability plan." [CA Water Code Sec. 10727.8(a)]
- "The groundwater sustainability agency shall consider the interests of all beneficial uses and users of groundwater." [CA Water Code Sec. 10723.2]

GSAs are given broad discretion in the methods and processes utilized to meet engagement requirements. SGMA explicitly authorizes GSAs to form Public Advisory Committees if they choose, but does not require them to do so. The decision to form an advisory committee is left to the individual GSA based on need and effectiveness of these processes within their communities. However, SGMA does have several GSA-specific requirements regarding public notice, public hearings, and public meetings. Requirements include:

1. Within 30 days of electing to be (or forming) a GSA, the GSA must inform the State of this development and its intent to manage groundwater sustainably. In doing so, the GSA must:
    a. Include a list of parties who wish to receive "plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents"; and
    b. Explain how the interested parties' perspectives will be considered, both during the development and operation of the GSA and during development and implementation of the GSP. This information must also be sent to the legislative bodies of any city and county in the area covered by the plan.

    Illuminating the term "interested parties," SGMA requires that GSAs consider the interests of "all beneficial uses and users of groundwater," along with entities expected to share responsibilities for implementing GSPs. As a starting point, SGMA specifies a number of types of "interested parties." The GSA must maintain its list of interested parties on an ongoing basis. Anyone who wishes to be put on this list can do so upon making this request in writing. [CA Water Code Section 10730. (b) (2); 10723.2; 10723.4; and 10723.8. (a)]

2. GSAs planning to develop a GSP must provide notice of their intent to do so to the public and the State before proceeding. The notice must describe opportunities for interested parties to participate in the development and implementation of the GSP. This written notice must be provided to the legislative bodies of any city or county located within the basin to be managed by the GSP. [CA Water Code Section 10727.8. (a)]

Phase 1: 2015–2017

Phase 1 Engagement Requirements

- **Establish and Maintain List of Interested Parties** §10723.4
- **GSA Formation Public Notice** §10723(b)
- **GSA Formation Public Hearing** §10723(b)
- **GSA Formation (due 6/30/17)** §10723(b)
  Notify DWR:
  - Include list of interested parties
  - Explain how parties' interests will be considered
- **Pre-GSP Development** §10727.8
  Provide a written statement describing how interested parties may participate to:
  - DWR
  - Cities within the GSA boundary
  - Counties within the GSA boundary

Phase 2: 2017–2022

Phase 2 Engagement Requirements

- **GSP Initial Notification** §353.6*
- **GSP Preparation** §10727.8 and §10723.2
  - Encourage active involvement
  - Consider beneficial uses and users of groundwater when describing *Undesirable Results, Minimum Thresholds, and Projects & Actions*
- **GSP Communications Section** §354.10*
  - GSA decision-making process
  - Opportunities for engagement and how public input is used
  - How GSA encourages active involvement
  - Method of informing the public
- **Public Notice of Proposed Adoption** §10728.4
- **GSP Adoption Public Hearing** §10728.4
- **GSP Submittal** §354.10*
  - Include a summary of communications: description of beneficial uses/users, list of public meetings, comments received/responses

3. A GSA seeking to adopt or amend a GSP must provide notice to cities and counties within the area encompassed by the proposed plan or amendment, and consider comments provided by the cities and counties. Cities and counties receiving the notice may request consultation with the GSA, in which case the GSA must accommodate that request within 30 days. The GSA also must hold a public hearing prior to adopting or amending a GSP. There must be at least 90 days between the notice issued to cities and counties and the public hearing. [CA Water Code Section 10728.4]

4. If a GSA intends to impose or increase a fee, it must first hold at least one public meeting, at which attendees may make oral or written comments. This public notice must include:
    a. Information about the time and place of the meeting and a general explanation of the topic to be discussed.
    b. Public notice must be posted on the GSA's website and mailed to any interested party who submits a written request for mailed notice of meetings on new or increased fees. (The GSA must establish and maintain a list of interested parties, and the list is subject to renewal by April 1 of each year.)
    c. The public notice must also be consistent with Section 6066 of the Government Code.
    d. In addition, the GSA must share with the public the data upon which the proposed fee is based, and this must be done at least ten days before the public meeting takes place. [CA Water Code Section 10730.(b)(1),(2), and (3)]

Phase 3: 2018+

Phase 3 Engagement Requirements

- **60 Day Comment Period** §353.8*
  - Any person may provide comments to DWR regarding a proposed or adopted GSP via the SGMA Portal at http://sgma.water.ca.gov/portal/
  - Comments will be posted to DWR's website

Phase 4: 2022+

Phase 4 Engagement Requirements

- **Public Notices and Meetings** §10730
  - Before amending a GSP
  - Prior to imposing or increasing a fee
- **Encourage Active Involvement** §10727.8

Engagement Requirements Applicable to ALL PHASES

- **Beneficial Uses and Users** §10723.2
  Consider interests of all beneficial uses and users of groundwater
- **Advisory Committee** §10727.8
  GSA may appoint and consult with an advisory committee
- **Public Notices and Meetings** §10730
  - Before electing to be a GSA
  - Before adopting or amending a GSP
  - Prior to imposing or increasing a fee
- **Encourage Active Involvement** §10727.8
  Encourage the active involvement of diverse social, cultural, and economic elements of the population within the groundwater basin
- **Native American Tribes** §10720.3
  - May voluntarily agree to participate
  - See Engagement with Tribal Government Guidance Document
- **Federal Government** §10720.3
  - May voluntarily agree to participate

Chowchilla Subbasin: Challenges and Opportunities for Outreach and Engagement

An initial assessment of the community of beneficial users show that much of the community is inadequately informed about SGMA and the implications thereof on their water use. The GSAs have a responsibility to and will gain great benefit from expanded SGMA education that helps inform beneficial user input and subsequent GSA decision-making.

Centralized Outreach and Engagement Strategies

The following strategies are meant to ensure successful engagement of Chowchilla Subbasin stakeholders during the GSP development and implementation process:

1. Integrate and expand on existing SGMA communication and outreach efforts
2. Develop and maintain a list of interested parties
3. Maintain a centralized Chowchilla Subbasin website
4. Provide regular public notices and updates; ensure Brown Act compliance
5. Provide notices and updates in local newspaper periodicals
6. Institute regular stakeholder outreach and engagement opportunities
7. Strategically engage local, special SGMA identified groups
8. Develop and update Subbasin outreach and engagement resources table
9. Develop consistent, coordinated messages and talking points

These centralized activities should be conducted by all Subbasin GSAs for purposes of efficiency and clear messaging. Individual Subbasin GSAs are responsible for identifying and contributing appropriate staff and resources for outreach and engagement activities.

1. Integrate and Expand on Existing SGMA Communication and Outreach Efforts

The GSA Board Meetings and Advisory Committee meetings are open to the public. Other outreach activities already conducted to date include public and focused outreach and informational meetings with farmers, private landowners, and other stakeholders. The Technical Advisory Committee (TAC), as formed, will also be open to the public.

2. Develop and Maintain a List of Interested Parties

A list of stakeholders and beneficial users is to be developed and updated throughout the GSP planning, implementation and enforcement processes. Each GSA is required to maintain a singular list, however coordinating these lists into a single Subbasin list will improve stakeholder engagement.

Timely notification of opportunities for interested parties to participate in the development and implementation of the GSP should be given via the channels and strategies described in this document.

To assist in determining the topics, types and sequencing of outreach vis-à-vis specific stakeholder interests, DWR has recommended conducting a "Lay of the Land" exercise (Table 2). The table was developed from a stakeholder assessment conducted in the Subbasin.

Table 2: SGMA GSA/GSP Stakeholder Constituency – "Lay of the Land" Exercise

Organization/ Individual *(Name of stakeholder organization or individual)*	Type of Stakeholder *(Based on Water Code §10723.2)*	Key Interests *(Stakeholder's key interests related to groundwater)*	Key Issues *(Documented issues [media coverage, statements, reports, etc.] or specific issues such as past events)*	GSP *(Which section(s) of the GSP may this interest be applicable to?)*	Rationale *(Reasons why this is a stakeholder that requires a certain level of engagement)*
Madera County Farm Bureau	Farmers and agricultural allied industries	Agricultural water use	Allocations. Fees (extraction and regulatory). Water Quality. Subsidence.	All	Direct dependency on groundwater
Merced County Farm Bureau	Farmers and agricultural allied industries	Agricultural water use	Allocations. Fees (extraction and regulatory). Water Quality. Subsidence.	All	Direct dependency on groundwater

County of Madera	All beneficial users	All uses	All issues	All	Direct dependency on groundwater
County of Merced	All beneficial users	All uses	All issues	All	Direct dependency on groundwater
Exclusive GSAs	Agricultural uses. Domestic uses.	All uses	Allocations. Fees (extraction and regulatory). Water Quality. Subsidence.	All	Direct dependency on groundwater
Self-Help Enterprises	Domestic uses. Public water systems. DACs. Municipal well operators. Environmental users.	All uses	All issues	All	Direct dependency on groundwater
Leadership Council for Justice and Accountability	Agricultural uses. Domestic uses. Public water systems. DACs. Municipal well operators. Environmental users.	All uses	All issues	All	Direct dependency on groundwater

3. Maintain a Centralized Chowchilla Subbasin Website

Allocate staff and resources to maintain a website with information about Chowchilla Subbasin-wide planning efforts related to SGMA, such as joint GSP planning activities and meetings, and other relevant information. While individual GSAs may seek to maintain separate websites, a centralized location for activities that are Subbasin-wide or related to the Coordinated GSAs GSP development will demonstrate coordination and maintain distribution of consistent messaging. Note: This effort is being conducted by the County of Madera. The website can be accessed at: https://www.maderacountywater.com/maps/chowchilla-subbasin/

1. Include Resources and Materials:
    a. Links to external sites (Department of Water Resources and State Water Resources Control Board)
    b. Links to individual GSA websites, relevant blogs, etc.
    c. Frequently Asked Questions (FAQ) and/or white papers
    d. GSA documents (MOUs, bylaws, etc.)
    e. GSP documents (draft GSP documents, notices and meeting calendars for GSP

workshops)

2. Recommended Structure:
    a. Provide a one-stop location for Coordinated GSAs.
    b. Include tabs for each GSA's specific information about management areas, maps, Individual GSA board meetings, updates and opportunities for stakeholder input.

4. Provide Regular Public Notices and Updates; Ensure Brown Act Compliance

Coordinate consistent messaging and outreach regarding SGMA information and updates as they relate to the Subbasin.

1. Types of notices include and are not limited to:
    a. GSP development and planning updates
    b. GSP implementation and enforcement updates
        i. GSP workshops
        ii. GSP work plan and timeline
    c. General GSA updates, including without limitation:
        i. GSA Board meetings
        ii. Advisory Committee meetings
        iii. Public workshops and/or stakeholder roundtables
        iv. GSA annual reports
        v. Other SGMA-related updates
2. Schedule notices to be sent on a regular schedule, for example, bi-monthly, monthly or as needed.
    a. Meetings subject to the Brown Act, such as GSA Board meetings, Advisory Committee meetings and others, must provide public notice and post an agenda 72 hours in advance of each regularly scheduled meeting (emergency meetings require 24 hour advance notice).
3. Develop content appropriate to the audience and their interests, ensuring information is articulated in a way that is easily understood.
    a. Notices to community members with less SGMA or technical experience should be easily understood, with streamlined, relatable and repetitive information.
    b. Updates and messages should be condensed to one page when possible, providing a succinct summary of the issues discussed, and including links for further or additional information.
    c. As applicable, specific items should have an estimated timeline and a designated point of contact, including the person's position, email and telephone.
    d. Updates and information are needed in both English and Spanish.
4. Designate responsible staff and appropriate resources for ongoing interagency coordination regarding joint messaging, consistent outreach and communication with stakeholders.
5. Determine appropriate dissemination channels.
    a. Utilize Constant Contact or similar email marketing platform for management of interested party stakeholder lists.
    b. Utilize member agency listservs delivered via standard email and/or U.S. Mail.
    c. Utilize updated interested party stakeholder list for Chowchilla Subbasin, including

organizations and agencies such as the Madera and Merced Farm Bureaus, DAC groups, schools, hospitals, utilities, mutual water companies, neighborhood groups, and local non-profits such as the Leadership Council for Justice and Accountability, Self-Help Enterprises, and Community Water Center.

5. Provide Notices and Updates in Local Newspaper Periodicals

Notices can take the form of public notices, op-ed articles, letters to the editor, advertisements or earned media.

1. Send information and/or media releases to regional and local media outlets and contacts.
    a. Trusted radio stations in the region, including stations broadcasting in languages other than English.
    b. Organization and community newsletters and periodicals
    c. Identify trusted bi-lingual and/or Spanish speaking media outlets.
2. Provide follow-up or wrap-up articles written by staff when appropriate.
3. Include notices for:
    a. Public workshops
    b. Specific stakeholder meetings (targeted or special topic meetings)
    c. GSA Board meetings
    d. Advisory Committee meetings
    e. Other standing meetings of particular interest related to SGMA
    f. GSP development and planning updates
    g. GSP implementation and enforcement updates
    h. General GSA and SGMA related updates

6. Institute Regular Stakeholder Outreach and Engagement Opportunities

It is critical that stakeholders and beneficial users understand SGMA requirements, as well as GSA and GSP planning and development activities. Stakeholders need to understand when and how their input will be incorporated into GSA governance and decision-making processes, as well as when and how they are able to contribute to the GSP planning and implementation processes.

Stakeholder engagement opportunities include but are not limited to:

1. Standing Operations Meetings
    a. GSA Board meetings
    b. Advisory Committee meetings
    c. GSP Technical Workshops
    d. Technical Advisory Committee meetings (if appropriate)
2. Public Workshops and Roundtables
    a. Scheduled workshops and roundtables bi-monthly or as needed
        i. Scheduled in evenings and/or near community areas as feasible.
    b. Provide translation and facilitation services in English and Spanish
    c. Public workshop or roundtable content includes but is not limited to:
        i. Updates on GSA coordination activities
        ii. SGMA informational workshops

iii. Updates on GSP development and planning activities
iv. Opportunities for interested parties to participate in the development and implementation of the GSP (i.e., technical workshops on specific GSP components)
v. Notice of GSA intent to adopt or amend a GSP
vi. Updates on groundwater management activities in the Subbasin
vii. Notice to impose fees

7. Strategically Engage Local, Special SGMA Identified Groups

Develop a targeted communication strategy to engage difficult to reach communities and community members that will be impacted by SGMA. This may include development of a targeted communication strategy or coordination with existing advisory groups or non-profit organizations as part of roundtable discussions.

8. Develop and Update Subbasin Outreach and Engagement Resources Table

Assess and define coordinated GSAs outreach tools and resources available for Subbasin-wide outreach and engagement activities.

9. Develop Consistent, Coordinated Messages and Talking Points

Define the key messages needed to effectively convey SGMA related information to various audiences, and ensure consistency in a coordinated outreach effort to all stakeholders.

1. Develop a set of talking points that can be used by GSA members when speaking to specific stakeholder groups or audiences. Talking points and messaging may be customized to specific stakeholder groups as appropriate.
2. Develop tools, such as a Q&A document and SGMA information/education documents, that contain easy to understand information as well as likely questions and responses anticipated from stakeholder groups.
3. Identify and communicate opportunities for public engagement and/or public comment during meetings on GSP development.
4. Provide clear messaging that GSAs retain legal responsibility for final GSA and GSP related decisions.

Localized Outreach and Engagement Strategies

While consistent messaging is to be coherently coordinated at the Subbasin level, specifically among the coordinated GSAs, localized outreach is to be coordinated at the GSA management area level through existing, trusted channels. GSAs will utilize local agencies' standing meetings, utilize local agencies' existing resources, and build on strategies to engage local, special SGMA identified groups.

1. Utilize Local Agencies with Standing Meetings

The most effective way to inform and engage many stakeholders and beneficial users regarding SGMA requirements and soliciting feedback is through trusted local agencies and community organizations with standing meetings and communication channels.

1. Support local agencies and community organizations in disseminating information and engaging stakeholders in the following ways:
    a. During standing board and/or community meetings

   b. Through monthly information pieces in newsletters or included in utility bills of associated fee assessing organizations
   c. Disseminating information in both English and Spanish

2. Local trusted agencies and community organizations include but are not limited to:
   a. Madera County and Merced County Farm Bureaus
   b. Mutual water companies (such as Sierra Vista)
   c. Merced Area Groundwater Pool Interests
   d. DAC community meetings and leaders
   e. Growers associations and industry organizations (such as wine and dairy)
   f. Resource conservation groups
   g. Local and regional environmental justice groups (such as Self-Help Enterprises, Leadership Council for Justice and Accountability, and Community Water Center)
   h. Local hospitals and schools

3. Leverage local, trusted resources for community meetings, such as schools, churches, and community centers.

4. Organize public meetings around concrete impacts to specific stakeholders, including:
   a. SGMA educational workshops to inform stakeholders of important changes in groundwater management and how it will impact them.
   b. Meetings that detail when and how opportunities to provide input to the GSA decision making and GSP development processes will occur.
   c. Public meetings regarding fee structures to help people understand how to interpret the impacts on them.

5. Make information and meetings accessible to various stakeholder groups.
   a. Provide information in easy to understand and streamlined terms.
   b. Provide information and facilitation in both English and Spanish.
   c. Hold meetings during hours that do not impede with regular work schedules of affected stakeholders (i.e., nights and weekends).

2. Utilize Existing Local Agency Resources

Effectively inform and engage diverse beneficial users in SGMA through trusted local agencies and community organizations with existing communication channels such as newsletters, websites and social media.

1. Disseminate consistent, coordinated messages and talking points through existing local newsletters, websites and social media.

2. Tailor messages to audiences, providing easy to understand updates.

3. Provide information in both English and Spanish (most websites and social media allow users to set preferred translation).

3. Build on Strategies to Engage Local, Special SGMA Identified Groups

Develop a locally targeted communication strategy to engage difficult to reach communities and community members that will be impacted by SGMA. Groups include: DACs, underrepresented communities, Latino communities, and remote private pumpers.

1. Some groups may need to be engaged through channels that do not include the need for

internet access, via door-to-door and other opportunities for face-to face engagement.

Process for Reporting Stakeholder Input to Chowchilla Subbasin GSP Advisory Committee

Chowchilla Subbasin GSAs recognize that stakeholder input into the development and implementation of a GSP is critical, as well as a SGMA requirement. As such, stakeholders are welcome to participate in the Chowchilla Subbasin GSP Advisory Committee meetings.

Roundtables can also be used to best incorporate Chowchilla Subbasin stakeholder/beneficial user input into the GSP development and implementation process.

The circumstances of the Chowchilla Subbasin are such that each of the four GSAs has different resources, responsibilities, capacities, and stakeholder representation to take into consideration as they form Subbasin committees and workgroups, and coordinate among themselves for the GSP. There is a need to identify tools and processes whereby GSAs and their beneficial users are given fair representation while the resources and capacities of each GSA, as well as beneficial users, are taken into account.

To this end, voluntary participation in Chowchilla Subbasin GSP Advisory Committee meetings by stakeholders will be helpful. Additional roundtable sessions or workgroups may be developed on specific topics as needed and identified through stakeholder outreach and engagement activities.

Recommended Milestones for Engaging Stakeholders

To employ the Stakeholder Communication and Engagement Plan effectively, Chowchilla Subbasin GSAs will need to develop a schedule for outreach and engagement activities. The below table (Table 3) identifies milestones required by SGMA, as well as centralized and localized engagement strategies. This schedule shall be updated into a Task oriented work plan and timeline as communication and engagement tasks are allocated.

Table 3: Summary of Engagement Opportunities and Milestones

Timeframe	Milestone or Stage	Required Community Engagement Under SGMA	Centralized & Localized Communication Strategies
After GSA formation, before GSP development activities	After identification of outreach responsibilities among GSA member agencies		• Provide notice of GSA outreach resources: website, email listserv, calendar of GSA Board meetings, Technical Advisory meetings, and Chowchilla Subbasin GSP Advisory Committee
After GSA formation, before GSP planning activities	Prior to beginning GSP development	• Provide to the public and State notice of intent to begin GSP planning and description of opportunities for interested parties to participate in GSP development and implementation	• Public workshop on SGMA and general GSP development information (e.g., required components of a GSP, how sustainability indicators are developed, etc.) • Email notice and updates • Newspaper notice of Public Workshop
Between Notice of GSP Planning and August 30, 2021	During GSP Development	• Public Workshops and other opportunities providing stakeholder avenues to	*Centralized:* • Public workshop on GSP development. See topics for GSP development (e.g., basin

Timeframe	Milestone or Stage	Required Community Engagement Under SGMA	Centralized & Localized Communication Strategies
		participate in GSP development	conditions, GSP roadmap, etc.) • Email notice of Public Workshops • Newspaper notice of Public Workshops *Localized:* • Make time in standing meetings for updates and information on GSP development • Develop newsletter updates • Disseminate updates via websites and social media
Between Notice of GSP Planning and August 30, 2021	During GSP development	• Active involvement of diverse social, cultural, and economic elements of the population within the Subbasin	*Centralized:* • Provide monthly email notices and updates • Update website regularly • Convene monthly or bimonthly meetings of Chowchilla Subbasin GSP Advisory Committee • Convene quarterly or monthly meetings of GSA Boards • Identify and communicate opportunities for public engagement and/or public comment during meetings on GSP development, (providing clear messages that GSAs retain legal responsibility for final GSA and GSP related decisions). • Arrange for technical support to stakeholder groups through presentations or workshops • Update area legislative bodies at strategic mileposts (and any other groups upon request) *Localized:* • Utilize local channels and meetings to identify and communicate opportunities for public engagement and/or public comment during meetings on GSP development.
GSP adoption no later than August 30, 2021	Prior to GSP adoption or amendment	• Provide notice to cities and counties within area encompassed by the proposed plan or amendment • Consider comments provided by the cities and counties • Accommodate requests for consultation received from the cities and counties within 30 days	SEE ABOVE

Timeframe	Milestone or Stage	Required Community Engagement Under SGMA	Centralized & Localized Communication Strategies
GSP adoption no later than August 30, 2021	Prior to GSP adoption or amendment	• No sooner than 90 days following public notice, hold public hearing/ Public Workshop	SEE ABOVE
Prior to GSA imposing fee or increasing fee	If GSA intends to impose or increase a fee	• Provide public with access to the data serving as the basis for the proposed fee, the time and place of explanatory public meeting, and general explanation of topic to be discussed. Post on project website and mail to any interested party who submits written request for mailed notice of meetings on new or increased fees. • No sooner than 10 days following public notice, hold a public meeting.	SEE ABOVE

Evaluation and Assessment

The communication strategy should include opportunities to check in at various points during implementation to ensure that it is meeting the communication and engagement goals and complying with SGMA. These check-ins should include the following inquiry and topics:

- ✓ What worked well?
- ✓ What didn't work as planned?
- ✓ Meeting recaps with next steps
- ✓ Listing lessons learned … and developing mid-course corrections
- ✓ (As relevant) communications budget analysis

Educational Materials

DWR has developed various educational materials about SGMA and GSA/GSP development. In addition to DWR materials, academic institutions and foundations have published useful reports about SGMA implementation. While not comprehensive, Table 4 lists some essential SGMA educational and reference materials.

Table 4. Educational and Reference Documents for SGMA Implementation

Educational/Reference Document Titles	Publishing Entity	Date
Groundwater Sustainability Agency Frequently Asked Questions http://www.water.ca.gov/groundwater/sgm/pdfs/DWR_GSA_FAQ_2016-01-07.pdf	DWR	January 2016
Groundwater Sustainability Plan (GSP) Emergency Regulations Guide http://www.water.ca.gov/groundwater/sgm/pdfs/GSP_Final_Regs_Guidebook.pdf	DWR	July 2016
Collaborating for Success: Stakeholder Engagement for Sustainable Groundwater Management Act Implementation http://waterfoundation.net/wp-content/uploads/2015/07/SGMA_Stakeholder_Engagement_White_Paper.pdf	Community Water Center Clean Water Fund Union of Concerned Scientist	July 2015
The 2014 Sustainable Groundwater Management Act: A Handbook to Understanding and Implementing the Law http://www.watereducation.org/sites/main/files/file-attachments/groundwatermgthandbook_oct2015.pdf	Water Education Foundation	October 2015
SGMA Engagement With Tribal Governments https://www.water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/GD_Tribal_Final_2017-06-28.pdf	DWR	June 2017

Appendix: Tribal Engagement

Relevant DWR Information

SGMA Section 10720.3. …any federally recognized Indian Tribe, appreciating the shared interest in assuring the sustainability of groundwater resources, may voluntarily agree to participate in the preparation or administration of a groundwater sustainability plan or groundwater management plan under this part through a joint powers authority or other agreement with local agencies in the basin. A participating Tribe shall be eligible to participate fully in planning, financing, and management under this part, including eligibility for grants and technical assistance, if any exercise of regulatory authority, enforcement, or imposition and collection of fees is pursuant to the Tribe's independent authority and not pursuant to authority granted to a groundwater sustainability agency under this part.
Draft Discussion Paper Tribal Participation with Groundwater Sustainability Agencies http://www.water.ca.gov/groundwater/sgm/pdfs/SGMA_Tribal_GSAs.pdf
Must a local agency exclude federal and tribal lands from its service area when forming a GSA? No, federal lands and tribal lands need not be excluded from a local agency's GSA area if a local agency has jurisdiction in those areas; however, those areas are not subject to SGMA. But, a local agency in its GSA formation notice shall explain how it will consider the interests of the federal government and California Native American tribes when forming a GSA and developing a GSP. DWR strongly recommends that local agencies communicate with federal and tribal representatives prior to deciding to become a GSA. As stated in Water Code §10720.3, the federal government or any federally recognized Indian tribe, appreciating the shared interest in assuring the sustainability of groundwater resources, may voluntarily agree to participate in the preparation or administration of a GSP or groundwater management plan through a JPA or other agreement with local agencies in the basin. Water Code References: §10720.3, §10723.2, §10723.8

Tribal Outreach Resources

The follow are links to agency tribal outreach resources and considerations, each of which captures important principles and resources for tribal outreach. A short summary of key outreach principles can be found below.

- Draft Discussion Paper Tribal Participation with Groundwater Sustainability Agencies
- CalEPA Tribal Consultation Policy Memo (August 2015)
- DWR Tribal Engagement Policy (May 2016)
- CA Natural Resources Agency Tribal Consultation Policy (November 2012)
- SWRCB Proposed Tribal Beneficial Uses
- Butte County Associate of Governments: Policy For Government-To-Government Consultation With Federally Recognized Native American Tribal Governments *(a model from the transportation sector)*
- CA Court Tribal Outreach and Engagement Strategies
- Traditional Ecological Knowledge resources
- Water Education Foundation Tribal Water Issues

Key Outreach Principles

- *Engage early and often*
- *Consider tribal beneficial uses in decision-making (identified by region* here*); identify and seek to protect tribal cultural resources*
- *Share relevant documentation with tribal officials*
- *Conduct meetings at times convenient for tribal participation with ample notifications*
- *Request relevant process input/data/information from tribes*
- *Empower tribes to act as tribal cultural resources caretakers*
- *Designate a tribal liaison(s) where appropriate*
- *Share resources for tribal involvement as is feasible*
- *Develop MOUs where relevant*

Be mindful of the traditions and cultural norms of tribes in your area

APPENDIX 2.C. NOTICE AND COMMUNICATION

2.C.b. Chowchilla Subbasin Interested Parties List

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020

GSP Team:

Davids Engineering, Inc
Luhdorff & Scalmanini
ERA Economics
Stillwater Sciences and
California State University, Sacramento

All announcements are sent to the mailing list of Chowchilla Water District, Madera County, Farm Bureau, and to the individuals listed below:

Alfredo Martinez
Andre Tolmachoff
Anthony Fagundes
Bert Wilgenberg
Bill Brinkop
Brad Robson
Bruce Chapman
Carl Janzen
Chad Crivelli
Chad Hayes
Darrly Azavedo
David Massaro
Derrick Upton
Doug Brunner
Edward Walker
Harry & Dianne Haynes
Jason Gill
Jason Rogers
Jay Mahil
Jeff Troost
Johnny Troost
Julie Merriam
Karun Samran
Keith Cederquest
Keith White
Kelby Hooper
Larkin Harman
Lisa Baker
Manual Cabral
Marcus McDaniel
Marvin Arendse
Mathew McCarthy
Michael Bliss
Mike Fagundes
Morris Garcia
Nolon Doss
Paul Mesple
Pete Fry
Philip Fagundes
Richard DeBenedetto
Rick Cosyns
Rick Iger
Roger Faust
Samantha Lopes

Contact Group Name: Chowchilla Subbasin SGMA Group
Members:

Alan Becker
Amanda Peisch
B Nelson
Brad Samuelson
Brandon Tomlinson
Breanne Ramos
Briana Seapy
Celeste Gray
Chase Hurley
Chris Montoya
Christina Beckstead
Clay Daulton
Dan Maddalena Farms
David Rodgers
Debbie Tiller
Dennis Braga
Devin Aviles
Diana Palmer
David Orth
Eddie Verdugo
Edgar DeJager
Eric Fleming
Fairmead Community & Friends
Geoffrey Vandenheuvel
Glenna Jarvis
Greg Hooker
Ilse Lopez-Narvaez
Jackson, Matthew
Jason Rogers
Jay Mahil
Jeanne Zolezzi
Jeannie Habben
Jennifer Spaletta
Joe Hopkins
Judy Gutierrez
Julia Berry
Katie Lucchesi
Lacey Kiriakou
Kole Upton
Lauren Layne
Liesbet Olaerts
Lloyd Pareira
Luis Gill
Maria Herrera
Mark Hutson

Michael Kalua
Michael Mandala
Miguel Guerrero
Mike Fenn
Nate Ray
Phil Janzen
Ralph Pistoresi
Rodrigo Espinoza
Russell Harris
Sal Alhomedi
Samantha Lopes
Sarah Woolf
Sean Kirkpatrick
Stephanie Anagnoson
Stephanie Lucero
Terry Violett
Tom Wheeler
Vince Taylor
Wood Fish
Sarah Donaldson
Steve Massaro
Steve Stewart
Steven Haworth
Tim Heskett
Tom Fry
Wayne Cederquist
Zach Thompson
Zeferino Hernandez

APPENDIX 2.C. NOTICE AND COMMUNICATION

2.C.c. Chowchilla Subbasin Engagement Matrix

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020

GSP Team:

Davids Engineering, Inc
Luhdorff & Scalmanini
ERA Economics
Stillwater Sciences and
California State University, Sacramento

Madera Subbasin Outreach Check List
Subbasin-Wide Centralized Engagement
Informing the Public about GSP Development Progress

Meeting/Event	Meeting/ Event date	Topics presented	Audience (estimated # participants; interests represented)	E-blast to Interested Parties list? Which list and when?	Email to Others? Which list and when?	Flyer created?	Flyer distributed at other meetings/events? Where and when?	Information provided at other meetings/events? Where and when?	Additional outreach and publicity (e.g., pop-ups)?	Press release? Which outlets?	Advertised on website? Which website(s)?	Advertised on social media? Which platforms and accounts?	Translation of meeting provided?	Additional comments
SGMA GSP-Specific Events: Subbasin-wide meetings, capacity-building events, educational tours, e-blasts														
Chowchilla Subbasin Coordination Committee Meeting	5/27/2016	List of eligible agencies, Interbasin Agreements, governance, plan structure, outreach, stakeholder engagement, data gaps	11, CWD, Madera County, Triangle T, Madera Farm Bureau	Chowchilla Subbasin Coordination Committee		No	No	Madera RWMG , CWD Board mtg					No	
Chowchilla Subbasin Coordination Committee Meeting	6/29/2016	List of eligible agencies, Interbasin Agreements, governance, plan structure, outreach, stakeholder engagement, data gaps, funding, future workshops	15, CWD, Madera County, Merced County, Triangle T, Madera Farm Bureau, City of Chowchilla	Chowchilla Subbasin Coordination Committee		No	No	Madera RWMG , CWD Board mtg					No	
Chowchilla Subbasin Coordination Committee Meeting	8/3/2016	List of eligible agencies & interested parties,Boundary Modification, governance, plan structure, outreach, stakeholder engagement, data gaps, funding, future workshops	9, CWD, Madera County, Triangle T, Madera Farm Bureau	Chowchilla Subbasin Coordination Committee		No	No	Madera RWMG , CWD Board mtg					No	
Chowchilla Subbasin Coordination Committee Meeting	8/31/2016	Interbasin Agreement, GSA Formation, Plan Structure Alternatives, Guiding Principles, retention of consultant to prepare plan, outreach to stakeholders, data gap report, budget	11, CWD, Madera County, Triangle T, Madera Farm Bureau, SVMWC, City of Chowchilla	Chowchilla Subbasin Coordination Committee		No	No	Madera RWMG , CWD Board mtg					No	
Chowchilla Subbasin Coordination Committee Meeting	9/28/2016	Interbasin Agreement, GSA Formation, Plan Structure Alternatives, Guiding Principles, cost share, retention of consultant to prepare plan, outreach to stakeholders, data gap report, budget	14, CWD, Madera County, Merced County, Triangle T, Madera Farm Bureau, SVMWC, City of Chowchilla, Clayton WD	Chowchilla Subbasin Coordination Committee		No	No	Madera RWMG , CWD Board mtg					No	

Meeting/Event	Meeting/ Event date	Topics presented	Audience (estimated # participants; interests represented)	E-blast to Interested Parties list? Which list and when?	Email to Others? Which list and when?	Flyer created?	Flyer distributed at other meetings/events? Where and when?	Information provided at other meetings/events? Where and when?	Additional outreach and publicity (e.g., pop-ups)?	Press release? Which outlets?	Advertised on website? Which website(s)?	Advertised on social media? Which platforms and accounts?	Translation of meeting provided?	Additional comments
Chowchilla Subbasin Coordination Committee Meeting	10/26/2016	Interbasin Agreement, master timeline, GSA Formation, cost sharing agreement, retention of consultant to prepare plan, outreach to stakeholders, data gap report, budget	16, CWD, Madera County, Merced County, Triangle T, Madera Farm Bureau, SVMWC, City of Chowchilla, Clayton WD	Chowchilla Subbasin Coordination Committee		No	No	Madera RWMG , CWD Board mtg					No	
Chowchilla Subbasin Coordination Committee Meeting	12/7/2016	Interbasin Agreement, master timeline, GSA Formation, cost sharing agreement, retention of consultant RFP, outreach to stakeholders, data gap report, budget,future workshops	14, CWD, Madera County, Merced County, Triangle T, Madera Farm Bureau, SVMWC, City of Chowchilla, Clayton WD	Chowchilla Subbasin Coordination Committee		No	No	Madera RWMG , CWD Board mtg					No	
Chowchilla Subbasin Coordination Committee Meeting	1/25/2017	master timeline, GSA Formation, cost sharing agreement, Madera County approved contract w/ Davids Eng to prepare Data Gap, outreach to stakeholders, future workshops	13, CWD, Madera County, Merced County, Triangle T, Madera Farm Bureau, SVMWC, City of Chowchilla, Clayton WD	Chowchilla Subbasin Coordination Committee		No	No	Madera RWMG , CWD Board mtg					No	
Chowchilla Subbasin Coordination Committee Meeting	3/29/2017	Master timeline, GSA Formation, draft GSP cost sharing agreement, Triangle T WD formation, upload data to Data Gap, stakeholder outreach plan	13, CWD, Madera County, Merced County, Triangle T, Madera Farm Bureau, SVMWC, Clayton WD	Chowchilla Subbasin Coordination Committee		No	No	Madera RWMG , CWD Board mtg					No	
Chowchilla Subbasin Coordination Committee Meeting	4/27/2017	Master timeline, GSA Overlap, draft GSP cost sharing agreement, Triangle T WD formation, stakeholder outreach plan, multi GSA workshop July-Sept	11, CWD, Madera County, Triangle T, SVMWC, City of Chowchilla, Clayton WD, DWR	Chowchilla Subbasin Coordination Committee		No	No	Madera RWMG , CWD Board mtg					No	
Chowchilla Subbasin Coordination Committee Meeting	5/31/2017	Master timeline, Interbasin Agreement, GSA Boundary Overlap, draft GSP cost sharing agreement, Triangle T WD formation, stakeholder outreach plan, multi GSA workshop Aug-Sept	9, CWD, Madera County, Merced County, Triangle T, Clayton WD	Chowchilla Subbasin Coordination Committee		No	No	Madera RWMG , CWD Board mtg					No	

Meeting/Event	Meeting/ Event date	Topics presented	Audience (estimated # participants; interests represented)	E-blast to Interested Parties list? Which list and when?	Email to Others? Which list and when?	Flyer created?	Flyer distributed at other meetings/events? Where and when?	Information provided at other meetings/events? Where and when?	Additional outreach and publicity (e.g., pop-ups)?	Press release? Which outlets?	Advertised on website? Which website(s)?	Advertised on social media? Which platforms and accounts?	Translation of meeting provided?	Additional comments
Chowchilla Subbasin Coordination Committee Meeting	6/28/2017	Master timeline, Interbasin Agreement, Madera County MOU signed, Data Gap Report, GSP cost sharing agreement out for signatures, Management Areas, stakeholder outreach plan, multi GSA workshop Oct-Nov	12, CWD, Madera County, Merced County, Madera Farm Bureau Triangle T, SVMWC, City of Chowchilla, Clayton WD, DWR	Chowchilla Subbasin Coordination Committee		No	No	Madera RWMG , CWD Board mtg					No	
Chowchilla Subbasin Coordination Committee Meeting	7/26/2017	Master timeline, Interbasin Agreement, Madera County MOU signed, GSP cost sharing agreement, stakeholder outreach plan, multi GSA workshop Oct-Nov	12, CWD, Merced County, Madera Farm Bureau Triangle T, SVMWC, City of Chowchilla, small farmer	Chowchilla Subbasin Coordination Committee		No	No	Madera RWMG , CWD Board mtg					No	
Chowchilla Subbasin Coordination Committee Meeting	8/30/2017	Master timeline, Interbasin Agreement, draft Data Gap Report, GSP cost sharing agreement out for signatures, stakeholder outreach plan, multi GSA workshop Oct-Nov	13, CWD, Madera County, Madera Farm Bureau Triangle T, SVMWC, City of Chowchilla, small farmers	Chowchilla Subbasin Coordination Committee		No	No	Madera RWMG , CWD Board mtg					No	
Chowchilla Subbasin Coordination Committee Meeting	10/4/2017	Master timeline, Interbasin Agreement, GSP cost sharing agreement, stakeholder outreach plan, multi GSA workshop Oct-Nov, Chowchilla Subbasin GSP Advisory Committee	12, CWD, Madera County, Merced County, Triangle T, SVMWC, small farmers, DWR	Chowchilla Subbasin Coordination Committee		No	No	Madera RWMG , CWD Board mtg					No	
Chowchilla Subbasin GSP Advisory Committee	11/8/2017	Election of Officers, appt of staff, Davids Eng selected to prepare GSP, Interbasin Agreement, Communications Plan and Stakeholder Outreach, Prop 1 Grant Application, Budget	12, CWD, Madera County, Merced County, Madera Farm Bureau Triangle T, SVMWC, City of Chowchilla, small farmers	Chowchilla Subbasin GSP Advisory Committee Interested Parties	Chowchilla News, Madera Tribune	No	No	Madera RWMG, CWD Board			cwdwater.com, MaderaCountyWater.com		No	

Meeting/Event	Meeting/ Event date	Topics presented	Audience (estimated # participants; interests represented)	E-blast to Interested Parties list? Which list and when?	Email to Others? Which list and when?	Flyer created?	Flyer distributed at other meetings/events? Where and when?	Information provided at other meetings/events? Where and when?	Additional outreach and publicity (e.g., pop-ups)?	Press release? Which outlets?	Advertised on website? Which website(s)?	Advertised on social media? Which platforms and accounts?	Translation of meeting provided?	Additional comments
Chowchilla Subbasin GSP Advisory Committee	1/31/2018	Election of Officers, appt of staff, Davids Eng selected to prepare GSP, Communications Plan and Stakeholder Outreach, Prop 1 Grant Application, Budget	22, CWD, Madera County, Merced County, Madera Farm Bureau Triangle T, SVMWC, City of Chowchilla, small farmers, Clayton WD, SHE	Chowchilla Subbasin GSP Advisory Committee Interested Parties	Chowchilla News, Madera Tribune	No	No	Madera RWMG, CWD Board			cwdwater.com, MaderaCountyWater.com		No	
Chowchilla Subbasin GSP Advisory Committee	3/7/2018	Davids Eng presentation, Surface System Water Budget, GW System Water Budget, Subbasin Water Budget, Project Costs & Management Actions, Management Areas, Stakeholder Outreach Plan by CCP	27, CWD, Madera County, Merced County, Madera Farm Bureau, Merced Farm Bureau, Triangle T, SVMWC, City of Chowchilla, small farmers, Clayton WD, SHE, DWR	Chowchilla Subbasin GSP Advisory Committee Interested Parties	Chowchilla News, Madera Tribune	No	No	Madera RWMG, CWD Board			cwdwater.com, MaderaCountyWater.com		No	
Chowchilla Subbasin GSP Advisory Committee	4/25/2018	CWD reviewing water delivery data, Management Area criteria, consideration of two MA, subsidence area and non-subsidence area, CCP preparing Stakeholder Outreach Plan	17, CWD, Madera County, Merced County, Triangle T, SVMWC, City of Chowchilla, small farmers, Clayton WD, DWR	Chowchilla Subbasin GSP Advisory Committee Interested Parties	Chowchilla News, Madera Tribune	No	No	Madera RWMG, CWD Board			cwdwater.com, MaderaCountyWater.com		No	
Chowchilla Subbasin GSP Advisory Committee	5/30/2018	Boundary Modification, Davids Eng Presentation, Surface Water System Overview, Surface water System for CWD, Madera County East & West, Triangle T WD, SVMWC, seepage allocation, Management Areas, Stakeholder outreach Plan	28, CWD, Madera County, Merced County, Madera Farm Bureau, Triangle T, SVMWC, City of Chowchilla, small farmers, Clayton WD, SHE, DWR	Chowchilla Subbasin GSP Advisory Committee Interested Parties	Chowchilla News, Madera Tribune	No	No	Madera RWMG, CWD Board			cwdwater.com, MaderaCountyWater.com		No	
Chowchilla Subbasin GSP Advisory Committee	6/27/2018	Interbasin Agreement, Boundary Modification, Base Period, Seepage Allocation, GSA Water Budgets, Management Areas, Stakeholder Outreach	19, CWD, Merced County, Madera Farm Bureau, Triangle T, SVMWC, City of Chowchilla, small farmers, Clayton WD, Root Creek WD, Dairy Industry, SHE, DWR,	Chowchilla Subbasin GSP Advisory Committee Interested Parties	Chowchilla News, Madera Tribune	No	No	Madera RWMG, CWD Board			cwdwater.com, MaderaCountyWater.com		No	

Meeting/Event	Meeting/ Event date	Topics presented	Audience (estimated # participants; interests represented)	E-blast to Interested Parties list? Which list and when?	Email to Others? Which list and when?	Flyer created?	Flyer distributed at other meetings/events? Where and when?	Information provided at other meetings/events? Where and when?	Additional outreach and publicity (e.g., pop-ups)?	Press release? Which outlets?	Advertised on website? Which website(s)?	Advertised on social media? Which platforms and accounts?	Translation of meeting provided?	Additional comments
Chowchilla Subbasin GSP Advisory Committee	7/18/2018	Interbasin Agreement, Boundary Modification, Management Areas, Basin Setting, Sustainability Goals, Undesirable Results, Minimum Threasholds, Measurable Objectives, Projects, Management Actions, Stakeholder Outreach	24, CWD, Madera County, Merced County, Madera Farm Bureau, Triangle T, SVMWC, Dairy Industry, small farmers, Clayton WD, DWR	Chowchilla Subbasin GSP Advisory Committee Interested Parties	Chowchilla News, Madera Tribune	No	No	Madera RWMG, CWD Board			cwdwater.com, MaderaCountyWater.com		No	
Chowchilla Subbasin GSP Advisory Committee	8/22/2018	Boundary Modification, Management Areas, Water Availability, Projets, Management Actions, GW Allotment	24, CWD, Madera County, Merced County, Madera Farm Bureau, City of Chowchilla, Triangle T, SVMWC, Dairy Industry, small & large farmers, Clayton WD, DWR, CCP	Chowchilla Subbasin GSP Advisory Committee Interested Parties	Chowchilla News, Madera Tribune	No	No	Madera RWMG, CWD Board			cwdwater.com, MaderaCountyWater.com		No	
Chowchilla Subbasin GSP Advisory Committee	9/26/2018	Boundary Modification, Management Areas, Projects, water use reduction concepts, GW trading, CV Salts	31, CWD, Madera County, Merced County, Madera Farm Bureau, Merced Farm Bureau, City of Chowchilla, Triangle T, SVMWC, Dairy Industry, small & large farmers, Clayton WD, DWR, CCP	Chowchilla Subbasin GSP Advisory Committee Interested Parties	Chowchilla News, Madera Tribune	No	No	Madera RWMG, CWD Board			cwdwater.com, MaderaCountyWater.com		No	
Chowchilla Subbasin GSP Advisory Committee	12/5/2018	Review SGMA Requirements, Hydrogeologic Conceptual Model, Subasin Water Budget & Overdraft Estimate, Projects & Water Use Reduction, Impacts to individual Landowners	77, CWD, Madera County, Merced County, City of Chowchilla, Triangle T, SVMWC, Dairy Industry, small & large farmers, Clayton WD, DWR, Madera ID, LeGrand Athlone WD, SHE	Chowchilla Subbasin GSP Advisory Committee Interested Parties, CWD Interested Parties, direct mailing to all CWD waterusers, Madera Farm Bureau Interested Parties, MaderaCountyWater.com	Chowchilla News, Madera Tribune	Yes	No	Madera RWMG, CWD Board			cwdwater.com, MaderaCountyWater.com		No	
Chowchilla Subbasin GSP Advisory Committee	3/27/2019	GW Model Calibration, GW Model Results With & W/O Climate Change, GW Model Results With & WO Projects, Measurable Objectives, Minimum Thresholds	44, CWD, Madera County, Merced County, Madera Farm Bureau, Merced Farm Bureau, City of Chowchilla, Triangle T, SVMWC, Dairy Industry, small & large farmers, Clayton WD, DWR, SHE	Chowchilla Subbasin GSP Advisory Committee Interested Parties, CWD Interested Parties, Madera Farm Bureau, MaderaCountyWater.com	Chowchilla News, Madera Tribune	Yes	No	Madera RWMG, CWD Board			cwdwater.com, MaderaCountyWater.com		No	

Meeting/Event	Meeting/ Event date	Topics presented	Audience (estimated # participants; interests represented)	E-blast to Interested Parties list? Which list and when?	Email to Others? Which list and when?	Flyer created?	Flyer distributed at other meetings/events? Where and when?	Information provided at other meetings/events? Where and when?	Additional outreach and publicity (e.g., pop-ups)?	Press release? Which outlets?	Advertised on website? Which website(s)?	Advertised on social media? Which platforms and accounts?	Translation of meeting provided?	Additional comments
Chowchilla Subbasin GSP Advisory Committee	5/29/2019	Sustainability Goal, Monitoring Network, Minimum Thresholds, Measurable Objectives, 5 Year Interim Milestones	43, CWD, Madera County, Merced County, Madera Farm Bueau, Merced Farm Bureau, Triangle T, Dairy Industry, small & large farmers, Clayton WD, DWR, Madera ID, SHE	Chowchilla Subbasin GSP Advisory Committee Interested Parties, CWD Interested Parties, Madera Farm Bureau, MaderaCountyWater.com	Chowchilla News, Madera Tribune	Yes	No	Madera RWMG, CWD Board			cwdwater.com, MaderaCountyWater.com		No	
Chowchilla Subbasin GSP Advisory Committee	7/31/2019	GSP Purpose, Plan Area, Basin Setting, Sustainable Management Criteria, Projects, Management Actions, Implementation Plan	55, CWD, Madera County, Merced County, Merced Farm Bureau, Chowchilla High School, City of Chowchilla, Triangle T, Dairy Farmers, small & large farmers, Clayton WD, NRCS	Chowchilla Subbasin GSP Advisory Committee Interested Parties, CWD Interested Parties, Madera Farm Bureau, MaderaCountyWater.com	Chowchilla News, Madera Tribune	Yes	No	Madera RWMG, CWD Board		Chowchilla News, Madera Tribune	cwdwater.com, MaderaCountyWater.com		No	
Chowchilla Subbasin GSP Advisory Committee	10/23/2019	Highlights of SGMA, listening session to receive comments	28, CWD, Madera County, Merced County, City of Chowchilla, Triangle T, Dairy Farmers, small & large farmers	Chowchilla Subbasin GSP Advisory Committee Interested Parties, CWD Interested Parties, Madera Farm Bureau, MaderaCountyWater.com	Chowchilla News, Madera Tribune	Yes	No	Madera RWMG, CWD Board		Chowchilla News, Madera Tribune	cwdwater.com, MaderaCountyWater.com		No	
Chowchilla Subbasin GSP Advisory Committee	11/20/2019	Review of Comments received on GSP, Recommend Approval of GSP	future meeting	Chowchilla Subbasin GSP Advisory Committee Interested Parties, CWD Interested Parties, Madera Farm Bureau, MaderaCountyWater.com	Chowchilla News, Madera Tribune	No	No	Madera RWMG, CWD Board		Chowchilla News, Madera Tribune	cwdwater.com, MaderaCountyWater.com		No	
CWD	6/8/2016	SGMA, Coordination Committee, Governance Stakeholder Outreach	14, CWD, small farmers,			No		Madera RWMG			cwdwater.com		No	
CWD	7/17/2016	SGMA, Coordination Committee,Governance Stakeholder Outreach, Notice of Intent to form GSA	11, CWD, small farmers,			No		Madera RWMG			cwdwater.com		No	
CWD	9/14/2016	SGMA, Coordination mtg with Merced County & City of Chowchilla, Stakeholder Outreach, Data Gap Analysis	11, CWD, small farmers, Madera County, Madera Farm Bureau			No		Madera RWMG			cwdwater.com		No	
CWD	9/26/2016	SGMA, Potential Boundaries of CWD-GSA	10, CWD, small farmers, Madera County, Madera Farm Bureau			No		Madera RWMG			cwdwater.com		No	

Meeting/Event	Meeting/ Event date	Topics presented	Audience (estimated # participants; interests represented)	E-blast to Interested Parties list? Which list and when?	Email to Others? Which list and when?	Flyer created?	Flyer distributed at other meetings/events? Where and when?	Information provided at other meetings/events? Where and when?	Additional outreach and publicity (e.g., pop-ups)?	Press release? Which outlets?	Advertised on website? Which website(s)?	Advertised on social media? Which platforms and accounts?	Translation of meeting provided?	Additional comments
CWD	10/12/2016	SGMA, Formation of JPA, Potential Boundaries of CWD-GSA, Notice of Intent to Form GSA	11, CWD, small farmers			No		Madera RWMG			cwdwater.com		No	
CWD	11/9/2016	SGMA, Inter Basin Agreement, Potential Boundaries of CWD-GSA, Notice of Intent to Form GSA	12, CWD, small farmers			No		Madera RWMG			cwdwater.com		No	
CWD & City of Chowchilla	12/13/2016	SGMA, local management, stakeholder involvement, coordination, 20 years, roles of DWR & SWRCB, sustainabiity, GSA, GSP	15, CWD, City of Chowchilla, Madera Farm Bureau, small farmers, urban water users	CWD Interested Parties, City of Chowchilla Interested Parties		yes		Madera RWMG			cwdwater.com		No	
CWD	12/14/2016	SGMA, Approved Notice of Intent to Form GSA, Data Gap Analysis awarded to Davids Eng	10, CWD, small farmers			No		Madera RWMG			cwdwater.com		No	
CWD-GSA	3/8/2017	SGMA, Madera County SGMA activities, formation of Triangle T Water District, Interbasin Agreement	12, CWD, small farmers, Madera County		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	4/12/2017	SGMA, Coordination Agreement, formation of Triangle T Water District, Interbasin Agreement	11, CWD, small farmers		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	6/15/2017	SGMA, local management, stakeholder involvement, coordination, 20 years, roles of DWR & SWRCB, sustainabiity, GSA, GSP	68, CWD, Madera Farm Bureau, small farmers, urban water users	CWD Interested Parties, direct mailing to all CWD Waterusers	Chowchilla News, Madera Tribune	yes		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	7/12/2017	SGMA, approved Madera County - CWD Cooperation MOU, reviewed Chowchilla Subbasin Cost Sharing MOU	13, CWD, small farmers		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	8/9/2017	SGMA, discussed the RFP for prep of Chowchilla Subbasin GSP	11, CWD, small farmers		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	9/20/2017	SGMA, approved Chowchilla Subbasin GSP Cost Share MOU, authorized Notice of Intent to prepare GSP	9, CWD, small farmers		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	11/8/2017	SGMA, Reviewed Budget, preparing Grant Application for GSP	9, CWD, small farmers		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	

Meeting/Event	Meeting/ Event date	Topics presented	Audience (estimated # participants; interests represented)	E-blast to Interested Parties list? Which list and when?	Email to Others? Which list and when?	Flyer created?	Flyer distributed at other meetings/events? Where and when?	Information provided at other meetings/events? Where and when?	Additional outreach and publicity (e.g., pop-ups)?	Press release? Which outlets?	Advertised on website? Which website(s)?	Advertised on social media? Which platforms and accounts?	Translation of meeting provided?	Additional comments
CWD-GSA	12/13/2017	SGMA, Approved Budget, submitted Grant Application for GSP to DWR, selected Davids Eng to prepare GSP, met with City to discuss corrdination	8, CWD, small farmers		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	2/14/2018	SGMA, DWR awarded $1.5M for GSP and $1M for Monitring Wells, reviewed Water Budget	10, CWD, small farmers		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	3/14/2018	SGMA, Chowchilla Subbasin Water Budget	10, CWD, small farmers		Chowchilla News, Madera Tribune	No		Madera RWMG			MaderaCountyWater .com		No	
CWD-GSA	4/11/2018	SGMA, Chowchilla Subbasin Water Budget	9, CWD, small farmers		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	5/16/2018	SGMA, Interbasin Agreement, Management Areas, Water Budget	10, CWD, small farmers		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	6/13/2018	SGMA, Interbasin Agreement, Surface Water Budgets, Management Areas, Basin Boundary Modification	15, CWD, small farmers, Madera County, Triangle T WD		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	7/11/2018	SGMA, Interbasin Agreement, Basin Boundary Modfication	15, CWD, small farmers, Madera County, City of Chowchilla, Triangle T WD,		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	8/8/2018	SGMA, Basin Setting, Hydrogeologic Conceptual Model, Groundwater Conditions, Sustainable Management Criteria, Monitoring Networks, Projects, Management Actions, Boundary Modification	8, CWD, small farmers		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	9/12/2018	SGMA, Basin Setting, Hydrogeologic Conceptual Model, Groundwater Conditions, Sustainable Management Criteria, Monitoring Networks, Projects, Management Actions, Boundary Modification	13, CWD, small farmers, Madera County, Triangle T WD, Friant Water Authority		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	

Meeting/Event	Meeting/ Event date	Topics presented	Audience (estimated # participants; interests represented)	E-blast to Interested Parties list? Which list and when?	Email to Others? Which list and when?	Flyer created?	Flyer distributed at other meetings/events? Where and when?	Information provided at other meetings/events? Where and when?	Additional outreach and publicity (e.g., pop-ups)?	Press release? Which outlets?	Advertised on website? Which website(s)?	Advertised on social media? Which platforms and accounts?	Translation of meeting provided?	Additional comments
CWD-GSA	10/10/2018	SGMA, Projects, Development Concepts, GW Trading, water Restrictions, Administrative Considerations, Baseline Allotments, land fallowing, Operational Considerations	9, CWD, small farmers, Triangle T WD		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	11/14/2018	SGMA, Luncheon Meeting	10 , CWD, small farmers, Triangle T WD		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	12/11/2018	Review SGMA Requirements, Hydrogeologic Conceptual Model, Subasin Water Budget & Overdraft Estimate, Projects & Water Use Reduction, Impacts to individual Landowners	10, CWD, small farmers		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	1/9/2019	SGMA, Calibration of GW Model, Base Period GW Model, Sustainability Indicators,Minimum Thresholds	9, CWD, small farmers		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	2/20/2019	SGMA, Calibration of GW Model, Base Period GW Model, Sustainability Indicators,Minimum Threasholds, Transfer to White Areas	13, CWD, small farmers, Madera County, Madera Farm Bureau, Triangle T WD		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	3/13/2019	SGMA, Calibration of GW Model, Base Period GW Model, Sustainability Indicators,Minimum Threasholds, Madera Canal Capacity Increase	7, CWD, small farmers		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	4/10/2019	SGMA, Sustainability Indicators, Minimum Threasholds, Measurable Objectives, CWD Projects	10, CWD, small farmers, Madera County		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	5/15/2019	SGMA, Transfer to White areas, Representative Monitoring Sites, Minimum Thresholds, Measurable Objectives	16, CWD, small farmers		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	

Meeting/Event	Meeting/ Event date	Topics presented	Audience (estimated # participants; interests represented)	E-blast to Interested Parties list? Which list and when?	Email to Others? Which list and when?	Flyer created?	Flyer distributed at other meetings/events? Where and when?	Information provided at other meetings/events? Where and when?	Additional outreach and publicity (e.g., pop-ups)?	Press release? Which outlets?	Advertised on website? Which website(s)?	Advertised on social media? Which platforms and accounts?	Translation of meeting provided?	Additional comments
CWD-GSA	6/12/2019	SGMA, Sustainable Yield, Well Monitoring Network, Management Areas, Minimum Thresholds, Sustainability Indicators, Undesireable Results, Mitigation Program for Impacted Drinking Water Wells,	13, CWD, small farmers		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	7/17/2019	SGMA, Sustainable Yield, Well Monitoring Network, Management Areas, Minimum Thresholds, Sustainability Indicators, Undesireable Results	16, CWD, small farmers, City of Chowchilla, Urban Water Users		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	8/14/2019	SGMA, Plan Area, Basin Setting, Sustainable Management Criteria, Projects, Management Actions, Implementation Plan, White Area Transfers	18, CWD, small farmers, Madera County, Madera Farm Bureau		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	9/11/2019	SGMA Overview	5, CWD, small farmers		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	10/9/2019	SGMA Highlights, Cost Sharing MOU, Annual Report Budget	6, CWD, small farmers		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	11/13/2019	SGMA Highlights, Cost Sharing MOU, Annual Report Budget	Future Meeting		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
CWD-GSA	12/11/2019	Conduct Hearing, Adopt GSP	Future Meeting		Chowchilla News, Madera Tribune	No		Madera RWMG			cwdwater.com, MaderaCountyWater .com		No	
Other Events/Meetings: non-SGMA meetings at which information was provided about GSP development, updates provided to area legislative bodies														
Madera Water Forum	7/9/2019	SGMA Overview, Overdraft, Projects, Management Actions	48, small & Large farmers, dairy farmers											
Madera RWMG	7/11/2016	SGMA, PSP Grant, Public Outreach, Ad Hoc Committee to discuss JPA	10, Madera County, MID, CWD, SEMCU, GFWD, City of Madera, Coarsegold RCD, SHE, Madera Valley Water											
Madera RWMG	8/8/2016	GSAs being formed	12, Madera County, MID, CWD, SEMCU, GFWD, City of Madera, Coarsegold RCD, SHE											

Meeting/Event	Meeting/ Event date	Topics presented	Audience (estimated # participants; interests represented)	E-blast to Interested Parties list? Which list and when?	Email to Others? Which list and when?	Flyer created?	Flyer distributed at other meetings/events? Where and when?	Information provided at other meetings/events? Where and when?	Additional outreach and publicity (e.g., pop-ups)?	Press release? Which outlets?	Advertised on website? Which website(s)?	Advertised on social media? Which platforms and accounts?	Translation of meeting provided?	Additional comments
Madera RWMG	9/12/2013	SGMA, GSAs being formed,	11, Madera County, MID, CWD, RCWD, GFWD, City of Madera, Coarsegold RCD, City of Chowchilla, CSU Fresno, Fairmead Community and Friends											
Madera RWMG	10/10/2016	SGMA, Update on SGMA activities by agencies	12, Madera County, MID, CWD, SEMCU, GFWD, City of Chowchilla, NF Mono Rancheris, Madera Farm Bureau											
Madera RWMG	11/14/2016	SGMA, Update on SGMA activities by agencies, Madera County Public Meetings	17, Madera County, MID, CWD, SEMCU, GFWD, City of Madera, RWQCB, Madera Farm Bureau, CSU Fresno, NRCS,											
Madera RWMG	1/9/2017	SGMA, public hearings for 3 GSAs	15, Madera County, MID, CWD, SEMCU, GFWD, RCWD, City of Madera, RWQCB, SHE											
Madera RWMG	2/13/2017	SGMA, CWD filed NOI to form GSA, Madera County filed NOI to form 3 GSAs,	17, Madera County, MID, CWD, SEMCU, GFWD, City of Chowchilla,RWQCB, SHE, NF Mono Rancheria											
Madera RWMG	3/13/2017	SGMA, Data Gap Analysis, hired Davids Eng.	13, Madera County, MID, CWD, SEMCU, GFWD, City of Madera,RWQCB, SHE, Yosemite Sequoia RC&D											
Madera RWMG	4/10/2117	SGMA, Data Gap Study, Merced County filed NOI to form GSA, Madera County-CWD MOU,	10, Madera County, MID, CWD, SEMCU, GFWD, City of Chowchilla,RWQCB, SHE, NRCS											
Madera RWMG	5/8/2017	SGMA, GSA meeting dates, CIT Sustainable GW Management Act Forum	14, Madera County, MID, CWD, SEMCU, GFWD, City of Chowchilla, City of Madera, RWQCB, SHE, NRCS, NF Mono Rancheria											
Madera RWMG	6/12/2017	SGMA, Data Gap Analysis, DWR hosting public meetings, Sustainable GW Planning Conference, SGMA Portal	13, Madera County, MID, CWD, SEMCU, GFWD, RWQCB, SHE, Coarsegold RCD, Madera Farm Bureau											

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Madera RWMG	7/10/2017	SGMA, Prop 1 Grant Application, SHE applying for Grant	16, Madera County, MID, CWD, SEMCU, GFWD, RWQCB, SHE, Chowchilla Red Top RCD, City of Madera, Madera Farm Bureau,											
Madera RWMG	8/14/2017	SGMA, Madera County froming Advisory Committees, RFP for GSP posted, Applying for GSP Grant for Chowchilla Madera Subbasins	14, Madera County, MID, CWD, SEMCU, GFWD, RWQCB, SHE, City of Madera, Madera Farm Bureau, NF Mono Rancheria											
Madera RWMG	9/11/2017	SGMA, Hired Davids Eng to prepare GSP for Madera & Chowchilla Subbasins	11, Madera County, MID, CWD, SEMCU, RWQCB, SHE,											
Madera RWMG	10/9/2017	SGMA, GSP Prop 1 Grant Application, GW Sustainability Plan Workshop	16, Madera County, MID, CWD, SEMCU, RWQCB, SHE, GFWD, City of Chowchilla, Chowchilla Red Top RCD											
Madera RWMG	11/13/2017	SGMA, Chowchilla Subbasin Advisory Committee held 1st mtg, submitted GSP Grant Appication, Working on Madera Subbasins Grant Application	13, Madera County, MID, CWD, SEMCU, RWQCB, GFWD, City of Madera, NF Mono Rancheria											
Madera RWMG	1/8/2018	SGMA, applications from Chowchilla SB, Madera SB and SHE for grants have been submitted, hiring new Water and Natural Resources Director	18, Madera County, MID, CWD, SEMCU, RWQCB, GFWD, City of Madera, NF Mono Rancheria, SHE, Coarsegold RCD, Madera Farm Bureau											
Madera RWMG	2/12/2018	SGMA, 4 grants approved for GSP and Monitoring Wells, Madera Subbasin Committees formed	16, Madera County, MID, CWD, SEMCU, RWQCB, GFWD, RCWD, City of Chowchilla, SHE, NF Mono Rancheria											
Madera RWMG	3/12/2018	SGMA, Chowchilla Subbasin Water Budget	13, Madera County, MID, CWD, SEMCU, RWQCB, GFWD, RCWD, SHE,											
Madera RWMG	5/14/2018	SGMA Workshop at Gracey Elementary School, GW Model selection, Water Budget, GDE	12, Madera County, MID, CWD, SEMCU, RWQCB, SHE, NRCS City of Madera,											
Madera RWMG	7/9/2018	SGMA, Madera Subbasin Workshop, Management Areas, Water Budget	13, Madera County, MID, CWD, SEMCU, RWQCB, City of Madera,											
Madera RWMG	9/10/2018	SGMA, Technical Roundtables, 7 GSAs in Madera Subbasin, 4 in Chowchilla Subbasin, FloodMAR,	15, Madera County, MID, CWD, SEMCU, SHE, NRCS, City of Chowchilla, RCWD, TTWD, RWQCB											

Meeting/Event	Meeting/ Event date	Topics presented	Audience (estimated # participants; interests represented)	E-blast to Interested Parties list? Which list and when?	Email to Others? Which list and when?	Flyer created?	Flyer distributed at other meetings/events? Where and when?	Information provided at other meetings/events? Where and when?	Additional outreach and publicity (e.g., pop-ups)?	Press release? Which outlets?	Advertised on website? Which website(s)?	Advertised on social media? Which platforms and accounts?	Translation of meeting provided?	Additional comments
Madera RWMG	10/8/2018	SGMA Update on GSA activities	15, Madera County, MID, CWD, SEMCU, SHE, NRCS, City of Chowchilla, RCWD, TTWD,											
Madera RWMG	11/13/2018	SGMA, Groundwater Dependent Ecosystems, GW Modeling,	18, Madera County, MID, CWD, SEMCU, SHE, NRCS, City of Chowchilla, City of Madera, Madera Farm Bureau, RWQCB, GFWD											
Madera RWMG	12/10/2018	SGMA, Groundwater Sustainability Plan Workshop at Fresno State	16, Madera County, MID, CWD, SEMCU, SHE, RCWD, RWQCB City of Madera, Sugar Pine HOA, GFWD											
Madera RWMG	1/14/2019	SGMA, Madera Chowchilla Subbasin Workshop Feb 7th	17, Madera County, MID, CWD, SEMCU, SHE, Sugar Pine HOA, RWQCB, ILEPOA, GFWD											
Madera RWMG	2/11/2019	SGMA Update on GSA activities	11, Madera County, MID, CWD, SEMCU, RWQCB, Madera Farm Bureau, GFWD											
Madera RWMG	3/11/2019	SGMA Update on GSA activities, Rountable meetings scheduled for March 21st	18, Madera County, MID, CWD, SEMCU, GFWD, RWQCB, SHE, RCWD, City of Madera											
Madera RWMG	4/8/2019	SGMA Update on GSA activities, GSP Chapter 1 out for review	11, Madera County, MID, SEMCU, GFWD, SHE, NRCS, Indian Lakes											
Madera RWMG	5/13/2016	SGMA Update on GSA activities, Rountable meetings scheduled for May 29th	14, Madera County, MID, CWD, SEMCU, GFWD, RWQCB, SHE, RCWD, City of Madera, City of Chowchilla											
Madera RWMG	6/24/2019	SGMA Update on GSA activity, GSP Chapters are coming out for review, complete draft GSP for Chowchilla & Madera will be released August 1, 2019	17, Madera County, MID, CWD, SEMCU, GFWD, RWQCB, SHE, RCWD, City of Chowchilla, NRCD, CRCD											
Madera RWMG	7/22/2019	SGMA Update on GSA activity, complete draft GSP for Chowchilla & Madera was released August 1, 2019, 90 day review	13, Madera County, MID, CWD, SEMCU, City of Madera, CRCD, Indian Lakes											
Madera RWMG	8/26/2019	SGMA Update on GSA activity, complete draft GSP for Chowchilla & Madera was released August 1, 2019, 90 day review	14, Madera County, MID, CWD, SEMCU, City of Madera, CRCD, Indian Lakes											

Meeting/Event	Meeting/ Event date	Topics presented	Audience (estimated # participants; interests represented)	E-blast to Interested Parties list? Which list and when?	Email to Others? Which list and when?	Flyer created?	Flyer distributed at other meetings/events? Where and when?	Information provided at other meetings/events? Where and when?	Additional outreach and publicity (e.g., pop-ups)?	Press release? Which outlets?	Advertised on website? Which website(s)?	Advertised on social media? Which platforms and accounts?	Translation of meeting provided?	Additional comments
Red Top Landowners	6/25/2018	SGMA activies by Chowchilla Subbasin, water budget	15, small & large farmers, dairy farmers											
Red Top Landowners	9/17/2018	SGMA activies by Chowchilla Subbasin, GW Modeling, Sustainability	18, small & large farmers, dairy farmers											
Red Top Landowners	11/16/2018	SGMA activies by Chowchilla Subbasin, Water Budget,	19, small & large farmers, dairy farmers											
Red Top Landowners	8/21/2019	SGMA activies by Chowchilla Subbasin, draft GSP available for review	17, small & large farmers, dairy farmers											

APPENDIX 2.C. NOTICE AND COMMUNICATION

2.C.d. Chowchilla Subbasin Stakeholder Input Matrix

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020

GSP Team:

Davids Engineering, Inc
Luhdorff & Scalmanini
ERA Economics
Stillwater Sciences and
California State University, Sacramento

Madera Subbasin Stakeholder Input

Type of Beneficial User	Interests of Beneficial User	How interests were taken into consideration in GSP development

APPENDIX 2.C. NOTICE AND COMMUNICATION

2.C.e. Responses to Comments

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020

GSP Team:

Davids Engineering, Inc
Luhdorff & Scalmanini
ERA Economics
Stillwater Sciences and
California State University, Sacramento

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1 COMMENTS RECEIVED

Under the Sustainable Groundwater Management Act (SGMA), the four GSAs, Chowchilla Water District GSA, Madera County--Chowchilla GSA, County of Merced--Chowchilla GSA, and Triangle T Water District GSA for the Chowchilla Subbasin (Subbasin) have solicited and responded to comments from the public and from other agencies concerned with the Draft Groundwater Sustainability Plan (GSP). The Draft GSP was made available by the GSA's for public review on August 5, 2019. The public comment period for the Draft GSP ended on November 5, 2019. Agencies, organizations, and individuals submitting comments on the plan are listed below.

- AgIS Property Management (10/21/19)
- Clayton Water District (submitted 11/5/19)
- Dairy Water Budget Parameters (submitted 11/1/19)
- Hancock Farmland Services (submitted 11/5/19)
- Joint letter from various organizations (11/5/19)
- Madera Agricultural Water Association (MAWA) (submitted 11/9/19)
- Mark Hutson (11/2/19)
- Sierra Vista Mutual Water Company (SVMWC) (10/23/19)
- San Joaquin River Exchange Contractors (SJREC) (11/4/19)
- The Nature Conservancy (11/4/19)
- Verbal comments transcribed at the Chowchilla GSP Advisory Meeting Listening Session (10/23/19)

To finalize the GSP, the GSA's have prepared the following responses to comments that were received during the public review period.

2 MULTIPLE COMMENT SUBJECT AREA RESPONSES

2.1 Demand Management Reduction Program

2.1.1 Comment Summary

Numerous comments have been received stating that the GSP does not adequately develop the details of the demand management program. Commenters believe that pumping restrictions should, only be implemented, if necessary to achieve sustainability, and should gradually ramp down pumping over the implementation period to avoid a sudden adverse impact on the local economy. Other comments implied that the demand management program should be implemented faster. The overarching sentiment is that the demand management program should be developed through a stakeholder driven process.

2.1.2 Response

The demand reduction targets described in the GSP correspond to the estimated subbasin groundwater budget shortfall after inclusion of planned water supply. The details of demand reduction are being evaluated and vetted with stakeholders and the public through numerous venues including the Madera County GSAs Advisory Committee (Committee), Madera County GSA meetings, Coordination Committee meetings, discussions with Madera County Farm Bureau, and the Madera Ag Water Association. The vast majority of demand reduction is anticipated to occur within the Madera County GSA area. The required scale of the demand management program will be reassessed every five years as part of the five-year review. It will be scaled down, or up, as necessary to balance groundwater extraction and groundwater recharge as other projects are implemented over the 20-year implementation period and subsequent sustainability period. The Madera County GSA has been meeting regularly and will continue to meet regularly with stakeholders, the Committee and the other organizations highlighted above with the objective of formulating workable demand management program that is acceptable to stakeholders and meets subbasin sustainability objectives, and providing such information to the Madera County Board of Supervisors (the elected body for the Madera County GSA) for implementation consideration.

Based on the best available data and appropriate analytical tools applied in the GSP, some demand reductions are necessary in the Chowchilla Subbasin in order to achieve long-term groundwater sustainability. These reductions are focused primarily within the Madera County GSA's service area. To avoid a sudden and adverse disruption to the local economy, the anticipated demand reductions will be introduced gradually during the implementation period as described in Section 4.2.3 of the GSP.

The method for monitoring and enforcing anticipated demand reduction is being developed by the GSAs, with input provided to Madera County GSA from the various stakeholders and groups identified above. Demand reductions will likely be verified through a combination of remote sensing and water meters, the details of which will be further developed during the initial year of the implementation period.

2.2 Groundwater Dependent Ecosystems

2.2.1 Comment Summary

Comments regarding groundwater dependent ecosystems (GDEs) focused on the methods used to identify GDEs, the analysis of potential impacts to GDEs, and the consideration of GDEs in setting sustainability goals, measurable objectives and minimum thresholds. Comments included recommendations that environmental uses and users of groundwater, including GDEs, should receive additional attention in the GSP and that environmental priorities and benefits should be a consideration in selecting and describing projects and management actions. Several comments identified perceived deficiencies in the data used to map shallow groundwater levels, the use of a depth to water (DTW) criterion to screen potential GDEs, and the assumptions regarding surface water – groundwater interactions in the San Joaquin River and several other rivers and sloughs in the subbasin. Comments regarding surface water – groundwater interactions are addressed in Section 2.3 below. One comment expressed appreciation for the comprehensive evaluation of GDEs in the subbasin and acknowledged the appropriate use of tools and guidance recommended by The Nature Conservancy.

2.2.2 Response

Methods used to identify and screen potential GDEs for further analysis included analyzing shallow groundwater depth beneath areas mapped as potential GDEs. A DTW of 30 feet was used as one of the primary criteria in the initial screening of potential GDEs. Potential GDEs were retained for further analysis if the underlying DTW in either winter/spring 2014 or winter/spring 2016 was equal to or shallower than 30 feet. The 2014 and 2016 DTW data were the most accurate and recent DTW data available for the Chowchilla Subbasin. While the 2016 data represent conditions after the 2015 SGMA baseline, the use of shallow groundwater data from both years was deemed appropriate because it provided a more conservative (i.e., more inclusive) indicator of potential GDEs than the use of a data from a single year.

Where DTW was greater than 30 feet, other criteria including surface flow characteristics of waterbodies were used to determine whether potential GDEs should be subject to further analysis. The GSP has been revised to clarify the data and approach used for identification and screening of GDEs and to provide additional description of environmental uses and users of groundwater, including GDEs. The GDE Appendix (Appendix 2.B) has also been revised to include these clarifications.

Identification of final GDEs and analysis of potential impacts related to groundwater use was based on multiple sources of information to identify historical and current ecological conditions and trends, ecological value, and vulnerability to future changes in groundwater and interconnected surface water (if any). Information sources included multiple vegetation mapping datasets; field evaluation of potential GDEs; climate and surface hydrology data; satellite-derived vegetation data; hydrogeology data; lists and spatial data for potentially-occurring special-status and groundwater-dependent species and natural communities provided by the California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Pacific Fishery Management Council, and The Nature Conservancy; and beneficial uses of water from the Basin Plan. Appendix 2.B describes the sources of data used for the GDE analysis and how protected species and habitats were considered in the analysis of potential impacts to GDEs. It also describes gaps in the shallow groundwater data for some of the GDE units and recommended methods for collecting data to fill these gaps and periodically re-evaluate GDE conditions using an adaptive management approach

The GDE analysis determined there were no undesirable results related to GDEs. Groundwater in the San Joaquin River Riparian GDE Unit is tightly coupled with surface flow and runoff, with surface flow likely contributing directly to the shallow groundwater system that supports the vegetation in the unit. Based on current evidence and recent historical response patterns, the dominant native vegetation composing the San Joaquin River Riparian GDE Unit appears sufficiently resilient to maintain ecosystem integrity and function in the face of predicted fluctuations in groundwater conditions around the recent historical baseline level. Evidence also suggests that groundwater quality is not limiting ecosystem functions essential for the survival and reproduction of riparian plant species in the GDE unit.

The sustainability goal developed for the Chowchilla GSP is expected to maintain the ecological integrity and function of the San Joaquin River Riparian GDE Unit. This includes maintenance of riparian habitat conditions for special-status species and other native species in the unit or those likely to occur, and provision of important ecosystem support functions for Central Valley spring-run Chinook salmon, Central Valley steelhead, and other special-status species and native aquatic species in the adjacent San Joaquin River. The native vegetation communities composing the San Joaquin River Riparian GDE are expected to be maintained in good health by sustainable groundwater management in the Chowchilla Subbasin and are therefore resilient to short-term adverse impacts, thus the minimum thresholds are not expected to cause substantial adverse impacts to GDEs. Measurable objectives and interim milestones for groundwater levels, the sustainability indicator most likely to affect GDEs in the subbasin, are well within the range of maximum vegetation rooting depth and are expected to maintain or increase the spatial extent of the GDE unit, with no net loss of native plant species dominance. These objectives and milestones are measured at multiple wells in close proximity to and thus representative of the GDE unit in the subbasin.

2.3 Surface Water Groundwater Interactions

2.3.1 Comment Summary

The comments received regarding surface water – groundwater interaction center around there being insufficient characterization of surface water – groundwater interactions, insufficient description of data gaps and how they will be filled, that the GSP states a surface water – groundwater connection did exist for the San Joaquin River prior to 2008, and disagreement with the conclusion that surface water and groundwater are disconnected in the subbasin. One comment also notes that the adjacent Delta-Mendota Subbasin GSP analyses determined that a surface water – groundwater connection does exist along a portion of the San Joaquin River along the Chowchilla/Delta-Mendota Subbasin boundary.

2.3.2 Response

The evaluation of surface water – groundwater interaction included: evaluation of DWR unconfined groundwater elevation contour maps and data from the late 1950's through 2016; compilation and contouring of shallow groundwater level data representative of SGMA baseline conditions for winter/spring 2014 and winter/spring 2016 time periods (to bracket January 2015 conditions for which very limited data are available); evaluation of the presence of shallow clay layers – particularly the "A" and "C" Clays of the Tulare Formation (and other shallow clay layers at equivalent depths or shallower) and "C" Clay that are above the Corcoran Clay; evaluation of perched groundwater conditions relative to conditions in the regional unconfined groundwater system; review of existing studies on stream infiltration; stream gaging data; and discussion with local GSA representatives regarding seepage of irrigation water conveyed through natural waterways during the irrigation season.

As described in various sections of the GSP, these data consistently demonstrate a lack of groundwater – surface water interaction throughout the vast majority of the subbasin because of the great depths to the regional groundwater system. As noted previously, based on groundwater levels alone, only the San Joaquin River has a potential for a surface water – groundwater connection, although hydrogeologic conditions along the San Joaquin River are considerably more complicated than for other rivers/streams. This is due to the presence of shallow clay layers along the San Joaquin River combined with stream infiltration leading to unusually shallow groundwater levels in some reaches – particularly west of the river in Delta-Mendota Subbasin. These shallow clay layers extend a short distance into the Chowchilla Subbasin in some areas, causing a relatively narrow strip along the San Joaquin River with shallow groundwater levels within Chowchilla Subbasin (essentially, the area where the GDE unit is delineated in the subbasin).

The depths to shallow groundwater increase rapidly where the shallow clay layers pinch out within Chowchilla Subbasin (see Figures 2-70 and 2-71), which demonstrates the important role that shallow clay layers play in maintaining shallow groundwater levels and impeding vertical water movement within Delta-Mendota Subbasin and a narrow strip along the San Joaquin River within Chowchilla Subbasin. Were it not for the shallow clay layers, shallow groundwater levels in Delta-Mendota Subbasin and the narrow strip along the western end of Chowchilla Subbasin would be considerably deeper. The connection between regional groundwater pumping at greater depths within the Upper Aquifer and shallow groundwater levels that are essentially perched/mounded on shallow clay layers is not well defined.

As described in the GSP, even when considering the very shallowest wells screened above the shallow clay layers, shallow groundwater levels for winter/spring of 2014 and 2016 appear to be below the San Joaquin River thalweg. While shallow groundwater levels rise and fall from wet to dry season and wet year to dry year and may become connected to surface water for shorter durations, defining an interconnected surface water – groundwater system should require that such a connection exists under a broader range of seasonal and climatic year conditions. It is important to note that regional groundwater pumping is most substantial during dry seasons and dry years, when the connection between groundwater and surface water is least likely to exist.

While it appears that a surface water – groundwater connection to the San Joaquin River did exist historically (prior to 2008), SGMA does not require restoration of basin groundwater conditions prior to January 2015. However, there remains a possibility that projects/management actions implemented to reach sustainability may ultimately restore the surface water – groundwater connection for the San Joaquin River.

Although one comment refers to an adjacent subbasin finding that a portion of the San Joaquin River displays a connection between surface water and groundwater, the analyses supporting this assertion are not yet available for public review. Without the supporting analyses, this comment cannot be addressed.

As described above, a detailed analysis of surface water – groundwater connection has been conducted for the GSP based on available data. In addition, seven new monitoring locations are currently under construction for nested monitoring wells screened at three different depths, including a shallow well to represent the unconfined aquifer water table at each location. These new nested monitoring well data, collection of under the GSP monitoring program, and other ongoing data collection efforts (e.g., SJRRP, ILRP) will be evaluated in terms of surface water – groundwater connections as part each the five-year progress evaluation report.

2.4 Outreach (including DACs/SDACs)

2.4.1 Comment Summary

The comments received regarding outreach and disadvantaged/severely disadvantaged communities (DACs/SDACs) relate to providing further information about sensitive beneficial users and how they were engaged. Comments requested details about the DACs, Tribes, and small community water systems in the subbasin, including their size, locations, how they use groundwater, and how the locations of these users were or were not considered in defining management areas. Information was requested about impacts, to DACs and other sensitive users specifically, of the projects and management actions. Comments also requested that the plan explicitly note which engagement efforts targeted DAC beneficial users, the level of participation achieved, which input came from DACs, and how that input was incorporated into the development of the undesirable results, measurable objectives, and minimum thresholds. One comment requested that the GSP include specific environmental groups in the stakeholder list.

2.4.2 Response

Further detail was added to section 2.1.5.3 about how engagement efforts encouraged the active involvement of DACs. Madera County worked with Self-Help Enterprises and the Leadership Counsel for Justice and Accountability, organizations that represent DAC communities, to inform DAC members about the plan and encourage their involvement. Engagement matrices in Appendix 2.c.c list the numerous opportunities for engagement and the participation in the meetings held. Participants in engagement efforts, such as attendees of public meetings, were not asked to identify themselves by beneficial user category.

The Environmental and Ecosystem category of interest in Table 2-4 has been expanded with the names of specific groups. Throughout GSP development and beyond, any interested person or organization could be added to the Interested Parties list by submitting a request at https://www.maderacountywater.com/join-list/.

2.5 Subsurface Inflows

2.5.1 Comment Summary

The comments received on subsurface inflows relate to the need to calculate subsurface inflows/outflows separately for the Upper Aquifer and Lower Aquifer, that subsurface inflows/outflows were calculated using an uncalibrated numerical model, that there have historically and consistently been subsurface inflow to Chowchilla Subbasin from Delta Mendota Subbasin, and that net subsurface inflows to Chowchilla Subbasin from the Delta Mendota Subbasin have caused migration of high TDS groundwater into Delta Mendota Subbasin.

2.5.2 Response

In the Chowchilla Subbasin area, subsurface groundwater flows between subbasins likely occurred naturally under historical and pre-development conditions. More recently, groundwater development in and around the Chowchilla Subbasin has likely resulted in alterations of groundwater flows between subbasins; however, SGMA does not require correction of conditions that existed prior to 2015. Calibration of the Chowchilla Subbasin GSP groundwater model is described in detail in Appendix 6D. Estimates of projected future conditions based on the best available data and scientific methods show subsurface lateral inflow decreasing over the 2020 to 2040 implementation period and the 2040 through 2090 sustainability period, such that the lateral inflows from the Delta-Mendota subbasin will be significantly reduced during the sustainability period. Calibrated model estimates indicate that due to projects and management actions implemented in the Chowchilla Subbasin, the cumulative lateral inflows from the Delta-Mendota subbasin to the Chowchilla Subbasin will be significantly less than they would be without SGMA

The numerical groundwater model estimates of net subsurface inflow/outflow are highly dependent on available groundwater level data for the Upper and Lower Aquifers in adjacent subbasins, which provide important boundary conditions for the model. There is a particular lack of data for the Lower Aquifer in the Delta-Mendota Subbasin, which impacts reliability of absolute estimates of groundwater inflow/outflow regardless of whether a numerical groundwater model (computer model) or analytical approach (e.g., Darcy's Law calculation) is being used. Numerical and analytical modeling techniques rely on many of the same assumptions and both rely heavily on observed data for calibrating a numerical model or for input in analytical methods. A numerical modeling approach provides the additional ability to evaluate conditions at a higher temporal resolution than is typically possible with analytical techniques and also enables the ability to simulate outcomes under future scenarios of conditions/activities. It is more important to evaluate how historical/current groundwater inflows/outflows are anticipated to change as the Chowchilla Subbasin and surrounding subbasins evolve towards sustainability in 2040 and beyond, and a calibrated numerical groundwater model is a commonly used and widely accepted tool that can be used to evaluate the relative change in groundwater levels and subsurface inflow/outflows. The numerical groundwater model developed and utilized in the Chowchilla Subbasin GSP analyses was refined from DWR's C2VSim regional model and recalibrated to local conditions. Still, there is need for additional review and analysis of hydrogeologic conditions within and around Chowchilla Subbasin, and it is anticipated that revisions to the model will be conducted as part of the model update to be completed in conjunction with five-year reporting in 2025.

Regardless of how subsurface inflow/outflow is quantified and what the estimated values are historically, currently, and in the future; the most important point to recognize related to the Chowchilla Subbasin GSP is that net subsurface inflow does not factor into the water balance shortage (also described as net recharge in the GSP) that forms the basis for required projects and management actions to reach sustainability. Thus, relative to sustainability as defined in the GSP, subsurface inflows do not contribute to meeting the sustainability goals.

The comment regarding migration of high TDS groundwater related to subsurface flow between subbasins appears to be based on analyses conducted for the Delta Mendota Subbasin GSP (for SJREC Plan Area) that are not yet available for public review and comment. Thus, it is not possible to evaluate this comment. However, it is notable that groundwater occurring on the west side of the San Joaquin Valley associated with Coast Range-sourced sediments from the west, including throughout much of the Delta-Mendota Subbasin, has naturally high salinity, at levels considerably higher than in most of the Chowchilla Subbasin. The mechanism and/or conditions that would cause or exacerbate migration of high TDS groundwater into the Delta-Mendota Subbasin is not described in the comment.

The Chowchilla subbasin anticipates updating the calibrated numerical groundwater model with new information collected between now and the five-year update in 2025. Subsurface inflows and outflows from the updated model will be re-evaluated during preparation of the five-year update report in 2025. These updates will include a review of a refined calibrated regional model (Central Valley IWFM) that DWR is continuing to work on in 2019, additional water level data from existing and new monitoring wells being installed in Chowchilla Subbasin, and possibly additional water level data in adjacent subbasins that are lacking key data as of 2019 (e.g., Lower Aquifer in Delta-Mendota Subbasin).

3 ALL COMMENTS AND RESPONSES

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
Climate change assumptions	not noted	[The GSP does not use "other" as the basis for climate change assumptions (other than DWR-provided climate change data and guidance)]	Comment unclear.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Climate change assumptions	not noted	The draft GSP does not consider different climate scenarios, except that "Two primary projected water budget scenarios were considered: a projected without projects (no action) scenario, and a projected with projects scenario."	The GSP considers climate change as a sensitivity model run and analysis, and uses a specific set of climate change parameters specified by DWR. The intent is to show the magnitude of effects on groundwater due to a given reasonably foreseeable scenario of potential climate change impacts on precipitation, evapotranspiration, and surface water supply. The GSP does not evaluate multiple potential climate change scenarios because there are an endless number of possibilities for future climate change. Ultimately, the GSAs will have to do adaptive management and likely adjust the amount of demand management to address the climate change scenario that actually occurs. This is now reinforced in the Executive Summary (ES-2, Water Budget section).	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Climate change assumptions	Table 2-23 and 2-24, page 142-144	[The GSP does not explicitly account for climate change in the subsurface inflow, surface water outflows (incl. exports), and groundwater outflows (incl. exports) elements of the future/projected water budget.] The tables include projected climate change adjustments for precipitation, evaporation, surface water inflow, diversions from Madera Canal, and other diversions/bypasses.	Tables 2-23 and 2-24 only describe the changes in climate change model parameter inputs. The comment's noted missing parameters are model outputs; therefore, they weren't intended to be included in these tables. The climate change model outputs are described in Appendix 6e (need to check if info extracted from model and stated in Appendix 6e).	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
DACs	not noted	[The SGMA monitoring network map does not include identified DACs]	Added map of SDAC, DAC and EDA areas and added these areas to monitoring network map.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
DACs	182, 188-189,	The draft GSP does not explicitly describe impacts to DACs, although impacts to drinking water users and domestic well users are discussed.	Consider adding something similar to the explanation of impacts to drinking water and domestic well users, but focused on DACs in particular.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
	195, 197			California, American Rivers, The Nature Conservancy
Data Management System	4-27	HFS encourages the development of a coordinated basin-wide data management system (DMS) that is capable of tracking groundwater and surface water use at the landowner, field, or parcel level, and a coordinated methodology for measuring landowner-level use of groundwater. The DMS should also include, or be capable of interfacing with, a groundwater market platform that allows for individual users to conduct transactions. Markets are essential in facilitating the highest and best use of a limited resource and will be most effective if there is trust in the accuracy of measurements and consistency in data sources, and flexibility available to allow for transactions across the basin.	Consider adding interfacing mechanism between the DMS and a groundwater market platform	Hancock Farmland Management Services
Demand management	4-27	The description of Demand Management in Section 4.2.3 (Page 4-27) is confusing and unclear. Section 4.2.3.1 (Page 4-28) Project Overview lists a number of demand management actions as options (emphasis added) to be implemented by growers, but goes on to list additional methods (allocation, markets, fees and fallowing) that lack any detail as to how they would be implemented as alternatives. The discussion then shifts to enforcement of pumping to ensure compliance with demand reduction targets. Further clarification of how these elements will be developed and implemented is necessary. The GSP lacks sufficient detail in defining how these reductions will be applied, measured, enforced and responded to if not met. These are critical details that must be addressed. For example, the baseline pumping period that the reductions will be applied to must be, at a minimum, a period of multiple years to avoid unnecessary and perhaps unintended penalization of lands in redevelopment or not yet in full demand due to planting schedules. Additionally, there is no significant discussion of how use will be measured and calculated, or of the costs to perform these activities.	See Multiple Comment Subject Area Response.	AgIS Property Management
Demand management	4-28	Section 4.2.3.2 (Page 4/28) Implementation includes a discussion of Allocations that may be implemented as a demand management component. The discussion identifies various approaches to allocation. The GSAs in the Basin should initiate a stakeholder-driven process to develop a methodology for establishing landowner-level allocations of native yield that are coordinated across the basin. The allocation methodology should be consistent with various legal considerations drawn from applicable case law and attempt to be consistent with groundwater rights, recognizing that GSAs do not have statutory authority to make a final determination of water rights. An equal-per-gross acre approach to allocations is not likely to be consistent with established water rights doctrine, which must take into account many equitable considerations, in addition to acreage owned, to determine a legally defensible allocation.	See Multiple Comment Subject Area Response.	AgIS Property Management

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
Demand Management		The plan talks about land retirement and specifically purchasing current farm ground in the Madera West Management Area for recharge purposes. From whom? And where? This may be an unnecessary step given the crops being grown in this area (winter forage, alfalfa and grapes) can use the recharge water for irrigation purposes and/or can be flooded during dormancy Flood MAR projects. Win-Win for the farmer and the county with respect to recharge and taxes. a. If we still need to reduce water in Madera West Management Area, perhaps explore the idea of limiting land to a single irrigated crop per year (minus the ground directly linked to dairy lagoon water). This would give still give the farmers the ability to dry land farm winter crops and conserve a large amount of water without explicitly fallowing ground.	See Multiple Comment Subject Area Response.	Clayton Water District
Demand Management		If much of CLWD is sustainable on shallow aquifers (given relatively constant groundwater levels for the last 25+ years documented by the Bureau), why would land fallowing be appropriate for this area, opposed to land locked areas in the county that are not easily recharged to our East?	See Multiple Comment Subject Area Response.	Clayton Water District
Demand Management		Evapotranspiration: question of quantification vs. meters: how will actual water use be verified?	See Multiple Comment Subject Area Response.	Clayton Water District
Demand Management	4-27	HFS applauds Madera County's efforts to work with stakeholders in developing specific details of a demand management policy. We encourage the GSAs in the basin to initiate a stakeholder-driven process to develop a methodology for establishing landowner-level allocations of native yield that are coordinated across the basin. The allocation methodology should be consistent with various legal considerations drawn from applicable case law and attempt to be consistent with groundwater rights, recognizing that GSAs do not have statutory authority to make a final determination of water rights. An equal-per-gross acre approach to allocations is not likely to be consistent with established water rights doctrine, which must recognize many equitable considerations, in addition to acreage owned, to determine a legally defensible allocation. Further information regarding allocation methodology can be found in Groundwater Pumping Allocations Under California's Sustainable Groundwater Management Act – EDF and NCWL, dated July, 2018.	See Multiple Comment Subject Area Response.	Hancock Farmland Management Services

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
Demand Management	4-28	While HFS encourages the use of remote sensing to calculate crop evapotranspiration (ET) as a measurement of consumptive use, we also request the development of methodologies and quality assurance elements to allow for grower provided information to be included into the ET calculation and calibration. These methodologies should be developed in consultation with the vendor providing ET data to ensure it is applicable and useful in creating the best available data set. Additionally, GSAs should establish criteria and procedures to address apparent inaccuracies in the ET calculations. An obvious use of the procedure would be in instances where the grower can demonstrate that applied water, plus precipitation, is less than the calculated ET. In these instances, and subject to any requirements established by the GSA, the grower's use of groundwater should be reduced to the applied water total as the ET calculation should not be greater than applied water.	See Multiple Comment Subject Area Response.	Hancock Farmland Management Services
Demand Management	4-28	Section 4.2.3.2 also describes groundwater pumping limits, beginning in 2020, to be imposed by Madera County. Starting in 2020 and continuing through 2025, average annual groundwater pumping is reduced by 2% (of the total demand reduction amount) per year, for a total cumulative reduction of 10% by 2025. Groundwater pumping is reduced by 6% per year starting in 2026 and continuing through 2040 to achieve an estimated reduction in groundwater pumping of 27,550 acre feet per year by 2040. The GSA should implement pumping restrictions, only if necessary to achieve sustainability, when supported by the best available data and appropriate analytical tools and implement such reductions by gradually ramping down pumping over the implementation period to avoid a sudden disruption in economic activity. The ramp down schedule should include an initial period where current levels of pumping can continue as data is gathered and potential water supply projects are pursued. As with native yield allocations, ramp down schedules should be developed in a coordinated manner across the basin. Any imposed pumping restrictions should be "eased" or "flexed" during drought periods provided that overdraft during those periods can be replenished.	See Multiple Comment Subject Area Response.	Hancock Farmland Management Services
Demand Management	244	[GSP demand management measures do not include prohibition on new well construction, limits on municipal pumping, limits on domestic well pumping, or 'other.']	See Multiple Comment Subject Area Response.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
Projects and Management Actions to Achieve Sustainability Goal (23 CCR §354.44)	4	[GSP water supply augmentation projects do not include on-farm recharge, conjunctive use of surface water, developing/utilizing recycled water, or 'other.']	See Multiple Comment Subject Area Response.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Demand Management	274	[Proposed management actions do not include changes to local ordinances or land use planning] Potential new regulations or ordinances are still under development by the GSAs.	See Multiple Comment Subject Area Response.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Demand Management	not noted	[the GSP does not identify additional/contingent actions and funding mechanisms in the event that MOs are not met by the identified actions.]	See Multiple Comment Subject Area Response.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Demand Management	not noted	Measurement – Section 4.4.4.3/4.2.3.3: The Draft GSPs identify several methods for measuring groundwater use that may be used in the basins. While simply identifying these tools is appropriate for the GSP, it will be useful to for tools like remote-sensing measurement and analysis of ETAW to be implemented quickly so that bugs can be worked out and groundwater users can gain confidence in these systems as soon as possible.	See Multiple Comment Subject Area Response.	Madera Ag Water Association
Demand Management	not noted	Rampdown – Section 4.4.4.2/4.2.3.2: The Draft GSPs identify a target for ramping down groundwater use of 2% per year for the first five years and 6% per year thereafter. While this is an appropriate goal, there are two clarifications that would be useful to include. First, it would be helpful to further explain that the annual rampdown targets apply to the Madera County GSA area as a whole and not to individual parcels or ownerships. Although the Draft GSP already indicates this is the case, highlighting this fact in the Executive Summary and in the relevant sections may help alleviate some confusion. Second, during the first few years of implementation, information and tools may not be available to provide specificity about whether these targets are being met. This is an expected challenge as not all the information needed to demonstrate these conditions is available. However, it may be useful to indicate this fact so that an inability to conclusively demonstrate planned reductions in the first year of implementation does	See Multiple Comment Subject Area Response.	Madera Ag Water Association

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
		not suggest the plan is inadequate. While actions will be taken to reduce demand immediately upon implementation of the GSPs, whether certain targets are hit may not be demonstrable for some time.		
Demand Management	not noted	Allocations – Section 4.4.4.2/4.2.3.2: Implementing a groundwater allocation program may not be the only way to achieve the required demand reduction goals. Another option may be carefully managing access, consistent with property rights, and limiting the total available water without individual user allocations. Amending the Draft GSP to refer to “Allocation/Access” may clarify that approaches other than allocation may also be used to meet demand reduction goals.	See Multiple Comment Subject Area Response.	Madera Ag Water Association
Demand Management	not noted	Trading – Section 4.4.4.2/4.2.3.2: The Draft GSPs refer to a “water trading program” as a means of trading water credits. While market systems can add important flexibility to a system where available supply is limited, the details of the market system may end up being something other than a water trading program. Consider describing a “market system” generally to ensure that other types of market systems are also anticipated in the GSP.	See Multiple Comment Subject Area Response.	Madera Ag Water Association
Demand Management	not noted	Easements – Section 4.4.4.2/4.2.3.2: Because the term “easements” can be understood in different ways, it would be helpful to use a more descriptive term to refer to voluntary programs to cease irrigating lands. Whether through easements or leases, irrigation abeyance agreements are a useful tool and should remain in the GSP. Find a good term to describe the range of such alternatives will help reduce confusion.	See Multiple Comment Subject Area Response.	Madera Ag Water Association
Demand Management	not noted	Fallowing – Section 4.4.4.2/4.2.3.2: The Draft GSPs appear to use the term fallowing to refer to ceasing to irrigate land that is currently irrigated. To the extent this term is used in the typical agronomic context, namely referring to land that has been plowed and left unseeded or is otherwise not in use, it is unnecessarily restrictive. As the GSP is implemented and land come out of irrigated agricultural production, much of that land may find other uses that do not require irrigation. Such land, for example, may be dryland farmed, transitioned to rangeland, converted to habitat, or be used for a solar array. Each of these new uses would cease irrigation, but would not technically be fallowing. Consider amending the Draft GSPs to refer to “land transition” or a similar term that indicates cessation of irrigation but anticipates a future economic use.	See Multiple Comment Subject Area Response.	Madera Ag Water Association
Description of general plans and other land use plans relevant to GDEs and their relationship to the GSP (23 CCR §354.8	2-8 to 2-10	This section describes the types of monitoring performed by federal, state and local agencies of surface water inflows, outflows, and irrigation releases. The monitoring stations for flows and water deliveries are listed in Table 2-3. Local stations for flow or irrigation releases are listed in the text (p. 2-8 to 2-9). Please explain the relationship of existing stream flow monitoring to the protection of ISWs and GDEs.	Added explanation to Section 2.1.2.2: "These monitoring stations are important for monitoring surface water available to interconnected surface water (ISW) habitats and groundwater dependent ecosystems (GDEs)."	The Nature Conservancy

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
Description of general plans and other land use plans relevant to GDEs and their relationship to the GSP (23 CCR §354.8	2-8 to 2-10	There is no discussion of the in-stream flow requirements for the San Joaquin River or any other surface water. The San Joaquin River Restoration Program (SJRRP) requires the release of flows from Friant Dam to the confluence with the Merced River to support the life-stages of salmon and other fish species. This section should discuss or reference any instream flow requirements, especially flow needs for critical species, including the amount, time of year when the flow minimum is specified, the duration, the species for which it applies, associated permits that set forth the requirements, and the regulating agency setting forth the compliance requirements. Please discuss the future impact of the SJRRP on the riparian areas and potential GDEs present along or adjacent to the river.	In Section 2.1.2.2: A footnote is added to sentences referencing the SJRRP program that described this purpose and the annual calculation of instream flow requirements. (p. 2-8, 2-19)	The Nature Conservancy
Description of general plans and other land use plans relevant to GDEs and their relationship to the GSP (23 CCR §354.8	2-12 to 2-14	The Madera County General Plan from 1995 (with updates from 2015) includes restrictions on development in “areas with sensitive environmental resources” (Policy 1.A.5) and provides ”the preservation of natural vegetation, land forms, and resources as open space, with permanent protection where feasible” (Policy 5.H.1) (p. 2-12). This section should include a discussion of General Plan goals and policies related to the protection and management of GDEs and aquatic resources that could be affected by groundwater withdrawals. Please include a discussion of how implementation of the GSP may affect and be coordinated with General Plan policies and procedures regarding the protection of wetlands, aquatic resources and other GDEs and ISWs.	Added description to Section 2.1.3.1	The Nature Conservancy
Description of general plans and other land use plans relevant to GDEs and their relationship to the GSP (23 CCR §354.8	2-12 to 2-14	The Merced County General Plan adopted in December 2013 and amended in 2016 “has established policies to promote compact development of existing or well-planned new urban communities established apart from productive agricultural land, to limit growth in rural centers, and to forbid development adjacent to wetland habitat (Policies LU-1.1-5, 7, 9-10, 13)” (p. 2-13). Agricultural land uses “shall not have a detrimental effect on surface water or groundwater resources.” Please include a discussion of how implementation of the GSP may affect and be coordinated with General Plan policies and procedures regarding the protection of wetlands, aquatic resources and other GDEs and ISWs.	Added description to Section 2.1.3.1	The Nature Conservancy
Description of general plans and other land use plans relevant to GDEs and their relationship to the GSP (23 CCR §354.8	2-12 to 2-14	These sections should identify Habitat Conservation Plans (HCPs) or Natural Community Conservation Plans (NCCPs) within the Subbasin and if they are associated with critical, GDE or ISW habitats. Please identify all relevant HCPs and NCCPs within the Subbasin and address how GSP implementation will coordinate with the goals of these HCPs or NCCPs.	Added description to Section 2.1.2.1. The PG&E San Joaquin Valley Operations & Maintenance Habitat Conservation Plan overlaps with Chowchilla Subbasin. No NCCPs overlap with the Chowchilla Subbasin (https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=68626&inline).	The Nature Conservancy

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
Description of general plans and other land use plans relevant to GDEs and their relationship to the GSP (23 CCR §354.8	2-12 to 2-14	Please refer to the Critical Species Lookbook4 to review and discuss the potential groundwater reliance of critical species in the basin. Please include a discussion regarding the management of critical habitat for these aquatic species and its relationship to the GSP.	See the discussion of the San Joaquin River GDE Unit in section 2.2.2.6 for information on special status species. Also see the discussion of the GDE Monitoring Program in section 3.5.2.5 and the GDE Appendix 2.B for more information on special species and management of critical habitat.	The Nature Conservancy
Description of general plans and other land use plans relevant to GDEs and their relationship to the GSP (23 CCR §354.8	2-15 to 2-16	Madera County Environmental Health Division has an online well permitting system that includes agricultural wells, observation/monitoring wells, community water supply wells, and individual domestic water supply wells. There is a requirement for new wells to “include a flow measurement device on new wells and the resulting groundwater pumping records” (p. 2-9). Other requirements follow the State standards (DWR, 1981). Please include a discussion of how future well permitting will be coordinated with the GSP to assure achievement of the Plan’s sustainability goals.	Added description to Section 2.1.3.4	The Nature Conservancy
Description of general plans and other land use plans relevant to GDEs and their relationship to the GSP (23 CCR §354.8	2-15 to 2-16	The State Third Appellate District recently found that Counties have a responsibility to consider the potential impacts of groundwater withdrawals on public trust resources when permitting new wells near streams with public trust uses (ELF vs. SWRCB and Siskiyou County, No. C083239). Compliance of well permitting programs with this requirement should be stated in the GSP.	Added description to Section 2.1.3.4	The Nature Conservancy
Description of general plans and other land use plans relevant to GDEs and their relationship to the GSP (23 CCR §354.8	2-15 to 2-16	Madera County allows wells designated for abandonment to be converted into a monitoring well. Please clarify in the text that only wells screened in one aquifer and appropriate for monitoring will be include in the monitoring program.	The potential conversion of a well designated for abandonment as a monitoring well should be handled on a case by case basis. The clear definition of Upper and Lower Aquifers that exists in the Western Management Area does not necessarily exist in the Eastern Management Area, where the Corcoran Clay becomes shallow and the Upper Aquifer is unsaturated (or only contains a thin perched aquifer) and/or the Corcoran Clay pinches out. In addition, the history of water level data at the well should also be considered.	The Nature Conservancy
Domestic Wells	not noted	[The GSP does not include maps related to Drinking Water Users "based on other sources" (other than well density, domestic and public supply well locations and depths, based on DWR Well Completion Report Map Application)]	The maps provided in the GSP showing locations and density of domestic, municipal, and agricultural wells from a DWR well log completion database should provide a relatively accurate and good representation or drinking water and irrigation water users.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
edit suggestions	(graphics)	Eastside Bypass Water Rights Application – There is mention (on executive summary graphics) of the application, but only credits Triangle T Water District (TTWD) with involvement, when in fact Clayton Water District is funding the application and is applying for 2 diversion points in the Madera West Management Area, within the CLWD boundary. Flood MAR and Recharge Basins need to be added to our Madera West Management Area category as well in the graphic.	The graphic has been modified to include mention of Madera County West GSA with respect to the Eastside Bypass Water Rights Application with Clayton Water District mentioned in a footnote.	Clayton Water District
edit suggestions	not noted	There are a couple of deep aquifer typos in our Madera West sections, which should be corrected.	GSP revised accordingly.	Clayton Water District
GDEs	not noted	[The SGMA monitoring network map does not include GDEs]	Added GDEs to monitoring network map.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
GDEs	216	The depth to groundwater contour maps (Figures 2-70 and 2-71) shows large areas of data gaps, given the marked data points on the map where data exists. These maps were used to exclude all GDEs located adjacent to Chowchilla River, Ash Slough, and Berenda Slough (Figure 1 of Appendix 2.B). The GSP should therefore propose additional upper aquifer wells to reconcile this data gap.	See multiple comment subject area response.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
GDEs	not noted	There is a need to evaluate and discuss potential effects on beneficial uses of surface and groundwater. In addition, the applicable state, federal and local standards for the protection of aquatic, riparian and other protected habitats should be discussed. This is necessary, at a minimum, so that the nature of the data gaps can be understood. See https://groundwaterresourcehub.org/sgma-tools/environmental-surface-wate r-beneficiaries/ for a list of freshwater species in Chowchilla Subbasin that may be exist within ISWs. It is recommended that after identifying which freshwater species exist in your basin, especially federal and state listed species, that you contact staff at the Department of Fish and Wildlife (DFW), United States Fish and Wildlife Service (USFWS) and/or National Marine Fisheries Services (NMFS) to obtain their input on the groundwater and surface water needs of the organisms on the freshwater species list. Because effects to plants and animals are difficult and sometimes impossible to reverse, we recommend erring on the side of caution to preserve sufficient groundwater conditions to sustain GDEs and ISWs. Refer to the Critical Species Look book to review and discuss the potential groundwater reliance of critical 14 species in the basin.	Text added on pg. 3-21, referring to Appx. 2.B for more detail. Let's discuss if needed.If regional pumping depletes shallow groundwater, beneficial uses and users of surface water and groundwater could be negatively affected. These include riparian vegetation along the San Joaquin River and the wildlife habitat and ecosystem functions it provides, as well as riverine habitat in the San Joaquin River that supports migration and potentially spawning of special-status fishes including salmon and steelhead. Special-status species and their habitat in the San Joaquin River are included in the analyses of potential effects on the San Joaquin River Riparian GDE Unit presented in Appendix 2.B.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
GDEs	189	This Minimum Threshold does not consider water quality needs of GDEs. "Protection of municipal and domestic beneficial uses is also protective of all other groundwater beneficial uses." The GSP should elaborate on this statement and include a discussion about GDEs and water quality and whether the measurable objectives and interim milestones will help achieve the sustainability goal as it pertains to the environment.	Consider adding one sentence to say that water of sufficient quality for drinking is also of sufficient quality for GDEs.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
GDEs	not noted	The draft GSP only describes undesirable results relating to human beneficial uses of groundwater and neglects environmental beneficial uses that could be adversely affected by chronic groundwater level decline. The GSP should add "potential adverse impacts to GDEs" to the list of potential undesirable results presented in Table 3-8.	GSP was revised with "potential adverse impacts to GDEs" added to Table 3-8.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
GDEs	195	"Using the Fall measurements (assumed to be collected in October), a groundwater elevation undesirable result is defined to occur when greater than 30% of the RMS [representative monitoring sites] each exceed the groundwater level minimum thresholds for the same two consecutive Fall readings. Given a total of 36 RMS sites, a total of 11 or more the RMS would need to exceed MTs as defined above to constitute an undesirable result for chronic lowering of groundwater levels." The use of 30 percent to define an undesirable result does not allow for the occurrence of low water levels in one area, such as near a GDE, to be an Undesirable Result, which may impact environmental beneficial use. There are three RMS near the San Joaquin River Riparian GDE unit, which could be evaluated separately. The GSP should consider the use of a separate management area for the San Joaquin River Riparian GDE unit so that different sustainable management criteria can be established for this GDE unit.	See earlier response.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Groundwater Conditions	94	Figures 2-70 and 2-71 present depth to shallow groundwater for 2014 and 2016. There are large data gaps over the Chowchilla Subbasin, particularly for 2016 (Figure 2-71). The GSP should further describe how these figures were developed, specifically noting the following best practices for developing depth to groundwater contours presented in Attachment D. Specifically, ensure that the first step is contouring groundwater elevations, and the subtracting this layer from land surface elevations from a DEM to estimate depth to groundwater contours across the landscape. This will provide much more accurate contours of depth-to-groundwater along streams and other land surface depressions where GDEs are commonly found. Depth to groundwater contours developed from depth to groundwater measurements at wells assumes that the land surface is constant, which is a poor assumption to make.	GSP revised to describe contouring process. The depth to groundwater contouring presented in the draft GSP was conducted as requested in this comment.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
GW model	not noted	The GSP relies too heavily on a numerical groundwater model that has not been calibrated and therefore does not accurately reflect boundary conditions with the Delta Mendota Subbasin. In addition, the numerical model used has projected water levels to decline significantly in the Delta-Mendota Subbasin by the year 2040. This is contradictory to SJREC GSP which will maintain historic water levels through 2040 in order to maintain sustainability.	The numerical groundwater model was extensively calibrated as described in the groundwater model documentation in Appendix 6E. The model does not indicate significant declines in groundwater levels in the Delta-Mendota Subbasin by the year 2040. We note that this comment makes reference to the SJREC GSP, which has not yet been made available for public review.	San Joaquin River Exchange Contractors GSA
Hydrogeologic Conceptual Model (23 CCR §354.14)	2-26 to 2-27	In the Chowchilla Subbasin, the base of the usable aquifer corresponds with the base of fresh water, generally defined as groundwater with total dissolved solids (TDS) of 1,000 milligrams per liter (mg/l) as modified from Page (1973), except in the eastern part of the basin where the of basement complex is shallower. As noted on page 9 of DWR's Hydrogeologic Conceptual Model BMP (https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_HCM_Final_2016-12-23.pdf) "the definable bottom of the basin should be at least as deep as the deepest groundwater extractions". Thus, groundwater extraction well depth data should also be included in the determination of the basin bottom. Properly defining the bottom of the basin will prevent the possibility of extractors with wells deeper than the basin boundary from claiming exemption from SGMA due to their well residing outside the vertical extent of the basin boundary.	Edits were made to the text to address this comment.	The Nature Conservancy
Hydrogeologic Conceptual Model (23 CCR §354.14)	2-26 to 2-27	The cross sections in Chapter 2 (Figures 2-23 through 2-33) clearly show the base of freshwater and the top of the basement rocks. However, they do not include a graphical representation of the manner in which shallow groundwater may interact with ISWs or GDEs that would allow the reader to understand this topic. Please include an example near-surface cross section that depicts the conceptual understanding of shallow groundwater and river interactions at different locations, as well as potential GDEs and ISWs.	The referenced cross sections do show recent groundwater levels for the Upper Aquifer, which demonstrate a clear lack of surface water - groundwater connection throughout the subbasin. The depth to shallow groundwater, including the perched/mounded shallow groundwater levels along the San Joaquin River, are further illustrated in Figures 2-70 and 2-71. Regional aquifer and perched groundwater levels are discussed in detail in Section 2.2.2.1 on pages 2-31 through 2-35. Surface water - groundwater interaction and GDEs are discussed in Sections 2.2.2.5 and 2.2.2.6 on pages 2-39 through 2-43. Considerable discussion and graphics have been devoted to this topic in the GSP. Potential for interconnection between surface water and groundwater will be further evaluated for the 5-year update report due in 2025 using data collected over the next five years.	The Nature Conservancy

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
Hydrogeologic Conceptual Model (23 CCR §354.14)	2-29	On Page 2-29 the groundwater system conceptualization in the draft plan only analyzes a single homogenous aquifer which renders it untenable for predicting aquifer trends etc. the analysis must recognize actual conditions and include at least two aquifers: a shallow semi or unconfined aquifer and a deeper confined aquifer	It is not correct that the GSP only analyzes a single homogeneous aquifer. The Chowchilla Subbasin describes delineation of the Upper Aquifer and Lower Aquifer throughout the Chapter 2 HCM discussion, in Chapter 3 delineation of SMC, and in the groundwater model documentation (Appendix 6E). The groundwater model and portions of the HCM discussion further incorporate/describe the effects of shallow clay layers within the Upper Aquifer (e.g., A Clay and C Clay). The GSP modeling effort devoted considerable effort to evaluation of DWR well logs and variability in lithology, which resulted in capturing a large degree of the inhomogeneity of the aquifer systems in the analyses conducted for the GSP.	San Joaquin River Exchange Contractors GSA
Identification of Beneficial Users	Table 2-4, p 76	Disadvantaged communities and tribes are included as examples of stakeholder groups in Table 2-4 Stakeholder Engagement Chart for GSP Development. However, the draft GSP does not identify the specific DACs or Tribes in the subbasin and does not include detailed descriptions of these. Table 2-4 also includes small community systems, but the GSP does not clearly define what they are and how are they considered as beneficial users.	Consider if this should be done, or note why not in the comment summary response section.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Identification of Beneficial Users	49	Appendix 2.C "Notice and Communication" of the draft GSP states that "The Chowchilla Subbasin has been identified by the California Department of Water Resources (DWR) as a high-priority and critically-overdrafted subbasin with conditions of historical groundwater level declines, land subsidence, and groundwater quality degradation. The area has a substantial agricultural community heavily reliant on groundwater. Nearly 79 percent of the Subbasin is designated as part of a severely disadvantaged community (SDAC) and approximately 30 percent of the Subbasin (primarily in the northern and southern central parts of the Subbasins and also around the City of Chowchilla) is designated as part of a DAC". However, the GSP still needs to identify DACs in the main GSP and throughout the discussions of the development of sustainable management criteria.	Consider if this should be done, or note why not in the comment summary response section. (i.e., will detail be added throughout the body of the GSP regarding how DAC feedback was considered in development of sustainable management criteria?)	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Identifying and Mapping GDEs (23 CCR §354.16)	2-40 and Appx. 2.B	The text states (p. 2-40): "A DTW cutoff of 30 feet was used in the initial screening of potential GDEs. The use of a 30-foot DTW criterion to identify potential GDEs is based on reported maximum rooting depths of California phreatophytes and is consistent with guidance provided by The Nature Conservancy (Rohde et al. 2018) for identifying potential GDEs." We have the following comments regarding this sentence and on the methodology for identifying GDEs in the Subbasin. [see bulleted list in next 5 entries for details]	See Multiple Comment Subject Area Response. A DTW cutoff of 30 feet was used as one of the primary criteria in the initial screening of potential GDEs. It was not used as a stand-alone criterion for exclusion of potential GDEs. Edits made in Section 2.2.2.6 (pg. 2-40) to further explain and clarify.	The Nature Conservancy

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
Identifying and Mapping GDEs (23 CCR §354.16)	2-40 and Appx. 2.B	[Continued from above] o 30-ft criteria from TNC Guidance: In TNC's GDE Guidance, the depth criterion of 30 feet is presented as a criterion for inclusion, not a standalone criterion for exclusion. In other words, if groundwater is within 30 feet of the ground surface, then a GDE can be identified. If it is not, then further analysis must be conducted (see Appendix III of the GDE Guidance, Worksheet 1, for other indicators of GDEs).	See Multiple Comment Subject Area Response. Where DTW was greater than 30 feet, other criteria such as river hydrology (flow permanence and gaining vs. losing reaches) and dominant vegetation were used to determine whether potential GDEs should be considered as final GDEs. Screening of potential GDEs also included field evaluation of potential GDEs where initial uncertainty was high. Edits made in Section 2.2.2.6 (pg. 2-40) to further explain and clarify.	The Nature Conservancy
Identifying and Mapping GDEs (23 CCR §354.16)	2-40 and Appx. 2.B	[Continued from above] o 30-ft as maximum rooting depths of California phreatophytes: Please use care when considering rooting depths of vegetation. While Valley Oak (Quercus lobata) have been observed to have a max rooting depth of ~24 feet (https://groundwaterresourcehub.org/gde-tools/gde-rooting-depths-database-for-gdes/), rooting depths are likely to spatially vary based on the local hydrologic conditions available to the plant. Also, max rooting depths do not take capillary action into consideration, which will vary with soil type and is an important consideration since woody phreatophytes generally do not like to have their roots submerged in groundwater for extended periods of time, and hence can access groundwater at deeper depths. In addition, while it is likely to be true that shallow water availability is necessary to support the recruitment of saplings, hydraulic lift of groundwater to shallow depths has been observed in Quercus spp.	Comment noted. Our analysis considered all available data on vegetation rooting depth and the importance of capillary action, as well as recent published research indicating variability in rooting depth according to local topography and groundwater conditions.	The Nature Conservancy

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
Identifying and Mapping GDEs (23 CCR §354.16)	2-40 and Appx. 2.B	[Continued from above] o Use of depth to water maps from 2014 and 2016: ▪ 2016 is after the SGMA benchmark date of January 1, 2015. Please rely on groundwater condition data prior to the SGMA benchmark date. ▪ We highly recommend using depth to groundwater data from multiple seasons and water year types (e.g., wet, dry, average, drought) to determine the range of depth to groundwater around NC dataset polygons. Please refer to Attachment D of this letter for best practices for using local groundwater data to verify whether polygons in the NC Dataset are supported by groundwater in an aquifer. If insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset, include those polygons in the GSP until data gaps are reconciled in the monitoring network. While depth to groundwater levels within 30 feet are generally accepted as being a proxy for confirming that polygons in the NC dataset are connected to groundwater, it is highly advised that seasonal and interannual groundwater fluctuations in the groundwater regime are taken into consideration. Utilizing groundwater data from one or two points in time can misrepresent groundwater levels required by GDEs, and inadvertently result in adverse impacts to the GDEs. Based on a study we recently submitted to Frontiers in Environmental Science Journal, we've observed riparian forests along the Cosumnes River to experience a range in groundwater levels between 1.5 and 75 feet over seasonal and interannual timescales. Seasonal fluctuations in the regional water table can support perched groundwater near an intermittent river that seasonally runs dry due to large seasonal fluctuations in the regional water table. While perched groundwater itself cannot directly be managed due to its position in the vadose zone, the water table position within the regional aquifer (via pumping rate restrictions, restricted pumping at certain depths, restricted pumping around GDEs, well density rules) and its interactions with surface water (e.g., timing and duration) can be managed to prevent adverse impacts to ecosystems due to changes in groundwater quality and quantity under SGMA.	See Multiple Comment Subject Area Response. The 2014 and 2016 DTW data were the most accurate and recent DTW data available for the Chowchilla Subbasin. While the 2016 data represent conditions after the 2015 SGMA baseline, the use of shallow groundwater data from both years was deemed appropriate because it provided a more conservative (i.e., more inclusive) indicator of potential GDEs than the use of a data from a single year. Omitting 2016 data as suggested by TNC would reduce the number and extent of potential GDEs. Edits made in Section 2.2.2.6 (pg. 2-40) to justify the use of both 2014 and 2016 data.	The Nature Conservancy

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
Identifying and Mapping GDEs (23 CCR §354.16)	2-40 and Appx. 2.B	[Continued from above] Please provide more details on how depth to groundwater contour maps were developed (Figures 2-70 and 2-71): ▪ Are the wells used for interpolating depth to groundwater sufficiently close (<5km) to NC Dataset polygons to reflect local conditions relevant to ecosystems? ▪ Are the wells used for interpolating depth to groundwater screened within the surficial unconfined aquifer and capable of measuring the true water table? ▪ Is depth to groundwater contoured using groundwater elevations at monitoring wells to get groundwater elevation contours across the landscape? This layer can then be subtracted from land surface elevations from a Digital Elevation Model (DEM)5 to estimate depth-to-groundwater contours across the landscape. This will provide much more accurate contours of depth-to-groundwater along streams and other land surface depressions where GDEs are commonly found. Depth to groundwater contours developed from depth to groundwater measurements at wells assumes that the land surface is constant, which is a poor assumption to make. It is better to assume that water surface elevations are constant in between wells, and then calculate depth to groundwater using a DEM of the land surface to contour depth to groundwater.	See Multiple Comment Subject Area Response	The Nature Conservancy
Identifying and Mapping GDEs (23 CCR §354.16)	2-40 and Appx. 2.B	[Continued from above] o The depth to groundwater contour maps (Figures 2-70 and 2-71) show large areas of data gaps, given the marked data points on the map where data exists. These maps were used to exclude all GDEs located adjacent to Chowchilla River, Ash Slough, and Berenda Slough (Figure 1 of Appendix 2.B). As stated above, if insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset, include those polygons in the GSP until data gaps are reconciled in the monitoring network.	See Multiple Comment Subject Area Response	The Nature Conservancy
Identifying and Mapping GDEs (23 CCR §354.16)	Appen dix 2.B	TNC acknowledges and appreciates the comprehensive evaluation of the San Joaquin River Riparian GDE unit following our guidance, including analyzing hydrologic conditions, ecological conditions, providing an inventory of species and ecological value, along with concurrent field studies and reconnaissance. We also appreciate the use of TNC's GDE Pulse to examine NDVI and NDMI trend data for the GDE polygons within the GDE unit.	See Multiple Comment Subject Area Response	The Nature Conservancy

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
Inter connected Surface Waters (ISWs) (23 CCR §354.16)	2-39	The text states (p. 2-39): "A review of historical regional aquifer groundwater levels compared to stream thalweg (deepest portion of stream channel) elevations conducted for this study indicate that surface water – groundwater interactions are not a significant issue (i.e., regional groundwater levels are relatively far below creek thalweg elevations) along Chowchilla River, Ash Slough, and Berenda Slough in Chowchilla Subbasin." ISWs are best estimated by first determining which reaches are completely disconnected from groundwater. This approach would involve comparing groundwater elevations with a land surface Digital Elevation Model that could identify which surface waters have groundwater consistently below surface water features, such that an unsaturated zone would separate surface water from groundwater. Please provide further evidence that that ISWs are not present along Chowchilla River, Ash Slough, and Berenda Slough, such as a cross-section or corresponding hydrographs to show the relationship between the river channel and the depth to groundwater at wells near the rivers.	See Multiple Comment Subject Area Response	The Nature Conservancy
Inter connected Surface Waters (ISWs) (23 CCR §354.16)	2-39	Figures 2-70 and 2-71 present depth to shallow groundwater for 2014 and 2016. There are large data gaps over the Chowchilla Subbasin, particularly for 2016 (Figure 2-71). Please further describe how these figures were developed, specifically noting the following best practices for developing depth to groundwater contours presented in Attachment D. Specifically, ensure that the first step is contouring groundwater elevations, and the subtracting this layer from land surface elevations from a DEM to estimate depth to groundwater contours across the landscape. This will provide much more accurate contours of depth-to-groundwater along streams and other land surface depressions where GDEs are commonly found. Depth to groundwater contours developed from depth to groundwater measurements at wells assumes that the land surface is constant, which is a poor assumption to make.	See Multiple Comment Subject Area Response	The Nature Conservancy
Inter connected Surface Waters (ISWs) (23 CCR §354.16)	2-39	The regulations [23 CCR §351(o)] define interconnected surface waters (ISW) 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". "At any point" has both a spatial and temporal component. Even short durations of interconnections of groundwater and surface water can be crucial for surface water flow and supporting environmental users of groundwater and surface water. The GSP states in several places that the San Joaquin River is losing in the section adjacent to the Subbasin, and uses this as evidence that ISWs do not exist. However, ISWs can be either gaining or losing. The defining feature of disconnected surface waters is that groundwater is consistently below surface water features such that an unsaturated zone always separates surface water from groundwater, not whether the reach is gaining or losing. To improve ISW mapping, please reconcile data gaps	See Multiple Comment Subject Area Response	The Nature Conservancy

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		(shallow monitoring wells, stream gauges, and nested/clustered wells) along surface water features in the Monitoring Network section of the GSP.		
Inter connected Surface Waters (ISWs) (23 CCR §354.16)	2-39	The GSP states (p. 2-40): "It is likely that seepage from the San Joaquin River is the source of water that combined with the presence of shallow clay layers that serves to maintain shallow groundwater levels at these locations." Please provide estimates of current and historical surface water depletions for ISWs quantified and described by reach, season, and water year type.	See Multiple Comment Subject Area Response	The Nature Conservancy
Inter connected Surface Waters (ISWs) (23 CCR §354.16)	216	The draft GSP does not identify monitoring network for DACs.	See Multiple Comment Subject Area Response. SGMA does not require defining management areas to manage DACs. Generally, given the size of these areas compared to the remainder of the subbasin, managing these areas separately from the subbasin would be practically impossible.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Inter connected Surface Waters (ISWs) (23 CCR §354.16)	216	Per the GSP Regulations (23 CCR §354.34 (a) and (b)), monitoring must address trends in groundwater and related surface conditions (emphasis added). Groundwater level monitoring alone may be insufficient to establish a linkage between groundwater extraction and potentially resulting impacts to environmental resources associated with GDEs and ISWs. The cause-effect relationship between groundwater levels and the biological responses that could result in significant and unreasonable impacts to ISWs and GDEs depends on a number of complicated factors, and this relationship is not characterized or discussed. The Monitoring Network section currently does not address future needs for ISW monitoring.	See Multiple Comment Subject Area Response	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Inter connected Surface Waters (ISWs) (23 CCR §354.16)	216	In addition to the need for additional shallow monitoring wells in the upper aquifer to map GDEs, there is also a need to enhancing monitoring of stream flow and vertical groundwater gradients by installing more stream gauges and clustered/nested wells near streams, rivers or wetlands. Ideally, co-locating stream gauges with wells that can monitor groundwater levels in both the upper and lower aquifers would enhance understanding about where ISWs exist in the basin and whether pumping is causing depletions of surface water or impacts on beneficial users of surface water and groundwater. The GSP should provide sufficient detail for the investigation and monitoring program including stream gauges, screened intervals and frequency of monitoring, in order to describe monitoring of both the extent of ISWs and the quantity of surface water depletions from ISWs.	See Multiple Comment Subject Area Response	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy

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Inter connected Surface Waters (ISWs) (23 CCR §354.16)	158	"Groundwater in the GDE unit is tightly coupled with surface flow and runoff and is generally maintained at depths within the maximum rooting depth range of the dominant phreatophytic species present in the unit (see Section 2.2.2). The groundwater that is potentially accessible to the vegetation composing the GDE unit likely occurs as a shallow perched/mounded aquifer fed largely by percolation of surface flow from the San Joaquin River. As described in Section 2.2.5 [should be 2.2.2.5], it has been determined that a connection between regional groundwater and streams does not currently exist in the subbasin." Section 2.2.2.5 does not present evidence that ISWs do not exist in the Subbasin, and states that a historical connection between groundwater and the San Joaquin River did exist through 2008.	See Multiple Comment Subject Area Response	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Inter connected Surface Waters (ISWs) (23 CCR §354.16)	not noted	The GSP fails to establish measurable objectives or minimum thresholds for this sustainability indicator. The existence of riparian GDEs along the streams in the basin has been identified in Appendix 2.B, and their connection to groundwater is assumed. Their occurrence in the riparian zone means that these GDEs should be considered a beneficial user of groundwater that could be affected by chronic groundwater level decline as discussed above, as well as beneficial users of surface water that could be depleted by groundwater extraction. A more robust discussion of the known facts regarding these surface-groundwater interactions in the riparian zone should be provided. In addition, more detailed discussion regarding specific data gaps should be included.	See Multiple Comment Subject Area Response. It is unclear what SMC the commenter means by "this".	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Inter connected Surface Waters (ISWs) (23 CCR §354.16)	not noted	The analysis for ISWs should include all beneficial users of surface water that could be affected by groundwater withdrawals, including environmental. Refer to the San Joaquin River Restoration Program (SJRRP) that identifies instream flow needs for salmon. The GSP should include instream flow requirements in this section and whether the measurable objectives and interim milestones will help achieve the sustainability goal as it pertains to the environment.	See Multiple Comment Subject Area Response	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Inter connected Surface Waters (ISWs) (23 CCR §354.16)	193	"Therefore, the surface water depletion sustainability criteria is not applicable to the subbasin." However, no evidence is provided in the GSP to show that a hydraulic connection between groundwater and surface water does not exist. Following the discussion presented above for, the GSP should include a discussion of Sustainable Management Criteria for ISWs, including Minimum Thresholds, in the GSP. Cite data gaps regarding ISWs and make plans to reconcile them in the Monitoring Section of the GSP.	See Multiple Comment Subject Area Response	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Inter connected Surface Waters (ISWs) (23 CCR §354.16)	not noted	The GSP should include a discussion of Sustainable Management Criteria for ISWs, including Undesirable Results, in the GSP. The GSP should cite data gaps regarding ISWs and make plans to reconcile them in the Monitoring Section of the GSP.	See Multiple Comment Subject Area Response	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
				Rivers, The Nature Conservancy
Interconnected Surface Waters (ISWs) (23 CCR §354.16)	199	[The GSP does not provide a plan to study the interconnectedness of surface water bodies.]	See Multiple Comment Subject Area Response	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Inter connected Surface Waters (ISWs) (23 CCR §354.16)	not noted	Existing shallow monitor wells on both sides of the San Joaquin River should be used to determine if surface water and groundwater are connected. The SJREC GSP has determined that portions of the San Joaquin River are at times connected along the boundary between the Delta-Mendota and Chowchilla Subbasins.	The shallow monitoring wells along both sides of the San Joaquin River were used extensively in evaluation of surface water – groundwater interconnection as displayed on Figures 2-70 and 2-71, and discussed in Sections 2.2.2.5 and 2.2.2.6 on pages 2-39 through 2-41 of the Chowchilla Subbasin GSP. The SJREC GSA has not provided publicly available evidence or analyses of surface water – groundwater interconnection that is applicable to Chowchilla Subbasin. See multiple comment subject area response for more discussion of this comment.	San Joaquin River Exchange Contractors GSA
Inter connected Surface Waters (ISWs) (23 CCR §354.16)	94	"A review of historical regional aquifer groundwater levels compared to stream thalweg (deepest portion of stream channel) elevations conducted for this study indicate that surface water – groundwater interactions are not a significant issue (i.e., regional groundwater levels are relatively far below creek thalweg elevations) along Chowchilla River, Ash Slough, and Berenda Slough in Chowchilla Subbasin." ISWs are best estimated by first determining which reaches are completely disconnected from groundwater. This approach would involve comparing groundwater elevations with a land surface Digital Elevation Model that could identify which surface waters have groundwater consistently below surface water features, such that an unsaturated zone would separate surface water from groundwater. Groundwater elevations that are always deeper than 50 feet below the land surface can be used to identify the above ground reaches as disconnected surface waters. The GSP should provide further evidence that that ISWs are not present along Chowchilla River, Ash Slough, and Berenda Slough, such as a cross-section or corresponding hydrographs to show the relationship between the river channel and the depth to groundwater at wells near the rivers.	See Multiple Comment Subject Area Response	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
Inter connected Surface Waters (ISWs) (23 CCR §354.16)	94	The regulations [23 CCR §351(o)] define interconnected surface waters (ISW) 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". "At any point" has both a spatial and temporal component. Even short durations of interconnections of groundwater and surface water can be crucial for surface water flow and supporting environmental users of groundwater and surface water. The GSP states in several places that the San Joaquin River is losing in the section adjacent to the Subbasin, and uses this as evidence that ISWs do not exist. However, ISWs can be either gaining or losing. To improve ISW mapping, The GSP should reconcile data gaps (shallow monitoring wells, stream gauges, and nested/clustered wells) along surface water features in the Monitoring Network section of the GSP.	See Multiple Comment Subject Area Response	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Inter connected Surface Waters (ISWs) (23 CCR §354.16)	94	"It is likely that seepage from the San Joaquin River is the source of water that combined with the presence of shallow clay layers that serves to maintain shallow groundwater levels at these locations." The GSP should provide estimates of current and historical surface water depletions for ISWs quantified and described by reach, season, and water year type.	See Multiple Comment Subject Area Response	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Language/ copy edit	5.5	I would remove the word "all" in "comply with all of the requirements"	GSP revised accordingly.	Mark Hutson
Language/ copy edit	5.6.2	Implementation of all projects. Remove "all." In short - remove the words all, shall, will, etc. These words are strong assertions and can be left out. This would apply to all chapters.	GSP revised accordingly.	Mark Hutson
Language/ copy edit	4	I believe it is very important to strongly state in this chapter and others, that as knowledge, technology + management practices adapt and change, that the methodology of projects will adapt. This area of operation is so new, what we think is right may be wrong, and vice-versa. Please leave a wide area to maneuver within the GSP as GSAs become more knowledgeable. They need to be nimble and not constrained by a plan that may become obsolete.	Added paragraph on page 4.1 and in Executive Summary on page 18.	Mark Hutson
Management areas	not noted	[Management areas were not defined to specifically manage DACs]	SGMA does not require defining management areas to manage DACs. Generally, given the size of these areas compared to the remainder of the subbasin, managing these areas separately from the subbasin would be practically impossible.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
Management areas	not noted	The GSP does not appear to have more restrictive / aggressive management actions for GDE/DAC management areas.	SGMA does not require defining management areas to manage DACs. Generally, given the size of these areas compared to the remainder of the subbasin, managing these areas separately from the subbasin would be practically impossible.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Management areas	not noted	[The GSP does not include maps or descriptions indicating what DACs are located in each management area.]	SGMA does not require this. However, a map of DAC areas has been added for comparison to the map of management areas.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Management areas	not noted	[The GSP does not include maps or descriptions indicating what GDEs are located in each management area.]	Consider adding GDEs to management area map. This is not required, but is discussed. GDEs occur only in the Western Management Area; thus inclusion of GDE areas on the management area map does not seem necessary. The reader can compare the two maps for GDEs and management areas.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Management Areas and Monitoring Network: Summary/ Comments	not noted	The draft GSP appears to be incomplete, and does not include Section 2.2.4, which is referenced in Table 1-1 and Table 1-5 as containing the description of management areas, maps of the areas, etc. This information must be included in the GSP per 23 CCR § 354.20. For transparency, the GSP should explicitly identify (preferably via maps) the extents of identified DACs and potential GDEs located within each separate Management Area; the GSP should also clearly present the proposed MOs and MTs in the two management areas (e.g., in Tables 3-2, 3-3, 3-4, etc.), and if the MOs and MTs for the GDE management area are more or less restrictive. The GSP should provide sufficient detail for the investigation and monitoring program including stream gauges, screened intervals and frequency of monitoring, in order to describe monitoring of both the extent of ISWs and the quantity of surface water depletions from ISWs. The GSP should propose additional upper aquifer wells to reconcile the data gap shown in Figure 2-70 and Figure 2-71.	Section 2.2.4 describing creation of management areas and a map were added to GSP.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
Maps Related to Key Beneficial Uses: Summary/ Comments	not noted	Providing maps of the monitoring network overlaid with location of DACs, domestic wells, community water systems, GDEs, and any other sensitive beneficial users will allow the reader to evaluate the adequacy of the network to monitor conditions near these beneficial users. The comprehensive evaluation of the San Joaquin River Riparian GDE unit following TNC's guidance, including analyzing hydrologic conditions, ecological conditions, providing an inventory of species and ecological value, along with concurrent field studies and reconnaissance, is appreciated. We also appreciate the use of TNC's GDE Pulse to examine NDVI and NDMI trend data for the GDE polygons within the GDE unit. The GSP should rely on groundwater condition data prior to the SGMA benchmark date. The GSP should provide more details on how depth to groundwater contour maps were developed (Figures 2-70 and 2-71): - Are the wells used for interpolating depth to groundwater sufficiently close (<5km) to NC Dataset polygons to reflect local conditions relevant to ecosystems? - Are the wells used for interpolating depth to groundwater screened within the surficial unconfined aquifer and capable of measuring the true water table? - Is depth to groundwater contoured using groundwater elevations at monitoring wells to get groundwater elevation contours across the landscape? This layer can then be subtracted from land surface elevations from a Digital Elevation Model (DEM) to estimate depth-to-groundwater contours across the landscape. This will provide much more accurate contours of depth-to-groundwater along streams and other land surface depressions where GDEs are commonly found. Depth to groundwater contours developed from depth to groundwater measurements at wells assumes that the land surface is constant, which is a poor assumption to make. It is better to assume that water surface elevations are constant in between wells, and then calculate depth to groundwater using a DEM of the land surface to contour depth to groundwater. If insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset, include those polygons in the GSP until data gaps are reconciled in the monitoring network. The GSP should provide further evidence that that ISWs are not present along Chowchilla River, Ash Slough, and Berenda Slough, such as a cross-section or corresponding hydrographs to show the relationship between the river channel and the depth to groundwater at wells near the rivers. To improve ISW mapping, the GSP should reconcile data gaps (shallow monitoring wells, stream gauges, and nested/clustered wells) along surface water features in the Monitoring Network section of the GSP. The GSP should provide estimates of current and historical surface water depletions for ISWs quantified and described by reach, season, and water year type.	In general, the various maps included in the GSP attempt not to illustrate too many different components on the same map to avoid clutter and making the maps hard to utilize for each maps intended purpose. The reader is able to compare maps illustrating various components since most maps use a similar scale. However, some accommodations for such comment requests were made where it was deemed both useful and feasible. For example, DACs and GDEs were added to Section 3 water level and water quality monitoring network maps.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
Measurable Objectives (23 CCR §354.30)	3-21	The GSP states (p. 3-5): "Groundwater in the GDE unit is tightly coupled with surface flow and runoff and is generally maintained at depths within the maximum rooting depth range of the dominant phreatophytic species present in the unit (see Section 2.2.2). The groundwater that is potentially accessible to the vegetation composing the GDE unit likely occurs as a shallow perched/mounded aquifer fed largely by percolation of surface flow from the San Joaquin River. As described in Section 2.2.5 [should be 2.2.2.5], it has been determined that a connection between regional groundwater and streams does not currently exist in the subbasin." However, Section 2.2.2.5 does not present evidence that ISWs do not exist in the Subbasin, and states that a historical connection between groundwater and the San Joaquin River did exist through 2008.	See Multiple Comment Subject Area response.	The Nature Conservancy
Measurable Objectives (23 CCR §354.30)	3-21	The GSP fails to establish measurable objectives or minimum thresholds for this sustainability indicator. The existence of riparian GDEs along the streams in the basin has been identified in Appendix 2.B, and their connection to groundwater is assumed. Their occurrence in the riparian zone means that these GDEs should be considered a beneficial user of groundwater that could be affected by chronic groundwater level decline as discussed above, as well as beneficial users of surface water that could be depleted by groundwater extraction. A more robust discussion of the known facts regarding these surface-groundwater interactions in the riparian zone should be provided. In addition, more detailed discussion regarding specific data gaps should be included.	See Multiple Comment Subject Area response.	The Nature Conservancy
Measurable Objectives (23 CCR §354.30)	3-21	There is a need to evaluate and discuss potential effects on beneficial uses of surface and groundwater. In addition, the applicable state, federal and local standards for the protection of aquatic, riparian and other protected habitats should be discussed. This is necessary, at a minimum, so that the nature of the data gaps can be understood. Please refer to Attachment C for a list of freshwater species in Chowchilla Subbasin that may be exist within ISWs. We recommend that after identifying which freshwater species exist in your basin, especially federal and state listed species, that you contact staff at the Department of Fish and Wildlife (DFW), United States Fish and Wildlife Service (USFWS) and/or National Marine Fisheries Services (NMFS) to obtain their input on the groundwater and surface water needs of the organisms on the freshwater species list. Because effects to plants and animals are difficult and sometimes impossible to reverse, we recommend erring on the side of caution to preserve sufficient groundwater conditions to sustain GDEs and ISWs. Please refer to the Critical Species Lookbook6 to review and discuss the potential groundwater reliance of critical species in the basin.	Edits made in Section 3.2.5 (pg. 3-21) referring to Appendix 2.B.	The Nature Conservancy

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
Measurable Objectives (23 CCR §354.30)	3-21	The analysis for ISWs should include all beneficial users of surface water that could be affected by groundwater withdrawals, including environmental. Refer to the San Joaquin River Restoration Program (SJRRP) that identifies instream flow needs for salmon. Please include instream flow requirements in this section and whether the measurable objectives and interim milestones will help achieve the sustainability goal as it pertains to the environment.	The GSP has determined that ISWs are not present.	The Nature Conservancy
Minimum Thresholds (23 CCR §354.28)	3-22	Please correct the call-out on p. 3-23 to Appendix 6.D (it should be 2.B).	GSP revised accordingly.	The Nature Conservancy
Minimum Thresholds (23 CCR §354.28)	3-22	The text states (p. 3-23): “The minimum thresholds for chronic lowering of groundwater levels are based on selection of RMS from among existing production and monitoring wells located throughout the subbasin and screened in both in the Upper and Lower Aquifers.” Please clarify the text to state that wells were chosen that monitor a single aquifer, but not both at the same time (i.e. composite), if that is the intended meaning.	The GSP text, maps, and figures describe RMS sites being designated as representative of the Upper Aquifer, Lower Aquifer, or both (composite). Composite wells were minimized to the extent possible, and were only included if no other suitable RMS were available specific to the Upper or Lower Aquifer only. Nested well sites are currently being installed to fill data gaps.	The Nature Conservancy
Minimum Thresholds (23 CCR §354.28)	3-35	This Minimum Threshold does not consider water quality needs of GDEs. The text states (p. 3-36): “Protection of municipal and domestic beneficial uses is also protective of all other groundwater beneficial uses.” Please elaborate on this statement and include a discussion about GDEs and water quality and whether the measurable objectives and interim milestones will help achieve the sustainability goal as it pertains to the environment.	In general, meeting municipal and domestic water quality MO/MT is expected to be protective of GDEs. It should also be noted that the GSP is not responsible for existing constituent levels or ongoing non-GSP related activities that may result in increasing constituent concentrations. As described in the GSP, there are many other agencies/programs devoted to monitoring and protection of groundwater quality, with which the GSAs plan to coordinate.	The Nature Conservancy
Minimum Thresholds (23 CCR §354.28)	3-40	The text states (p. 3-40): “Therefore, the surface water depletion sustainability criteria is not applicable to the subbasin.” However, no evidence is provided in the GSP to show that a hydraulic connection between groundwater and surface water does not exist. Following the discussion presented above for Checklist Item 26 (Measurable Objectives), please include a discussion of Sustainable Management Criteria for ISWs, including Minimum Thresholds, in the GSP. Please cite data gaps regarding ISWs and make plans to reconcile them in the Monitoring Section of the GSP.	See Multiple Comment Subject Area Response	The Nature Conservancy

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Monitoring Network (23 CCR §354.34)	3-45	Per the GSP Regulations (23 CCR §354.34 (a) and (b)), monitoring must address trends in groundwater and related surface conditions (emphasis added). Groundwater level monitoring alone may be insufficient to establish a linkage between groundwater extraction and potentially resulting impacts to environmental resources associated with GDEs and ISWs. The cause-effect relationship between groundwater levels and the biological responses that could result in significant and unreasonable impacts to ISWs and GDEs depends on a number of complicated factors, and this relationship is not characterized or discussed. The Monitoring Network section currently does not address future needs for ISW monitoring. In this section, please describe monitoring for ISWs as described below:o In addition to the need for additional shallow monitoring wells in the upper aquifer to map GDEs, there is also a need to enhancing monitoring of stream flow and vertical groundwater gradients by installing more stream gauges and clustered/nested wells near streams, rivers or wetlands. Ideally, co-locating stream gauges with wells that can monitor groundwater levels in both the upper and lower aquifers would enhance understanding about where ISWs exist in the basin and whether pumping is causing depletions of surface water or impacts on beneficial users of surface water and groundwater. Please provide sufficient detail for the investigation and monitoring program including stream gauges, screened intervals and frequency of monitoring, in order to describe monitoring of both the extent of ISWs and the quantity of surface water depletions from ISWs.	There is extensive discussion in the GSP regarding groundwater levels and GDEs, and specific RMS sites were selected to represent GDEs. See Multiple Comment Response Section regarding ISW.	The Nature Conservancy
Monitoring Network (23 CCR §354.34)	3-47	As noted in our comments above on Checklist Items 11-15, the depth to groundwater contour maps (Figures 2-70 and 2-71) show large areas of data gaps, given the marked data points on the map where data exists. These maps were used to exclude all GDEs located adjacent to Chowchilla River, Ash Slough, and Berenda Slough (Figure 1 of Appendix 2.B). Please propose additional upper aquifer wells to reconcile this data gap.	Additional nested monitoring wells, including shallow Upper Aquifer wells are currently being installed. Additional analyses will be conducted related to GDEs and ISW for the 5-year update based on additional data collected during the next five years.	The Nature Conservancy
MOs, MTs, URs	not noted	The GSP does not discuss the anticipated water level decline. However, Appendix 3.A. provides hydrographs which include information on current water levels, MTs/MOs, and depths of domestic wells. [It should clearly identify and detail the anticipated degree of water level decline from current elevations to the water level MOs and MTs, including this information presented in tables, maps, relative to location of DAC and domestic well users, and relative to location of ISW and GDEs.]	Consider adding this.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
MOs, MTs, URs - well dewatering	not noted	[The GSP does not include an analysis, conducted and clearly illustrated (with maps), to identify what wells would be expected to be partially and fully dewatered at the MTs and at the MOs.] No maps are included and no explicit comparison to MOs and MTs is presented.	SGMA does not require this. Partial dewatering of a well is not applicable. We currently only have domestic well data summarized by section - not sure if we can address comment with what we have in hand and not sure we have exact domestic well locations to present on a map anyway.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American

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				Rivers, The Nature Conservancy
Notice & Communication	2-20	The GSP authors have listed environmental agencies and environmental groups as one of the beneficial users of groundwater in the Subbasin in Table 2-4 (p. 2-20 to 2-21). The following footnote was added to the table: "The groups and communities referenced are examples identified during initial assessment. GSA Interested Parties lists shall maintain current and more exhaustive lists of stakeholders fitting into these groups." Environmental groups should be expanded in a manner similar to the environmental justice groups in the Human Right to Water category. Please expand the stakeholder list associated with the Environmental and Ecosystem Uses category in Table 2-4 to include the appropriate agencies and list of environmental groups.	The Environmental and Ecosystem category of interest in Table 2-4 has been expanded with the names of specific groups.	The Nature Conservancy
Notice & Communication	2-20	The types and locations of environmental uses, species and habitats supported, instream flow requirements, and other designated beneficial environmental uses of surface waters that may be affected by groundwater extraction in the Subbasin should be specified. To identify environmental users, please refer to the following: o The NC Dataset (https://gis.water.ca.gov/app/NCDatasetViewer/) which identifies the potential presence of groundwater dependent ecosystems in this basin o The list of freshwater species located in the Chowchilla Subbasin in Attachment C of this letter. Please take particular note of the species with protected status. o CDFW's California Natural Diversity Database (CNDDB) - https://www.wildlife.ca.gov/Data/CNDDB o USFWS's IPAC report for the Chowchilla Area - https://ecos.fws.gov/ipac/ o Lands that are protected as open space preserves, habitat reserves, wildlife refuges, etc. or other lands protected in perpetuity and supported by groundwater or interconnected surface waters should be identified and acknowledged.	See Multiple Comment Subject Area Response	The Nature Conservancy

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Outreach	Table 2-4, p 75; Appendix 2.C, p 51	The GSP does not indicate specifically how DAC beneficial users were engaged during the planning process. Table 2-4. Stakeholder Engagement Chart for GSP Development in the GSP or named Table 1: Stakeholder Engagement Chart for GSP Development in Appendix 2.C includes DACs and the "Engagement purpose", which is "Inform and involve to provide a safe and secure groundwater supplies to all communities reliant on groundwater". The SCEP describes the planned strategy to engage DACs but the GSP does not explicitly identify efforts made during the planning process in terms of being "DAC outreach." However, as identified below, outreach included assistance by Self-Help Enterprises and the Leadership Counsel for Justice and Accountability, which focus on outreach to DAC beneficial users.	See Multiple Comment Subject Area Response	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Outreach	155, 179	According to the draft GSP, stakeholder input was considered for developing the URs, MOs, and MTs. However, input received from DACs is not explicitly identified or described and it is thus not clear what extent these community members were actively engaged in the process.	See Multiple Comment Subject Area Response	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Outreach	not noted	The Appendix 2.C of the draft GSP indicates that a majority of the subbasin area is considered to be DACs, however, the specific DACs are not clearly identified in the GSP. The GSP should explicitly provide a detailed description of how the DACs were identified, the names and locations of the communities and details of the population in the communities and how they use groundwater. Without this information, it is not clear how the GSP can consider the needs of these beneficial users. The GSP should also identify other sensitive drinking water users, such as tribes and small community water systems, if any are present in the subbasin. If community water systems are present, the GSP should include information on the number of service connections and/or population served by each water system. This information is valuable for the reader to understand the scale of the vulnerable population dependent on groundwater for drinking water. Environmental groups identified in the GSP should be expanded in a manner similar to the environmental justice groups in the Human Right to Water category. The GSP should expand the stakeholder list associated with the Environmental and Ecosystem Uses category in Table 2-4 to include the appropriate agencies and list of environmental groups. The GSP should expand the stakeholder list associated with the Environmental and Ecosystem Uses category in Table 2-4 to include the appropriate agencies and list of environmental groups. The GSP should expand the stakeholder list associated with the Environmental and Ecosystem Uses category in Table 2-4 to include the appropriate agencies and list of environmental	See Multiple Comment Subject Area Response	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy

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		groups. The types and locations of environmental uses, species and habitats supported, instream flow requirements, and other designated beneficial environmental uses of surface waters that may be affected by groundwater extraction in the Subbasin should be specified. To identify environmental users, please refer to the following: 1) The NC Dataset (https://gis.water.ca.gov/app/NCDatasetViewer/) which identifies the potential presence of groundwater dependent ecosystems in this basin 2) The list of freshwater species located in the Chowchilla Subbasin can be found here: https://groundwaterresourcehub.org/sgma-tools/environmental-surface-water-beneficiaries/. Especially take note of the species with protected status.3) CDFW's California Natural Diversity Database (CNDDB) - https://www.wildlife.ca.gov/Data/CNDDB 4) USFWS's IPAC report for the Chowchilla Area - https://ecos.fws.gov/ipac/. Lands that are protected as open space preserves, habitat reserves, wildlife refuges, etc. or other lands protected in perpetuity and supported by groundwater or interconnected surface waters should be identified and acknowledged		
Outreach	not noted	The GSP describes the methods used to disseminate information but does not explicitly describe engagement of DAC members in such terms. It is recommended that further details of how DACs were engaged be provided in the GSP, and what level of participation was achieved. The GSP states that stakeholder input was incorporated; however, detailed information about stakeholder input and responses from the GSA to address the stakeholder input are not presented.	See Multiple Comment Subject Area Response	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Outreach and GDEs	not noted	Based on the presented information, domestic well uses are considered under URs and for the development of water level MOs and MTs, but input from DAC members is not explicitly identified or discussed. More detail and specifics regarding DAC members, including those that rely on smaller community drinking water systems, not only domestic wells, is necessary to demonstrate that these beneficial users were adequately considered. The GSP should discuss whether and how input from DAC members was considered 15 and incorporated into the development of undesirable results, MOs, and MTs. The GSP should present a thorough, robust, and transparent analysis, supported by maps, that identifies: (1) which domestic wells are likely to be impacted at the MTs and at the MOs, and (2) the location of the likely impacted wells with respect to DACs and other communities and systems dependent on groundwater. The draft GSP should include more detailed information about the potential impacts on sensitive drinking water users, such as 1) where the likely impacted wells are located, 2) what communities are most affected (including DACs), 3) an estimate of the size of the population that relies on these domestic wells, or 4) if the creation of a new or expanded community water system could address some or all of the population affected by the loss of domestic wells. A more robust discussion of the known facts regarding these surface-	See Multiple Comment Subject Area Response	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy

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		groundwater interactions in the riparian zone should be provided. In addition, more detailed discussion regarding specific data gaps should be included. It is recommended that after identifying which freshwater species exist in your basin, especially federal and state listed species, that you contact staff at the Department of Fish and Wildlife (DFW), United States Fish and Wildlife Service (USFWS) and/or National Marine Fisheries Services (NMFS) to obtain their input on the groundwater and surface water needs of the organisms on the freshwater species list. Because effects to plants and animals are difficult and sometimes impossible to reverse, we recommend erring on the side of caution to preserve sufficient groundwater conditions to sustain GDEs and ISWs. Refer to the Critical Species Lookbook to review and discuss the potential groundwater reliance of critical species in the basin. The analysis for ISWs should include all beneficial users of surface water that could be affected by groundwater withdrawals, including environmental. Refer to the San Joaquin River Restoration Program (SJRRP) that identifies instream flow needs for salmon. The GSP should include instream flow requirements in this section and whether the measurable objectives and interim milestones will help achieve the sustainability goal as it pertains to the environment. The GSP should include a discussion of Sustainable Management Criteria for GDE and ISWs, including MOs, MTs and Undesirable Results, in the GSP.		
Projects and Management Actions to Achieve Sustainability Goal (23 CCR §354.44)	4-1	The Subbasin area includes GDEs and ISWs that are beneficial uses and users of groundwater, and may include potentially sensitive resources and protected lands. Protection of environmental uses and users should be considered in establishing project priorities. In addition, consistent with existing grant and funding guidelines for SGMA-related work, priority should be given to multi-benefit projects that can address water quantity as well as providing environmental benefits or benefits to disadvantaged communities. Please include environmental benefits and multiple benefits as criteria for assessing project priorities.	Edits made in Section 4 (pg. 4-1) and text on pg. 4-7 which provides an example of benefits of recharge basins.	The Nature Conservancy

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Projects and Management Actions to Achieve Sustainability Goal (23 CCR §354.44)	4-1	This section identifies many important projects; however, the descriptions of Measurable Objectives for these projects only identifies benefits to water level and storage. Because maintenance or recovery of groundwater levels, or construction of recharge facilities, may have potential environmental benefits in many cases it would be advantageous to demonstrate multiple benefits from a funding and prioritization perspective.o For the projects already identified, please consider stating how ISWs and GDEs will benefit or be protected, or what other environmental benefits will accrue. o If ISWs will not be adequately protected by those listed, please include and describe additional management actions and projects targeted for protecting ISWs.o Recharge ponds, reservoirs and facilities for managed stormwater recharge can be designed as multiple-benefit projects to include elements that act functionally as wetlands and provide a benefit for wildlife and aquatic species. In some cases, such facilities have been incorporated into local Habitat Conservation Plans (HCPs) and Natural Community Conservation Plans (NCCPs), more fully recognizing the value of the habitat that they provide and the species they support. For projects that construct recharge ponds, please consider identifying if there is habitat value incorporated into the design and how the recharge ponds can be managed as multiple-benefit projects that have a benefit to environmental users. Grant and funding opportunities for SGMA-related work may apply to multi-benefit projects that can address water quantity as well as provide environmental benefits.o For examples of case studies on how to incorporate environmental benefits into groundwater projects, please visit our website: https://groundwaterresourcehub.org/case-studies/recharge-case-studies/	In addition to the proposed projects/management actions in the GSP; it should be noted that the San Joaquin River Restoration Project, which reduces diversions available for irrigation, will provide a major source of new water to support GDEs along the San Joaquin River. Edits made in Section 4.1.1.5 (pg. 4-7).	The Nature Conservancy
Projects and Management Actions to Achieve Sustainability Goal (23 CCR §354.44)	Figure 2-68	The reduction in land subsidence, shown on Figure 2-68, should describe the joint project between CCID/SLCC and the Triangle T Water District. The plan should have more emphasis on the successes of the Red Top area subsidence mitigation and require others in the vicinity to similarly solve the subsidence problem	The joint project between CCID/SLCC and Triangle T Water District is described in some detail on pages 3-33 through 3-34 in Section 3.3.3.4 of the draft Chowchilla Subbasin GSP. The collective SMC set in the draft Chowchilla Subbasin GSP will effectively require similar actions in other portions of the Western Management Area.	San Joaquin River Exchange Contractors GSA
Projects and Management Actions to Achieve Sustainability Goal (23 CCR §354.44)	(graphics)	Costs identified in the Plan associated with the Eastside Bypass diversions and recharge basins seem high. Is Madera County planning to submit its own application? If so, Clayton will not be interested in paying for this work twice. Secondly, the O& M costs seem very high at $450,000. Are these costs annual or across 20 years? What would these charges be for if CLWD and TTWD are going to maintain the sites? Unless perhaps the County is offering to chip money in on CLWD's behalf?	Regarding the costs for Eastside Bypass Diversions and recharge basins, these are conceptual costs that assume some of the water will need to be pumped to the east of the eastside bypass. In addition, the costs assume that sometime of water agency is formed to manage the project and deliver the water. These costs will be refined as the project details are refined and cost sharing agreements are negotiated. Care was taken so that these costs and water yields do NOT overlap the Eastside Bypass Water Rights Application Project. Communication is emphasized to prevent duplication of	Clayton Water District

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			costs. It is hoped that CLWD and TTWD will maintain the sites, but since this has not been discussed, the cost estimate does not assume this.	
Projects and Management Actions to Achieve Sustainability Goal (23 CCR §354.44)	not noted	[a plan to mitigate impacts on DAC drinking water users is not included in the proposed Projects and Management Actions.] Appendix 3.C. identifies that a domestic well mitigation program may be developed.	Added text in Projects and Management Actions related to Domestic Well Mitigation Program.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Projects and Management Actions to Achieve Sustainability Goal (23 CCR §354.44)	217	Section 4 identifies many important projects; however, the descriptions of Measurable Objectives for these projects only identifies benefits to water level and storage. Because maintenance or recovery of groundwater levels, or construction of recharge facilities, may have potential environmental benefits in many cases it would be advantageous to demonstrate multiple benefits from a funding and prioritization perspective. For the projects already identified, the GSP should consider stating how ISWs and GDEs will benefit or be protected, or what other environmental benefits will accrue. If ISWs will not be adequately protected by those listed, additional management actions and projects targeted for protecting ISWs should be included and described. Recharge ponds, reservoirs and facilities for managed stormwater recharge can be designed to include elements that act functionally as wetlands and provide a benefit for wildlife and aquatic species. In some cases, such facilities have been incorporated into local Habitat Conservation Plans (HCPs) and Natural Community Conservation Plans (NCCPs), more fully recognizing the value of the habitat that they provide and the species they support. For projects that construct recharge ponds, the GSP should consider identifying if there is habitat value incorporated into the design and how the recharge ponds will be managed to benefit environmental users. For examples of case studies on how to incorporate environmental benefits into groundwater projects, visit our website: https://groundwaterresourcehub.org/case-studies/recharge-case-studies/.	Recharge basins would provide environmental benefits by creating seasonal or perennial habitat for wildlife including waterfowl, amphibians, and reptiles and serve as drinking water sources and foraging habitat for mammals. Groundwater flowing laterally from recharge basins to nearby rivers, particularly the San Joaquin River, may also support beneficial uses by providing an additional source of relatively cold water to support riparian vegetation and both cold and warmwater aquatic habitat including migration habitat for special-status salmonids. See comment in Section 4 intro (pg. 4-1) and text on pg. 4-7 which provides an example of benefits of recharge basins.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Projects and Management Actions to	not noted	A discussion should be added for each project or management action to clearly identify the benefits to DACs, drinking water users, and potential impacts to the water supply. For all potential impacts, the	The identified projects and management actions bring the subbasin into sustainability by 2040 benefiting ISWs and GDEs by leading to stabilization and some recovery	Clean Water Action/Clean Water Fund, Local Government

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Achieve Sustainability Goal (23 CCR §354.44)		project/management action should include a clear plan to monitor for, prevent, and/or mitigate against such impacts. For example, groundwater recharge projects can have either a positive or negative impact on local groundwater quality, depending upon the design of the project. The GSP should identify additional actions and funding mechanisms for potential failures of achieving the MOs by the identified actions. The GSP should include environmental benefits and multiple benefits as criteria for assessing project priorities. For the projects already identified, the GSP should consider stating how ISWs and GDEs will benefit or be protected, or what other environmental benefits will accrue. For projects that construct recharge ponds, the GSP should consider identifying if there is habitat value incorporated into the design and how the recharge ponds will be managed to benefit environmental users. For examples of case studies on how to incorporate environmental benefits into groundwater projects, visit: https://groundwaterresourcehub.org/case-studies/recharge-case-studies/.	of groundwater levels. Recharge basins would provide environmental benefits by creating seasonal or perennial habitat for wildlife including waterfowl, amphibians, and reptiles and serve as drinking water sources and foraging habitat for mammals. Groundwater flowing laterally from recharge basins to nearby rivers, particularly the San Joaquin River, may also support beneficial uses by providing an additional source of relatively cold water to support riparian vegetation and both cold and warmwater aquatic habitat including migration habitat for special-status salmonids. See comment in Section 4 intro (pg. 4-1) and text on pg. 4-7 which provides an example of benefits of recharge basins.	Commission, Audubon California, American Rivers, The Nature Conservancy
Projects and Management Actions to Achieve Sustainability Goal (23 CCR §354.44)	not noted	Planning vs. Prescribing: One of the key challenges in drafting a GSP is balancing between establishing a workable long-term strategy and providing near-term certainty through specific prescriptions. The reality is that the first step in the journey to groundwater sustainability is establishing and refining critical measurement and monitoring systems. While this means that certainty about some parameters is delayed, this is a necessary foundation to ensuring a fair and workable system is ultimately implemented. The Draft GSPs appropriately manage this balance by clearly identifying what is needed, how it will be obtained, and how it will be used to implement the management actions and projects that will achieve sustainability. The specific prescriptions and implementation of the tools is rightfully left to the implementation phase of the GSP. While this does leave some uncertainty at present, it is important that the tools and prescriptions be based on the needed information and not hurriedly placed on a flawed foundation.	No response needed.	Madera Ag Water Association
Projects and Management Actions to Achieve Sustainability Goal (23 CCR §354.44)	not noted	Projects and Management Actions – Section 4: The Draft GSPs identify recharge, conveyance, and (for the Chowchilla Subbasin) storage as projects, and demand management as a management action. These tools will be utilized to bring the basins into balance over the next twenty years.While these projects and management actions may be implemented by the GSAs, it would be useful to clarify in the Draft GSPs how these projects and management actions may be also implemented by other entities or individuals. This would allow others, in coordination with the GSAs and consistent with the GSPs, to implement projects and management actions that move us toward sustainability. In some cases, these entities may be able to implement these projects or management actions more quickly and efficiently than the GSAs.	Added text to GSP to indicate that entities or individuals can also implement projects and management actions.	Madera Ag Water Association

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Projects and Management Actions to Achieve Sustainability Goal (23 CCR §354.44)	not noted	Recharge – Section 2.2.3.3 & Section 4 (Table 4-2): In discussing groundwater recharge, the Draft GSPs appropriately focus on Flood-MAR, recharge basins, and in lieu recharge. While these surface water diversion projects should remain the priority of the GSP, it may be useful for the GSP to anticipate inclusion of other types of projects and management actions that may not divert surface water but may contribute to the groundwater replenishment portfolio. Increasing consideration and study is being given to forest management, tillage practices, stormwater management, and other management practices that may increase the amount of precipitation infiltrating into the groundwater system. While these management practices are not sufficiently developed to be included in the projected budget, it would be helpful if the GSP also referenced groundwater replenishment practices that do not rely on diverted surface water.	Added text or emphasis that other projects may be considered in the future.	Madera Ag Water Association
Regulatory agencies	4-5	Under "Permitting process and agencies with potential permitting and regulatory control" HFS believes the California State Water Resources Control Board should be included.	GSP revised accordingly.	Hancock Farmland Management Services
Subsurface Inflows	2-34	On Page 2-34 the lower aquifer discussion should include lateral groundwater inflow and outflow across Subbasin boundaries. There has consistently been groundwater flows in both the upper and lower aquifers from the Delta-Mendota Subbasin to the Chowchilla Subbasin. Based on natural (pre-pumping) conditions, all of these flows have been induced by pumping in the Chowchilla Subbasin.	See Multiple Comment Subject Area Response	San Joaquin River Exchange Contractors GSA
Sustainability Goal (23 CCR §354.24)	3-2	The sustainability goal does not specifically mention beneficial uses or users of groundwater, including environmental users. It states "the six sustainability indicators, established measurable objectives, and minimum thresholds will ensure that no undesirable results of significant and unreasonable economic, social, or environmental impacts occur…" Please rephrase the Sustainability Goal to specifically call out beneficial uses and users of groundwater including environmental users. Please state how the sustainability of environmental uses will be protected. In addition, a statement about any intention to address pre-SGMA impacts should be included.	Comment noted. The sustainability goal was discussed in public meetings and incorporates feedback received by GSAs from stakeholders during public meetings.	The Nature Conservancy
Undesirable Results (23 CCR §354.26)	3-40	This section only describes undesirable results relating to human beneficial uses of groundwater and neglects environmental beneficial uses that could be adversely affected by chronic groundwater level decline. Please add "potential adverse impacts to GDEs" to the list of potential undesirable results presented in Table 3-8 (p. 3-41).	This section, in particular Table 3-8, describes undesirable results in terms of physical groundwater parameters. How these groundwater parameters relate to beneficial uses of groundwater are described in other sections. The relation to environmental beneficial uses is described in the sections and appendix that describe the GDE analysis completed.	The Nature Conservancy

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Undesirable Results (23 CCR §354.26)	3-42	The GSP states (p. 3-42): "Using the Fall measurements (assumed to be collected in October), a groundwater elevation undesirable result is defined to occur when greater than 30% of the RMS [representative monitoring sites] each exceed the groundwater level minimum thresholds for the same two consecutive Fall readings. Given a total of 36 RMS sites, a total of 11 or more the RMS would need to exceed MTs as defined above to constitute an undesirable result for chronic lowering of groundwater levels." The use of 30 percent to define an undesirable result does not allow for the occurrence of low water levels in one area, such as near a GDE, to be an Undesirable Result, which may impact environmental beneficial use. There are three RMS near the San Joaquin River Riparian GDE unit, which could be evaluated separately. Please consider the use of a separate management area for the San Joaquin River Riparian GDE unit so that different sustainable management criteria can be established for this GDE unit.	GDEs are not one of the six sustainability indicators designated under SGMA and GSP regulations. However, GDEs were considered in detail in the GSP and specific GDE RMS sites incorporated in the Plan.	The Nature Conservancy
Undesirable Results (23 CCR §354.26)	3-44	This section describes undesirable results in terms of meeting drinking water standards. The following is a link to a paper by Smith, Knight and Fendorf (2018) titled "Overpumping leads to California groundwater arsenic threat": (https://www.nature.com/articles/s41467-018-04475-3). The section should be modified to state that overpumping and dewatering of aquitards has been identified as a potential source of elevated arsenic concentrations above drinking water standards in San Joaquin Valley aquifers. In addition, any potential undesirable results from degradation of water quality that may impact GDEs and freshwater species in the area should be discussed in this section.	Arsenic is included as one of the key constituents for which MT and MO have been set. The GSP accounts for arsenic regardless of the mechanism by which the concentrations may increase, provided that increase in concentrations is caused by GSP projects/management actions.	The Nature Conservancy
Undesirable Results (23 CCR §354.26)	3-45	Following the discussion presented above for Checklist Item 26 (Measurable Objectives), please include a discussion of Sustainable Management Criteria for ISWs, including Undesirable Results, in the GSP. Please cite data gaps regarding ISWs and make plans to reconcile them in the Monitoring Section of the GSP.	See Multiple Comment Subject Area Response	The Nature Conservancy
Water Budget	not noted	This plan assumed that no land subsidence will occur so long as water levels do not drop below historic low water levels. Evidence in the El Nido area, the Mendota area, and elsewhere, shows that land subsidence will significantly occur at levels above historic low levels.	The Chowchilla GSP did not assume no land subsidence will occur if water levels do not drop below historic low water levels. Subsidence tends to occur with a lag time and it is likely some subsidence will continue based on recent low levels achieved, even though groundwater levels have rebounded to some degree in many wells since 2015 lows. It is important to note here that groundwater level/subsidence MT requirements in the Western Management Area of Chowchilla Subbasin generally are similar to groundwater level MTs set in the SJREC GSP Plan Area.	San Joaquin River Exchange Contractors GSA

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Water Budget	Table 2-26	The groundwater overdraft presented in this report vary substantially. Table 2-26 indicates an average annual overdraft of 29,000 acre-feet while the Figure ES-3 estimates the average annual overdraft to be 101,900 acre-feet.	Table 2-26 presents historical (1989-2014) overdraft that includes net subsurface inflows. Figure ES-3 presents current (2015) land use that does not include net subsurface inflows. Referring to this as overdraft was a typo and the text has been edited to refer to this as a shortage or a negative net recharge. Additionally, the GSP text has been clarified to further emphasize the basis for each calculation. However, it should be noted that Projects and Managements actions were developed in Chowchilla Subbasin to address the shortage shown in Figure ES-3; meaning net subsurface inflows will not be relied on to correct the subbasin water balance.	San Joaquin River Exchange Contractors GSA
Water Budget	6	Page 6 of the Executive Summary references that the sustainable yield was only calculated for the period 2040-2090. A sustainable yield should be calculated for the period 2020-2040 in order to achieve sustainability. One method used to calculate sustainable yield uses "average annual groundwater extraction minus the average annual change in groundwater storage". Groundwater extractions in this subbasin has resulted in inelastic land subsidence. These extractions need to be removed from the sustainable yield calculation.	A single sustainable yield cannot be calculated for 2020 to 2040 because it will change during this time as projects/management actions are implemented. Furthermore, SGMA allows 20 years to achieve sustainability and sustainable yield numbers during this time are not applicable or required under SGMA. The groundwater extractions used in the calculation are during the sustainability period when groundwater extractions have been reduced by the demand management program and are sustainable. Thus, groundwater extractions that would result in inelastic land subsidence are not included in the sustainable yield calculation.	San Joaquin River Exchange Contractors GSA
Water Budget	not noted	The plan mentions Fresno River Rights and credit for water diverted - This may be one of the most concerning items in the Chowchilla GSP from the perspective of Madera County GSA. The water diverted from the Fresno River is 100% allocated to Triangle T GSA as it reads in the Plan currently. This is incorrect. Triangle T only has a right to divert 60% of the flows from the Fresno River each year. Portions of the other 40% is allocated to landowners in the Madera County GSA: Case Vlot and Harman. This is technically Vlot (all Chowchilla Subbasin), Harman (portions mostly in Chowchilla and some in Merced Subbasin) and Menefee (Merced Subbasin).	The phrasing in the GSP is unclear. In the historical and current water budgets, the total water in the Fresno River (downstream of Eastside Bypass) is reported by MID Recorder 24 (Rd. 9 at Fresno River). Of this total, only the volume of diversions reported by water rights holders in TTWD (per eWRIMS) is "assigned" to TTWD land. The remaining water (minus seepage/evaporation) flowed out of the subbasin. Diversions to Vlot and Harman that were missing in the earlier water budget will be added to the updated water budget. These diversions will be "assigned" to Madera County land in the same way.Clarification has also been added in Section 2.2.3.3 of the GSP (under Surface Water Data): "Deliveries along Fresno River to water rights holders in TTWD and Madera County are reported by eWRIMS. In the water budget, reported water rights diversions are subtracted from the total flows along their respective waterways."	Clayton Water District

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Water budget	not noted	Recharge ponds- growers may wish to plant a dryland crop to keep invasive species (i.e. tumbleweeds) out of basins – however, this will give a signature of water use with satellite imagery. How do growers prove that they aren't using/pumping groundwater?	This potential occurrence would likely occur outside of primary growing months and will likely have a very small impact on the water balance analysis.	Clayton Water District
Water budget	not noted	There should be a recognition that Sustainable Yield is higher in the shallow aquifer vs. the lower aquifer.	Increased use of the Upper Aquifer is already occurring in the Triangle T GSA area. The demand management program being discussed with stakeholders may include specific requirements with regard to pumping from the upper and lower aquifers. The GSP MTs and MOs also will encourage and likely lead to increase use of the Upper Aquifer and decreased use of the Lower Aquifer in the Western Management Area of Chowchilla Subbasin.	Clayton Water District
Water Budget	not noted	There needs to be an accounting for past recharge and losses from the Eastside Bypass in the areas affected, and credit/accounting for actual recharge and diversions from the Bypass in the past.	Historic, current, and future recharge and diversions from the Eastside Bypass were accounted for in the GSP water balance and model. The GSP describes how they were accounted for.	Clayton Water District
Water Budget	not noted	After attending the confined animal Ad Hoc Committee on October 3, 2019, I was concerned that the calculation of Dairy water use was not well developed in the Madera and Chowchilla Basin GSPs. Provost & Pritchard Consulting Group has been working on understanding Dairy use of groundwater for several years. We would like to share our methodology with the County to demonstrate how the consumptive use of dairies has been handled in the past and in other GSPs. Dairy water budgeting parameters, calculations, and data sources have been based on field calculations, canal turnout and water well measurements, annual dairy reports and milk production. Generally, about 9 gallons per cow each day is exported from the dairy as milk and another 7 to 10 is excreted as urine, sweat and solids; equating to 0.01 to 0.02 Acre Foot (AF) per cow each year. Wash water varies by operation and is reported in dairy reports as outflow to lagoons; generally, about 72 gallons/cow each day which equates to about 0.08 AF per cow each year. The total water used in the dairy facility ranges from 80 to 90 gallons per cow each day, or 0.09 to 0.1 AF/cow each year. [See letter for detailed methodology]	Respectfully, we do not see anything in the Provost & Pritchard memo that is different than we've discussed and considered in development of the Chowchilla GSP. We have used ~70 gallons/cow in other work, so their value is consistent with our expectations. Dairy water is included in the Chowchilla GSP "Land Use System" agricultural land water balance. Almost all of the dairy water ends up being applied to crops (89% in their water budget). Methodologies to estimate applied water requirements based on ET analysis accommodate the source(s) of water. If water used by a dairy is pumped, then the ET method will calculate the correct groundwater pumping. See clarifications in: Section 2.1.1 (p. 2-1) and Section 2.2.3.3, under "Land Use Data" (p. 2-63)	Provost & Pritchard
Water Budget	not noted	ETAW vs. AW: In discussing the Draft GSPs with stakeholders there is some confusion about the difference between the Evapotranspiration of Applied Water (ETAW) and Applied Water (AW). Although the Draft GSPs are not deficient in their explanation of this distinction, additional clarification, perhaps in the Executive Summary, would help the reader understand the difference between these terms and how they are used in the Draft GSPs.	Explanation added to GSP executive summary and water budget section.	Madera Ag Water Association
Water Budget - Allocation of	Chapter 2, App 2F	Sierra Vista Mutual Water Company provides these comments regarding the allocation of seepage from the Chowchilla River in Appendix 2.F.d and Appendix 2.F.a, and as further reflected in Chapter 2 and the balance of the	As stated in the comment, 70% of the non-flood period seepage in Reach C-2 will be allocated to SVMWC, while the remaining 30% will be allocated to CWD. See the	Sierra Vista Mutual Water Company

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seepage from Chowchilla River		Draft GSP using the information from these two appendices. Currently the non-flood period seepage for Reach C-2 is allocated 100% to Chowchilla Water District in the water balances and none of this seepage is allocated to Sierra Vista Mutual Water Company. Sierra Vista Mutual Water Company contends it has a right to some or all of the Reach C-2 seepage pursuant to its existing water rights, agreements with Chowchilla Water District and a court judgment. To avoid a dispute over this allocation, for purposes of the GSP and SGMA water balance calculations should be amended to allocate 70% of the non-flood period seepage for Reach C-2 to Sierra Vista Mutual Water Company and 30% to Chowchilla Water District. The allocation of seepage for Reach C-2 between Sierra Vista Mutual Water Company and Chowchilla Water District has no impact on the total water balance for the subbasin. We understand that this change will be incorporated into the final GSP.	WB appendices (App. 2.F.) and discussion of the Chowchilla River in Chapter 2 for updates related to this.	
Water Budget - Allocation of seepage from Chowchilla River	79	The text states (p. 2-79): "…while for native vegetation lands, groundwater extraction by riparian vegetation was considered to be negligible because of the depth to groundwater in the subbasin." Because there are potential GDEs included in the Chowchilla Subbasin, please quantify the evapotranspiration from groundwater by riparian vegetation even if small. Please revise the text and budget as necessary.	Evapotranspiration from groundwater by riparian vegetation is included in the evapotranspiration of native vegetation. Riparian vegetation is not included in the list of water use sectors requiring separate quantification by the GSP regulations. The GSP regulations require that outflow be quantified by water use sector defined as "categories of water demand based on the general land uses to which the water is applied, including urban, industrial, agricultural, managed wetlands, managed recharge, and native vegetation.	The Nature Conservancy
Water budget - drinking water users	not noted	The demands by drinking water users are not explicitly identified in the projected water budget. [Demands by drinking water users would include domestic well users, state small water systems, small community water systems, medium and large community water systems, and non-community water systems]	Description of urban per-capita water use is included in Appendix 2.F.g (includes drinking water users). For clarity, a short section has been added to describe this module and its inputs in Section 2.2.3.3, under "Land Use Data" (p. 2-63 and 2-64) Section is now referenced under the "Projected Period" description (p. 2-58)	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
water budget - native vegetation and/or wetlands	134	"…while for native vegetation lands, groundwater extraction by riparian vegetation was considered to be negligible because of the depth to groundwater in the subbasin." Because there are potential GDEs included in the Chowchilla Subbasin, the GSP should quantify the evapotranspiration from groundwater by riparian vegetation even if small.	Added clarification top. 2-83, with footnote indicating that "Groundwater extraction of native vegetation estimated by ETaw from the Chowchilla IDC application is less than 5 AF/yr."	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy

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water budget - native vegetation and/or wetlands	not noted	[water uses for native vegetation and/or wetlands are not explicitly included in the projected/future water budget]	Water use for native vegetation is included in the projected/future water budget.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Water Budgets: Summary/Comm ents	not noted	Given the uncertainties of climate change, it is appropriate to analyze the impacts of climate change for a range of scenarios (e.g., a mild effects scenario and a high (worst case) effects scenario). Based on the data presented, it is not clear how climate change is expected to affect specific elements of the water budget (i.e., subsurface flows, surface water and groundwater outflows, including exports). The water budget does not include future water demands for drinking water users, including residential wells and small community water systems, and by doing so has omitted key drinking water beneficial users from consideration of future conditions. The GSP should incorporate and make reasonable demand projection assumptions relative to historic water demand and future growth projections for these drinking water users, including DACs. Because there are potential GDEs included in the Chowchilla Subbasin, the GSP should quantify the evapotranspiration from groundwater by riparian vegetation even if small. The text and water budget should be revised as necessary to reflect this.	SGMA does not require riparian vegetation to be accounted for separately from native vegetation.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Water Quality	not noted	This GSP did not include a regional water quality concern of the northeasterly flow of high TDS groundwater associated with overdraft in the Chowchilla Subbasin. Declining water levels in the upper aquifer of the Chowchilla Subbasin has increased the migration of high TDS groundwater into the Delta-Mendota Subbasin.	The comment raises concerns about flow of high TDS groundwater into Delta-Mendota Subbasin due to historical overdraft in Chowchilla Subbasin, but provides no evidence or analysis to support the comment. Given statements by SJREC GSA at our interbasin coordination meetings of not being in overdraft historically and actually being a net recharger, it is not clear how Chowchilla Subbasin groundwater levels are impacting flow of high TDS groundwater into Delta-Mendota Subbasin that is occurring at a location far removed from the Chowchilla Subbasin/Delta-Mendota Subbasin boundary. Furthermore, as explained in response to another comment, the natural flow of groundwater under pre-development conditions is similar to the current groundwater flow direction in the referenced high TDS area. The source of this TDS water is likely naturally occurring, and the movement of this groundwater from its origin towards the northeast is the natural flow direction towards the river independent of Chowchilla Subbasin groundwater pumping. Additional data/analyses (such as	San Joaquin River Exchange Contractors GSA

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			development of a numerical groundwater flow model) would need to be developed and presented to demonstrate how/if this natural flow of groundwater is really influenced by groundwater pumping in the distant Chowchilla Subbasin.	
Water Quality	not noted	[OEHHA Public Health Goals were not "used to assess drinking water BUs in the development of Minimum Thresholds (MTs)]	MCLs are considered the appropriate standards for setting SMC for groundwater quality.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Water Quality	not noted	[Water Quality Objectives (WQOs) in Regional Water Quality Control Plans were not "used to assess drinking water BUs in the development of Minimum Thresholds (MTs)]	MCLs are considered the appropriate standards for setting SMC for groundwater quality.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Water Quality	not noted	[Sustainable Communities Strategies/Regional Transportation Plans were not "used to assess drinking water BUs in the development of Minimum Thresholds (MTs)]	MCLs are considered the appropriate standards for setting SMC for groundwater quality.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Water Quality	not noted	[County and/or City General Plans, Zoning Codes and Ordinances were not "used to assess drinking water BUs in the development of Minimum Thresholds (MTs)]	MCLs are considered the appropriate standards for setting SMC for groundwater quality.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy

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Water Quality	not noted	[The GSP does not include maps of Water Board Regulated monitoring sites.]	MCLs are considered the appropriate standards for setting SMC for groundwater quality.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Water Quality	not noted	The following is a link to a paper by Smith, Knight and Fendorf (2018) titled “Overpumping leads to California groundwater arsenic threat”: (https://www.nature.com/articles/s41467-018-04475-3). The section should be modified to state that overpumping and dewatering of aquitards has been identified as a potential source of elevated arsenic concentrations above drinking water standards in San Joaquin Valley aquifers. In addition, any potential undesirable results from degradation of water quality that may impact GDEs and freshwater species in the area should be discussed in this section.	The GSP discusses this subject.	Clean Water Action/Clean Water Fund, Local Government Commission, Audubon California, American Rivers, The Nature Conservancy
Subsidence	not noted	Your draft plan sets the Land Subsidence Undesirable Result for the Western Management Area as "50 percent of Western MA Lower Aquifer wells below minimum threshold for two consecutive fall measurements. " It also sets the minimum threshold for Land Subsidence in the Western Management Area as "the highest of (a) projected lowest future groundwater level at the end of estimated 10-year drought or (b) or recent groundwater level lows". As defined, the Sustainable Management Criteria for Land Subsidence poses an immediate and long-term risk to the SJREC GSA and its member entities. Chapter 10 Section 10733 of the SGMA requires DWR to "evaluate whether a groundwater sustainability plan adversely affects the ability of an adjacent basin to implement their groundwater sustainability plan or impedes achievement of sustainability goals in an adjacent basin". Your draft plan will adversely impact our ability to successfully implement our GSP and prevent our achievement of sustainability. The Chowchilla GSP should be updated to mitigate land subsidence in the areas closest to the Delta-Mendota Subbasin. A successful mitigation program is being implemented by the Triangle T Water District in cooperation with the member agencies of the SJRECWA GSA. Other areas in the western Madera County should be held to a similar standard and immediately reduce extractions from the lower aquifer at or below the sustainable yield. Of particular importance is the area within the Clayton Water District. The SJREC GSA has participated in several conversations with the Chowchilla Subbasin to describe the need for regional coordination to achieve regional sustainability	The comment claims that Chowchilla GSP land subsidence SMC pose immediate/long-term risks to SJREC GSA. However, no evidence is provided to support this comment. In fact, groundwater level/subsidence MTs set for the Western Management Area of Chowchilla Subbasin (historical low groundwater levels) are generally consistent with SJREC GSP MTs stated during our meeting (2015 water levels). Available data in the Chowchilla GSP suggest water levels in Delta-Mendota are expected to remain relatively stable despite some modest water level declines in Chowchilla during the Implementation Period. The comment also refers to the agreement with Triangle T GSA as a model for land subsidence mitigation for the rest of western Chowchilla Subbasin. We note that the SMC for the Western Management Area of Chowchilla Subbasin effectively will require similar actions as are provided for in the Tri-T agreement. It is not anticipated that the Chowchilla Subbasin GSP will impede the ability of the SJREC GSP Plan Area from achieving sustainability in 2040 and beyond.	San Joaquin River Exchange Contractors GSA

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Subsurface Inflows	not noted	In your plan the minimum threshold for Chronic Lowering of Groundwater Levels is defined as "the lowest of a) projected lowest future groundwater level at end of estimated 10-year drought orb) lowest modeled groundwater level from projected with projects model simulation (2019-2090)". The undesirable result for this same indicator is defined as "30 percent of wells below minimum threshold for two consecutive fall measurements". As defined, this poses an immediate risk to the SJREC GSA and the Delta-Mendota Subbasin. Water levels at the end of a 10-year drought are projected to be significantly lower this historic water levels. Intentional decline in water levels in the Chowchilla Subbasin will directly impact the Delta-Mendota Subbasins infrastructure, water supply, and for the following sustainability indicators: a) chronic lowering of groundwater levels, b) reduction of groundwater storage, c) land subsidence, d) degraded water quality and e) depletion of interconnected surface water. a. Chronic lowering of groundwater levels: the SJREC GSP is managing groundwater levels to maintain historic levels. If the Chowchilla subbasin intends to lower the water levels across the subbasin boundary, inherently more groundwater will flow out of the Delta-Mendota Subbasin inducing a groundwater imbalance and overdraft in the Delta-Mendota Basin. b. Reduction of groundwater storage: As described above lowering water levels will increase the lateral groundwater outflow from the Delta-Mendota Subbasin. The results of increased outflow will result in a reduction in groundwater storage in the Delta-Mendota Subbasin. c. Land subsidence: this GSP plans to use water levels as a proxy for land subsidence. It should be noted that the proposed water level minimum thresholds will have very significant impacts to the Delta-Mendota Subbasin d. Degraded water quality: Lowering water levels in the Chowchilla subbasin will exacerbate the problem of migrating high TDS water into the SJREC GSA. This problem is not discussed in the GSP and should be evaluated to ensure regional sustainability. e. Depletion of interconnected surface water: The plan indicates that overdraft in the Chowchilla subbasin has caused water levels to drop low enough to a point where the surface water is not connected with the ground water. The SJREC GSP describes that there are times when the area adjacent to the San Joaquin River has interconnected surface water and groundwater. This GSP needs to describe how its groundwater management efforts are not depleting surface waters. Ofparticular importance are the areas adjacent to the Delta-Mendota Subbasin in the Madera County white areas and the Clayton Water District.	It is not clear how Chowchilla Subbasin groundwater level MTs pose an immediate risk to Delta-Mendota Subbasin, especially given that the overriding subsidence MT in the Western Management Area of Chowchilla Subbasin are generally consistent with SJREC Plan Area MTs. Furthermore, there are no "intential decline" in water levels within Chowchilla Subbasin; rather an anticipated modest temporary decline in water levels within Chowchilla Subbasin (given the time needed to implement projects and management actions) that is not expected to significantly impact groundwater levels in the Delta-Mendota Subbasin. There is only anticipated to be very modest impacts on net subsurface inflows during the Implementation Period, that will evolve into significantly reduced net subsurface net inflows during the sustainability period. The Delta-Mendota Subbasin water budget and sustainability will be enhanced by reduced net outflows to Chowchilla Subbasin related to implementation of the Chowchilla Subbasin GSP. Also, see Multiple Comment Subject Area Response.	San Joaquin River Exchange Contractors GSA

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
Interconnected Surface Waters (ISWs) (23 CCR §354.16)	not noted	Depletion of interconnected surface water: The plan indicates that overdraft in the Chowchilla subbasin has caused water levels to drop low enough to a point where the surface water is not connected with the ground water. The SJREC GSP describes that there are times when the area adjacent to the San Joaquin River has interconnected surface water and groundwater. This GSP needs to describe how its groundwater management efforts are not depleting surface waters. Of particular importance are the areas adjacent to the Delta-Mendota Subbasin in the Madera County white areas and the Clayton Water District.	The Chowchilla Subbasin GSP is not responsible for restoration of groundwater conditions that existing prior to 2015. However, it does remain possible that eliminating the subbasin water budget deficit by 2040 may have ancillary benefits such as restoration of the groundwater - surface water connection under certain conditions. It is also important to note that San Joaquin River Restoration Project flows will reduce surface water available for irrigation within Chowchilla Subbasin to allow for greater flows in the San Joaquin River. Also, see Multiple Comment Subject Area Response.	San Joaquin River Exchange Contractors GSA
Projects and Management Actions to Achieve Sustainability Goal (23 CCR §354.44)	not noted	In the plan do you have any idea of what the timing of the two sides of supply enhancement and groundwater enhancement? – How does that roll out in 20 years?	See Figure 5-1 on page 5-7 for the implementation schedule. Generally, recharge projects will be implemented as fast as possible and other larger projects come on later and demand management starts slowly for the first five years and then steadily increases through the last 15 years of the implementation period.	agricultural user
Edits to plan	not noted	What does the hydrology mean on Figure 3-3A	The question is not clear. The GSP explains that the future hydrology is based on 50 years of historical hydrology spanning the period 1965-2015, which represents an approximately average climatic period. Figure 3-3A plots both observed and simulated groundwater levels at the well from the groundwater model over the period from 1980-2090. The groundwater model extends from 1989-2090 and includes actual historical hydrology through 2018 with a future hydrology scenario applied for 2019-2090 based on years of historical hydrology from the 1965-2015. The GSP discusses the sequence of historical hydrology used for the future hydrology in analyses.	agricultural user
Demand Management	not noted	On the project side – starting right now on the reduction and demand side – when do you expect that to kick in in any meaningful way?	See Multiple Comment Subject Area Response	agricultural user
Demand Management	not noted	One question not clear to landowners – The 2%, is that a target for the whole GSA or is it a target for each individual to reach?	See Multiple Comment Subject Area Response	agricultural user
Demand Management	not noted	The longer we could avoid allocating the better for farmers – see how the projects and other things will make it happen without out the farmers having to cut back. Maybe the projects and other things will take care of the problem.	See Multiple Comment Subject Area Response	agricultural user
Demand Management	not noted	Merced County is suggesting 2% voluntary per year – they are probably not going to do anything for 5 years. Can we wait? (Correction from Merced member - They are still going to work out what is going to happen during	See Multiple Comment Subject Area Response	agricultural user

Comment Category/ General Topic	GSP Page	Comment	Response	Organization or Commenter
		the first 5 years – it will be voluntary in the beginning because there is no enforcement action now.)		
Demand Management	not noted	A lot of what is being talked about are management strategies - Triangle T just changed their management strategies and if you check the DWR website you can see maps that show the change in groundwater, just from the change of management policies. Farmers need to just work on their farm management strategies. The Madera/Chowchilla RCD is going to help farmers do some of this – farmers can do a lot on their own property, without asking permission. They can take out 5% of their land and it won’t be the worst farming decision they will ever make.	Comment noted.	agricultural user
Demand Management	not noted	I hope that allocating and pumping to individual farmer is a long way off. I think there should be some way for the farmers to receive credit for the water they are putting into the ground. With a credit it will give farmers incentive to put more water into the ground.	Comment noted.	agricultural user
Demand Management	not noted	Merced is proposing a pumping fee on the growers - How many growers didn’t take surface water this year when it was available because they can still pump? The frustration is our neighbors that are not helping and are pumping when they don’t take surface water when it is available.	Comment noted.	agricultural user
Projects and Management Actions to Achieve Sustainability Goal (23 CCR §354.44)	not noted	I didn’t know what recharge was until recharge happened. Neighbors are pumping and not using surface water – it is the need of education – people don’t know – you have to always educate because the wheels of agriculture turns slow. All of this technology is going to change over time, but what we do on our farms we can do now without technology. We just need to educate farmers.	Comment noted	agricultural user
Projects and Management Actions to Achieve Sustainability Goal (23 CCR §354.44)	not noted	We can’t accomplish this without your cooperation (pointing at the Committee at the head table). We have two canals that drain water to the southern state – they cut the water off from the south side of the valley. Somehow or another we need to put enough clout in the system. We are proposing to set those limits not as a tomorrow morning demand – but every time we have a wet year – we have to do it now – we have to be able to send it into our water districts, not south or to the ocean. Kings River sends ½ of their water to LA and San Diego, we need to put a stop to that and put the water in the ground here and now. It is up to you and I – we have deep wells. Draw a line in the middle of Madera County, use highway 99 or the airport as a goal, and get the water up at least 50 feet if not 100 feet – we are currently below sea level. We have run our limit out so we have to all give a little up. We have to do something – we can’t keep on doing what we are doing.	Comment noted.	agricultural user
Implementation	not noted	The GSA had to be formed quickly, the GSP had to be formed quickly – there is no thought to what other GSAs are charging.	Comment noted.	agricultural user

4 DOCUMENTATION OF COMMENTS RECEIVED

All comments received are included in this section exactly as they were received. This is where the pdf with all the comments received goes.

- *Date Submitted:* October 21, 2019

- *Submitted by:* Jeff Hillberg
  VP of Operations
  AgIS Property Management
  P.O. Box 1332
  Turlock, CA 95381
  Office: (209)262-1997

- *APNs:* 020-160-016-000, 020-190-009-000, 020-220-003-000, 021-100-014-000, 021-100-015-000, 021-100-016

- *Located in Madera County GSA*

- *Affiliation – Irrigated Ag*

- *Comment:*

  - The description of <u>Demand Management</u> in Section 4.2.3 (Page 4-27) is confusing and unclear. Section 4.2.3.1 (Page 4-28) <u>Project Overview</u> lists a number of demand management actions as **options** (emphasis added) to be implemented by growers, but goes on to list additional methods (allocation, markets, fees and fallowing) that lack any detail as to how they would be implemented as alternatives. The discussion then shifts to **enforcement** of pumping to ensure compliance with demand reduction targets. Further clarification of how these elements will be developed and implemented is necessary. The GSP lacks sufficient detail in defining how these reductions will be applied, measured, enforced and responded to if not met. These are critical details that must be addressed. For example, the baseline pumping period that the reductions will be applied to must be, at a minimum, a period of multiple years to avoid unnecessary and perhaps unintended penalization of lands in redevelopment or not yet in full demand due to planting schedules. Additionally, there is no significant discussion of how use will be measured and calculated, or of the costs to perform these activities.

  - Section 4.2.3.2 (Page 4/28) <u>Implementation</u> includes a discussion of Allocations that may be implemented as a demand management component. The discussion identifies various approaches to allocation. The GSAs in the Basin should initiate a stakeholder-driven process to develop a methodology for establishing landowner-level allocations of native yield that are coordinated across the basin. The allocation methodology should be consistent with various legal considerations drawn from applicable case law and attempt to be consistent with groundwater rights, recognizing that GSAs do not have statutory authority to make a final determination of water rights. An equal-per-gross acre approach to allocations is not likely to be consistent with established water rights doctrine, which must take into account many equitable considerations, in addition to acreage owned, to determine a legally defensible allocation.

Jeff Hillberg
VP of Operations
AgIS Property Management
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Turlock, CA 95381
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Clayton Water District

P.O. Box 35
El Nido, CA 95317

November 5, 2019

Stephanie Anagnoson
Water and Natural Resources Department
Madera County
200 W. 4th Street
Madera, CA 93637

Dear Stephanie:

Thank you for the opportunity to comment on the Draft Chowchilla Subbasin Groundwater Sustainability Plan (“the Plan). Clayton Water District (CLWD) offers the following comments:

1. Eastside Bypass Water Rights Application – There is mention (on executive summary graphics) of the application, but only credits Triangle T Water District (TTWD) with involvement, when in fact Clayton Water District is funding the application and is applying for 2 diversion points in the Madera West Management Area, within the CLWD boundary. Flood MAR and Recharge Basins need to be added to our Madera West Management Area category as well in the graphic.

   Costs identified in the Plan associated with the Eastside Bypass diversions and recharge basins seem high. Is Madera County planning to submit its own application? If so, Clayton will not be interested in paying for this work twice. Secondly, the O& M costs seem very high at $450,000. Are these costs annual or across 20 years? What would these charges be for if CLWD and TTWD are going to maintain the sites? Unless perhaps the County is offering to chip money in on CLWD’s behalf?

2. Page 31, Section 4.2.1 states that “deep aquifer recharge” will occur. We know that only shallow aquifer recharging will be possible.

3. There are a couple of deep aquifer typos in our Madera West sections, which should be corrected.

4. The plan mentions Fresno River Rights and credit for water diverted - This may be one of the most concerning items in the Chowchilla GSP from the perspective of Madera County GSA. The water diverted from the Fresno River is 100% allocated to Triangle T GSA as it reads in the Plan

currently. This is incorrect. Triangle T only has a right to divert 60% of the flows from the Fresno River each year. Portions of the other 40% is allocated to landowners in the Madera County GSA: Case Vlot and Harman. This is technically Vlot (all Chowchilla Subbasin), Harman (portions mostly in Chowchilla and some in Merced Subbasin) and Menefee (Merced Subbasin).

5. The plan talks about land retirement and specifically purchasing current farm ground in the Madera West Management Area for recharge purposes. From whom? And where? This may be an unnecessary step given the crops being grown in this area (winter forage, alfalfa and grapes) can use the recharge water for irrigation purposes and/or can be flooded during dormancy Flood MAR projects. Win-Win for the farmer and the county with respect to recharge and taxes.
    a. If we still need to reduce water in Madera West Management Area, perhaps explore the idea of limiting land to a single irrigated crop per year (minus the ground directly linked to dairy lagoon water). This would give still give the farmers the ability to dry land farm winter crops and conserve a large amount of water without explicitly fallowing ground.

6. If much of CLWD is sustainable on shallow aquifers (given relatively constant groundwater levels for the last 25+ years documented by the Bureau), why would land fallowing be appropriate for this area, opposed to land locked areas in the county that are not easily recharged to our East?

7. Recharge ponds- growers may wish to plant a dryland crop to keep invasive species (i.e. tumbleweeds) out of basins – however, this will give a signature of water use with satellite imagery. How do growers prove that they aren't using/pumping groundwater?

8. There should be a recognition that Sustainable Yield is higher in the shallow aquifer vs. the lower aquifer.

9. There needs to be an accounting for past recharge and losses from the Eastside Bypass in the areas affected, and credit/accounting for actual recharge and diversions from the Bypass in the past.

10. Evapotranspiration: question of quantification vs. meters: how will actual water use be verified?

Again, thank you for the opportunity to comment. Do not hesitate to reach out to us in the future for any reason.

Sincerely,

LARKIN HARMAN
President
CLWD Board of Directors

PROVOST & PRITCHARD CONSULTING GROUP
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Memorandum

To:	Stephanie Anagnoson, Director of Water and Natural Resources, Madera County
CC:	Larkin Harman and Julia Berry, Clayton Water District
From:	Rick Iger (P&P) and Keasha Blew (former P&P)
Subject:	Dairy Water Budget Parameters
Date:	11/1/2019 Revised from 10/3/2018 Internal Draft

Introduction and Summary:

After attending the confined animal Ad Hoc Committee on October 3, 2019, I was concerned that the calculation of Dairy water use was not well developed in the Madera and Chowchilla Basin GSPs. Provost & Pritchard Consulting Group has been working on understanding Dairy use of groundwater for several years. We would like to share our methodology with the County to demonstrate how the consumptive use of dairies has been handled in the past and in other GSPs. Dairy water budgeting parameters, calculations, and data sources have been based on field calculations, canal turnout and water well measurements, annual dairy reports and milk production. Generally, about 9 gallons per cow each day is exported from the dairy as milk and another 7 to 10 is excreted as urine, sweat and solids; equating to 0.01 to 0.02 Acre Foot (AF) per cow each year. Wash water varies by operation and is reported in dairy reports as outflow to lagoons; generally, about 72 gallons/cow each day which equates to about 0.08 AF per cow each year. The total water used in the dairy facility ranges from 80 to 90 gallons per cow each day, or 0.09 to 0.1 AF/cow each year.

Methodology:

The following parameters are taken into consideration in determining groundwater use by dairy facilities:

Surface Water:
- Surface water from all sources should be monitored monthly and totaled annually
- Calculate all water flowing into and out of the Ranch and dairy facility

Groundwater
- If possible, collect all well construction reports and map shallow and deep wells
- Track pumping from deep and shallow wells separately in dairy facility and cropped land
- Monitor groundwater levels in both shallow and deep aquifers

Recycled Water
- Recycled water or lagoon water produced and applied is found in dairy reports

Precipitation
- Typically, about 50% of precipitation is used for crops. The remainder can become deep percolation or runoff depending on geographic location

Consumptive use

- For dairies consumptive use is from both fodder crops and cows so it is important to know:
  - Number of cows
  - Total lagoon water produced from dairy operations (dairy permit report)
  - Acreage of dairy facility (non-cropped area), of dairy lagoons/ponds and of crops by crop type
  - Location and quantity of irrigation for crops
- This information can be found in annual dairy reports as part of the State Dairy Permit requirements. A couple of studies were also referenced for use by another consulting firm (EKI) we are working with in Kern County using University of Nebraska-Lincoln resource: https://beef.unl.edu/water-requirements-for-beef-cattle, http://extensionpublications.unl.edu/assets/html/g2060/build/g2060.htm and https://beef.unl.edu/amountwatercowsdrink.
- Consumptive use for dairies also includes milk production. Milk is about 88% water and a cow can produce an average of 75 lbs of milk per day. This becomes approximately 9 gallons of water used for milk production per cow each day, adding cow consumption and dairy facility wash water the total becomes about 80 to 90 gallons of water per cow each day. This was verified with local dairymen and numbers calculated were within a small margin of error.

Other Losses

- Evaporation is the main source of losses that are not returned to the system. Publications have several different references for open water evaporation. Upon examination it was found that evaporation from small ponds surrounded by irrigated agriculture is about 0.8 or 80% of reference ET.

Groundwater Replenishment

- In order to know how surface water recharges back into the groundwater system it is important to know about soil types and recharge rates of the soil which can vary.
- It is assumed that any applied water not lost to evaporation or ET of crops is recharged into the system
- Ponding seepage or canal seepage can be determined many ways. The easiest being the difference between measurements at specific monitoring points and pond drops under no inflow and outflow conditions. Soil types can also be used to estimate seepage by comparing to known/measured recharge areas on various soil types. In the case of dairy lagoons, the State Permit requires lining to prevent seepage, so the majority of losses from the lagoons are due to evaporation, not seepage.

Example Calculation:

In the case of one particular dairy studied in Merced County with 2,900 cows, about 0.009 AF/cow each year was exported as milk and 0.08 AF/cow each year was effluent sent to lagoon (per Dairy Annual Report). The total being 0.089 AF/cow each year, say 0.09 AF/cow each year.

In this case the dairy facility footprint was about 105 acres resulting in an average annual unit rate of 2.5 AF/Ac (2,900 cows x 0.09 = 261 AF; 261 AF/105 Ac = 2.5 AF/Ac). Keep in mind that the effluent component (0.08 x 2,900 cows = 232 AF) of the water generated in the Dairy facility minus that part lost to evaporation, is sent to the cropped grounds for effluent disposal/irrigation, which does reduce the crop water needs as would be estimated on the cropped field using ET methods. In this case there is about 2,000 acres of cropped land, so about 0.12 AF/Ac (232 AF/2000 Ac) is provided for irrigation coming from the Dairy facility lands. If the ET method was used to calculate groundwater pumping from the cropped field, the pumping would be overestimated from the cropped acreage which could be inappropriately subject to reduction if demand reduction is implemented.

CHOWCHILLA SUBBASIN
GROUNDWATER SUSTAINABILITY PLAN (GSP)
COMMENT FORM

Please complete the following information to provide comments on the draft Chowchilla Subbasin GSP. Type or print legibly for your comments to be considered.

Please return this form to (hand delivery, mail, or email accepted):

Stephanie Anagnoson
Madera County
200 W. Fourth Street
Madera, CA 93637
Email:ChowchillaGSPComments@maderacounty.com

Date Submitted: November 5, 2019

Submitted By: Molly Thurman, Water Resource Manager, Hancock Farmland Services (HFS)

Address: 301 E. Main Street, Turlock, CA 95380

Phone Number / Email: (661) 204-0568 / mthurman@hnrg.com

APNs: __________

Located in Groundwater Sustainability Agency (GSA):

☒ Madera County ☐ CWD ☒ Triangle TWD ☐ Merced County ☐ Other __________

Affiliation: ☒ Irrigated Ag ☐ Non-Irrigated Ag ☐ Rural Residential

☐ Disadvantaged Community Member ☐ Agency/Government ☐ Other __________

Chapter No. / Page No. of GSP: General

Comments: Hancock Farmland Services (HFS) would like to thank you for the momentous amount of work that has been put into the Draft Chowchilla Subbasin Groundwater Sustainability Plan (GSP). We especially appreciate the acknowledgment of the vitality of the agriculture industry in the local economy. In an effort to bolster the Draft GSP we provide the following comments:

Chapter No. / Page No. of GSP: Section 4.4.1.2, Page 4-5

Comments:
Under "Permitting process and agencies with potential permitting and regulatory control" HFS believes the California State Water Resources Control Board should be included.

Chapter No. / Page No. of GSP: Section 4.2.3, Page 4-27

Comments:
HFS applauds Madera County's efforts to work with stakeholders in developing specific details of a demand management policy. We encourage the GSAs in the basin to initiate a stakeholder-driven process to develop a methodology for establishing landowner-level allocations of native yield that are coordinated across the basin. The allocation methodology should be consistent with various legal considerations drawn from applicable case law and attempt to be consistent with groundwater rights, recognizing that GSAs do not have statutory authority to make a final determination of water rights. An equal-per-gross acre approach to allocations is not likely to be consistent with established water rights doctrine, which must recognize many equitable considerations, in addition to acreage owned, to determine a legally defensible allocation. Further information regarding allocation methodology can be found in Groundwater Pumping Allocations Under California's Sustainable Groundwater Management Act – EDF and NCWL, dated July, 2018.

Chapter No. / Page No. of GSP: Section 4.2.3, Page 4-27

Comments:
HFS encourages the development of a coordinated basin-wide data management system (DMS) that is capable of tracking groundwater and surface water use at the landowner, field, or parcel level, and a coordinated methodology for measuring landowner-level use of groundwater. The DMS should also include, or be capable of interfacing with, a groundwater market platform that allows for individual users to conduct transactions. Markets are essential in facilitating the highest and best use of a limited resource and will be most effective if there is trust in the accuracy of measurements and consistency in data sources, and flexibility available to allow for transactions across the basin.

Chapter No. / Page No. of GSP: Section 4.2.3.1, Page 4-28

Comments:

While HFS encourages the use of remote sensing to calculate crop evapotranspiration (ET) as a measurement of consumptive use, we also request the development of methodologies and quality assurance elements to allow for grower provided information to be included into the ET calculation and calibration. These methodologies should be developed in consultation with the vendor providing ET data to ensure it is applicable and useful in creating the best available data set. Additionally, GSAs should establish criteria and procedures to address apparent inaccuracies in the ET calculations. An obvious use of the procedure would be in instances where the grower can demonstrate that applied water, plus precipitation, is less than the calculated ET. In these instances, and subject to any requirements established by the GSA, the grower's use of groundwater should be reduced to the applied water total as the ET calculation should not be greater than applied water.

Chapter No. / Page No. of GSP: Section 4.2.3.2, Page 4-28

Comments:

Section 4.2.3.2 also describes groundwater pumping limits, beginning in 2020, to be imposed by Madera County. Starting in 2020 and continuing through 2025, average annual groundwater pumping is reduced by 2% (of the total demand reduction amount) per year, for a total cumulative reduction of 10% by 2025. Groundwater pumping is reduced by 6% per year starting in 2026 and continuing through 2040 to achieve an estimated reduction in groundwater pumping of 27,550 acre feet per year by 2040.

Chapter No. / Page No. of GSP: Section 4.2.3.2, Page 4-28

Comments:

The GSA should implement pumping restrictions, only if necessary to achieve sustainability, when supported by the best available data and appropriate analytical tools and implement such reductions by gradually ramping down pumping over the implementation period to avoid a sudden disruption in economic activity. The ramp down schedule should include an initial period where current levels of pumping can continue as data is gathered and potential water supply projects are pursued. As with native yield allocations, ramp down schedules should be developed in a coordinated manner across the basin.. Any imposed pumping restrictions should be "eased" or "flexed" during drought periods provided that overdraft during those periods can be replenished.

Chapter No. / Page No. of GSP: Section 4.2.3.2, Page 4-28

Comments:

The GSP lacks sufficient detail in defining how pumping reductions will be applied, measured, enforced and responded to if not met. These are critical details that must be addressed. For example, what is the baseline pumping period that the reductions will be applied to? At a minimum, the baseline period should be multiple years to avoid unnecessary and perhaps unintended penalization of lands in redevelopment or not yet in full demand due to planting schedules. Additionally, there is no significant discussion of how use will be measured and calculated, or of the costs to perform these activities.

Chapter No. / Page No. of GSP:

Comments:

Chapter No. / Page No. of GSP:

Comments:

November 5, 2019

Sent via email to ChowchillaGSPComments@maderacounty.com

Re: Comments on Draft Groundwater Sustainability Plan for Chowchilla Groundwater Basin

To Whom It May Concern,

On behalf of the above-listed organizations, we would like to offer the attached comments on the draft Groundwater Sustainability Plan for the Chowchilla Groundwater Basin. Our organizations are deeply engaged in and committed to the successful implementation of the Sustainable Groundwater Management Act (SGMA) because we understand that groundwater is a critical piece of a resilient California water portfolio, particularly in light of our changing climate. Because California's water and economy are interconnected, the sustainable management of each basin is of interest to both local communities and the state as a whole.

Our organizations have significant expertise in the environmental needs of groundwater and the needs of disadvantaged communities.

- The Nature Conservancy, in collaboration with state agencies, has developed several tools[1] for identifying groundwater dependent ecosystems in every SGMA groundwater basin and has made that tool available to each Groundwater Sustainability Agency.
- Local Government Commission supports leadership development, performs community engagement, and provides technical assistance dealing with groundwater management and other resilience-related topics at the local and regional scales; we provide guidance and resources for statewide applicability to the communities and GSAs we are working with directly in multiple groundwater basins.
- Audubon California is an expert in understanding wetlands and their role in groundwater recharge and applying conservation science to develop multiple-benefit solutions for sustainable groundwater management.
- American Rivers is committed to restoring damaged rivers and conserving clean water for people and nature.

[1] https://groundwaterresourcehub.org/

- Clean Water Action and Clean Water Fund are sister organizations that have deep expertise in the provision of safe drinking water, particularly in California's small disadvantaged communities, and co-authored a report on public and stakeholder engagement in SGMA[2].

Because of the number of draft plans being released and our interest in reviewing every plan, we have identified key plan elements that are necessary to ensure that each plan adequately addresses essential requirements of SGMA. A summary review of your plan using our evaluation framework is attached to this letter as Appendix A. Our hope is that you can use our feedback to improve your plan before it is submitted in January 2020.

This review does not look at data quality but instead looks at how data was presented and used to identify and address the needs of disadvantaged communities (DACs), drinking water and the environment. In addition to informing individual groundwater sustainability agencies of our analysis, we plan to aggregate the results of our reviews to identify trends in GSP development, compare plans and determine which basins may require greater attention from our organizations.

Key Indicators

Appendix A provides a list of the questions we posed, how the draft plan responds to those questions and an evaluation by element of major issues with the plan. Below is a summary by element of the questions used to evaluate the plan.

1. Identification of Beneficial Users. This element is meant to ascertain whether and how DACs and groundwater-dependent ecosystems (GDEs) were identified, what standards and guidance were used to determine groundwater quality conditions and establish minimum thresholds for groundwater quality, and how environmental beneficial users and stakeholders were engaged through the development of the draft plan.
2. Communications plan. This element looks at the sufficiency of the communications plan in identifying ongoing stakeholder engagement during plan implementation, explicit information about how DACs were engaged in the planning process and how stakeholder input was incorporated into the GSP process and decision-making.
3. Maps related to Key Beneficial Uses. This element looks for maps related to drinking water users, including the density, location and depths of public supply and domestic wells; maps of GDE and interconnected surface waters with gaining and losing reaches; and monitoring networks.
4. Water Budgets. This element looks at how climate change is explicitly incorporated into current and future water budgets; how demands from urban and domestic water users were incorporated; and whether the historic, current and future water demands of native vegetation and wetlands are included in the budget.
5. Management areas and Monitoring Network. This element looks at where, why and how management areas are established, as well what data gaps have been identified and how the plan addresses those gaps.
6. Measurable Objectives and Undesirable Results. This element evaluates whether the plan explicitly considers the impacts on DACs, GDEs and environmental beneficial users in the development of Undesirable Results and Measurable Objectives. In addition, it examines

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2 https://www.cleanwater.org/publications/collaborating-success-stakeholder-engagement-sustainable-groundwater-management-act

whether stakeholder input was solicited from these beneficial users during the development of those metrics.

7. Management Actions and Costs. This element looks at how identified management actions impact DACs, GDEs and interconnected surface water bodies; whether mitigation for impacts to DACs is discussed or funded; and what efforts will be made to fill identified data gaps in the first five years of the plan. Additionally, this element asks whether any changes to local ordinances or land use plans are included as management actions.

Conclusion

We know that SGMA plan development and implementation is a major undertaking, and we want every basin to be successful. We would be happy to meet with you to discuss our evaluation as you finalize your Plan for submittal to DWR. Feel free to contact Suzannah Sosman at suzannah@aginnovations.org for more information or to schedule a conversation.

Sincerely,

Jennifer Clary
Water Program Manager
Clean Water Action/Clean Water Fund

Samantha Arthur
Working Lands Program Director
Audubon California

Sandi Matsumoto
Associate Director, California Water Program
The Nature Conservancy

Danielle V. Dolan
Water Program Director
Local Government Commission

Lisa Hunt, Ph.D.
Director of California River Restoration Science
American Rivers

Appendix A
Review of Public Draft GSP

Groundwater Basin/Subbasin: Chowchilla Subbasin (DWR 5-022.05)
GSA: Chowchilla Water District GSA, Madera County GSA, County of Merced Chowchilla GSA, and Triangle T Water District GSA
GSP Date: August 2019 Public Review Draft, dated January 2020

1. Identification of Beneficial Users

Were key beneficial users identified and engaged?

Selected relevant requirements and guidance:
GSP Element 2.1.5, "Notice & Communication" (§354.10):
(a) A description of the beneficial uses and users of groundwater in the basin, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.
GSP Element 2.2.2, "Groundwater Conditions" (§354.16):
(d) Groundwater quality issues that may affect the supply and beneficial uses of groundwater, including a description and map of the location of known groundwater contamination sites and plumes.
(f) Identification of interconnected surface water systems within the basin and an estimate of the quantity and timing of depletions of those systems, utilizing data available from the Department, as specified in Section 353.2, or the best available information.
(g) 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.
GSP Element 3.3, "Minimum Thresholds" (§354.28):
(4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

Review Criteria		Yes	No	N/A	Relevant Info per GSP	Location (Section, Page[1])
1. Do beneficial users (BUs) identified within the GSP area include:	a. Disadvantaged Communities (DACs)		X		"Beneficial users, therefore, are any stakeholders who have an interest in groundwater use and management in the Chowchilla Subbasin community. Their interest may be related to GSA activities, GSP development and implementation, and/or water access and management in general. To assist in identifying categories of beneficial uses and users in the Chowchilla Subbasin, the Communications and Engagement Plan included a Stakeholder Engagement chart (Table 2-4)."	2.1.5.2, page 75;
	b. Tribes		X		Disadvantaged communities and tribes are included as examples of stakeholder groups in Table 2-4 Stakeholder Engagement Chart for GSP Development. However, the draft GSP does not identify the specific DACs or Tribes in the subbasin and does not include detailed descriptions of these. Table 2-4 also includes small community systems, but the GSP does not clearly define what they are and how are they considered as beneficial users.	Table 2-4, page 76
	c. Small community public water systems (<3,300 connections)	X			Appendix 2.C "Notice and Communication" of the draft GSP states that "The Chowchilla Subbasin has been identified by the California Department of Water Resources (DWR) as a high-priority and critically-overdrafted subbasin with conditions of historical groundwater level declines, land subsidence, and groundwater quality degradation. The area has a substantial agricultural	Appendix 2.C, page 49

[1] Page numbers refer to the page of the PDF.

					community heavily reliant on groundwater. Nearly 79 percent of the Subbasin is designated as part of a severely disadvantaged community (SDAC) and approximately 30 percent of the Subbasin (primarily in the northern and southern central parts of the Subbasins and also around the City of Chowchilla) is designated as part of a DAC". However, the GSP still needs to identify DACs in the main GSP and throughout the discussions of the development of sustainable management criteria.	
2. What data were used to identify presence or absence of DACs?	a. DWR DAC Mapping Tool[2]			X	The draft GSP does not identify DACs.	
	i. Census Places			X		
	ii. Census Block Groups			X		
	iii. Census Tracts			X		
	b. Other data source			X		
3. Groundwater Conditions section includes discussion of:	a. Drinking Water Quality	X			"The U.S. Environmental Protection Agency (USEPA) has established a maximum contaminant level (MCL) for nitrate (as nitrogen) of 10 mg/L under its National Primary Drinking Water Regulations; this MCL standard is established for public health reasons and is a requirement of all public drinking water systems. Total Dissolved Solids (TDS) is a general measure of salinity and overall water quality. Elevated salinity in groundwater can be a result of land use activities, but can also be naturally-occurring, especially in western parts of the San Joaquin Valley where subsurface geologic materials are derived from marine sediments. Arsenic is a naturally occurring chemical found in groundwater and has a primary MCL of 10 mg/L." "A large percentage of the wells with nitrate data have maximum historical concentrations below 7.5 mg/L and many have concentrations below 5 mg/L. However, a number of areas of locally high nitrate concentrations above 7.5 mg/L or above 10 mg/L are apparent across the subbasin. The higher concentrations appear to be more common in the central parts of the subbasin. Several notable areas with a high density of wells with nitrate concentrations above the MCL of 10 mg/L (as N) are located in the more central parts of the subbasin to the west and southwest of the City of Chowchilla and between Ash Slough and Highway 152." "Although there are a few wells with higher arsenic concentrations above 7.5 µg/L, most of the wells with data have concentrations below 5 µg/L with a considerable number having concentrations of less than 2.5 µg/L. The available groundwater quality data do not indicate any wells with arsenic concentrations above the MCL of 10 µg/L. The map of arsenic concentrations in the Lower Aquifer (Figure 2-65) suggest that concentrations of arsenic may be somewhat higher in the Lower Aquifer, although still generally below the MCL."	2.2.2.3, page 92; 2.2.2.3, page 93; 2.2.2.3, page 94
	b. California Maximum Contaminant Levels (CA MCLs)[3] (or Public Health	X			See above.	2.2.2.3, page 92-94

[2] DWR DAC Mapping Tool: https://gis.water.ca.gov/app/dacs/
[3] CA MCLs: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/MCLsandPHGs.html

	Goals where MCL does not exist, e.g. Chromium VI)					
4. What local, state, and federal standards or plans were used to assess drinking water BUs in the development of Minimum Thresholds (MTs)?	a. Office of Environmental Health Hazard Assessment Public Health Goal (OEHHA PHGs)[4]		X			
	b. CA MCLs[3]	X			"In accordance with the Basin Plan, groundwater in the Subbasin is considered suitable or potentially suitable for municipal and domestic water supply (MUN), agricultural supply (AGR), industrial service supply (IND), and industrial process supply (PRO) beneficial uses. From a groundwater quality standpoint, the municipal and domestic supply beneficial use is the most restrictive with Basin Plan water quality objectives linked to drinking water MCLs. As a result, the minimum thresholds for groundwater quality set for each of the three identified key water quality constituents (nitrate, arsenic, TDS) are the respective MCL values, except for cases where existing or historical concentrations for these constituents already exceed the MCL. When existing or historical concentrations for the key constituents already exceed the MCL, the minimum threshold is set at the current concentration plus 20 percent. When current or historical water quality for the key constituents has not been measured, the minimum threshold will be set as the MCL and will be adjusted if needed after water quality monitoring commences."	3.3.4.1, page 189
	c. Water Quality Objectives (WQOs) in Regional Water Quality Control Plans		X			
	d. Sustainable Communities Strategies/ Regional Transportation Plans[5]		X			
	e. County and/or City General Plans, Zoning Codes and Ordinances[6]		X			
5. Does the GSP identify how environmental BUs and environmental stakeholders were engaged throughout the development of the GSP?		X			The GSP authors have listed environmental agencies and environmental groups as one of the beneficial users of groundwater in the Subbasin in Table 2-4. The following footnote was added to the table: "The groups and communities referenced are examples identified during initial assessment. GSA Interested Parties lists shall maintain current and more exhaustive lists of stakeholders fitting into these groups." Environmental groups should be expanded in a manner similar to the environmental justice groups in the Human Right to Water category. The GSP should expand the stakeholder list associated with the Environmental and Ecosystem Uses category in Table 2-4 to include the appropriate agencies and list of environmental groups.	Table 2-4, page 75-76

Summary/ Comments

The Appendix 2.C of the draft GSP indicates that a majority of the subbasin area is considered to be DACs, however, the specific DACs are not clearly identified in the GSP. The GSP should explicitly provide a detailed description of how the DACs were identified, the names and locations of the communities and details of the population in the communities and how they use groundwater. Without this information, it is not clear how the GSP can consider the needs of these beneficial users. The GSP should also identify

[4] OEHHA PHGs: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/MCLsandPHGs.html
[5] CARB: https://ww2.arb.ca.gov/resources/documents/scs-evaluation-resources
[6] OPR General Plan Guidelines: http://www.opr.ca.gov/planning/general-plan/

other sensitive drinking water users, such as tribes and small community water systems, if any are present in the subbasin. If community water systems are present, the GSP should include information on the number of service connections and/or population served by each water system. This information is valuable for the reader to understand the scale of the vulnerable population dependent on groundwater for drinking water.

Environmental groups identified in the GSP should be expanded in a manner similar to the environmental justice groups in the Human Right to Water category. The GSP should expand the stakeholder list associated with the Environmental and Ecosystem Uses category in Table 2-4 to include the appropriate agencies and list of environmental groups. The GSP should expand the stakeholder list associated with the Environmental and Ecosystem Uses category in Table 2-4 to include the appropriate agencies and list of environmental groups.

The GSP should expand the stakeholder list associated with the Environmental and Ecosystem Uses category in Table 2-4 to include the appropriate agencies and list of environmental groups.

The types and locations of environmental uses, species and habitats supported, instream flow requirements, and other designated beneficial environmental uses of surface waters that may be affected by groundwater extraction in the Subbasin should be specified. To identify environmental users, please refer to the following:

- The NC Dataset (https://gis.water.ca.gov/app/NCDatasetViewer/) which identifies the potential presence of groundwater dependent ecosystems in this basin
- The list of freshwater species located in the Chowchilla Subbasin can be found here: https://groundwaterresourcehub.org/sgma-tools/environmental-surface-water-beneficiaries/. Especially take note of the species with protected status.
- CDFW's California Natural Diversity Database (CNDDB) - https://www.wildlife.ca.gov/Data/CNDDB
- USFWS's IPAC report for the Chowchilla Area - https://ecos.fws.gov/ipac/

Lands that are protected as open space preserves, habitat reserves, wildlife refuges, etc. or other lands protected in perpetuity and supported by groundwater or interconnected surface waters should be identified and acknowledged.

2. Communications Plan

How were key beneficial users engaged and how was their input incorporated into the GSP process and decisions?

Selected relevant requirements and guidance: GSP Element 2.1.5, "Notice & Communication" (§354.10): *Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:* *(c) Comments regarding the Plan received by the Agency and a summary of any responses by the Agency.* *(d) A communication section of the Plan that includes the following:* *(1) An explanation of the Agency's decision-making process.* *(2) Identification of opportunities for public engagement and a discussion of how public input and response will be used.* *(3) A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin.* *(4) The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.* **DWR Guidance Document for GSP Stakeholder Communication and Engagement**[7]

Review Criteria	Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Is a Stakeholder Communication and Engagement Plan (SCEP) included?	X			"To facilitate stakeholder involvement in the GSA process, a Communication and Engagement Plan (Appendix 2) was created for the GSAs in the Chowchilla Subbasin" "Chowchilla Subbasin Stakeholder Communication and Engagement Plan August 2019"	2.1.5.1, page 74; Appendix 2.C, page 49
2. Does the SCEP or GSP identify that ongoing engagement will be conducted during GSP implementation?	X			"The Chowchilla Subbasin GSP Advisory Committee (Advisory Committee) was formed in 2018 to bring together local agencies and related parties vested with the authority and/or ability to support implementation of SGMA in the Subbasin… The GSAs agreed to hire a professional facilitator from California State University, Sacramento, to provide third-party facilitation support for GSP development and implementation, particularly to advance the GSAs' stakeholder engagement efforts." "A list of stakeholders and beneficial users is to be developed and updated throughout the GSP planning, implementation and enforcement processes. Each GSA is required to maintain a singular list, however coordinating these lists into a single Subbasin list will improve stakeholder engagement. Timely notification of opportunities for interested parties to participate in the development and implementation of the GSP should be given via the channels and strategies described in this document."	Appendix 2.C, page 49; Appendix 2.C, page 56; Appendix 2.C,

[7] DWR Guidance Document for GSP Stakeholder Communication and Engagement https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Guidance-Document-for-Groundwater-Sustainability-Plan---Stakeholder-Communication-and-Engagement.pdf

				"Chowchilla Subbasin GSAs recognize that stakeholder input into the development and implementation of a GSP is critical, as well as a SGMA requirement. As such, stakeholders are welcome to participate in the Chowchilla Subbasin GSP Advisory Committee meetings. Roundtables can also be used to best incorporate Chowchilla Subbasin stakeholder/beneficial user input into the GSP development and implementation process."	page 62
3. Does the SCEP or GSP specifically identify how DAC beneficial users were engaged in the planning process?		X		The GSP does not indicate specifically how DAC beneficial users were engaged during the planning process. Table 2-4. Stakeholder Engagement Chart for GSP Development in the GSP or named Table 1: Stakeholder Engagement Chart for GSP Development in Appendix 2.C includes DACs and the "Engagement purpose", which is "Inform and involve to provide a safe and secure groundwater supplies to all communities reliant on groundwater". The SCEP describes the planned strategy to engage DACs but the GSP does not explicitly identify efforts made during the planning process in terms of being "DAC outreach." However, as identified below, outreach included assistance by Self-Help Enterprises and the Leadership Counsel for Justice and Accountability, which focus on outreach to DAC beneficial users.	Table 2-4, page 75; Appendix 2.C, page 51
4. Does the SCEP or GSP explicitly describe how stakeholder input was incorporated into the GSP process and decisions?	X			"Subbasin-wide Technical meetings: Subbasin-wide technical meetings were held throughout the GSP development process to provide opportunities for the public to learn about the SGMA process and GSP components, receive updates about GSP planning activities, and provide input on GSP development. These meetings often included presentations by the GSP preparation consultants about technical aspects of GSP preparation, on topics such as basin setting, water budgets, and undesirable results. . . . There were also activities related to encouraging involvement and building capacity for engagement, including the following activities organized in coordination with Self-Help Enterprises and the Leadership Counsel for Justice and Accountability: • Capacity-building workshops: Workshops encouraged and prepared community members to participate in GSP development by providing technical information as well as information about opportunities for engagement. • Educational tours: Tours provided members of the public with additional opportunities to hear about the concerns of people with differing perspectives. Tours included stops in the community of Fairmead, La Vina, a farm, and at a groundwater recharge basin. • Presentations in communities: Self-Help Enterprises and the Leadership Counsel for Justice and Accountability both encouraged participation in GSP preparation through presentations held in communities around the Subbasin." "Chowchilla Subbasin GSAs recognize that stakeholder input into the development and implementation of a GSP is critical, as well as a SGMA requirement. As such, stakeholders are welcome to participate in the Chowchilla Subbasin GSP Advisory Committee meetings.	2.1.5.3, page 77; Appendix 2.C, page 62

				Roundtables can also be used to best incorporate Chowchilla Subbasin stakeholder/beneficial user input into the GSP development and implementation process. The circumstances of the Chowchilla Subbasin are such that each of the four GSAs has different resources, responsibilities, capacities, and stakeholder representation to take into consideration as they form Subbasin committees and workgroups, and coordinate among themselves for the GSP. There is a need to identify tools and processes whereby GSAs and their beneficial users are given fair representation while the resources and capacities of each GSA, as well as beneficial users, are taken into account. To this end, voluntary participation in Chowchilla Subbasin GSP Advisory Committee meetings by stakeholders will be helpful. Additional roundtable sessions or workgroups may be developed on specific topics as needed and identified through stakeholder outreach and engagement activities."	

Summary/ Comments

The GSP describes the methods used to disseminate information but does not explicitly describe engagement of DAC members in such terms. It is recommended that further details of how DACs were engaged be provided in the GSP, and what level of participation was achieved.

The GSP states that stakeholder input was incorporated; however, detailed information about stakeholder input and responses from the GSA to address the stakeholder input are not presented.

3. Maps Related to Key Beneficial Uses

Were best available data sources used for information related to key beneficial users?

Selected relevant requirements and guidance:
GSP Element 2.1.4 "Additional GSP Elements" (§354.8):
Each Plan shall include a description of the geographic areas covered, including the following information:
(a) One or more maps of the basin that depict the following, as applicable:
(5) The density of wells per square mile, by dasymetric or similar mapping techniques, showing the general distribution of agricultural, industrial, and domestic water supply wells in the basin, including de minimis extractors, and the location and extent of communities dependent upon groundwater, utilizing data provided by the Department, as specified in Section 353.2, or the best available information.

GSP Element 3.5 Monitoring Network (§354.34)
(b) Each Plan shall include a description of the monitoring network objectives for the basin, including an explanation of how the network will be developed and implemented to monitor groundwater and related surface conditions, and the interconnection of surface water and groundwater, with sufficient temporal frequency and spatial density to evaluate the affects and effectiveness of Plan implementation. The monitoring network objectives shall be implemented to accomplish the following:
(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:
(1) Chronic Lowering of Groundwater Levels. Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods:
(A) A sufficient density of monitoring wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.
(4) Degraded Water Quality. Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues.
(6) Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. The monitoring network shall be able to characterize the following:
(A) Flow conditions including surface water discharge, surface water head, and baseflow contribution.
(B) Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.
(C) Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.
(D) Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.
(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:
(3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.

Review Criteria		Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Does the GSP Include Maps Related to Drinking Water Users?	a. Well Density	X			"The densities of domestic wells and irrigation wells per section within the Chowchilla Subbasin are shown in Figures 2-4 and 2-5, respectively. Notably, the number of wells reported by section were determined from Well Completion Report (WCR) data provided by DWR. These numbers include only reported wells and may not reflect the total number of existing or active wells in the subbasin. The highest concentrations of domestic wells are centered primarily along the southern side of the City of Chowchilla. Irrigation wells are generally less concentrated and more evenly distributed across the subbasin, though slightly higher concentrations are found in sectors within the western portions of Madera Co GSA and CWD GSA. Maps of general locations of domestic, agricultural, and public supply wells are provided	2.1.1, page 57 Figures 2-4, 2-5, and 2-6

					in Figures 2-4, 2-5, and 2-6." "Maps of the average depths of domestic, agricultural, and public supply wells by section are provided in Figures 2-43, 2-44, and 2-45. These maps generally indicated the majority of domestic wells are located in the central to eastern portions of the subbasin, agricultural wells are relatively spread out throughout the entire subbasin, and public supply wells are concentrated in the central to eastern portions of the subbasin. Domestic well depths are variable across the subbasin, with the most common well depth in the 300 to 400-foot range. Similarly, agricultural well depths are variable across the subbasin, with the most common well depths in the 500 to 750-foot range. Public supply wells are most commonly in the 500 to 750-foot depth range."	2.2.1.5, page 86
	b. Domestic and Public Supply Well Locations & Depths	**X**			Well locations are shown on the density maps identified above. "Maps of the average depths of domestic, agricultural, and public supply wells by section are provided in Figures 2-43, 2-44, and 2-45."	2.2.1.5, page 86 Figures 2-43, 2-44, and 2-45
	i. Based on DWR Well Completion Report Map Application[8]?	**X**			"The densities of domestic wells and irrigation wells per section within the Chowchilla Subbasin are shown in Figures 2-4 and 2-5, respectively. Notably, the number of wells reported by section were determined from Well Completion Report (WCR) data provided by DWR. These numbers include only reported wells and may not reflect the total number of existing or active wells in the subbasin."	2.1.1, page 57
	ii. Based on Other Source(s)?		**X**			

[8] DWR Well Completion Report Map Application: https://www.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37

2. Does the GSP include maps related to Groundwater Dependent Ecosystem (GDE) locations?	a. Map of GDE Locations	X			"A DTW cutoff of 30 feet was used in the initial screening of potential GDEs. The use of a 30-foot DTW criterion to identify potential GDEs is based on reported maximum rooting depths of California phreatophytes and is consistent with guidance provided by The Nature Conservancy (Rohde et al. 2018) for identifying potential GDEs." ● 30-ft criteria from TNC Guidance: In TNC's GDE Guidance, the depth criterion of 30 feet is presented as a criterion for inclusion, not a standalone criterion for exclusion. In other words, if groundwater is within 30 feet of the ground surface, then a GDE can be identified. If it is not, then further analysis must be conducted (see Appendix III of the GDE Guidance, Worksheet 1, for other indicators of GDEs). ● 30-ft as maximum rooting depths of California phreatophytes: Please use care when considering rooting depths of vegetation. While Valley Oak (Quercus lobata) have been observed to have a max rooting depth of ~24 feet (https://groundwaterresourcehub.org/gde-tools/gde-rooting-depths-database-for-gdes/), rooting depths are likely to spatially vary based on the local hydrologic conditions available to the plant. Also, max rooting depths do not take capillary action into consideration, which will vary with soil type and is an important consideration since woody phreatophytes generally do not like to have their roots submerged in groundwater for extended periods of time, and hence can access groundwater at deeper depths. In addition, while it is likely to be true that shallow water availability is necessary to support the recruitment of saplings, hydraulic lift of groundwater to shallow depths has been observed in Quercus spp. 2016 is after the SGMA benchmark date of January 1, 2015. The GSP should rely on groundwater condition data prior to the SGMA benchmark date. It is highly recommended using depth to groundwater data from multiple seasons and water year types (e.g., wet, dry, average, drought) to determine the range of depth to groundwater around NC dataset polygons. Refer to TNC's guidance on Identifying GDEs Under SGMA (https://groundwaterresourcehub.org/public/uploads/pdfs/TNC_NCdataset_BestPracticesGuide_2019.pdf) for best practices for using local groundwater data to verify whether polygons in the NC Dataset are supported by groundwater in an aquifer. If insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset, include those polygons in the GSP until data gaps are reconciled in the monitoring network. While depth to groundwater levels within 30 feet are generally accepted as being a proxy for confirming that polygons in the NC dataset are connected to groundwater, it is highly advised that seasonal and interannual groundwater fluctuations in the groundwater regime are taken into consideration. Utilizing groundwater data from one or two points in time can misrepresent groundwater levels required by GDEs, and inadvertently result in adverse impacts to the GDEs. Based on a study we recently submitted to Frontiers in Environmental Science Journal, we've observed riparian forests along the Cosumnes River to experience a range in groundwater levels between 1.5 and 75 feet over seasonal and interannual timescales. Seasonal fluctuations in the regional water table can support perched groundwater near an intermittent river that seasonally runs dry due to large seasonal fluctuations in the regional water table. While perched groundwater itself cannot directly be managed due to its position in the vadose zone, the water table position within the regional aquifer (via pumping rate restrictions, restricted pumping at certain depths, restricted pumping around GDEs, well density rules) and its interactions with surface water	2.2.2.6, page 95 Figure 2-72

					(e.g., timing and duration) can be managed to prevent adverse impacts to ecosystems due to changes in groundwater quality and quantity under SGMA. The depth to groundwater contour maps (Figures 2-70 and 2-71) show large areas of data gaps, given the marked data points on the map where data exists. These maps were used to exclude all GDEs located adjacent to Chowchilla River, Ash Slough, and Berenda Slough (Figure 1 of Appendix 2.B). As stated above, if insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset, include those polygons in the GSP until data gaps are reconciled in the monitoring network.	
	b. Map of Interconnected Surface Waters (ISWs)		**X**		"A review of historical regional aquifer groundwater levels compared to stream thalweg (deepest portion of stream channel) elevations conducted for this study indicate that surface water – groundwater interactions are not a significant issue (i.e., regional groundwater levels are relatively far below creek thalweg elevations) along Chowchilla River, Ash Slough, and Berenda Slough in Chowchilla Subbasin." ISWs are best estimated by first determining which reaches are completely disconnected from groundwater. This approach would involve comparing groundwater elevations with a land surface Digital Elevation Model that could identify which surface waters have groundwater consistently below surface water features, such that an unsaturated zone would separate surface water from groundwater. Groundwater elevations that are always deeper than 50 feet below the land surface can be used to identify the above ground reaches as disconnected surface waters. The GSP should provide further evidence that that ISWs are not present along Chowchilla River, Ash Slough, and Berenda Slough, such as a cross-section or corresponding hydrographs to show the relationship between the river channel and the depth to groundwater at wells near the rivers. Figures 2-70 and 2-71 present depth to shallow groundwater for 2014 and 2016. There are large data gaps over the Chowchilla Subbasin, particularly for 2016 (Figure 2-71). The GSP should further describe how these figures were developed, specifically noting the following best practices for developing depth to groundwater contours presented in Attachment D. Specifically, ensure that the first step is contouring groundwater elevations, and the subtracting this layer from land surface elevations from a DEM to estimate depth to groundwater contours across the landscape. This will provide much more accurate contours of depth-to-groundwater along streams and other land surface depressions where GDEs are commonly found. Depth to groundwater contours developed from depth to groundwater measurements at wells assumes that the land surface is constant, which is a poor assumption to make. The regulations [23 CCR §351(o)] define interconnected surface waters (ISW) 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". "At any point" has both a spatial and temporal component. Even short durations of interconnections of groundwater and surface water can be crucial for surface water flow and supporting environmental users of groundwater and surface water. The GSP states in several places that the San Joaquin River is losing in the section adjacent to the Subbasin, and uses this as evidence that ISWs do not exist. However, ISWs can be either gaining or losing. To improve ISW mapping, The GSP should reconcile data gaps (shallow monitoring wells, stream gauges, and nested/clustered wells) along surface water features in the Monitoring Network section of the GSP. "It is likely that seepage from the San Joaquin River is the source of water that combined with the presence of shallow clay layers that serves to maintain shallow groundwater levels at these	2.2.2.5, page 94
	i. Does it identify which reaches are gaining and which are losing?			**X**		
	ii. Depletions to ISWs are quantified by stream segments.			**X**		
	iii. Depletions to ISWs are quantified seasonally.			**X**		

					locations." The GSP should provide estimates of current and historical surface water depletions for ISWs quantified and described by reach, season, and water year type.	
3. Does the GSP include maps of monitoring networks?	a. Existing Monitoring Wells	X			Maps of Existing and Historical Groundwater Monitoring Programs are included in the Appendix 2.E.	Appendix 2.E, page 24-26
	b. Existing Monitoring Well Data sources: i. California Statewide Groundwater Elevation Monitoring (CASGEM)	X			"Groundwater level monitoring has been conducted historically by variety of entities in the Subbasin including Chowchilla Water District, Madera County, Triangle T Water District, DWR, USBR, and Geospacer GAMA. The California State Groundwater Elevation Monitoring Program (CASGEM) was initiated in 2011, with the Madera-Chowchilla Groundwater Monitoring Group as the local monitoring entity. This Group includes Chowchilla Water District and the County, along with other entities in Madera Subbasin. Groundwater levels are collected and submitted each Fall and Spring as part of the CASGEM program."	2.1.2.3, page 65
	ii. Water Board Regulated monitoring sites		X			
	iii. Department of Pesticide Regulation (DPR) monitoring wells	X			"Groundwater quality monitoring has historically been conducted by a variety of entities in the Subbasin including the City of Chowchilla and other public drinking water suppliers, regulated facility operators and other contaminant site monitoring for the RWQCB, the East San Joaquin Water Quality Coalition (the third-party entity representing growers in the area) as part of the Irrigated Lands Regulatory Program (ILRP), USGS for the Groundwater Ambient Monitoring and Assessment Program (GAMA), and other programs under the direction of agencies such as the RWQCB, DPR, EPA, DTSC, USGS. Some historical groundwater quality monitoring has also been conducted by well owners in the Subbasin for other purposes."	2.1.2.3, page 65
	c. SGMA-Compliance Monitoring Network	X			"A map of the subbasin showing the overall groundwater level monitoring network is provided in Appendix 3.A, along with a table listing each well. Figures 3-5 and 3-6 illustrate the locations of the wells selected as representative monitoring sites for monitoring of groundwater levels in the Upper and Lower aquifers, respectively (composite wells are included in Figure 3-1)." "The representative monitoring sites for groundwater quality include a combination of irrigation, public supply, domestic, and monitoring wells to be sampled and analyzed by the Subbasin GSAs together with wells that are sampled by others as part of other groundwater quality monitoring programs. The selected RMS for groundwater quality are listed in Table 3-7 and shown on Figure 3-2. Information on well construction and historical groundwater quality monitoring for each of the indicator wells is included in Appendix 3.B."	3.5.1.1, page 200; Figure 3-1 3.5.1.4, page 205; Figure 3-2
	i. SGMA Monitoring Network map includes identified DACs?		X		The maps showing proposed Monitoring Network in the draft GSP do not include DACs. The draft GSP does not identify DACs.	
	ii. SGMA Monitoring Network map includes identified GDEs?		X		The maps showing proposed Monitoring Network in the draft GSP do not include GDEs.	

Summary/ Comments

Providing maps of the monitoring network overlaid with location of DACs, domestic wells, community water systems, GDEs, and any other sensitive beneficial users will allow the reader to evaluate the adequacy of the network to monitor conditions near these beneficial users.

The comprehensive evaluation of the San Joaquin River Riparian GDE unit following TNC's guidance, including analyzing hydrologic conditions, ecological conditions, providing an inventory of species and ecological value, along with concurrent field studies and reconnaissance, is appreciated. We also appreciate the use of TNC's GDE Pulse to examine

NDVI and NDMI trend data for the GDE polygons within the GDE unit.

The GSP should rely on groundwater condition data prior to the SGMA benchmark date.

The GSP should provide more details on how depth to groundwater contour maps were developed (Figures 2-70 and 2-71):

- Are the wells used for interpolating depth to groundwater sufficiently close (<5km) to NC Dataset polygons to reflect local conditions relevant to ecosystems?
- Are the wells used for interpolating depth to groundwater screened within the surficial unconfined aquifer and capable of measuring the true water table?
- Is depth to groundwater contoured using groundwater elevations at monitoring wells to get groundwater elevation contours across the landscape? This layer can then be subtracted from land surface elevations from a Digital Elevation Model (DEM) to estimate depth-to-groundwater contours across the landscape. This will provide much more accurate contours of depth-to-groundwater along streams and other land surface depressions where GDEs are commonly found. Depth to groundwater contours developed from depth to groundwater measurements at wells assumes that the land surface is constant, which is a poor assumption to make. It is better to assume that water surface elevations are constant in between wells, and then calculate depth to groundwater using a DEM of the land surface to contour depth to groundwater.

If insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset, include those polygons in the GSP until data gaps are reconciled in the monitoring network.

The GSP should provide further evidence that that ISWs are not present along Chowchilla River, Ash Slough, and Berenda Slough, such as a cross-section or corresponding hydrographs to show the relationship between the river channel and the depth to groundwater at wells near the rivers.

To improve ISW mapping, the GSP should reconcile data gaps (shallow monitoring wells, stream gauges, and nested/clustered wells) along surface water features in the Monitoring Network section of the GSP.

The GSP should provide estimates of current and historical surface water depletions for ISWs quantified and described by reach, season, and water year type.

4. Water Budgets

How were climate change projections incorporated into projected/future water budget and how were key beneficial users addressed?

Selected relevant requirements and guidance:
GSP Element 2.2.3 "Water Budget Information" (Reg. § 354.18)
Each Plan shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form.

*Projected water budgets shall be used to estimate future baseline conditions of supply, **demand**, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:*
(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:
(5) If overdraft conditions occur, as defined in Bulletin 118, the water budget shall include a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions.
(6) The water year type associated with the annual supply, demand, and change in groundwater stored.
(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:
*(1) Current water budget information shall quantify current inflows and outflows for the basin using the most recent hydrology, water supply, **water demand**, and land use information.*

DWR Water Budget BMP[9]
DWR Guidance for Climate Change Data Use During GSP Development and Resource Guide[10]

Review Criteria	Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Are climate change projections explicitly incorporated in future/ projected water budget scenario(s)?	X			"To evaluate sensitivity to climate change, projected water budgets were also developed using: 1. Historical hydrologic data from water years 1965-2015 adjusted by DWR-provided 2030 mean climate change factors40 2. Historical water supply data from 1989-2015 adjusted similarly by climate change factors, with additional adjustment of CVP supply based on projected alteration of available Friant Releases by the San Joaquin River Restoration Program 3. 2017 land use adjusted for urban area projected growth from 2017 through 2070 (areas were held constant from 2071 through 2090)"	2.2.3.2, page 112
2. Is there a description of the methodology used to include climate	X			"To evaluate sensitivity to climate change, projected water budgets were also developed using:	

[9] DWR BMP for the Sustainable <management of Groundwater Water Budget: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-4-Water-Budget.pdf
[10] DWR Guidance Document for the Sustainable Management of Groundwater Guidance for Climate Change Data Use During GSP Development: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Climate-Change-Guidance_Final.pdf

change?					1. Historical hydrologic data from water years 1965-2015 adjusted by DWR-provided 2030 mean climate change factors40 2. Historical water supply data from 1989-2015 adjusted similarly by climate change factors, with additional adjustment of CVP supply based on projected alteration of available Friant Releases by the San Joaquin River Restoration Program 3. 2017 land use adjusted for urban area projected growth from 2017 through 2070 (areas were held constant from 2071 through 2090)"	
3. What is used as the basis for climate change assumptions?	a. DWR-Provided Climate Change Data and Guidance[11]	X			"Climate change factors are from the DWR CalSim II simulated volume projections from State Water Project (SWP) and CVP operations under the 2030 mean climate change scenario."	2.2.3.2, page 112
	b. Other		X			
4. Does the GSP use multiple climate scenarios?			X		The draft GSP does not consider different climate scenarios, except that "Two primary projected water budget scenarios were considered: a projected without projects (no action) scenario, and a projected with projects scenario."	
5. Does the GSP quantitatively incorporate climate change projections?		X			"Table 2-25 provides a summary of the average annual inflows, outflows, change in GWS storage, and overdraft estimated at the subbasin-level in the historical, current, projected without projects, and projected with projects water budgets. This table also provides an estimate of subbasin sustainable yield from the projected with projects water budget." "Detailed projected with projects with climate change water budget results for Chowchilla Subbasin are presented in Appendix D.3.a. and Appendix D.3.c., and groundwater elevation hydrographs at select wells are included in Appendix E.2." "Detailed projected with climate change water budget results for Chowchilla Subbasin are presented in Appendix D.5.a. and Appendix D.5.c., and groundwater elevation hydrographs at select wells are included in Appendix E.4."	2.2.3.4, page 144 Appendix 6.E., page 242-243
6. Does the GSP explicitly account for climate change in the following elements of the	a. Inflows: i. Precipitation	X			"The development of projected timeseries for precipitation, evapotranspiration, and surface water flows are briefly summarized in Tables 2-23 and 2-24 below." The tables include projected climate change adjustments for precipitation,	Table 2-23 and Table 2-24, page 142-144
	ii. Surface Water	X				
	iii. Imported Water	X				
	iv. Subsurface Inflow		X			

[11] DWR Guidance Document for the Sustainable Management of Groundwater Guidance for Climate Change Data Use During GSP Development: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Climate-Change-Guidance_Final.pdf
DWR Resource Guide DWR-Provided Climate Change Data and Guidance for Use During GSP Development: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Resource-Guide-Climate-Change-Guidance_v8.pdf

future/projected water budget?	b. Outflows: i. Evapotranspiration	X			evaporation, surface water inflow, diversions from Madera Canal, and other diversions/bypasses.	
	ii. Surface Water Outflows (incl. Exports)		X			
	iii. Groundwater Outflows (incl. Exports)		X			
7. Are demands by these sectors (drinking water users) explicitly included in the future/projected water budget?	a. Domestic Well users (<5 connections)		X		The demands by drinking water users are not explicitly identified in the projected water budget.	
	b. State Small Water systems (5-14 connections)		X			
	c. Small community water systems (<3,300 connections)		X			
	d. Medium and Large community water systems (> 3,300 connections)		X			
	e. Non-community water systems		X			
8. Are water uses for native vegetation and/or wetlands explicitly included in the current and historical water budgets?			X		"…while for native vegetation lands, groundwater extraction by riparian vegetation was considered to be negligible because of the depth to groundwater in the subbasin." Because there are potential GDEs included in the Chowchilla Subbasin, the GSP should quantify the evapotranspiration from groundwater by riparian vegetation even if small.	2.2.3, page 134
9. Are water uses for native vegetation and/or wetlands explicitly included in the projected/future water budget?			X			

Summary/ Comments

Given the uncertainties of climate change, it is appropriate to analyze the impacts of climate change for a range of scenarios (e.g., a mild effects scenario and a high (worst case) effects scenario).

Based on the data presented, it is not clear how climate change is expected to affect specific elements of the water budget (i.e., subsurface flows, surface water and groundwater outflows, including exports).

The water budget does not include future water demands for drinking water users, including residential wells and small community water systems, and by doing so has omitted key drinking water beneficial users from consideration of future conditions. The GSP should incorporate and make reasonable demand projection assumptions relative to historic water demand and future growth projections for these drinking water users, including DACs.

Because there are potential GDEs included in the Chowchilla Subbasin, the GSP should quantify the evapotranspiration from groundwater by riparian vegetation even if small. The text and water budget should be revised as necessary to reflect this.

5. Management Areas and Monitoring Network

How were key beneficial users considered in the selection and monitoring of Management Areas and was the monitoring network designed appropriately to identify impacts on DACs and GDEs?

Selected relevant requirements and guidance:
GSP Element 3.3, "Management Areas" (§354.20):

(b) A basin that includes one or more management areas shall describe the following in the Plan:
(2) The minimum thresholds and measurable objectives established for each management area, and an explanation of the rationale for selecting those values, if different from the basin at large.
(3) The level of monitoring and analysis appropriate for each management area.
(4) An explanation of how the management area can operate under different minimum thresholds and measurable objectives without causing undesirable results outside the management area, if applicable.
(c) If a Plan includes one or more management areas, the Plan shall include descriptions, maps, and other information required by this Subarticle sufficient to describe conditions in those areas.

CWC Guide to Protecting Drinking Water Quality under the SGMA[12]
TNC's Groundwater Dependent Ecosystems under the SGMA, Guidance for Preparing GSPs[13]

Review Criteria	Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Does the GSP define one or more Management Area?	X			"Chowchilla Subbasin was divided into two management areas – the Western Management Area and the Eastern Management Area. The primary differences between these two management areas in terms of Sustainable Management Criteria are related to land subsidence and GDEs." However, the draft GSP does not provide a map showing the Management Areas identified. The GSP includes references to a description of the management areas in Section 2.2.4; however, this section does not appear to have been included in the public review draft.	3.2.7, page 175
2. Were the management areas defined specifically to manage GDEs?	X			"Chowchilla Subbasin was divided into two management areas – the Western Management Area and the Eastern Management Area. The primary differences between these two management areas in terms of Sustainable Management Criteria are related to land subsidence and GDEs. … A single GDE unit occurs in the Western Management Area along the San Joaquin River, and there are no GDE units in the Eastern Management Area. Because GDEs are present in only one of the two management areas, there are no concerns about the basin operating under different MOs for GDEs in the two management areas.	3.2.7, page 175

[12] CWC Guide to Protecting Drinking Water Quality under the SGMA: https://d3n8a8pro7vhmx.cloudfront.net/communitywatercenter/pages/293/attachments/original/1559328858/Guide_to_Protecting_Drinking_Water_Quality_Under_the_Sustainable_Groundwater_Management_Act.pdf?1559328858
[13] TNC's Groundwater Dependent Ecosystems under the SGMA, Guidance for Preparing GSPs: https://www.scienceforconservation.org/assets/downloads/GDEsUnderSGMA.pdf

				Thus, there will be no inconsistencies caused by setting of measurable objectives for the two different management areas. Differences in management area measurable thresholds for land subsidence and GDEs is discussed below in the section on Minimum Thresholds."	
3. Were the management areas defined specifically to manage DACs?		X			
a. If yes, are the Measurable Objectives (MOs) and MTs for GDE/DAC management areas more restrictive than for the basin as a whole?	X			"Groundwater level is the sustainability indicator most likely to affect GDEs in the subbasin. The subbasin's single GDE unit, the San Joaquin River Riparian GDE Unit, is located along the San Joaquin River in the Western Management Area (see Section 2.2.2.6 and Appendix 6.D). Groundwater in the GDE unit is tightly coupled with surface flow and runoff and is generally maintained at depths within the maximum rooting depth range of the dominant phreatophytic species present in the unit (see Section 2.2.2). The groundwater that is potentially accessible to the vegetation composing the GDE unit likely occurs as a shallow perched/mounded aquifer fed largely by percolation of surface flow from the San Joaquin River. As described in Section 2.2.5, it has been determined that a connection between regional groundwater and streams does not currently exist in the subbasin. However, there remains some potential for shallow groundwater and the associated GDE Unit to be affected by pumping from the regional aquifer (although the risk of this potential impact is considered low). Therefore, measurable objectives for the shallow Upper Aquifer wells in closest proximity to the San Joaquin River Riparian GDE Unit (SJRRP_MW-10-89, SJRRP_MW-11-161, and SJRRP_MW-11-163) are included in the list of RMS and are considered representative of groundwater conditions that could affect the GDE unit." "The Western Management area, which has had significant historic impacts to infrastructure related to subsidence, is subject to initial subsidence-based minimum thresholds. […] For the Eastern Management Area, with no historic subsidence-related impacts, subsidence will be monitored through an adaptive management approach."	3.2.1.1, page 158 3.3.3.1, page 185-186
b. If yes, are the proposed management actions for GDE/DAC management areas more restrictive/ aggressive than for the basin as a whole?		X		The GSP does not appear to have more restrictive / aggressive management actions for GDE/DAC management areas.	
4. Does the GSP include maps or descriptions indicating what DACs are located in each Management Area(s)?		X			
5. Does the GSP include maps or descriptions indicating what GDEs are located in each Management Area(s)?		X			
6. Does the plan identify gaps in the monitoring network for DACs and/or GDEs?	X			"Data gaps relative to GDEs can be characterized as incomplete information on the extent to which the vegetation composing the San Joaquin River GDE Unit may be impacted by occurrence of temporary short-term declines in shallow groundwater levels below historical lows. Biological monitoring, recommended every five years, will be used to evaluate potential beneficial or adverse effects on GDEs that may be related to changes in future groundwater conditions during the Implementation and Sustainability Periods." The draft GSP does not identify monitoring network for DACs.	3.5.4.2, page 216

a. If yes, are plans included to address the identified deficiencies?	X			Per the GSP Regulations (23 CCR §354.34 (a) and (b)), monitoring must address trends in groundwater and related surface conditions (emphasis added). Groundwater level monitoring alone may be insufficient to establish a linkage between groundwater extraction and potentially resulting impacts to environmental resources associated with GDEs and ISWs. The cause-effect relationship between groundwater levels and the biological responses that could result in significant and unreasonable impacts to ISWs and GDEs depends on a number of complicated factors, and this relationship is not characterized or discussed. The Monitoring Network section currently does not address future needs for ISW monitoring. In addition to the need for additional shallow monitoring wells in the upper aquifer to map GDEs, there is also a need to enhancing monitoring of stream flow and vertical groundwater gradients by installing more stream gauges and clustered/nested wells near streams, rivers or wetlands. Ideally, co-locating stream gauges with wells that can monitor groundwater levels in both the upper and lower aquifers would enhance understanding about where ISWs exist in the basin and whether pumping is causing depletions of surface water or impacts on beneficial users of surface water and groundwater. The GSP should provide sufficient detail for the investigation and monitoring program including stream gauges, screened intervals and frequency of monitoring, in order to describe monitoring of both the extent of ISWs and the quantity of surface water depletions from ISWs. The depth to groundwater contour maps (Figures 2-70 and 2-71) show large areas of data gaps, given the marked data points on the map where data exists. These maps were used to exclude all GDEs located adjacent to Chowchilla River, Ash Slough, and Berenda Slough (Figure 1 of Appendix 2.B). The GSP should therefore propose additional upper aquifer wells to reconcile this data gap.	

Summary/ Comments

The draft GSP appears to be incomplete, and does not include Section 2.2.4, which is referenced in Table 1-1 and Table 1-5 as containing the description of management areas, maps of the areas, etc. This information must be included in the GSP per 23 CCR § 354.20.

For transparency, the GSP should explicitly identify (preferably via maps) the extents of identified DACs and potential GDEs located within each separate Management Area; the GSP should also clearly present the proposed MOs and MTs in the two management areas (e.g., in Tables 3-2, 3-3, 3-4, etc.), and if the MOs and MTs for the GDE management area are more or less restrictive.

The GSP should provide sufficient detail for the investigation and monitoring program including stream gauges, screened intervals and frequency of monitoring, in order to describe monitoring of both the extent of ISWs and the quantity of surface water depletions from ISWs.

The GSP should propose additional upper aquifer wells to reconcile the data gap shown in Figure 2-70 and Figure 2-71.

6. Measurable Objectives, Minimum Thresholds, and Undesirable Results

How were DAC and GDE beneficial uses and users considered in the establishment of Sustainable Management Criteria?

<u>Selected relevant requirements and guidance:</u>
GSP Element 3.4 "Undesirable Results" (§ 354.26):
(b) The description of undesirable results shall include the following:
(3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results

GSP Element 3.2 "Measurable Objectives" (§ 354.30)
(a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.

Review Criteria	Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Are DAC impacts considered in the development of Undesirable Results (URs), MOs, and MTs for groundwater levels and groundwater quality?		X		The draft GSP does not explicitly describe impacts to DACs, although impacts to drinking water users and domestic well users are discussed. WL MTs: "Groundwater level minimum thresholds are likely to have several effects on beneficial uses, users, land use, and property owners. Those expected to be impacted include agricultural land use and users, urban land use and users, domestic land use and users, and ecological land use and users. Overall agricultural land use and users will be significantly impacted in terms of increased costs to design and construct recharge projects and in terms of reduced crop yields from required reductions in consumptive use for irrigation. While conversion of current agricultural lands to urban areas that may occur in the future will tend to reduce per acre water demands, it is likely that urban water users will need to continue water conservation efforts due to limited water supplies. Domestic well owners can generally expect to see declining groundwater levels during the initial 10 to 15 years of the Implementation Period, followed by stabilization of water levels during the latter portion of the Implementation Period and some potential recovery in groundwater levels after 2040. However, significant adverse impacts to domestic wells from declining groundwater levels are expected to be addressed through a temporary domestic well mitigation program currently under consideration by the GSAs (Appendix 3.C). The economic analyses conducted to compare costs of implementing a domestic well mitigation program versus immediately requiring full implementation of demand reduction in 2020 is provided in Appendix 3.C." WQ MTs: "Significant and unreasonable degradation of water quality occurs when beneficial uses for groundwater are adversely impacted by constituent concentrations increasing to levels above the drinking water MCLs for one of the key constituents (nitrate, arsenic, TDS) previously identified in Section 2 of	3.3.1.4, page 182 3.3.4.4, page 188-189

				the GSP at indicator wells in the representative groundwater quality monitoring network due to implementation of a GSP project or management action. When existing or historical concentrations for the key constituents already exceed the MCL, the minimum threshold is set at the recent concentration plus 20 percent." "Municipal and domestic supply is the most restrictive beneficial use standard for groundwater quality with water quality objectives equal to drinking water MCLs. Setting the groundwater quality minimum thresholds for key constituent concentrations at respective drinking water MCLs, or within a tolerance for no more than a 20 percent increase above historical concentrations when existing or historical concentrations already exceed the MCL, is intended to limit degradation of groundwater quality caused by GSP projects and management actions in order to protect municipal and domestic supply beneficial uses. Protection of municipal and domestic beneficial uses is also protective of all other groundwater beneficial uses." WL UR: "For the Chowchilla Subbasin, the chronic lowering of groundwater levels undesirable result is defined as a relationship between frequency of groundwater elevation minimum threshold exceedances at a given RMS, and the number of RMS locations experience the exceedances at the same time. Using the Fall measurements (assumed to be collected in October), a groundwater elevation undesirable result is defined to occur when greater than 30% of the RMS each exceed the groundwater level minimum thresholds for the same two consecutive Fall readings. Given a total of 36 RMS sites, a total of 11 or more the RMS would need to exceed MTs as defined above to constitute an undesirable result for chronic lowering of groundwater levels. As the number of RMS evolves over time (e.g., adding nested monitoring well sites), the total number of RMS that have to exceed their MTs will change accordingly." WQ UR: "Degraded water quality is significant and unreasonable if the magnitude of degradation precludes the use of groundwater for existing beneficial use(s). Therefore, an undesirable result for degraded groundwater quality occurs when groundwater quality exceeds an established MCL and minimum threshold for arsenic, nitrate, or TDS for a significant duration of time and at a significant number of representative monitoring sites and is the direct result of projects or management actions undertaken as part of the GSP implementation. An exceedance of a minimum threshold at a given representative monitoring site is defined based on the average concentration over a three-year monitoring period. An undesirable result for degraded groundwater quality is greater than 10 percent of representative groundwater quality monitoring wells exceeding the minimum threshold for a given key constituent related to a GSP project or management action."	3.4.1, page 195; 3.4.4, page 197
2. Does the GSP explicitly discuss how stakeholder input from DAC community members was considered in the development of URs, MOs, and MTs?		X		According to the draft GSP, stakeholder input was considered for developing the URs, MOs, and MTs. However, input received from DACs is not explicitly identified or described and it is thus not clear what extent these community	3, page 155;

				members were actively engaged in the process. "The SMC presented in this chapter were developed using information from stakeholder and public input and correspondence with the GSAs, public meetings, hydrogeologic analysis, and meetings with GSA technical experts. The general process for establishing SMC included: • GSA public meetings that outlined the GSP development process and introduced stakeholders to the SMC • Conducting public meetings to present proposed methodologies to establish minimum thresholds and measurable objectives and receive additional public input. Two public meetings on SMC were held in the Subbasin • Reviewing public input on preliminary SMC methodologies with GSA staff/technical experts • Providing a Draft GSP for public review and comment • Establishing and modifying minimum thresholds, measurable objectives, and definition of undesirable results based on feedback from public meetings, public/stakeholder review of the Draft GSP, and input from GSA staff/technical experts." "The methodology to develop minimum thresholds for groundwater levels was based on discussion with GSA staff and technical representatives, input received from interested stakeholders and the public through public meetings, individual public/stakeholder input to various GSA representatives, and a meeting with DWR."	 3.3.1.1, page 179
3. Does the GSP explicitly consider impacts to GDEs and environmental BUs of surface water in the development of MOs and MTs for groundwater levels and depletions of ISWs?		X		"Groundwater in the GDE unit is tightly coupled with surface flow and runoff and is generally maintained at depths within the maximum rooting depth range of the dominant phreatophytic species present in the unit (see Section 2.2.2). The groundwater that is potentially accessible to the vegetation composing the GDE unit likely occurs as a shallow perched/mounded aquifer fed largely by percolation of surface flow from the San Joaquin River. As described in Section 2.2.5 [should be 2.2.2.5], it has been determined that a connection between regional groundwater and streams does not currently exist in the subbasin." Section 2.2.2.5 does not present evidence that ISWs do not exist in the Subbasin, and states that a historical connection between groundwater and the San Joaquin River did exist through 2008. The GSP fails to establish measurable objectives or minimum thresholds for this sustainability indicator. The existence of riparian GDEs along the streams in the basin has been identified in Appendix 2.B, and their connection to groundwater is assumed. Their occurrence in the riparian zone means that these GDEs should be considered a beneficial user of groundwater that could be affected by chronic groundwater level decline as discussed above, as well as beneficial users of surface water that could be depleted by groundwater extraction. A more robust discussion of the known facts regarding these surface-groundwater interactions in the riparian zone should be provided. In addition, more detailed discussion regarding specific data gaps should be included.	3.2.1.1, page 158;

				There is a need to evaluate and discuss potential effects on beneficial uses of surface and groundwater. In addition, the applicable state, federal and local standards for the protection of aquatic, riparian and other protected habitats should be discussed. This is necessary, at a minimum, so that the nature of the data gaps can be understood. See https://groundwaterresourcehub.org/sgma-tools/environmental-surface-water-beneficiaries/ for a list of freshwater species in Chowchilla Subbasin that may be exist within ISWs. It is recommended that after identifying which freshwater species exist in your basin, especially federal and state listed species, that you contact staff at the Department of Fish and Wildlife (DFW), United States Fish and Wildlife Service (USFWS) and/or National Marine Fisheries Services (NMFS) to obtain their input on the groundwater and surface water needs of the organisms on the freshwater species list. Because effects to plants and animals are difficult and sometimes impossible to reverse, we recommend erring on the side of caution to preserve sufficient groundwater conditions to sustain GDEs and ISWs. Refer to the Critical Species Lookbook[14] to review and discuss the potential groundwater reliance of critical species in the basin. The analysis for ISWs should include all beneficial users of surface water that could be affected by groundwater withdrawals, including environmental. Refer to the San Joaquin River Restoration Program (SJRRP) that identifies instream flow needs for salmon. The GSP should include instream flow requirements in this section and whether the measurable objectives and interim milestones will help achieve the sustainability goal as it pertains to the environment. This Minimum Threshold does not consider water quality needs of GDEs. “Protection of municipal and domestic beneficial uses is also protective of all other groundwater beneficial uses.” The GSP should elaborate on this statement and include a discussion about GDEs and water quality and whether the measurable objectives and interim milestones will help achieve the sustainability goal as it pertains to the environment. “Therefore, the surface water depletion sustainability criteria is not applicable to the subbasin.” However, no evidence is provided in the GSP to show that a hydraulic connection between groundwater and surface water does not exist. Following the discussion presented above for, the GSP should include a discussion of Sustainable Management Criteria for ISWs, including Minimum Thresholds, in the GSP. Cite data gaps regarding ISWs and make plans to reconcile them in the Monitoring Section of the GSP.	3.3.4.4, page 189; 3.3.5, page 193
4. Does the GSP explicitly consider impacts GDEs and environmental BUs of surface water and recreational lands in the discussion and development of Undesirable Results?		X		The draft GSP only describes undesirable results relating to human beneficial uses of groundwater and neglects environmental beneficial uses that could be adversely affected by chronic groundwater level decline. The GSP should add “potential adverse impacts to GDEs” to the list of potential undesirable results presented in Table 3-8 .	

[14] Available online at: https://groundwaterresourcehub.org/sgma-tools/the-critical-species-lookbook/

				"Using the Fall measurements (assumed to be collected in October), a groundwater elevation undesirable result is defined to occur when greater than 30% of the RMS [representative monitoring sites] each exceed the groundwater level minimum thresholds for the same two consecutive Fall readings. Given a total of 36 RMS sites, a total of 11 or more the RMS would need to exceed MTs as defined above to constitute an undesirable result for chronic lowering of groundwater levels." The use of 30 percent to define an undesirable result does not allow for the occurrence of low water levels in one area, such as near a GDE, to be an Undesirable Result, which may impact environmental beneficial use. There are three RMS near the San Joaquin River Riparian GDE unit, which could be evaluated separately. The GSP should consider the use of a separate management area for the San Joaquin River Riparian GDE unit so that different sustainable management criteria can be established for this GDE unit. The following is a link to a paper by Smith, Knight and Fendorf (2018) titled "Overpumping leads to California groundwater arsenic threat": (https://www.nature.com/articles/s41467-018-04475-3). The section should be modified to state that overpumping and dewatering of aquitards has been identified as a potential source of elevated arsenic concentrations above drinking water standards in San Joaquin Valley aquifers. In addition, any potential undesirable results from degradation of water quality that may impact GDEs and freshwater species in the area should be discussed in this section. The GSP should include a discussion of Sustainable Management Criteria for ISWs, including Undesirable Results, in the GSP. The GSP should cite data gaps regarding ISWs and make plans to reconcile them in the Monitoring Section of the GSP.	3.4.1, page 195
5. Does the GSP clearly identify and detail the anticipated degree of water level decline from current elevations to the water level MOs and MTs?		X		The GSP does not discuss the anticipated water level decline. However, Appendix 3.A. provides hydrographs which include information on current water levels, MTs/MOs, and depths of domestic wells.	
6. If yes, does it include: b. Is this information presented in table(s)?		X			
c. Is this information presented on map(s)?		X			
d. Is this information presented relative to the locations of DACs and domestic well users?		X			
e. Is this information presented relative to the locations of ISW and GDEs?		X			
2. Does the GSP include an analysis of the anticipated impacts of water level MOs and MTs on drinking water users?	X			"In the Chowchilla subbasin, 127 domestic wells are impacted in the without-SGMA case, but 87 of those appear to be impacted prior to the 2020 implementation start (DTW is greater than minimum depth to top perforation). Therefore, 40 (127 minus 87) wells are potentially affected in the comparison of scenarios. Thirty out of the 40 wells are impacted between 2021 and 2033, with the remaining 10 impacted by 2066. The present value (at 2020) of replacement costs for the 40 wells is $0.69 million. All but seven	Appendix 3.C., page 60
3. If yes: a. On domestic well users?	X				
b. On small water system production wells?		X			
c. Was an analysis conducted and clearly illustrated (with maps) to identify what wells would be		X			

	expected to be partially and fully dewatered at the MOs?				well replacements are avoided in the with-SGMA scenario. The present value of replacement cost for these is $0.13 million. The net well replacement cost avoided by the draft proposed GSP implementation plan is $0.56 million in present value." No maps are included and no explicit comparison to MOs and MTs is presented.	
d.	Was an analysis conducted and clearly illustrated (with maps) to identify what wells would be expected to be partially and fully dewatered at the MTs?		X			
e.	Was an economic analysis performed to assess the increased operation costs associated with increased lift as a result of water level decline?	X			The GSP includes a discussion of well replacement costs (see above) and reduced pumping costs due to SGMA implementation. "This analysis applies an aggregate calculation of change in water depth and pumping cost, using an average depth over all sections (weighted by well count in each section). As DTW decreases in the with-SGMA scenario relative to without-SGMA, the benefit (reduced pumping lift and cost) grows year to year. Both domestic wells and agricultural users benefit from this, though the agricultural cost saving is many times greater simply due to volume pumped. A more precise estimate can be created using an estimate of agricultural and domestic pumping in each section. For the Chowchilla Subbasin, benefits after 10 years are about $105,000 per year in total for all domestic well pumping and $3.29 million per year for agricultural pumping. The present value of savings over the analysis period is about $5.94 million for domestic pumping and $169.84 million for agricultural pumping. These savings are small relative to the loss of net return from demand management (see Table 1), so the benefit of achieving them sooner does not appear to be justified by implementing demand management sooner."	Appendix 3.C., page 61

Summary/ Comments

Based on the presented information, domestic well uses are considered under URs and for the development of water level MOs and MTs, but input from DAC members is not explicitly identified or discussed. More detail and specifics regarding DAC members, including those that rely on smaller community drinking water systems, not only domestic wells, is necessary to demonstrate that these beneficial users were adequately considered.[15] The GSP should discuss whether and how input from DAC members was considered and incorporated into the development of undesirable results, MOs, and MTs.

The GSP should present a thorough, robust, and transparent analysis, supported by maps, that identifies: (1) which domestic wells are likely to be impacted at the MTs and at the MOs, and (2) the location of the likely impacted wells with respect to DACs and other communities and systems dependent on groundwater.

The draft GSP should include more detailed information about the potential impacts on sensitive drinking water users, such as 1) where the likely impacted wells are located, 2) what communities are most affected (including DACs), 3) an estimate of the size of the population that relies on these domestic wells, or 4) if the creation of a new or expanded community water system could address some or all of the population affected by the loss of domestic wells.

[15] Community Water Center and Stanford School of Earth, Energy, and the Environmental Sciences, *Groundwater Quality in the Sustainable Groundwater Management Act (SGMA): Scientific Factsheet on Arsenic, Uranium, and Chromium,* https://d3n8a8pro7vhmx.cloudfront.net/communitywatercenter/pages/293/attachments/original/1560371896/CWC_FS_GrndwtrQual_06.03.19a.pdf?1560371896; Community Water Center, *Guide to Protecting Drinking Water Quality Under the Sustainable Groundwater Management Act,* https://d3n8a8pro7vhmx.cloudfront.net/communitywatercenter/pages/293/attachments/original/1559328858/Guide_to_Protecting_Drinking_Water_Quality_Under_the_Sustainable_Groundwater_Management_Act.pdf?1559328858.

A more robust discussion of the known facts regarding these surface-groundwater interactions in the riparian zone should be provided. In addition, more detailed discussion regarding specific data gaps should be included.

It is recommended that after identifying which freshwater species exist in your basin, especially federal and state listed species, that you contact staff at the Department of Fish and Wildlife (DFW), United States Fish and Wildlife Service (USFWS) and/or National Marine Fisheries Services (NMFS) to obtain their input on the groundwater and surface water needs of the organisms on the freshwater species list. Because effects to plants and animals are difficult and sometimes impossible to reverse, we recommend erring on the side of caution to preserve sufficient groundwater conditions to sustain GDEs and ISWs. Refer to the Critical Species Lookbook to review and discuss the potential groundwater reliance of critical species in the basin.

The analysis for ISWs should include all beneficial users of surface water that could be affected by groundwater withdrawals, including environmental. Refer to the San Joaquin River Restoration Program (SJRRP) that identifies instream flow needs for salmon. The GSP should include instream flow requirements in this section and whether the measurable objectives and interim milestones will help achieve the sustainability goal as it pertains to the environment.

The GSP should include a discussion of Sustainable Management Criteria for GDE and ISWs, including MOs, MTs and Undesirable Results, in the GSP.

7. Management Actions and Costs

What does the GSP identify as specific actions to achieve the MOs, particularly those that affect the key BUs, including actions triggered by failure to meet MOs? What funding mechanisms and processes are identified that will ensure that the proposed projects and management actions are achievable and implementable?

Selected relevant requirements and guidance
GSP Element 4.0 Projects and Management Actions to Achieve Sustainability Goal (§ 354.44)
(a) Each Plan shall include a description of the projects and management actions the Agency has determined will achieve the sustainability goal for the basin, including projects and management actions to respond to changing conditions in the basin.
(b) Each Plan shall include a description of the projects and management actions that include the following:
(1) A list of projects and management actions proposed in the Plan with a description of the measurable objective that is expected to benefit from the project or management action.

Review Criteria	Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Does the GSP identify benefits or impacts to DACs as a result of identified management actions?	X			“Implementing projects and management actions to achieve sustainability objectives specified in the GSP will increase irrigation water costs and limit the quantity of water available for farming in some parts of the Chowchilla Subbasin. This will impact agriculture and create ripple effects across all sectors of the Madera County[54] economy, including County tax revenues and jobs that support many of the County’s disadvantaged communities.	5.4, page 269
2. If yes: f. Is a plan to mitigate impacts on DAC drinking water users included in the proposed Projects and Management Actions?		X		“With groundwater levels anticipated to decline further during the Implementation Period as projects are implemented and demand reduction programs expand, the subbasin GSAs are in the process of developing a temporary domestic well mitigation program (Appendix 3.C). By 2040 and during the sustainability period, groundwater levels are expected to stabilize	3.3.1, page 175

					and potentially rebound, thus the domestic well mitigation program is not anticipated to be needed beyond the implementation period." Appendix 3.C. identifies that a domestic well mitigation program may be developed.	 Appendix 3.C.
g.	Does the GSP identify costs to fund a mitigation program?	X			Section 2.1 and 3.1 of Appendix 3.C. discuss the costs for a potential domestic well mitigation program. "In addition to funding GSA activities, GSP updates, and ongoing monitoring and reporting, GSA's will develop and implement projects and management actions to provide groundwater benefits for the Subbasin (see Figure 5-2) … The capital cost of each project and management action is summarized and discussed in more detail in Chapter 4. Figure 5-3 illustrates the capital outlay required to implement all of the projects specified in the GSP. The figure indicates the year that the projects would be completed and begin operation, not when all the capital cost would be incurred. The total capital cost of all projects equals approximately $325 million. The GSP implementation plan includes significant outlays when large recharge and storage projects are planned for development by multiple GSAs. These capital costs do not include the cost of developing the Madera County GSA demand management program or the cost of demand management (economic impacts from land idling and crop switching) under that program." "Madera County is currently developing the demand management program and assessing potential costs. Since the details are still under development, project costs cannot be estimated at this time, but demand management is anticipated to require substantial County administration and implementation budgets. Costs to measure pumping and monitor groundwater conditions are part of overall GSP management and not imposed by this program. The most significant cost of the demand management program falls on agricultural groundwater pumpers (growers) and the regional economy. An economic impact analysis of the demand management program has estimated average annual direct economic costs at $32 million per year. This represents reduced net returns to crop production resulting from demand management. It does not include indirect and induced economic impacts to other businesses, employees, and the Madera County regional economy."	Appendix 3.C., page 60-63 5.4, page 270; 4.2.3.5, page 248
h.	Does the GSP include a funding mechanism to support the mitigation program?	X			"The program would be funded by fees and external support including grants and low interest loan." "Madera County will conduct economic and fiscal feasibility studies as part of its ongoing planning efforts to better understand willingness and ability to pay for the projects included in the GSP. Demand management program costs will be covered through grants and fees on groundwater pumpers. To cover project costs, Madera County will pursue available state and federal	Appendix 3.C., page 62 4.2.4, page 248

					grants or loans to help construct projects. The remaining construction costs will be financed through issuance of bonds, to be repaid from revenues raised through water fees and other assessments. Operation and maintenance costs will be paid using revenues raised through water fees and other assessments. Madera County will conduct the necessary studies and decision processes (including Proposition 218 elections) to approve fees or assessments to provide the required funding. To cover demand management program costs, Madera County will obtain available state and federal grants or loans to help set up and test the program. Any remaining set-up cost will be paid for using revenues raised through fees and assessments. Water trading program operating costs may be paid using a per-unit fee on trades or using revenues raised through fees and assessments. Madera County will conduct the necessary studies and decision processes (including Proposition 218 elections) to approve rates, fees, or assessments to provide the required funding."	
4. Does the GSP identify any demand management measures in its projects and management actions?		X			"A demand management action is described for the Madera County GSA, though the other GSAs within the Subbasin can also use it as needed to attain sustainability. The demand management action provides groundwater users a flexible way to meet any future pumping restrictions."	4, page 217
5. If yes, does it include:	a. Irrigation efficiency program	X			"The Madera County demand management program will reduce consumptive water use (measured as evapotranspiration, ET) over the GSP implementation period. Demand management actions that reduce consumptive use can include changing to lower water-using crops, water-stressing crops (providing less water than the crop would normally consume for full yield), reducing evaporation losses, and reducing irrigated acreage. However, Madera County will not dictate which of those reduction methods growers would implement. Madera County's primary approach to demand management is to set demand reduction targets for the GSA service area as a whole, based on conditions in the Subbasin. Achieving the targets can be approached through a variety of methods, including groundwater allocations, internal groundwater markets (e.g. limited to within the GSA), fee structures, and fallowing programs. The County seeks a balance of individual flexibility and GSA-wide accountability. Pumping will be monitored and enforced by Madera County to ensure compliance with the demand reduction targets and sustainability objectives. California Water Code §10726.4 (a)(2) provides the Madera County GSA with the authority to control groundwater extractions by regulating, limiting, or suspending extractions from individual groundwater wells or extractions from groundwater wells in the aggregate. The following principles are guiding development of the demand management program. These are in no order of preference and Madera County recognizes tradeoffs exist among these principles. • Minimize the economic impacts of any demand management required in Madera County • Maintain established water rights • Incentivize investment in water supply infrastructure • Incentivize economically efficient water use	4.2.3.1, page 244
	b. Ag land fallowing (voluntary or mandatory)	X				
	c. Pumping allocation/restriction	X				
	d. Pumping fees/fines	X				
	e. Development of a water market/credit system	X				
	f. Prohibition on new well construction		X			
	g. Limits on municipal pumping		X			
	h. Limits on domestic well pumping		X			
	i. Other		X			

					• Incentivize recharge in aggregate, and in specific regions • Allow sufficient program flexibility for groundwater pumpers to adjust over time • Ensure access to domestic water supply (de minimis domestic use as defined by SGMA is less than 2 acre-feet annually per user)"	
6. Does the GSP identify water supply augmentation projects in its projects and management actions?		X			"Three types of projects are included in the Chowchilla Subbasin GSP for implementation: recharge, conveyance, and storage (Table 4-1). Recharge projects are designed to support sustainability by increasing recharge. Conveyance projects facilitate the delivery of additional water supplies to increase recharge or use for irrigation, thereby reducing groundwater pumping. Storage projects store additional water supplies to increase recharge or use for irrigation, thereby reducing groundwater pumping. Some projects have a specific water source, but many of the recharge projects can draw from the same general sources. A section at the end of this chapter describes and quantifies available water from the potential sources."	4, page 217
7. If yes, does it include:	a. Increasing existing water supplies	X			"As part of the San Joaquin River Restoration Program, Reclamation, working with CWD, investigated the feasibility of expanding Eastman Lake[53]. The purpose of the project is to enlarge the capacity of Eastman Lake by approximately 50 thousand acre-feet (from 150 to 200 TAF). The additional capacity would allow for additional deliveries to CWD, and CWD would deliver water to growers to reduce groundwater pumping within the CWD service area. However, the additional deliveries would partially offset the availability of flood flows which are used for groundwater recharge benefits under other CWD projects (recharge basins and Flood-MAR). CWD will assess these tradeoffs under future project planning efforts."	4.1.5, page 232
	b. Obtaining new water supplies	X			"The County GSA would directly acquire or facilitate the acquisition of approximately 5,000 acre-feet of new surface water supplies that would be available for diversion from Millerton during an irrigation season. The water would be acquired from a water supplier with rights/contracts for water from Millerton, or from another water supplier whose supply can be exchanged with water from Millerton. The water would be conveyed to Madera County East parcels that are within ½ mile of an existing major water delivery system (e.g. Madera Canal, CWD delivery system, natural stream course). Water would be conveyed to the various locations under a conveyance agreement entered into with CWD and others, as may be appropriate. Diversion and conveyance facilities would be constructed to serve the lands not currently within the delivery system of a district. The 5,000 acre-feet would be expected to serve the irrigation needs of approximately 3,000 to 5,000 acres of currently irrigated lands – depending on the irrigation needs of the properties."	4.2.2.1, page 240
	c. Increasing surface water storage	X			"As part of the San Joaquin River Restoration Program, Reclamation, working with CWD, investigated the feasibility of expanding Eastman Lake[53]. The purpose of the project is to enlarge the capacity of Eastman Lake by approximately 50 thousand acre-feet (from 150 to 200 TAF). The additional capacity would allow for additional deliveries to CWD, and CWD would deliver water to growers to reduce groundwater pumping within the CWD service area. However, the additional deliveries would partially offset the availability of flood flows which are used for groundwater recharge benefits under other	4.1.5, page 232

					CWD projects (recharge basins and Flood-MAR). CWD will assess these tradeoffs under future project planning efforts."	
	d. Groundwater recharge projects – District or Regional level	X			"CWD will construct groundwater recharge basins totaling about 1,000 acres, distributed throughout its service area. Locations and sizes of basins will be selected based on land uses, access to delivery facilities, and soils having appropriate percolation rates. Sites will be selected to maximize recharge efficiency and benefits to the Subbasin groundwater system." "Flood-MAR is a groundwater recharge approach in which flood water available during winter and spring months is spread on agricultural or other suitable land for percolation to groundwater. The project is distinct from recharge basins that will be developed by CWD because existing land uses would be maintained, no basins would be constructed, and existing delivery facilities would be used. However, both projects rely on the same sources of supply: flood flows that are typically available in the winter and early spring that would have otherwise left the Subbasin." "Madera County will develop recharge basins. Water will be diverted off the Eastside Bypass into basins where it will percolate into the deep aquifer. The size, location, and performance of Madera County recharge basins depends on site-specific characteristics that are currently being assessed by Madera County. Madera County will develop recharge basins to maximize recharge efficiency to ensure maximum net recharge benefits stay within the Subbasin." "The project proposes to develop infrastructure and up to 300 acres of recharge ponds within the SVMWC area, or nearby lands, that could be used to recharge Chowchilla River flood flows during the winter months of wet years. SVMWC would keep track of the amount of water recharged and stored underground. In dry years, the recharged water would be pumped and used by landowners to irrigate the approximately 3,500 acres of irrigated farmland within SVMWC. Recharge ponds are assumed to recharge 4.6 inches of water per day when operating at full capacity." "The recharge basins are being developed under an OES Federal Emergency Management Agency (FEMA) grant. The project proposes to develop infrastructure and 310 acres of recharge ponds within the Red Top area that would allow San Joaquin/Fresno River flood flows to be stored in the shallow aquifer. The stored water would be pumped in dry years to reduce pumping from beneath the Corcoran Clay layer, in order to reduce overdraft and mitigate land subsidence. Recharge ponds can accept approximately 500 acre-feet of additional water per day when operating at full capacity from existing and new turnouts and facilities." "Water available to recharge projects in the Chowchilla Subbasin was evaluated following the process described in Appendix 4.F. In summary, four sources of water are available for the recharge and water supply projects: combined flood releases and Section 215 water from	4.1.1.1, page 220; 4.1.2.1, page 223; 4.2.1, page 237; 4.3.1.1, page 239; 4.4.1.1, page 253; 4.5, page 258

				Millerton Lake and Buchanan Dam, Eastside Bypass flows, Fresno River flood flows to Triangle T Water District, and water purchases. A summary of the total projected water available, the projected water committed to projects, and the expected water remaining after the projects recharge or use the water committed is provided below for each water source."	
e. On-farm recharge		X			
f. Conjunctive use of surface water		X			
g. Developing/utilizing recycled water		X			
h. Stormwater capture and reuse	X			"Flood-MAR is a groundwater recharge approach in which flood water available during winter and spring months is spread on agricultural or other suitable land for percolation to groundwater. The project is distinct from recharge basins that will be developed by CWD because existing land uses would be maintained, no basins would be constructed, and existing delivery facilities would be used. However, both projects rely on the same sources of supply: flood flows that are typically available in the winter and early spring that would have otherwise left the Subbasin."	4.1.2.1, page 223;
i. Increasing operational flexibility (e.g., new interties and conveyance)	X			"Water conveyance facilities consisting of a canal, pipeline and appurtenant facilities would be constructed to convey water from Merced Irrigation District (Merced ID) to CWD. CWD would then use that water within its service area in-lieu of groundwater pumping, or for recharge (basins or Flood-MAR), depending on conditions at the time water is available. The most likely option is that water would be acquired from Merced ID by short-term or long-term contract and delivered to CWD for direct irrigation use, thereby reducing groundwater demand within CWD's service area." "The Madera Canal is 36 miles in length. The first 7 miles are concrete lined and the remaining 29 miles are earth lined. The capacity at the head of the canal is 1,275 cfs and the capacity at the end is 600 cfs. The capacity of the first three siphons are 1,500 cfs with the remainder of the siphons and drop structures having capacities gradually declining to 935 cfs. This project would increase the capacity at the head of the canal to 1,500 cfs, with capacities gradually declining to 750 cfs at the end."	4.1.3.1, page 227; 4.1.4.1, page 230
j. Other		X			
8. Does the GSP identify specific management actions and funding mechanisms to meet the identified MOs for groundwater quality and groundwater levels?	X			The Subbasin area includes GDEs and ISWs that are beneficial uses and users of groundwater, and may include potentially sensitive resources and protected lands. Environmental resource protection needs should be considered in establishing project priorities. In addition, consistent with existing grant and funding guidelines for SGMA-related work, priority should be given to multi-benefit projects that can address water quantity as well as providing environmental benefits or benefits to disadvantaged communities. The GSP should include environmental benefits and multiple benefits as criteria for assessing project priorities.	4, page 217
9. Does the GSP include plans to fill identified data gaps by the first five-year report?	X			"Data gaps have been presented in the groundwater level, groundwater storage, land subsidence, and groundwater quality monitoring networks. The following steps will be taken to address these data gaps: • Madera County is in process of adding seven new nested monitoring well	3.5.4.3, page 216

				sites with up to three well completions at each site (total of up to 27 new monitoring wells) within the subbasin. These new wells will address many of the data gaps described in the Upper and Lower Aquifers for groundwater level and quality data (Figures 3-1 and 3-2). • The GSAs will install sampling taps (as needed) on groundwater level wells designated for groundwater quality monitoring. These wells will then be sampled for both groundwater elevation data and groundwater quality data. • Sampling events will be coordinated with well owners to prevent pumping and access issues. In addition to these steps, the monitoring networks will be evaluated on a yearly and five-year basis. If additional data gaps arise, the GSA will consider the implications of these gaps, associated costs, and importance to the continued implementation of the GSP and take appropriate actions to address the gaps."	
10. Do proposed management actions include any changes to local ordinances or land use planning?		X		Potential new regulations or ordinances are still under development by the GSAs. "GSAs are continuing to monitor, manage, and collaborate to meet sustainability goals specified in the GSP. Within their allowed authorities, GSAs are evaluating new regulations or ordinances that could be implemented to help achieve sustainability objectives. Any changes in regulations or ordinances will be summarized in the periodic update. The effect on any aspect of the GSP, including the basin setting, measurable objectives, minimum thresholds, or undesirable results will be described. The five-year periodic evaluation will include a summary of state laws and regulations or local ordinances related to the GSP that have been implemented since the previous periodic evaluation and address how these may require updates to the GSP. Enforcement or legal actions taken by the GSAs in relation to the GSP will be summarized along with how such actions support sustainability in the Subbasin."	5.6.3, page 274
11. Does the GSP identify additional/contingent actions and funding mechanisms in the event that MOs are not met by the identified actions?		X			
12. Does the GSP provide a plan to study the interconnectedness of surface water bodies?		X		"For depletion of interconnected surface waters, available data indicate that streams in the Subbasin do not have direct connections to the regional groundwater system; therefore, this GSP does not provide monitoring for the surface water depletion sustainability indicator."	3.5.1, page 199
13. If yes: a. Does the GSP identify costs to study the interconnectedness of surface water bodies?			X		
b. Does the GSP include a funding mechanism to support the study of interconnectedness surface water bodies?			X		

14. Does the GSP explicitly evaluate potential impacts of projects and management actions on groundwater levels near surface water bodies?		X		Section 4 identifies many important projects; however, the descriptions of Measurable Objectives for these projects only identifies benefits to water level and storage. Because maintenance or recovery of groundwater levels, or construction of recharge facilities, may have potential environmental benefits in many cases it would be advantageous to demonstrate multiple benefits from a funding and prioritization perspective. For the projects already identified, the GSP should consider stating how ISWs and GDEs will benefit or be protected, or what other environmental benefits will accrue. If ISWs will not be adequately protected by those listed, additional management actions and projects targeted for protecting ISWs should be included and described. Recharge ponds, reservoirs and facilities for managed stormwater recharge can be designed to include elements that act functionally as wetlands and provide a benefit for wildlife and aquatic species. In some cases, such facilities have been incorporated into local Habitat Conservation Plans (HCPs) and Natural Community Conservation Plans (NCCPs), more fully recognizing the value of the habitat that they provide and the species they support. For projects that construct recharge ponds, the GSP should consider identifying if there is habitat value incorporated into the design and how the recharge ponds will be managed to benefit environmental users. For examples of case studies on how to incorporate environmental benefits into groundwater projects, visit our website: https://groundwaterresourcehub.org/case-studies/recharge-case-studies/.	4, page 217

Summary/ Comments

A discussion should be added for each project or management action to clearly identify the benefits to DACs, drinking water users, and potential impacts to the water supply. For all potential impacts, the project/management action should include a clear plan to monitor for, prevent, and/or mitigate against such impacts. For example, groundwater recharge projects can have either a positive or negative impact on local groundwater quality, depending upon the design of the project.

The GSP should identify additional actions and funding mechanisms for potential failures of achieving the MOs by the identified actions.

The GSP should include environmental benefits and multiple benefits as criteria for assessing project priorities.

For the projects already identified, the GSP should consider stating how ISWs and GDEs will benefit or be protected, or what other environmental benefits will accrue.

For projects that construct recharge ponds, the GSP should consider identifying if there is habitat value incorporated into the design and how the recharge ponds will be managed to benefit environmental users.

For examples of case studies on how to incorporate environmental benefits into groundwater projects, visit:
https://groundwaterresourcehub.org/case-studies/recharge-case-studies/.

CHOWCHILLA SUBBASIN
GROUNDWATER SUSTAINABILITY PLAN (GSP)
COMMENT FORM

Please complete the following information to provide comments on the draft Chowchilla Subbasin GSP. Type or print legibly for your comments to be considered.

Please return this form to (hand delivery, mail, or email accepted):

Stephanie Anagnoson
Madera County
200 W. Fourth Street
Madera, CA 93637
Email:ChowchillaGSPComments@maderacounty.com

Date Submitted: November 9, 2019

Submitted By: Phil Janzen, President, Madera Ag Water Association

Address: 1102 S. Pine Street, Madera, CA 93637

Phone Number / Email: (559) 674-8871 maderaagwater@gmail.com

APNs: ____________________

Located in Groundwater Sustainability Agency (GSA):

☑ Madera County ☐ CWD ☐ Triangle TWD ☐ Merced County ☐ Other ____________

Affiliation: ☑ Irrigated Ag ☐ Non-Irrigated Ag ☐ Rural Residential
☐ Disadvantaged Community Member ☐ Agency/Government ☐ Other ____________

Chapter No. / Page No. of GSP: See attached letter.

Comments: ____________________

MADERA AG
WATER ASSOCIATION

November 5, 2019

Stephanie Anagnoson
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Email: ChowchillaGSPComments@maderacounty.com
MaderaGSPComments@maderacounty.com

Re: Comments on the Madera and Chowchilla Draft GSPs

Dear Ms. Anagnoson:

The Madera Ag Water Association (MAWA) appreciates the extraordinary effort that has gone into developing the Draft Groundwater Sustainability Plans for the Madera and Chowchilla Subbasins (Draft GSPs). Throughout the development process, the Madera County Groundwater Sustainability Agency (Madera County GSA) has made every effort to be inclusive and transparent in the development of the Draft GSPs. We thank you for that approach and for the opportunity to provide comments on the Draft GSPs.

MAWA is a non-profit membership organization representing farmers operating in areas of Madera County managed by the Madera County GSA. We are committed to working with all stakeholders in our community and with the Madera County GSA to make our basins sustainable. While this difficult task means significant changes for the agricultural community, we recognize the importance of being successful. State intervention is simply not an option.

We also want to thank the team at Madera County for identifying funding to offset the costs of establishing the Madera County Groundwater Sustainability Agency and developing the Draft GSPs. This allowed our community to comply with the rigorous initial requirements of the Sustainable Groundwater Management Act (SGMA) without simultaneously being financially burdened from the outset. We believe this deliberate approach has provided best possible opportunity for our community to successfully implement SGMA.

Even with this sound start, implementing the GSP will be challenging, particularly for agriculture. While many will be impacted, the greatest burden will be borne by the agricultural community. Because of that circumstance, MAWA encourages the Madera County GSA to continue to ensure that farmers and ranchers have the appropriate opportunity to engage with the SGMA process.

Comments

Planning vs. Prescribing: One of the key challenges in drafting a GSP is balancing between establishing a workable long-term strategy and providing near-term certainty through specific prescriptions. The reality is that the first step in the journey to groundwater sustainability is establishing and refining critical measurement and monitoring systems. While this means that certainty about some parameters is delayed, this is a necessary foundation to ensuring a fair and workable system is ultimately implemented.

The Draft GSPs appropriately manage this balance by clearly identifying what is needed, how it will be obtained, and how it will be used to implement the management actions and projects that will achieve sustainability. The specific prescriptions and implementation of the tools is rightfully left to the implementation phase of the GSP. While this does leave some uncertainty at present, it is important that the tools and prescriptions be based on the needed information and not hurriedly placed on a flawed foundation.

ETAW vs. AW: In discussing the Draft GSPs with stakeholders there is some confusion about the difference between the Evapotranspiration of Applied Water (ETAW) and Applied Water (AW). Although the Draft GSPs are not deficient in their explanation of this distinction, additional clarification, perhaps in the Executive Summary, would help the reader understand the difference between these terms and how they are used in the Draft GSPs.

Projects and Management Actions – Section 4: The Draft GSPs identify recharge, conveyance, and (for the Chowchilla Subbasin) storage as projects, and demand management as a management action. These tools will be utilized to bring the basins into balance over the next twenty years.

While these projects and management actions may be implemented by the GSAs, it would be useful to clarify in the Draft GSPs how these projects and management actions may be also implemented by other entities or individuals. This would allow others, in coordination with the GSAs and consistent with the GSPs, to implement projects and management actions that move us toward sustainability. In some cases, these entities may be able to implement these projects or management actions more quickly and efficiently than the GSAs.

Recharge – Section 2.2.3.3 & Section 4 (Table 4-2): In discussing groundwater recharge, the Draft GSPs appropriately focus on Flood-MAR, recharge basins, and in lieu recharge. While these surface water diversion projects should remain the priority of the GSP, it may be useful for the GSP to anticipate inclusion of other types of projects and management actions that may not divert surface water but may contribute to the groundwater replenishment portfolio.

Increasing consideration and study is being given to forest management, tillage practices, stormwater management, and other management practices that may increase the amount of precipitation infiltrating into the groundwater system. While these management practices are not sufficiently developed to be included in the projected budget, it would be helpful if the GSP also referenced groundwater replenishment practices that do not rely on diverted surface water.

Measurement – Section 4.4.4.3/4.2.3.3: The Draft GSPs identify several methods for measuring groundwater use that may be used in the basins. While simply identifying these tools is appropriate for the GSP, it will be useful to for tools like remote-sensing measurement and analysis of ETAW to be implemented quickly so that bugs can be worked out and groundwater users can gain confidence in these systems as soon as possible.

Rampdown – Section 4.4.4.2/4.2.3.2: The Draft GSPs identify a target for ramping down groundwater use of 2% per year for the first five years and 6% per year thereafter. While this is an appropriate goal, there are two clarifications that would be useful to include.

First, it would be helpful to further explain that the annual rampdown targets apply to the Madera County GSA area as a whole and not to individual parcels or ownerships. Although the Draft GSP already indicates this is the case, highlighting this fact in the Executive Summary and in the relevant sections may help alleviate some confusion.

Second, during the first few years of implementation, information and tools may not be available to provide specificity about whether these targets are being met. This is an expected challenge as not all the information needed to demonstrate these conditions is available. However, it may be useful to indicate this fact so that an inability to conclusively demonstrate planned reductions in the first year of implementation does not suggest the plan is inadequate. While actions will be taken to reduce demand immediately upon implementation of the GSPs, whether certain targets are hit may not be demonstrable for some time.

Allocations – Section 4.4.4.2/4.2.3.2: Implementing a groundwater allocation program may not be the only way to achieve the required demand reduction goals. Another option may be carefully managing access, consistent with property rights, and limiting the total available water without individual user allocations. Amending the Draft GSP to refer to "Allocation/Access" may clarify that approaches other than allocation may also be used to meet demand reduction goals.

Trading – Section 4.4.4.2/4.2.3.2: The Draft GSPs refer to a "water trading program" as a means of trading water credits. While market systems can add important flexibility to a system where available supply is limited, the details of the market system may end up being something other than a water trading program. Consider describing a "market system" generally to ensure that other types of market systems are also anticipated in the GSP.

Easements – Section 4.4.4.2/4.2.3.2: Because the term "easements" can be understood in different ways, it would be helpful to use a more descriptive term to refer to voluntary programs to cease irrigating lands. Whether through easements or leases, irrigation abeyance agreements are a useful tool and should remain in the GSP. Find a good term to describe the range of such alternatives will help reduce confusion.

Fallowing – Section 4.4.4.2/4.2.3.2: The Draft GSPs appear to use the term fallowing to refer to ceasing to irrigate land that is currently irrigated. To the extent this term is used in the typical agronomic context, namely referring to land that has been plowed and left unseeded or is otherwise not in use, it is unnecessarily restrictive.

As the GSP is implemented and land come out of irrigated agricultural production, much of that land may find other uses that do not require irrigation. Such land, for example, may be dryland farmed, transitioned to rangeland, converted to habitat, or be used for a solar array. Each of these new uses would cease irrigation, but would not technically be fallowing. Consider amending the Draft GSPs to refer to "land transition" or a similar term that indicates cessation of irrigation but anticipates a future economic use.

Conclusion

The GSAs that worked together on the Draft GSP have done a remarkable job setting forth a plan to bring the Madera and Chowchilla Subbasins into a sustainable condition. MAWA appreciates this work and looks forward to working with these GSAs and with other stakeholders to ensure our community follows the best path forward.

Thank you for considering these comments.

Sincerely,

/s/ *Phil Janzen*

Phil Janzen, President
Madera Ag Water Association, Inc.

CHOWCHILLA SUBBASIN
GROUNDWATER SUSTAINABILITY PLAN (GSP)
COMMENT FORM

Please complete the following information to provide comments on the draft Chowchilla Subbasin GSP. Type or print legibly for your comments to be considered.

Please return this form to (hand delivery, mail, or email accepted):

Stephanie Anagnoson
Madera County
200 W. Fourth Street
Madera, CA 93637
Email:ChowchillaGSPComments@maderacounty.com

Date Submitted: Nov 2, 2019

Submitted By: MARK Hutson

Address: 13534 Ave 19 1/2 Chowchilla, CA 93610

Phone Number / Email: 559-217-6609

APNs: 023-040-014 + 022 023-110-009 + 008

Located in Groundwater Sustainability Agency (GSA):
☐ Madera County ☒ CWD ☐ Triangle TWD ☐ Merced County ☐ Other ______

Affiliation: ☒ Irrigated Ag ☐ Non-Irrigated Ag ☐ Rural Residential
☐ Disadvantaged Community Member ☐ Agency/Government ☐ Other ______

Chapter No. / Page No. of GSP: 5.5

Comments: I would remove the word 'All' in comply with All of the Requirements"

Chapter No. / Page No. of GSP: 5.6.1

Comments: Implementation of all projects. Remove "all"

In Short – Remove The words All, shall, will, etc. These words are strong assertions + can Be left out. This would apply to all chapters

Chapter No. / Page No. of GSP: 4

Comments: I Believe it is very important to strongly state in This chapter + others, That as Knowledge, Technology + Management practices adapt + change, That The Methodology of projects will adapt. This Area of operation is so new, what we Think is Right May Be wrong, and visa-versa. Please leave

Chapter No. / Page No. of GSP:

Comments: A wide Area to manuver within The GSP As GSA's Become more Knowledgable. They need to Be Nimble and not constrained by a plan That may Become obsolete.

CHOWCHILLA SUBBASIN
GROUNDWATER SUSTAINABILITY PLAN (GSP)
COMMENT FORM

Please complete the following information to provide comments on the draft Chowchilla Subbasin GSP. Type or print legibly for your comments to be considered.

Please return this form to (hand delivery, mail, or email accepted):

Stephanie Anagnoson
Madera County
200 W. Fourth Street
Madera, CA 93637
Email:ChowchillaGSPComments@maderacounty.com

Date Submitted: 10-23-19

Submitted By: Jennifer Spaletta for Sierra Vista Mutual Water Co.

Address: PO Box 2660, Lodi, CA 95241

Phone Number / Email: jennifer@spalettalaw.com

APNs: Various

Located in Groundwater Sustainability Agency (GSA):
☑ Madera County ☐ CWD ☐ Triangle TWD ☑ Merced County ☐ Other ____________

Affiliation: ☑ Irrigated Ag ☐ Non-Irrigated Ag ☐ Rural Residential
☐ Disadvantaged Community Member ☐ Agency/Government ☐ Other ____________

Chapter No. / Page No. of GSP: Chapter 2, app2F

Comments: See attached

SIERRA VISTA MUTUAL WATER COMPANY COMMENTS

October 23, 2019

To: Chowchilla Subbasin Technical Committee, ChowchillaGSPcomments@maderacounty.com

Re: Comments on Draft Chowchilla Basin Groundwater Sustainability Plan

Sierra Vista Mutual Water Company provides these comments regarding the allocation of seepage from the Chowchilla River in Appendix 2.F.d and Appendix 2.F.a, and as further reflected in Chapter 2 and the balance of the Draft GSP using the information from these two appendices.

Currently the non-flood period seepage for Reach C-2 is allocated 100% to Chowchilla Water District in the water balances and none of this seepage is allocated to Sierra Vista Mutual Water Company. Sierra Vista Mutual Water Company contends it has a right to some or all of the Reach C-2 seepage pursuant to its existing water rights, agreements with Chowchilla Water District and a court judgment.

To avoid a dispute over this allocation, for purposes of the GSP and SGMA water balance calculations only, Chowchilla Water District and Sierra Vista Mutual Water Company have agreed that the GSP should be amended to allocate 70% of the non-flood period seepage for Reach C-2 to Sierra Vista Mutual Water Company and 30% to Chowchilla Water District. The allocation of seepage for Reach C-2 between Sierra Vista Mutual Water Company and Chowchilla Water District has no impact on the total water balance for the subbasin. We understand that this change will be incorporated into the final GSP.

Edgar deJager, SVMWC Board President

CHOWCHILLA SUBBASIN
GROUNDWATER SUSTAINABILITY PLAN (GSP)
COMMENT FORM

Please complete the following information to provide comments on the draft Chowchilla Subbasin GSP. Type or print legibly for your comments to be considered.

Please return this form to (hand delivery, mail, or email accepted):

Stephanie Anagnoson
Madera County
200 W. Fourth Street
Madera, CA 93637
Email:ChowchillaGSPComments@maderacounty.com

Date Submitted: November 4, 2019

Submitted By: San Joaquin River Exchange Contractors GSA

Address: 541 H Street, PO Box 2115, Los Banos, CA 93635

Phone Number / Email: 209-827-8616 / cwhite@sjrecwa.net

APNs: ______

Located in Groundwater Sustainability Agency (GSA):

☐ Madera County ☐ CWD ☐ Triangle TWD ☐ Merced County ☒ Other SJREC GSA

Affiliation: ☐ Irrigated Ag ☐ Non-Irrigated Ag ☐ Rural Residential

☐ Disadvantaged Community Member ☒ Agency/Government ☐ Other ______

Chapter No. / Page No. of GSP: ______

Comments: The SJREC GSA, representing two public water agencies, two mutual water companies, six disadvantaged communities and county white areas, include our comments in the attached letter.

Chapter No. / Page No. of GSP: ______________________________

Comments: ______________________________

Chapter No. / Page No. of GSP: ______________________________

Comments: ______________________________

Chapter No. / Page No. of GSP: ______________________________

Comments: ______________________________

SAN JOAQUIN RIVER EXCHANGE CONTRACTORS
GROUNDWATER SUSTAINABILITY AGENCY
Post Office Box 2115
Los Banos, CA 93625
(209) 827-8616

November 4, 2019

Ms. Stephanie Anagnoson
Chowchilla Subbasin GSP
Madera County
200 W. Fourth Street
Madera, CA 93637

RE: ***Comments on the draft Chowchilla Subbasin Groundwater Sustainability Plan***

Dear Stephanie:

The San Joaquin River Exchange Contractors Groundwater Sustainability Agency (SJREC GSA) has reviewed the draft GSP for the Chowchilla Subbasin. Additionally, the SJREC GSA participated in two joint workshops between the Delta-Mendota Subbasin and the Chowchilla Subbasin. The purpose of these workshops was to review groundwater conditions along our shared basin boundary and evaluate the draft proposed Sustainable Management Criteria and potential impacts our adjacent subbasin. Included herein are comments from the SJREC GSA.

1. The GSP relies too heavily on a numerical groundwater model that has not been calibrated and therefore does not accurately reflect boundary conditions with the Delta-Mendota Subbasin. In addition, the numerical model used has projected water levels to decline significantly in the Delta-Mendota Subbasin by the year 2040. This is contradictory to SJREC GSP which will maintain historic water levels through 2040 in order to maintain sustainability.

2. This plan assumed that no land subsidence will occur so long as water levels do not drop below historic low water levels. Evidence in the El Nido area, the Mendota area, and elsewhere, shows that land subsidence will significantly occur at levels above historic low levels.

3. Your draft plan sets the Land Subsidence Undesirable Result for the Western Management Area as "50 percent of Western MA Lower Aquifer wells below minimum threshold for two consecutive fall measurements." It also sets the minimum threshold for

Land Subsidence in the Wester Management Area as "the highest of (a) projected lowest future groundwater level at the end of estimated 10-year drought or (b) or recent groundwater level lows". As defined, the Sustainable Management Criteria for Land Subsidence poses an immediate and long-term risk to the SJREC GSA and its member entities. Chapter 10 Section 10733 of the SGMA requires DWR to "evaluate whether a groundwater sustainability plan adversely affects the ability of an adjacent basin to implement their groundwater sustainability plan or impedes achievement of sustainability goals in an adjacent basin". Your draft plan will adversely impact our ability to successfully implement our GSP and prevent our achievement of sustainability.

The Chowchilla GSP should be updated to mitigate land subsidence in the areas closest to the Delta-Mendota Subbasin. A successful mitigation program is being implemented by the Triangle T Water District in cooperation with the member agencies of the SJRECWA GSA. Other areas in the western Madera County should be held to a similar standard and immediately reduce extractions from the lower aquifer at or below the sustainable yield. Of particular importance is the area within the Clayton Water District. The SJREC GSA has participated in several conversations with the Chowchilla Subbasin to describe the need for regional coordination to achieve regional sustainability.

4. In your plan the minimum threshold for Chronic Lowering of Groundwater Levels is defined as "the lowest of a) projected lowest future groundwater level at end of estimated 10-year drought or b) lowest modeled groundwater level from projected with projects model simulation (2019-2090)". The undesirable result for this same indicator is defined as "30 percent of wells below minimum threshold for two consecutive fall measurements". As defined, this poses an immediate risk to the SJREC GSA and the Delta-Mendota Subbasin. Water levels at the end of a 10-year drought are projected to be significantly lower this historic water levels. Intentional decline in water levels in the Chowchilla Subbasin will directly impact the Delta-Mendota Subbasins infrastructure, water supply, and for the following sustainability indicators: a) chronic lowering of groundwater levels, b) reduction of groundwater storage, c) land subsidence, d) degraded water quality and e) depletion of interconnected surface water.
   a. Chronic lowering of groundwater levels: the SJREC GSP is managing groundwater levels to maintain historic levels. If the Chowchilla subbasin intends to lower the water levels across the subbasin boundary, inherently more groundwater will flow out of the Delta-Mendota Subbasin inducing a groundwater imbalance and overdraft in the Delta-Mendota Basin.
   b. Reduction of groundwater storage: As described above lowering water levels will increase the lateral groundwater outflow from the Delta-Mendota Subbasin. The

results of increased outflow will result in a reduction in groundwater storage in the Delta-Mendota Subbasin.

c. Land subsidence: this GSP plans to use water levels as a proxy for land subsidence. It should be noted that the proposed water level minimum thresholds will have very significant impacts to the Delta-Mendota Subbasin
d. Degraded water quality: Lowering water levels in the Chowchilla subbasin will exacerbate the problem of migrating high TDS water into the SJREC GSA. This problem is not discussed in the GSP and should be evaluated to ensure regional sustainability.
e. Depletion of interconnected surface water: The plan indicates that overdraft in the Chowchilla subbasin has caused water levels to drop low enough to a point where the surface water is not connected with the ground water. The SJREC GSP describes that there are times when the area adjacent to the San Joaquin River has interconnected surface water and groundwater. This GSP needs to describe how its groundwater management efforts are not depleting surface waters. Of particular importance are the areas adjacent to the Delta-Mendota Subbasin in the Madera County white areas and the Clayton Water District.

5. The groundwater overdraft presented in this report vary substantially. Table 2-26 indicates an average annual overdraft of 29,000 acre-feet while the Figure ES-3 estimates the average annual overdraft to be 101,900 acre-feet.

6. Page 6 of the Executive Summary references that the sustainable yield was only calculated for the period 2040-2090. A sustainable yield should be calculated for the period 2020-2040 in order to achieve sustainability. One method used to calculate sustainable yield uses "average annual groundwater extraction minus the average annual change in groundwater storage". Groundwater extractions in this subbasin has resulted in inelastic land subsidence. These extractions need to be removed from the sustainable yield calculation.

7. This GSP did not include a regional water quality concern of the northeasterly flow of high TDS groundwater associated with overdraft in the Chowchilla Subbasin. Declining water levels in the upper aquifer of the Chowchilla Subbasin has increased the migration of high TDS groundwater into the Delta-Mendota Subbasin.

8. On Page 2-29 the groundwater system conceptualization in the draft plan only analyzes a single homogenous aquifer which renders it untenable for predicting aquifer trends etc. the analysis must recognize actual conditions and include at least two aquifers: a shallow semi or unconfined aquifer and a deeper confined aquifer.

9. On Page 2-34 the lower aquifer discussion should include lateral groundwater inflow and outflow across Subbasin boundaries. There has consistently been groundwater flows in both the upper and lower aquifers from the Delta-Mendota Subbasin to the Chowchilla Subbasin. Based on natural (pre-pumping) conditions, all of these flows have been induced by pumping in the Chowchilla Subbasin.

10. The reduction in land subsidence, shown on Figure 2-68, should describe the joint project between CCID/SLCC and the Triangle T Water District. The plan should have more emphasis on the successes of the Red Top area subsidence mitigation and require others in the vicinity to similarly solve the subsidence problem

11. Existing shallow monitor wells on both sides of the San Joaquin River should be used to determine if surface water and groundwater are connected. The SJREC GSP has determined that portions of the San Joaquin River are at times connected along the boundary between the Delta-Mendota and Chowchilla Subbasins.

This letter serves as a continuation of the regional coordination the SJREC GSA has pursued with neighboring subbasins and GSP's adjacent to the Delta-Mendota Subbasin. Please feel free to contact us with any questions or concerns you have so we can collectively and collaboratively manage our groundwater sustainability in the future.

Sincerely truly,

Chris White

Chris White,
Executive Director

The Nature Conservancy
Protecting nature. Preserving life.

CALIFORNIA WATER | GROUNDWATER

555 Capitol Mall, Suite 1290
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[916] 449-2850

nature.org
GroundwaterResourceHub.org

November 4, 2019

Stephanie Anagnoson, Director
Water and Natural Resources Department
200 W. Fourth Street
Madera, CA 93637

Submitted via email to: ChowchillaGSPComments@maderacounty.com

Re: Chowchilla Subbasin Draft Groundwater Sustainability Plan

Dear Ms. Anagnoson,

The Nature Conservancy (TNC) appreciates the opportunity to comment on the Chowchilla Subbasin Draft Groundwater Sustainability Plan (GSP) being prepared under the Sustainable Groundwater Management Act (SGMA).

TNC as a Stakeholder Representative for the Environment

TNC is a global, nonprofit organization dedicated to conserving the lands and waters on which all life depends. We seek to achieve our mission through science-based planning and implementation of conservation strategies. For decades, we have dedicated resources to establishing diverse partnerships and developing foundational science products for achieving positive outcomes for people and nature in California. TNC was part of a stakeholder group formed by the Water Foundation in early 2014 to develop recommendations for groundwater reform and actively worked to shape and pass SGMA.

Our reason for engaging is simple: California's freshwater biodiversity is highly imperiled. We have lost more than 90 percent of our native wetland and river habitats, leading to precipitous declines in native plants and the populations of animals that call these places home. These natural resources are intricately connected to California's economy providing direct benefits through industries such as fisheries, timber and hunting, as well as indirect benefits such as clean water supplies. SGMA must be successful for us to achieve a sustainable future, in which people and nature can thrive within Chowchilla Subbasin region and California.

We believe that the success of SGMA depends on bringing the best available science to the table, engaging all stakeholders in robust dialog, providing strong incentives for beneficial outcomes and rigorous enforcement by the State of California.

Given our mission, we are particularly concerned about the inclusion of nature, as required, in GSPs. The Nature Conservancy has developed a suite of tools based on best available science to help GSAs, consultants, and stakeholders efficiently incorporate nature into GSPs. These tools and resources are available online at GroundwaterResourceHub.org. Some of these tools have been used in the preparation of the present draft plan. Additional resources are available and referred to in the comments that follow, and are considered pertinent to the development of this plan.

Addressing Nature's Water Needs *in GSPs*

SGMA requires that all beneficial uses and users, including environmental users of groundwater, be considered in the development and implementation of GSPs (Water Code § 10723.2).

The GSP Regulations include specific requirements to identify and consider groundwater dependent ecosystems [23 CCR §354.16(g)] when determining whether groundwater conditions are having potential effects on beneficial uses and users. GSAs must also assess whether sustainable management criteria may cause adverse impacts to beneficial uses, which include environmental uses, such as plants and animals. The Nature Conservancy has identified each part of the GSP where consideration of beneficial uses and users are required. That list is available here: https://groundwaterresourcehub.org/importance-of-gdes/provisions-related-to-groundwater-dependent-ecosystems-in-the-groundwater-s.
Please ensure that environmental beneficial users are addressed accordingly throughout the GSP. Adaptive management is embedded within SGMA and provides a process to work toward sustainability over time by beginning with the best available information to make initial decisions, monitoring the results of those decision, and using data collected through monitoring to revise decisions in the future. Over time, GSPs should improve as data gaps are reduced and uncertainties addressed.

To help ensure that GSPs adequately address nature as required under SGMA, The Nature Conservancy has prepared a checklist (Attachment A) for GSAs and their consultants to use. The Nature Conservancy believes the following elements are foundational for 2020 GSP submittals and are developed from our publication, *GDEs under SGMA: Guidance for Preparing GSPs*[1].

1. Environmental Representation

SGMA requires that groundwater sustainability agencies (GSAs) consider the interests of all beneficial uses and users of groundwater. To meet this requirement, we recommend actively engaging environmental stakeholders by including environmental representation on the GSA board, technical advisory group, and/or working groups. This could include local staff from state and federal resource agencies, nonprofit organizations and other environmental interests. By engaging these stakeholders, GSAs will benefit from access to additional data and resources, as well as a more robust and inclusive GSP.

2. Basin GDE and ISW Maps

SGMA requires that groundwater dependent ecosystems (GDEs) and interconnected surface waters (ISWs) be identified in the GSP. We recommend using the Natural Communities Commonly Associated with Groundwater Dataset (NC Dataset) provided online[2] by the Department of Water Resources (DWR) as a starting point for the GDE map. The NC Dataset was developed through a collaboration between DWR, the Department of Fish and Wildlife and TNC.

3. Potential Effects on Environmental Beneficial Users

[1]GDEs under SGMA: Guidance for Preparing GSPs is available at: https://groundwaterresourcehub.org/public/uploads/pdfs/GWR_Hub_GDE_Guidance_Doc_2-1-18.pdf

[2] The Department of Water Resources' Natural Communities Commonly Associated with Groundwater dataset is available at: https://gis.water.ca.gov/app/NCDatasetViewer/

SGMA requires that potential effects on GDEs and environmental surface water users be described when defining undesirable results. In addition to identifying GDEs in the basin, The Nature Conservancy recommends identifying beneficial users of surface water, which include environmental users. This is a critical step, as it is impossible to define "significant and unreasonable adverse impacts" without knowing *what* is being impacted. For your convenience, we've provided a list of freshwater species within the boundary of the Chowchilla Subbasin in Attachment C. Our hope is that this information will help your GSA better evaluate the impacts of groundwater management on environmental beneficial users of surface water. We recommend that after identifying which freshwater species exist in your basin, especially federal and state listed species, that you contact staff at the Department of Fish and Wildlife (DFW), United States Fish and Wildlife Service (USFWS) and/or National Marine Fisheries Services (NMFS) to obtain their input on the groundwater and surface water needs of the organisms on the GSA's freshwater species list. We also refer you to the Critical Species Lookbook[3] prepared by The Nature Conservancy and partner organizations for additional background information on the water needs and groundwater reliance of critical species. Because effects to plants and animals are difficult and sometimes impossible to reverse, we recommend erring on the side of caution to preserve sufficient groundwater conditions to sustain GDEs and ISWs.

4. Biological and Hydrological Monitoring

If sufficient hydrological and biological data in and around GDEs is not available in time for the 2020/2022 plan, data gaps should be identified along with actions to reconcile the gaps in the monitoring network.

The Nature Conservancy has reviewed the Chowchilla Draft GSP. We appreciate the work that has gone into the preparation of this plan. Specifically, we recognize the use of the NC dataset, GDE Pulse, and other TNC guidance for initial identification and evaluation of GDE areas in the basin. However, we believe that additional work is needed for further identification of GDEs and ISWs in the basin. Hence, we consider the current GSP draft to be incomplete under SGMA.

Our specific comments related to the Chowchilla Subbasin Draft GSP are provided in detail in Attachment B and are in reference to the numbered items in Attachment A. Attachment C provides a list of the freshwater species located in the Chowchilla Subbasin. Attachment D describes six best practices that GSAs and their consultants can apply when using local groundwater data to confirm a connection to groundwater for DWR's Natural Communities Commonly Associated with Groundwater Dataset[2].

Thank you for fully considering our comments as you develop your GSP.

Best Regards,

Sandi Matsumoto
Associate Director, California Water Program
The Nature Conservancy

[3] Available online at: https://groundwaterresourcehub.org/sgma-tools/the-critical-species-lookbook/

Attachment A

Environmental User Checklist

The Nature Conservancy is neither dispensing legal advice nor warranting any outcome that could result from the use of this checklist. Following this checklist does not guarantee approval of a GSP or compliance with SGMA, both of which will be determined by DWR and the State Water Resources Control Board.

GSP Plan Element*		GDE Inclusion in GSPs: Identification and Consideration Elements	Check Box
Admin Info	2.1.5 Notice & Communication *23 CCR §354.10*	Description of the types of environmental beneficial uses of groundwater that exist within GDEs and a description of how environmental stakeholders were engaged throughout the development of the GSP.	1
Planning Framework	2.1.2 to 2.1.4 Description of Plan Area *23 CCR §354.8*	Description of jurisdictional boundaries, existing land use designations, water use management and monitoring programs; general plans and other land use plans relevant to GDEs and their relationship to the GSP.	2
		Description of instream flow requirements, threatened and endangered species habitat, critical habitat, and protected areas.	3
		Summary of process for permitting new or replacement wells for the basin, and how the process incorporates any protection of GDEs	4
Basin Setting	2.2.1 Hydrogeologic Conceptual Model *23 CCR §354.14*	Basin Bottom Boundary: Is the bottom of the basin defined as at least as deep as the deepest groundwater extractions?	5
		Principal aquifers and aquitards: Are shallow aquifers adequately described, so that interconnections with surface water and vertical groundwater gradients with other aquifers can be characterized?	6
		Basin cross sections: Do cross-sections illustrate the relationships between GDEs, surface waters and principal aquifers?	7
	2.2.2 Current & Historical Groundwater Conditions *23 CCR §354.16*	Interconnected surface waters:	8
		Interconnected surface water maps for the basin with gaining and losing reaches defined (included as a figure in GSP & submitted as a shapefile on SGMA portal).	9
		Estimates of current and historical surface water depletions for interconnected surface waters quantified and described by reach, season, and water year type.	10
		Basin GDE map included (as figure in text & submitted as a shapefile on SGMA Portal).	11

		If NC Dataset *was* used:	Basin GDE map denotes which polygons were kept, removed, and added from NC Dataset (Worksheet 1, can be attached in GSP section 6.0).	12
			The basin's GDE shapefile, which is submitted via the SGMA Portal, includes two new fields in its attribute table denoting: 1) which polygons were kept/removed/added, and 2) the change reason (e.g., why polygons were removed).	13
			GDEs polygons are consolidated into larger units and named for easier identification throughout GSP.	14
		If NC Dataset *was not* used:	Description of why NC dataset was not used, and how an alternative dataset and/or mapping approach used is best available information.	15
		Description of GDEs included:		16
		Historical and current groundwater conditions and variability are described in each GDE unit.		17
		Historical and current ecological conditions and variability are described in each GDE unit.		18
		Each GDE unit has been characterized as having high, moderate, or low ecological value.		19
		Inventory of species, habitats, and protected lands for each GDE unit with ecological importance (Worksheet 2, can be attached in GSP section 6.0).		20
	2.2.3 Water Budget *23 CCR §354.18*	Groundwater inputs and outputs (e.g., evapotranspiration) of native vegetation and managed wetlands are included in the basin's historical and current water budget.		21
		Potential impacts to groundwater conditions due to land use changes, climate change, and population growth to GDEs and aquatic ecosystems are considered in the projected water budget.		22
Sustainable Management Criteria	3.1 Sustainability Goal *23 CCR §354.24*	Environmental stakeholders/representatives were consulted.		23
		Sustainability goal mentions GDEs or species and habitats that are of particular concern or interest.		24
		Sustainability goal mentions whether the intention is to address pre-SGMA impacts, maintain or improve conditions within GDEs or species and habitats that are of particular concern or interest.		25
	3.2 Measurable Objectives *23 CCR §354.30*	Description of how GDEs were considered and whether the measurable objectives and interim milestones will help achieve the sustainability goal as it pertains to the environment.		26
	3.3 Minimum Thresholds *23 CCR §354.28*	Description of how GDEs and environmental uses of surface water were considered when setting minimum thresholds for relevant sustainability indicators:		27
		Will adverse impacts to GDEs and/or aquatic ecosystems dependent on interconnected surface waters (beneficial user of surface water) be avoided with the selected minimum thresholds?		28
		Are there any differences between the selected minimum threshold and state, federal, or local standards relevant to the species or habitats residing in GDEs or aquatic ecosystems dependent on interconnected surface waters?		29
	3.4 Undesirable Results *23 CCR §354.26*	For GDEs, hydrological data are compiled and synthesized for each GDE unit:		30
		If hydrological data *are available* within/nearby the GDE	Hydrological datasets are plotted and provided for each GDE unit (Worksheet 3, can be attached in GSP Section 6.0).	31
			Baseline period in the hydrologic data is defined.	32

			GDE unit is classified as having high, moderate, or low susceptibility to changes in groundwater.	33
			Cause-and-effect relationships between groundwater changes and GDEs are explored.	34
		If hydrological data *are not available* within/nearby the GDE	Data gaps/insufficiencies are described.	35
			Plans to reconcile data gaps in the monitoring network are stated.	36
		For GDEs, biological data are compiled and synthesized for each GDE unit:		37
		Biological datasets are plotted and provided for each GDE unit, and when possible provide baseline conditions for assessment of trends and variability.		38
		Data gaps/insufficiencies are described.		39
		Plans to reconcile data gaps in the monitoring network are stated.		40
		Description of potential effects on GDEs, land uses and property interests:		41
		Cause-and-effect relationships between GDE and groundwater conditions are described.		42
		Impacts to GDEs that are considered to be "significant and unreasonable" are described.		43
		Known hydrological thresholds or triggers (e.g., instream flow criteria, groundwater depths, water quality parameters) for significant impacts to relevant species or ecological communities are reported.		44
		Land uses include and consider recreational uses (e.g., fishing/hunting, hiking, boating).		45
		Property interests include and consider privately and publicly protected conservation lands and opens spaces, including wildlife refuges, parks, and natural preserves.		46
Sustainable Management Criteria	3.5 Monitoring Network *23 CCR §354.34*	Description of whether hydrological data are spatially and temporally sufficient to monitor groundwater conditions for each GDE unit.		47
		Description of how hydrological data gaps and insufficiencies will be reconciled in the monitoring network.		48
		Description of how impacts to GDEs and environmental surface water users, as detected by biological responses, will be monitored and which GDE monitoring methods will be used in conjunction with hydrologic data to evaluate cause-and-effect relationships with groundwater conditions.		49
Projects & Mgmt Actions	4.0. Projects & Mgmt Actions to Achieve Sustainability Goal *23 CCR §354.44*	Description of how GDEs will benefit from relevant project or management actions.		50
		Description of how projects and management actions will be evaluated to assess whether adverse impacts to the GDE will be mitigated or prevented.		51

* In reference to DWR's GSP annotated outline guidance document, available at: https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/GD_GSP_Outline_Final_2016-12-23.pdf

Attachment B

TNC Evaluation of the
Chowchilla Subbasin Groundwater Sustainability Plan

A complete draft of the Chowchilla Subbasin Groundwater Sustainability Plan (GSP) Public Draft was provided for public review on August 9, 2019. This attachment summarizes our comments on the complete public draft GSP.

<u>Checklist Item 1 - Notice & Communication (23 CCR §354.10)</u>

[Section 2.1.5.2 Description of Beneficial Uses and Users (p. 2-20)]

- The GSP authors have listed environmental agencies and environmental groups as one of the beneficial users of groundwater in the Subbasin in Table 2-4 (p. 2-20 to 2-21). The following footnote was added to the table: "The groups and communities referenced are examples identified during initial assessment. GSA Interested Parties lists shall maintain current and more exhaustive lists of stakeholders fitting into these groups." Environmental groups should be expanded in a manner similar to the environmental justice groups in the Human Right to Water category. Please expand the stakeholder list associated with the Environmental and Ecosystem Uses category in Table 2-4 to include the appropriate agencies and list of environmental groups.
- The types and locations of environmental uses, species and habitats supported, instream flow requirements, and other designated beneficial environmental uses of surface waters that may be affected by groundwater extraction in the Subbasin should be specified. To identify environmental users, please refer to the following:
    - The NC Dataset (https://gis.water.ca.gov/app/NCDatasetViewer/) which identifies the potential presence of groundwater dependent ecosystems in this basin
    - The list of freshwater species located in the Chowchilla Subbasin in Attachment C of this letter. Please take particular note of the species with protected status.
    - CDFW's California Natural Diversity Database (CNDDB) - https://www.wildlife.ca.gov/Data/CNDDB
    - USFWS's IPAC report for the Chowchilla Area - https://ecos.fws.gov/ipac/
    - Lands that are protected as open space preserves, habitat reserves, wildlife refuges, etc. or other lands protected in perpetuity and supported by groundwater or interconnected surface waters should be identified and acknowledged.

Checklist Items 2 to 4 - Description of general plans and other land use plans relevant to GDEs and their relationship to the GSP (23 CCR §354.8

[Section 2.1.2.2 Surface Water Monitoring and Management Programs (p. 2-8 to 2-10)]

- This section describes the types of monitoring performed by federal, state and local agencies of surface water inflows, outflows, and irrigation releases. The monitoring stations for flows and water deliveries are listed in Table 2-3. Local stations for flow or irrigation releases are listed in the text (p. 2-8 to 2-9). Please explain the relationship of existing stream flow monitoring to the protection of ISWs and GDEs.
- There is no discussion of the in-stream flow requirements for the San Joaquin River or any other surface water. The San Joaquin River Restoration Program (SJRRP) requires the release of flows from Friant Dam to the confluence with the Merced River to support the life-stages of salmon and other fish species. This section should discuss or reference any instream flow requirements, especially flow needs for critical species, including the amount, time of year when the flow minimum is specified, the duration, the species for which it applies, associated permits that set forth the requirements, and the regulating agency setting forth the compliance requirements. Please discuss the future impact of the SJRRP on the riparian areas and potential GDEs present along or adjacent to the river.

[Section 2.1.3.1 Madera County General Plan (p. 2-12 to 2-14)]

- The Madera County General Plan from 1995 (with updates from 2015) includes restrictions on development in "areas with sensitive environmental resources" (Policy 1.A.5) and provides "the preservation of natural vegetation, land forms, and resources as open space, with permanent protection where feasible" (Policy 5.H.1) (p. 2-12). This section should include a discussion of General Plan goals and policies related to the protection and management of GDEs and aquatic resources that could be affected by groundwater withdrawals. Please include a discussion of how implementation of the GSP may affect and be coordinated with General Plan policies and procedures regarding the protection of wetlands, aquatic resources and other GDEs and ISWs.
- The Merced County General Plan adopted in December 2013 and amended in 2016 "has established policies to promote compact development of existing or well-planned new urban communities established apart from productive agricultural land, to limit growth in rural centers, and to forbid development adjacent to wetland habitat (Policies LU-1.1-5, 7, 9-10, 13)" (p. 2-13). Agricultural land uses "shall not have a detrimental effect on surface water or groundwater resources." Please include a discussion of how implementation of the GSP may affect and be coordinated with General Plan policies and procedures regarding the protection of wetlands, aquatic resources and other GDEs and ISWs.
- These sections should identify Habitat Conservation Plans (HCPs) or Natural Community Conservation Plans (NCCPs) within the Subbasin and if they are associated with critical, GDE or ISW habitats. Please identify all relevant HCPs

and NCCPs within the Subbasin and address how GSP implementation will coordinate with the goals of these HCPs or NCCPs.

- Please refer to the Critical Species Lookbook[4] to review and discuss the potential groundwater reliance of critical species in the basin. Please include a discussion regarding the management of critical habitat for these aquatic species and its relationship to the GSP.

[Section 2.1.3.4 Permitting Process for Wells in Chowchilla Subbasin (p. 2-15 to 2-16)]

- Madera County Environmental Health Division has an online well permitting system that includes agricultural wells, observation/monitoring wells, community water supply wells, and individual domestic water supply wells. There is a requirement for new wells to "include a flow measurement device on new wells and the resulting groundwater pumping records" (p. 2-9). Other requirements follow the State standards (DWR, 1981). Please include a discussion of how future well permitting will be coordinated with the GSP to assure achievement of the **Plan'**s sustainability goals.
- The State Third Appellate District recently found that Counties have a responsibility to consider the potential impacts of groundwater withdrawals on public trust resources when permitting new wells near streams with public trust uses (ELF vs. SWRCB and Siskiyou County, No. C083239). Compliance of well permitting programs with this requirement should be stated in the GSP.
- Madera County allows wells designated for abandonment to be converted into a monitoring well. Please clarify in the text that only wells screened in one aquifer and appropriate for monitoring will be include in the monitoring program.

Checklist Items 5, 6, and 7 – Hydrogeologic Conceptual Model (23 CCR §354.14)

[Section 2.2.1.2 Lateral and Vertical Subbasin Boundaries (p. 2-26 to 2-27)]

- In the Chowchilla Subbasin, the base of the usable aquifer corresponds with the base of fresh water, generally defined as groundwater with total dissolved solids (TDS) of 1,000 milligrams per liter (mg/l) as modified from Page (1973), except in the eastern part of the basin where the of basement complex is shallower. As noted on page 9 of DWR's Hydrogeologic Conceptual Model BMP (https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_HCM_Final_2016-12-23.pdf) "the definable bottom of the basin should be at least as deep as the deepest groundwater extractions". Thus, groundwater extraction well depth data should also be included in the determination of the basin bottom. Properly defining the bottom of the basin will prevent the possibility of extractors with wells deeper than the basin boundary from claiming exemption from SGMA due to their well residing outside the vertical extent of the basin boundary.
- The cross sections in Chapter 2 (Figures 2-23 through 2-33) clearly show the base of freshwater and the top of the basement rocks. However, they do not include a graphical representation of the manner in which shallow groundwater may interact

[4] Available online at: https://groundwaterresourcehub.org/sgma-tools/the-critical-species-lookbook/

with ISWs or GDEs that would allow the reader to understand this topic. Please include an example near-surface cross section that depicts the conceptual understanding of shallow groundwater and river interactions at different locations, as well as potential GDEs and ISWs.

Checklist Items 8, 9, and 10 – Interconnected Surface Waters (ISWs) (23 CCR §354.16)

[Section 2.2.2.5 Groundwater-Surface Water Interaction (p. 2-39)]

- The text states (p. 2-39): "A review of historical regional aquifer groundwater levels compared to stream thalweg (deepest portion of stream channel) elevations conducted for this study indicate that surface water – groundwater interactions are not a significant issue (i.e., regional groundwater levels are relatively far below creek thalweg elevations) along Chowchilla River, Ash Slough, and Berenda Slough in Chowchilla Subbasin." ISWs are best estimated by first determining which reaches are completely disconnected from groundwater. This approach would involve comparing groundwater elevations with a land surface Digital Elevation Model that could identify which surface waters have groundwater consistently below surface water features, such that an unsaturated zone would separate surface water from groundwater. Please provide further evidence that that ISWs are not present along Chowchilla River, Ash Slough, and Berenda Slough, such as a cross-section or corresponding hydrographs to show the relationship between the river channel and the depth to groundwater at wells near the rivers.
- Figures 2-70 and 2-71 present depth to shallow groundwater for 2014 and 2016. There are large data gaps over the Chowchilla Subbasin, particularly for 2016 (Figure 2-71). Please further describe how these figures were developed, specifically noting the following best practices for developing depth to groundwater contours presented in Attachment D. Specifically, ensure that the first step is contouring groundwater elevations, and the subtracting this layer from land surface elevations from a DEM to estimate depth to groundwater contours across the landscape. This will provide much more accurate contours of depth-to-groundwater along streams and other land surface depressions where GDEs are commonly found. Depth to groundwater contours developed from depth to groundwater measurements at wells assumes that the land surface is constant, which is a poor assumption to make.
- The regulations [23 CCR §351(o)] define interconnected surface waters (ISW) 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". "At any point" has both a spatial and temporal component. Even short durations of interconnections of groundwater and surface water can be crucial for surface water flow and supporting environmental users of groundwater and surface water. The GSP states in several places that the San Joaquin River is losing in the section adjacent to the Subbasin, and uses this as evidence that ISWs do not exist. However, ISWs can be either gaining or losing. The defining feature of disconnected surface waters is that groundwater is consistently below surface water features such that an unsaturated zone always separates surface water from groundwater, not whether the reach is gaining or losing. To improve ISW mapping, please

reconcile data gaps (shallow monitoring wells, stream gauges, and nested/clustered wells) along surface water features in the Monitoring Network section of the GSP.

- The GSP states (p. 2-40): "It is likely that seepage from the San Joaquin River is the source of water that combined with the presence of shallow clay layers that serves to maintain shallow groundwater levels at these locations." Please provide estimates of current and historical surface water depletions for ISWs quantified and described by reach, season, and water year type.

<u>Checklist Items 11 to 15, Identifying and Mapping GDEs (23 CCR §354.16)</u>

[Section 2.2.2.6 Groundwater Dependent Ecosystems (p. 2-40)]
[Appendix 2.B (Assessment of Groundwater Dependent Ecosystems)]

- The text states (p. 2-40): "A DTW cutoff of 30 feet was used in the initial screening of potential GDEs. The use of a 30-foot DTW criterion to identify potential GDEs is based on reported maximum rooting depths of California phreatophytes and is consistent with guidance provided by The Nature Conservancy (Rohde et al. 2018) for identifying potential GDEs." We have the following comments regarding this sentence and on the methodology for identifying GDEs in the Subbasin.
    - *30-ft criteria from TNC Guidance:* In TNC's GDE Guidance, the depth criterion of 30 feet is presented as a criterion for inclusion, not a standalone criterion for exclusion. In other words, if groundwater is within 30 feet of the ground surface, then a GDE can be identified. If it is not, then further analysis must be conducted (see Appendix III of the GDE Guidance, Worksheet 1, for other indicators of GDEs).
    - *30-ft as maximum rooting depths of California phreatophytes:* Please use care when considering rooting depths of vegetation. While Valley Oak (*Quercus lobata*) have been observed to have a max rooting depth of ~24 feet (https://groundwaterresourcehub.org/gde-tools/gde-rooting-depths-database-for-gdes/), rooting depths are likely to spatially vary based on the local hydrologic conditions available to the plant. Also, max rooting depths do not take capillary action into consideration, which will vary with soil type and is an important consideration since woody phreatophytes generally do not like to have their roots submerged in groundwater for extended periods of time, and hence can access groundwater at deeper depths. In addition, while it is likely to be true that shallow water availability is necessary to support the recruitment of saplings, hydraulic lift of groundwater to shallow depths has been observed in *Quercus* spp.
    - *Use of depth to water maps from 2014 and 2016:*
        - 2016 is <u>after</u> the SGMA benchmark date of January 1, 2015. Please rely on groundwater condition data prior to the SGMA benchmark date.
        - We highly recommend using depth to groundwater data from multiple seasons and water year types (e.g., wet, dry, average, drought) to determine the range of depth to groundwater around NC dataset polygons. Please refer to Attachment D of

this letter for best practices for using local groundwater data to verify whether polygons in the NC Dataset are supported by groundwater in an aquifer. If insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset, include those polygons in the GSP until data gaps are reconciled in the monitoring network. While depth to groundwater levels within 30 feet are generally accepted as being a proxy for confirming that polygons in the NC dataset are connected to groundwater, it is highly advised that seasonal and interannual groundwater fluctuations in the groundwater regime are taken into consideration. Utilizing groundwater data from one or two points in time can misrepresent groundwater levels required by GDEs, and inadvertently result in adverse impacts to the GDEs. Based on a study we recently submitted to Frontiers in Environmental Science Journal, we've observed riparian forests along the Cosumnes River to experience a range in groundwater levels between 1.5 and 75 feet over seasonal and interannual timescales. Seasonal fluctuations in the regional water table can support perched groundwater near an intermittent river that seasonally runs dry due to large seasonal fluctuations in the regional water table. While perched groundwater itself cannot directly be managed due to its position in the vadose zone, the water table position within the regional aquifer (via pumping rate restrictions, restricted pumping at certain depths, restricted pumping around GDEs, well density rules) and its interactions with surface water (e.g., timing and duration) can be managed to prevent adverse impacts to ecosystems due to changes in groundwater quality and quantity under SGMA.

- Please provide more details on how depth to groundwater contour maps were developed (Figures 2-70 and 2-71):
  - Are the wells used for interpolating depth to groundwater sufficiently close (<5km) to NC Dataset polygons to reflect local conditions relevant to ecosystems?
  - Are the wells used for interpolating depth to groundwater screened within the surficial unconfined aquifer and capable of measuring the true water table?
  - Is depth to groundwater contoured using groundwater elevations at monitoring wells to get groundwater elevation contours across the landscape? This layer can then be subtracted from land surface elevations from a Digital Elevation Model (DEM)[5] to estimate depth-to-groundwater contours across the landscape. This will provide much more accurate contours of depth-to-groundwater along streams and other land surface depressions where GDEs are commonly found. Depth to groundwater contours developed from depth to groundwater

[5] USGS Digital Elevation Model data products are described at: https://www.usgs.gov/core-science-systems/ngp/3dep/about-3dep-products-services and can be downloaded at: https://iewer.nationalmap.gov/basic/

measurements at wells assumes that the land surface is constant, which is a poor assumption to make. It is better to assume that water surface elevations are constant in between wells, and then calculate depth to groundwater using a DEM of the land surface to contour depth to groundwater.

- o The depth to groundwater contour maps (Figures 2-70 and 2-71) show large areas of data gaps, given the marked data points on the map where data exists. These maps were used to exclude all GDEs located adjacent to Chowchilla River, Ash Slough, and Berenda Slough (Figure 1 of Appendix 2.B). As stated above, if insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset, include those polygons in the GSP until data gaps are reconciled in the monitoring network.

Checklist Items 16 to 20, Describing GDEs (23 CCR §354.16)

[Appendix 2.B (Assessment of Groundwater Dependent Ecosystems)]

- TNC acknowledges and appreciates the comprehensive evaluation of the San Joaquin River Riparian GDE unit following our guidance, including analyzing hydrologic conditions, ecological conditions, providing an inventory of species and ecological value, along with concurrent field studies and reconnaissance. We also appreciate the use of TNC's GDE Pulse to examine NDVI and NDMI trend data for the GDE polygons within the GDE unit.

Checklist Items 21 and 22 – Water Budget (23 CCR §354.18)

[Section 2.2.3 Water Budget Information (p. 2-43 to 2-98)]

- The text states (p. 2-79): "…while for native vegetation lands, groundwater extraction by riparian vegetation was considered to be negligible because of the depth to groundwater in the subbasin." Because there are potential GDEs included in the Chowchilla Subbasin, please quantify the evapotranspiration from groundwater by riparian vegetation even if small. Please revise the text and budget as necessary.

Checklist Items 23 to 25 – Sustainability Goal (23 CCR §354.24)

[Section 3.1 Sustainability Goal (p. 3-2)]

- The sustainability goal does not specifically mention beneficial uses or users of groundwater, including environmental users. It states "the six sustainability indicators, established measurable objectives, and minimum thresholds will ensure that no undesirable results of significant and unreasonable economic, social, or environmental impacts occur…" Please rephrase the Sustainability Goal to specifically call out beneficial uses and users of groundwater including environmental users. Please state how the sustainability of environmental uses will be protected. In addition, a statement about any intention to address pre-SGMA impacts should be included.

Checklist Item 26 – Measurable Objectives (23 CCR §354.30)

[Section 3.2.5 Measurable Objectives for Depletion of Surface Water (p. 3-21)]

- The GSP states (p. 3-5): "Groundwater in the GDE unit is tightly coupled with surface flow and runoff and is generally maintained at depths within the maximum rooting depth range of the dominant phreatophytic species present in the unit (see Section 2.2.2). The groundwater that is potentially accessible to the vegetation composing the GDE unit likely occurs as a shallow perched/mounded aquifer fed largely by percolation of surface flow from the San Joaquin River. As described in Section 2.2.5 [should be 2.2.2.5], it has been determined that a connection between regional groundwater and streams does not currently exist in the subbasin." However, Section 2.2.2.5 does not present evidence that ISWs do not exist in the Subbasin, and states that a historical connection between groundwater and the San Joaquin River did exist through 2008.
- The GSP fails to establish measurable objectives or minimum thresholds for this sustainability indicator. The existence of riparian GDEs along the streams in the basin has been identified in Appendix 2.B, and their connection to groundwater is assumed. Their occurrence in the riparian zone means that these GDEs should be considered a beneficial user of groundwater that could be affected by chronic groundwater level decline as discussed above, as well as beneficial users of surface water that could be depleted by groundwater extraction. A more robust discussion of the known facts regarding these surface-groundwater interactions in the riparian zone should be provided. In addition, more detailed discussion regarding specific data gaps should be included.
- There is a need to evaluate and discuss potential effects on beneficial uses of surface and groundwater. In addition, the applicable state, federal and local standards for the protection of aquatic, riparian and other protected habitats should be discussed. This is necessary, at a minimum, so that the nature of the data gaps can be understood. Please refer to Attachment C for a list of freshwater species in Chowchilla Subbasin that may be exist within ISWs. We recommend that after identifying which freshwater species exist in your basin, especially federal and state listed species, that you contact staff at the Department of Fish and Wildlife (DFW), United States Fish and Wildlife Service (USFWS) and/or National Marine Fisheries Services (NMFS) to obtain their input on the groundwater and surface water needs of the organisms on the freshwater species list. Because effects to plants and animals are difficult and sometimes impossible to reverse, we recommend erring on the side of caution to preserve sufficient groundwater conditions to sustain GDEs and ISWs. Please refer to the Critical Species Lookbook[6] to review and discuss the potential groundwater reliance of critical species in the basin.
- The analysis for ISWs should include all beneficial users of surface water that could be affected by groundwater withdrawals, including environmental. Refer to the San Joaquin River Restoration Program (SJRRP) that identifies instream flow needs for salmon. Please include instream flow requirements in this section and

[6] Available online at: https://groundwaterresourcehub.org/sgma-tools/the-critical-species-lookbook/

whether the measurable objectives and interim milestones will help achieve the sustainability goal as it pertains to the environment.

Checklist Item 27-29 – Minimum Thresholds (23 CCR §354.28)

[Section 3.3.1 Minimum Thresholds for Lowering of Groundwater Levels (p. 3-22)]

- Please correct the call-out on p. 3-23 to Appendix 6.D (it should be 2.B).
- The text states (p. 3-23): "The minimum thresholds for chronic lowering of groundwater levels are based on selection of RMS from among existing production and monitoring wells located throughout the subbasin and screened in both in the Upper and Lower Aquifers." Please clarify the text to state that wells were chosen that monitor a single aquifer, but not both at the same time (i.e. composite), if that is the intended meaning.

[Section 3.3.4 Minimum Thresholds for Degraded Water Quality (p. 3-35)]

- This Minimum Threshold does not consider water quality needs of GDEs. The text states (p. 3-36): "Protection of municipal and domestic beneficial uses is also protective of all other groundwater beneficial uses." Please elaborate on this statement and include a discussion about GDEs and water quality and whether the measurable objectives and interim milestones will help achieve the sustainability goal as it pertains to the environment.

[Section 3.3.5 Minimum Thresholds for Depletion of Surface Water (p. 3-40)]

- The text states (p. 3-40): "Therefore, the surface water depletion sustainability criteria is not applicable to the subbasin." However, no evidence is provided in the GSP to show that a hydraulic connection between groundwater and surface water does not exist. Following the discussion presented above for Checklist Item 26 (Measurable Objectives), please include a discussion of Sustainable Management Criteria for ISWs, including Minimum Thresholds, in the GSP. Please cite data gaps regarding ISWs and make plans to reconcile them in the Monitoring Section of the GSP.

Checklist Item 30-46 – Undesirable Results (23 CCR §354.26)

[Section 3.4 Undesirable Results (p. 3-40)]

- This section only describes undesirable results relating to human beneficial uses of groundwater and neglects environmental beneficial uses that could be adversely affected by chronic groundwater level decline. **Please add "potential adverse** impacts to GDE**s" to the list of potential undesirable results presented in** Table 3-8 (p. 3-41).

[Section 3.4.1 Undesirable Results for Lowering of Groundwater Levels (p. 3-42)]

- The GSP states (p. 3-42): "Using the Fall measurements (assumed to be collected in October), a groundwater elevation undesirable result is defined to occur when greater than 30% of the RMS [representative monitoring sites] each exceed the groundwater level minimum thresholds for the same two consecutive Fall readings. Given a total of 36 RMS sites, a total of 11 or more the RMS would need to exceed MTs as defined above to constitute an undesirable result for chronic lowering of groundwater levels." The use of 30 percent to define an undesirable result does not allow for the occurrence of low water levels in one area, such as near a GDE, to be an Undesirable Result, which may impact environmental beneficial use. There are three RMS near the San Joaquin River Riparian GDE unit, which could be evaluated separately. Please consider the use of a separate management area for the San Joaquin River Riparian GDE unit so that different sustainable management criteria can be established for this GDE unit.

[Sections 3.4.4 Undesirable Results for Degraded Water Quality (p. 3-44)]

- This section describes undesirable results in terms of meeting drinking water standards. The following is a link to a paper by Smith, Knight and Fendorf (2018) titled "Overpumping leads to California groundwater arsenic threat": (https://www.nature.com/articles/s41467-018-04475-3). The section should be modified to state that overpumping and dewatering of aquitards has been identified as a potential source of elevated arsenic concentrations above drinking water standards in San Joaquin Valley aquifers. In addition, any potential undesirable results from degradation of water quality that may impact GDEs and freshwater species in the area should be discussed in this section.

[Sections 3.4.5 Undesirable Results for Depletion of Surface Water (p. 3-45)]

- Following the discussion presented above for Checklist Item 26 (Measurable Objectives), please include a discussion of Sustainable Management Criteria for ISWs, including Undesirable Results, in the GSP. Please cite data gaps regarding ISWs and make plans to reconcile them in the Monitoring Section of the GSP.

<u>Checklist Items 47, 48 and 49 – Monitoring Network (23 CCR §354.34)</u>

[Section 3.5 Monitoring Network (p. 3-45)]

- Per the GSP Regulations (23 CCR §354.34 (a) and (b)), monitoring must address trends in groundwater <u>*and related surface conditions*</u> (emphasis added). Groundwater level monitoring alone may be insufficient to establish a linkage between groundwater extraction and potentially resulting impacts to environmental resources associated with GDEs and ISWs. The cause-effect relationship between groundwater levels and the biological responses that could result in significant and unreasonable impacts to ISWs and GDEs depends on a number of complicated factors, and this relationship is not characterized or discussed. The Monitoring

Network section currently does not address future needs for ISW monitoring. In this section, please describe monitoring for ISWs as described below:

- In addition to the need for additional shallow monitoring wells in the upper aquifer to map GDEs, there is also a need to enhancing monitoring of stream flow and vertical groundwater gradients by installing more stream gauges and clustered/nested wells near streams, rivers or wetlands. Ideally, co-locating stream gauges with wells that can monitor groundwater levels in both the upper and lower aquifers would enhance understanding about where ISWs exist in the basin and whether pumping is causing depletions of surface water or impacts on beneficial users of surface water and groundwater. Please provide sufficient detail for the investigation and monitoring program including stream gauges, screened intervals and frequency of monitoring, in order to describe monitoring of both the extent of ISWs and the quantity of surface water depletions from ISWs.

[Section 3.5.1.1 Groundwater Level Monitoring Program (p. 3-47)]

- As noted in our comments above on Checklist Items 11-15, the depth to groundwater contour maps (Figures 2-70 and 2-71) show large areas of data gaps, given the marked data points on the map where data exists. These maps were used to exclude all GDEs located adjacent to Chowchilla River, Ash Slough, and Berenda Slough (Figure 1 of Appendix 2.B). Please propose additional upper aquifer wells to reconcile this data gap.

Checklist Items 50 and 51 – Projects and Management Actions to Achieve Sustainability Goal (23 CCR §354.44)

[Section 4 Projects (p. 4-1)]

- The Subbasin area includes GDEs and ISWs that are beneficial uses and users of groundwater, and may include potentially sensitive resources and protected lands. Protection of environmental uses and users should be considered in establishing project priorities. In addition, consistent with existing grant and funding guidelines for SGMA-related work, priority should be given to multi-benefit projects that can address water quantity as well as providing environmental benefits or benefits to disadvantaged communities. Please include environmental benefits and multiple benefits as criteria for assessing project priorities.
- This section identifies many important projects; however, the descriptions of Measurable Objectives for these projects only identifies benefits to water level and storage. Because maintenance or recovery of groundwater levels, or construction of recharge facilities, may have potential environmental benefits in many cases it would be advantageous to demonstrate multiple benefits from a funding and prioritization perspective.
    - For the projects already identified, please consider stating how ISWs and GDEs will benefit or be protected, or what other environmental benefits will accrue.

- If ISWs will not be adequately protected by those listed, please include and describe additional management actions and projects targeted for protecting ISWs.
- Recharge ponds, reservoirs and facilities for managed stormwater recharge can be designed as multiple-benefit projects to include elements that act functionally as wetlands and provide a benefit for wildlife and aquatic species. In some cases, such facilities have been incorporated into local Habitat Conservation Plans (HCPs) and Natural Community Conservation Plans (NCCPs), more fully recognizing the value of the habitat that they provide and the species they support. For projects that construct recharge ponds, please consider identifying if there is habitat value incorporated into the design and how the recharge ponds can be managed as multiple-benefit projects that have a benefit to environmental users. Grant and funding opportunities for SGMA-related work may apply to multi-benefit projects that can address water quantity as well as provide environmental benefits.
- For examples of case studies on how to incorporate environmental benefits into groundwater projects, please visit our website: https://groundwaterresourcehub.org/case-studies/recharge-case-studies/

Attachment C

Freshwater Species Located in the Chowchilla Subbasin

To assist in identifying the beneficial users of surface water necessary to assess the undesirable result "depletion of interconnected surface waters", Attachment C provides a list of freshwater species located in the Chowchilla Subbasin. To produce the freshwater species list, we used ArcGIS to select features within the California Freshwater Species Database version 2.0.9 within the Chowchilla groundwater basin boundary. This database contains information on ~4,000 vertebrates, macroinvertebrates and vascular plants that depend on fresh water for at least one stage of their life cycle. The methods used to compile the California Freshwater Species Database can be found in Howard et al. 2015[7]. The spatial database contains locality observations and/or distribution information from ~400 data sources. The database is housed in the California Department of Fish and Wildlife's BIOS[8] as well as on The Nature Conservancy's science website[9].

Scientific Name	Common Name	Legally Protected Status		
		Federal	State	Other
BIRD				
Actitis macularius	Spotted Sandpiper			
Aechmophorus occidentalis	Western Grebe			
Agelaius tricolor	Tricolored Blackbird	Bird of Conservation Concern	Special Concern	BSSC - First priority
Anas acuta	Northern Pintail			
Anas americana	American Wigeon			
Anas clypeata	Northern Shoveler			
Anas crecca	Green-winged Teal			
Anas cyanoptera	Cinnamon Teal			
Anas discors	Blue-winged Teal			
Anas platyrhynchos	Mallard			
Anas strepera	Gadwall			
Anser albifrons	Greater White-fronted Goose			
Ardea alba	Great Egret			
Ardea herodias	Great Blue Heron			
Aythya affinis	Lesser Scaup			
Aythya americana	Redhead		Special Concern	BSSC - Third priority
Aythya collaris	Ring-necked Duck			
Aythya valisineria	Canvasback		Special	
Botaurus lentiginosus	American Bittern			

[7] Howard, J.K. et al. 2015. Patterns of Freshwater Species Richness, Endemism, and Vulnerability in California. PLoSONE, 11(7). Available at: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0130710
[8] California Department of Fish and Wildlife BIOS: https://www.wildlife.ca.gov/data/BIOS
[9] Science for Conservation: https://www.scienceforconservation.org/products/california-freshwater-species-database

Bucephala albeola	Bufflehead			
Bucephala clangula	Common Goldeneye			
Butorides virescens	Green Heron			
Calidris alpina	Dunlin			
Calidris mauri	Western Sandpiper			
Calidris minutilla	Least Sandpiper			
Cistothorus palustris palustris	Marsh Wren			
Egretta thula	Snowy Egret			
Empidonax traillii	Willow Flycatcher	Bird of Conservation Concern	Endangered	
Fulica americana	American Coot			
Gallinago delicata	Wilson's Snipe			
Grus canadensis	Sandhill Crane			
Haliaeetus leucocephalus	Bald Eagle	Bird of Conservation Concern	Endangered	
Himantopus mexicanus	Black-necked Stilt			
Limnodromus scolopaceus	Long-billed Dowitcher			
Lophodytes cucullatus	Hooded Merganser			
Megaceryle alcyon	Belted Kingfisher			
Mergus merganser	Common Merganser			
Numenius americanus	Long-billed Curlew			
Numenius phaeopus	Whimbrel			
Nycticorax nycticorax	Black-crowned Night-Heron			
Oxyura jamaicensis	Ruddy Duck			
Pelecanus erythrorhynchos	American White Pelican		Special Concern	BSSC - First priority
Phalacrocorax auritus	Double-crested Cormorant			
Phalaropus tricolor	Wilson's Phalarope			
Plegadis chihi	White-faced Ibis		Watch list	
Pluvialis squatarola	Black-bellied Plover			
Podiceps nigricollis	Eared Grebe			
Podilymbus podiceps	Pied-billed Grebe			
Porzana carolina	Sora			
Rallus limicola	Virginia Rail			
Recurvirostra americana	American Avocet			
Setophaga petechia	Yellow Warbler			BSSC - Second priority
Tachycineta bicolor	Tree Swallow			
Tringa melanoleuca	Greater Yellowlegs			
Tringa semipalmata	Willet			

Tringa solitaria	Solitary Sandpiper			
Xanthocephalus xanthocephalus	Yellow-headed Blackbird		Special Concern	BSSC - Third priority
CRUSTACEAN				
Branchinecta lynchi	Vernal Pool Fairy Shrimp	Threatened	Special	IUCN - Vulnerable
Branchinecta mesovallensis	Midvalley Fairy Shrimp		Special	
Lepidurus packardi	Vernal Pool Tadpole Shrimp	Endangered	Special	IUCN - Endangere d
Linderiella occidentalis	California Fairy Shrimp		Special	IUCN - Near Threatened
FISH				
Catostomus occidentalis occidentalis	Sacramento sucker			Least Concern - Moyle 2013
Cottus asper ssp. 1	Prickly sculpin			Least Concern - Moyle 2013
Lampetra hubbsi	Kern brook lamprey		Special Concern	Vulnerable - Moyle 2013
Lavinia exilicauda exilicauda	Sacramento hitch		Special	Near-Threatened - Moyle 2013
Mylopharodon conocephalus	Hardhead		Special Concern	Near-Threatened - Moyle 2013
Oncorhynchus mykiss irideus	Coastal rainbow trout			Least Concern - Moyle 2013
Oncorhynchus tshawytscha - CV fall	Central Valley fall Chinook salmon	Species of Special Concern	Special Concern	Vulnerable - Moyle 2013
Oncorhynchus tshawytscha - CV late fall	Central Valley late fall Chinook salmon	Species of Special Concern		Endangere d - Moyle 2013
Orthodon microlepidotus	Sacramento blackfish			Least Concern - Moyle 2013
Ptychocheilus grandis	Sacramento pikeminnow			Least Concern - Moyle 2013
HERP				
Actinemys marmorata marmorata	Western Pond Turtle		Special Concern	ARSSC

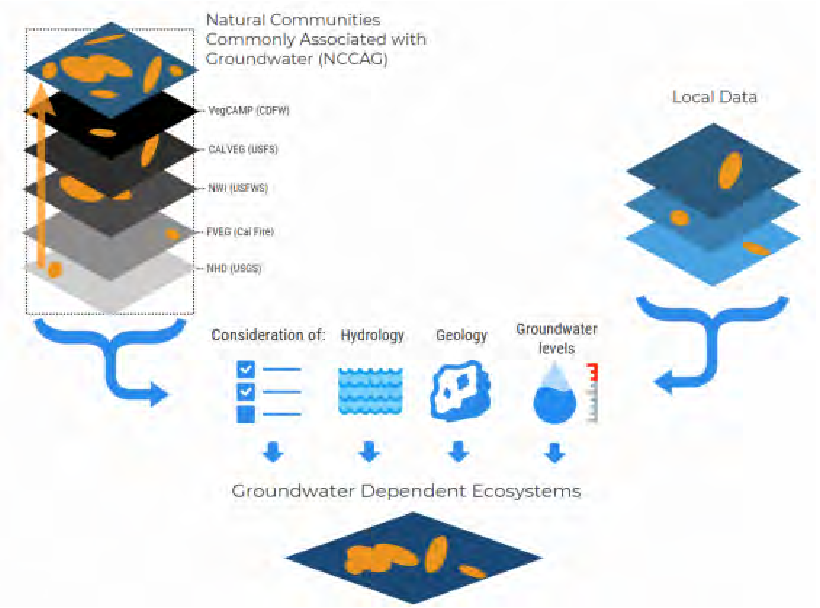
Ambystoma californiense californiense	California Tiger Salamander	Threatened	Threatened	ARSSC
Anaxyrus boreas boreas	Boreal Toad			
Spea hammondii	Western Spadefoot	Under Review in the Candidate or Petition Process	Special Concern	ARSSC
Thamnophis gigas	Giant Gartersnake	Threatened	Threatened	
Thamnophis sirtalis sirtalis	Common Gartersnake			
INSECT & OTHER INVERT				
MAMMAL				
Castor canadensis	American Beaver			Not on any status lists
Lontra canadensis canadensis	North American River Otter			Not on any status lists
Neovison vison	American Mink			Not on any status lists
Ondatra zibethicus	Common Muskrat			Not on any status lists
MOLLUSK				
Anodonta californiensis	California Floater		Special	
Margaritifera falcata	Western Pearlshell		Special	
PLANT				
Callitriche longipedunculata	Longstock Water-starwort			
Castilleja campestris succulenta	Fleshy Owl's-clover	Threatened	Endangered	CRPR - 1B.2
Chloropyron palmatum	NA	Endangered	Special	CRPR - 1B.1
Crassula aquatica	Water Pygmyweed			
Eryngium spinosepalum	Spiny Sepaled Coyote-thistle		Special	CRPR - 1B.2
Lasthenia fremontii	Fremont's Goldfields			
Myosurus minimus	NA			
Orcuttia inaequalis	San Joaquin Valley Orcutt Grass	Threatened	Endangered	CRPR - 1B.1
Phacelia distans	NA			
Pilularia americana	NA			
Plagiobothrys leptocladus	Alkali Popcorn-flower			
Psilocarphus brevissimus brevissimus	Dwarf Woolly-heads			

Attachment D

July 2019

IDENTIFYING GDEs UNDER SGMA
Best Practices for using the NC Dataset

The Sustainable Groundwater Management Act (SGMA) requires that groundwater dependent ecosystems (GDEs) be identified in Groundwater Sustainability Plans (GSPs). As a starting point, the Department of Water Resources (DWR) is providing the Natural Communities Commonly Associated with Groundwater Dataset (NC Dataset) online[10] to help Groundwater Sustainability Agencies (GSAs), consultants, and stakeholders identify GDEs within individual groundwater basins. To apply information from the NC Dataset to local areas, GSAs should combine it with the best available science on local hydrology, geology, and groundwater levels to verify whether polygons in the NC dataset are likely supported by groundwater in an aquifer (Figure 1)[11]. This document highlights six best practices for using local groundwater data to confirm whether mapped features in the NC dataset are supported by groundwater.



[10] *NC Dataset Online Viewer: https://gis.water.ca.gov/app/NCDatasetViewer/*

[11] California Department of Water Resources (DWR). 2018. Summary of the "Natural Communities Commonly Associated with Groundwater" Dataset and Online Web Viewer. Available at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Data-and-Tools/Files/Statewide-Reports/Natural-Communities-Dataset-Summary-Document.pdf

The NC Dataset identifies vegetation and wetland features that are good indicators of a GDE. The dataset is comprised of 48 publicly available state and federal datasets that map vegetation, wetlands, springs, and seeps commonly associated with groundwater in California[12]. It was developed through a collaboration between DWR, the Department of Fish and Wildlife, and The Nature Conservancy (TNC). TNC has also provided detailed guidance on identifying GDEs from the NC dataset[13] on the Groundwater Resource Hub[14], a website dedicated to GDEs.

BEST PRACTICE #1. Establishing a Connection to Groundwater

Groundwater basins can be comprised of one continuous aquifer (Figure 2a) or multiple aquifers stacked on top of each other (Figure 2b). In unconfined aquifers (Figure 2a), using the depth-to-groundwater and the rooting depth of the vegetation is a reasonable method to infer groundwater dependence for GDEs. If groundwater is well below the rooting (and capillary) zone of the plants and any wetland features, the ecosystem is considered disconnected and groundwater management is not likely to affect the ecosystem (Figure 2d). However, it is important to consider local conditions (e.g., soil type, groundwater flow gradients, and aquifer parameters) and to review groundwater depth data from multiple seasons and water year types (wet and dry) because intermittent periods of high groundwater levels can replenish perched clay lenses that serve as the water source for GDEs (Figure 2c). Maintaining these natural groundwater fluctuations are important to sustaining GDE health.

Basins with a stacked series of aquifers (Figure 2b) may have varying levels of pumping across aquifers in the basin, depending on the production capacity or water quality associated with each aquifer. If pumping is concentrated in deeper aquifers, SGMA still requires GSAs to sustainably manage groundwater resources in shallow aquifers, such as perched aquifers, that support springs, surface water, domestic wells, and GDEs (Figure 2). This is because vertical groundwater gradients across aquifers may result in pumping from deeper aquifers to cause adverse impacts onto beneficial users reliant on shallow aquifers or interconnected surface water. The goal of SGMA is to sustainably manage groundwater resources for current and future social, economic, and environmental benefits. While groundwater pumping may not be currently occurring in a shallower aquifer, use of this water may become more appealing and economically viable in future years as pumping restrictions are placed on the deeper production aquifers in the basin to meet the sustainable yield and criteria. Thus, identifying GDEs in the basin should done irrespective to the amount of current pumping occurring in a particular aquifer, so that future impacts on GDEs due to new production can be avoided. A good rule of thumb to follow is: *if groundwater can be pumped from a well - it's an aquifer*.

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[12] *For more details on the mapping methods, refer to: Klausmeyer, K., J. Howard, T. Keeler-Wolf, K. Davis-Fadtke, R. Hull, A. Lyons. 2018. Mapping Indicators of Groundwater Dependent Ecosystems in California: Methods Report. San Francisco, California. Available at: https://groundwaterresourcehub.org/public/uploads/pdfs/iGDE_data_paper_20180423.pdf*

[13] "Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans" is available at: https://groundwaterresourcehub.org/gde-tools/gsp-guidance-document/

[14] *The Groundwater Resource Hub: www.GroundwaterResourceHub.org*

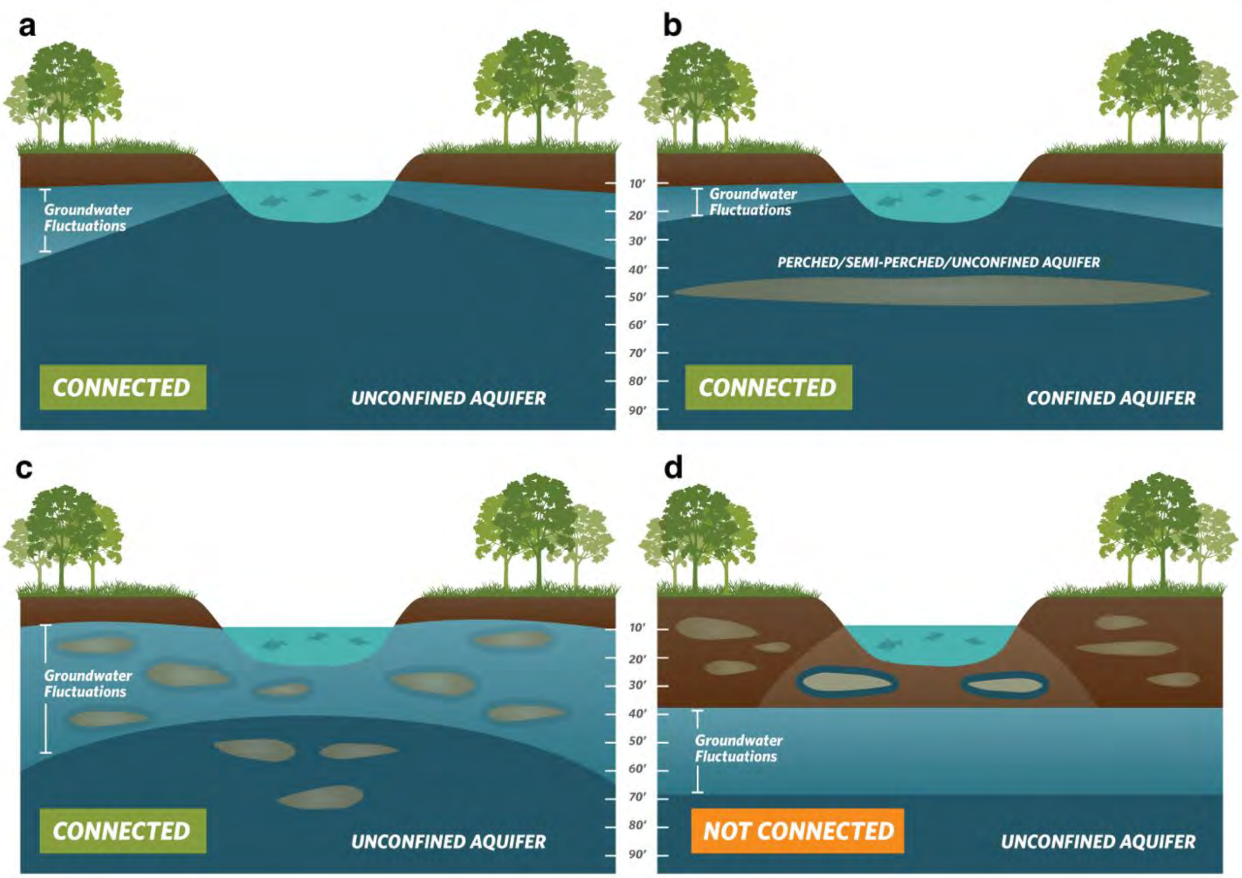

Figure 2. Confirming whether an ecosystem is connected to groundwater. Top: (a) Under the ecosystem is an unconfined aquifer with depth-to-groundwater fluctuating seasonally and interannually within 30 feet from land surface. (b) Depth-to-groundwater in the shallow aquifer is connected to overlying ecosystem. Pumping predominately occurs in the confined aquifer, but pumping is possible in the shallow aquifer. Bottom: (c) Depth-to-groundwater fluctuations are seasonally and interannually large, however, clay layers in the near surface prolong the ecosystem's connection to groundwater. (d) Groundwater is disconnected from surface water, and any water in the vadose (unsaturated) zone is due to direct recharge from precipitation and indirect recharge under the surface water feature. These areas are not connected to groundwater and typically support species that do not require access to groundwater to survive.

BEST PRACTICE #2. Characterize Seasonal and Interannual Groundwater Conditions

SGMA requires GSAs to describe current and historical groundwater conditions when identifying GDEs [23 CCR §354.16(g)]. Relying solely on the SGMA benchmark date (January 1, 2015) or any other single point in time to characterize groundwater conditions (e.g., depth-to-groundwater) is inadequate because managing groundwater conditions with data from one time point fails to capture the seasonal and interannual variability typical of California's climate. DWR's Best Management Practices document on water budgets[15] recommends using 10 years of water supply and water budget information to describe how historical conditions have impacted the operation of the basin within sustainable yield, implying that a baseline[16] could be determined based on data between 2005 and 2015. Using this or a similar time period, depending on data availability, is recommended for determining the depth-to-groundwater.

GDEs depend on groundwater levels being close enough to the land surface to interconnect with surface water systems or plant rooting networks. The most practical approach[17] for a GSA to assess whether polygons in the NC dataset are connected to groundwater is to rely on groundwater elevation data. As detailed in TNC's GDE guidance document[4], one of the key factors to consider when mapping GDEs is to contour depth-to-groundwater in the aquifer that is supporting the ecosystem (see Best Practice #5).

Groundwater levels fluctuate over time and space due to California's Mediterranean climate (dry summers and wet winters), climate change (flood and drought years), and subsurface heterogeneity in the subsurface (Figure 3). Many of California's GDEs have adapted to dealing with intermittent periods of water stress, however if these groundwater conditions are prolonged, adverse impacts to GDEs can result. While depth-to-groundwater levels within 30 feet[4] of the land surface are generally accepted as being a proxy for confirming that polygons in the NC dataset are supported by groundwater, it is highly advised that fluctuations in the groundwater regime be characterized to understand the seasonal and interannual groundwater variability in GDEs. Utilizing groundwater data from one point in time can misrepresent groundwater levels required by GDEs, and inadvertently result in adverse impacts to the GDEs. Time series data on groundwater elevations and depths are available on the SGMA Data Viewer[18]. However, if insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset, include those polygons in the GSP until data gaps are reconciled in the monitoring network (see Best Practice #6).

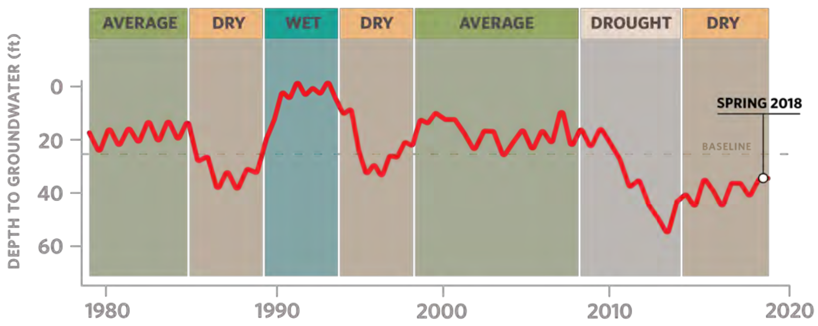

Figure 3. Example seasonality and interannual variability in depth-to-groundwater over time. Selecting one point in time, such as Spring 2018, to characterize groundwater conditions in GDEs fails to capture what groundwater conditions are necessary to maintain the ecosystem status into the future so adverse impacts are avoided.

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[15] DWR. 2016. Water Budget Best Management Practice. Available at: https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_Water_Budget_Final_2016-12-23.pdf

[16] *Baseline is defined under the GSP regulations as "historic information used to project future conditions for hydrology, water demand, and availability of surface water and to evaluate potential sustainable management practices of a basin." [23 CCR §351(e)]*

[17] Groundwater reliance can also be confirmed via stable isotope analysis and geophysical surveys. For more information see The GDE Assessment Toolbox (Appendix IV, GDE Guidance Document for GSPs[4]).

[18] *SGMA Data Viewer: https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer*

BEST PRACTICE #3. Ecosystems Often Rely on Both Groundwater and Surface Water

GDEs are plants and animals that rely on groundwater for all or some of its water needs, and thus can be supported by multiple water sources. The presence of non-groundwater sources (e.g., surface water, soil moisture in the vadose zone, applied water, treated wastewater effluent, urban stormwater, irrigated return flow) within and around a GDE does not preclude the possibility that it is supported by groundwater, too. SGMA defines GDEs as "ecological communities and species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface" [23 CCR §351(m)]. Hence, depth-to-groundwater data should be used to identify whether NC polygons are supported by groundwater and should be considered GDEs. In addition, SGMA requires that significant and undesirable adverse impacts to beneficial users of surface water be avoided. Beneficial users of surface water include environmental users such as plants or animals[19], which therefore must be considered when developing minimum thresholds for depletions of interconnected surface water.

GSAs are only responsible for impacts to GDEs resulting from groundwater conditions in the basin, so if adverse impacts to GDEs result from the diversion of applied water, treated wastewater, or irrigation return flow away from the GDE, then those impacts will be evaluated by other permitting requirements (e.g., CEQA) and may not be the responsibility of the GSA. However, if adverse impacts occur to the GDE due to changing groundwater conditions resulting from pumping or groundwater management activities, then the GSA would be responsible (Figure 4).

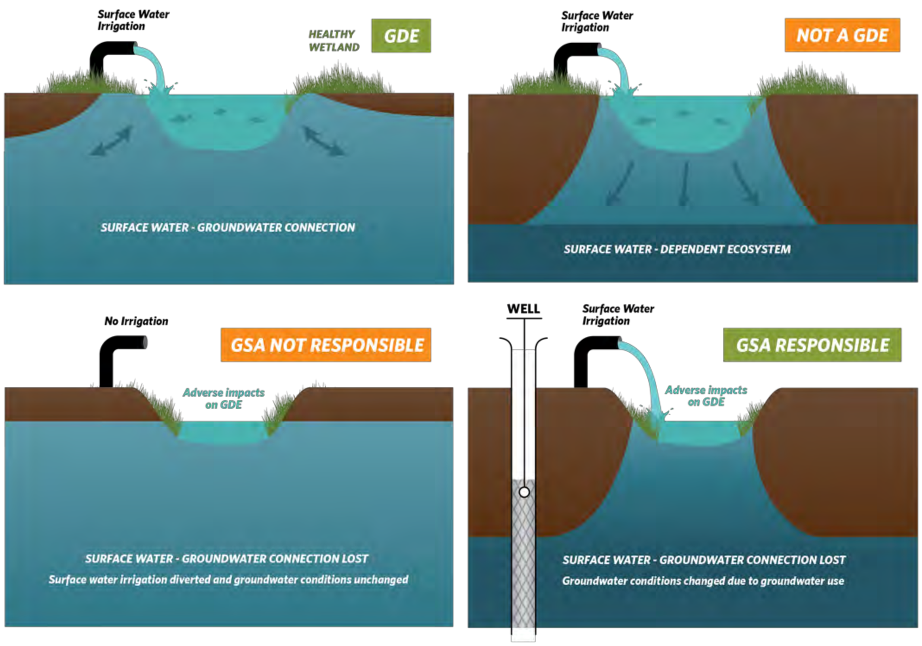

Figure 4. Ecosystems often depend on multiple sources of water. Top: (Left) Surface water and groundwater are interconnected, meaning that the GDE is supported by both groundwater and surface water. (Right) Ecosystems that are only reliant on non-groundwater sources are not groundwater-dependent. Bottom: (Left) An ecosystem that was once dependent on an interconnected surface water, but loses access to groundwater solely due to surface water diversions may not be the GSA's responsibility. (Right) Groundwater dependent ecosystems once dependent on an interconnected surface water system, but loses that access due to groundwater pumping is the GSA's responsibility.

[19] *For a list of environmental beneficial users of surface water by basin, visit: https://groundwaterresourcehub.org/gde-tools/environmental-surface-water-beneficiaries/*

BEST PRACTICE #4. Select Representative Groundwater Wells

Identifying GDEs in a basin requires that groundwater conditions are characterized to confirm whether polygons in the NC dataset are supported by the underlying aquifer. To do this, proximate groundwater wells should be identified to characterize groundwater conditions (Figure 5). When selecting representative wells, it is particularly important to consider the subsurface heterogeneity around NC polygons, especially near surface water features where groundwater and surface water interactions occur around heterogeneous stratigraphic units or aquitards formed by fluvial deposits. The following selection criteria can help ensure groundwater levels are representative of conditions within the GDE area:

- Choose wells that are within 5 kilometers (3.1 miles) of each NC Dataset polygons because they are more likely to reflect the local conditions relevant to the ecosystem. If there are no wells within 5km of the center of a NC dataset polygon, then there is insufficient information to remove the polygon based on groundwater depth. Instead, it should be retained as a potential GDE until there are sufficient data to determine whether or not the NC Dataset polygon is supported by groundwater.

- Choose wells that are screened within the surficial unconfined aquifer and capable of measuring the true water table.

- Avoid relying on wells that have insufficient information on the screened well depth interval for excluding GDEs because they could be providing data on the wrong aquifer. This type of well data should not be used to remove any NC polygons.

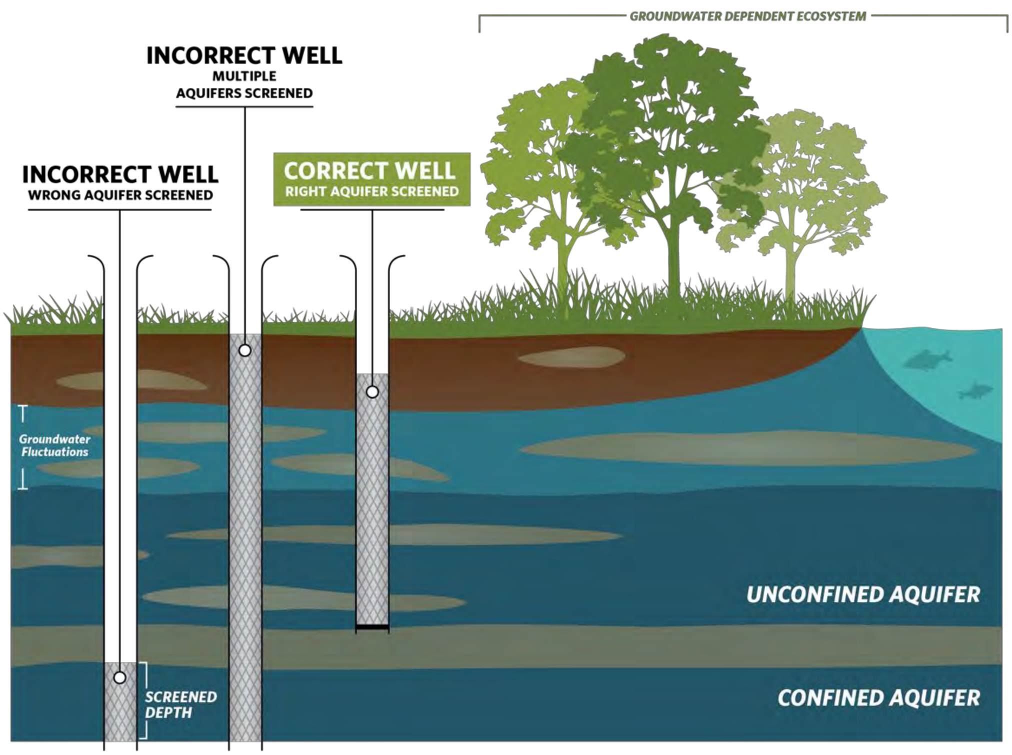

Figure 5. Selecting representative wells to characterize groundwater conditions near GDEs.

BEST PRACTICE #5. Contouring Groundwater Elevations

The common practice to contour depth-to-groundwater over a large area by interpolating measurements at monitoring wells is unsuitable for assessing whether an ecosystem is supported by groundwater. This practice causes errors when the land surface contains features like stream and wetland depressions because it assumes the land surface is constant across the landscape and depth-to-groundwater is constant below these low-lying areas (Figure 6a). A more accurate approach is to interpolate groundwater elevations at monitoring wells to get groundwater elevation contours across the landscape. This layer can then be subtracted from land surface elevations from a Digital Elevation Model (DEM)[20] to estimate depth-to-groundwater contours across the landscape (Figure b; Figure 7). This will provide a much more accurate contours of depth-to-groundwater along streams and other land surface depressions where GDEs are commonly found.

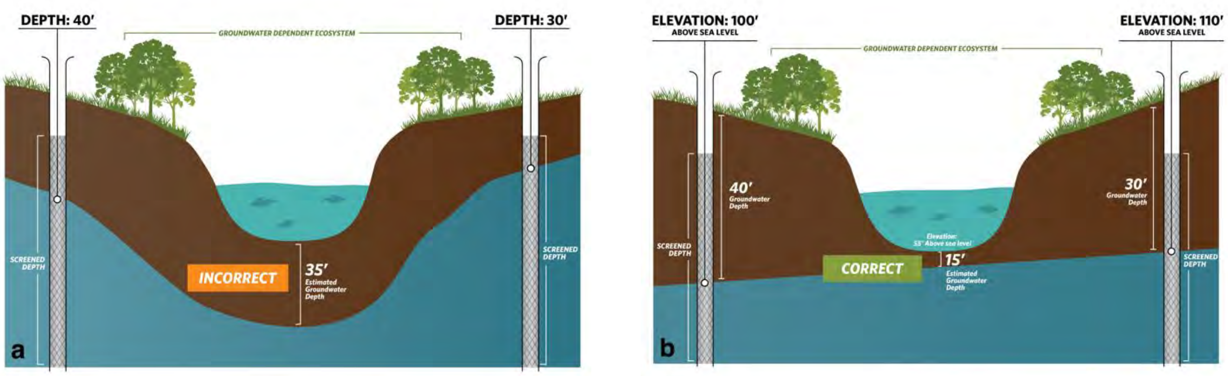

Figure 6. Contouring depth-to-groundwater around surface water features and GDEs. (a) Groundwater level interpolation using depth-to-groundwater data from monitoring wells. (b) Groundwater level interpolation using groundwater elevation data from monitoring wells and DEM data.

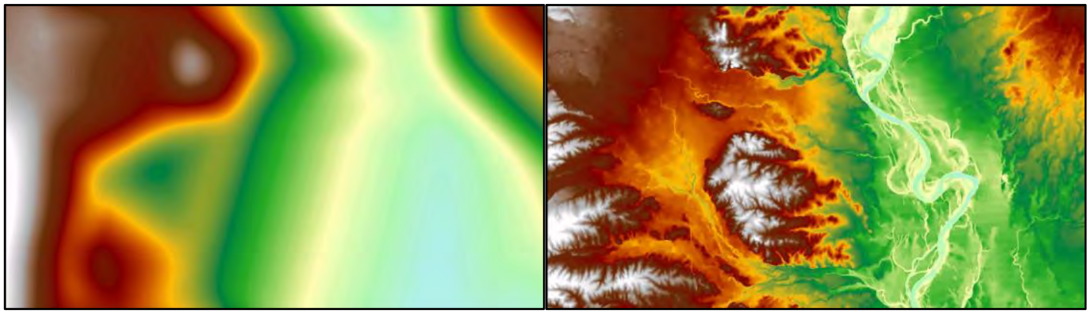

Figure 7. Depth-to-groundwater contours in Northern California. (Left) Contours were interpolated using depth-to-groundwater measurements determined at each well. (Right) Contours were determined by interpolating groundwater elevation measurements at each well and superimposing ground surface elevation from DEM spatial data to generate depth-to-groundwater contours. The image on the right shows a more accurate depth-to-groundwater estimate because it takes the local topography and elevation changes into account.

[20] USGS Digital Elevation Model data products are described at: https://www.usgs.gov/core-science-systems/ngp/3dep/about-3dep-products-services and can be downloaded at: https://iewer.nationalmap.gov/basic/

BEST PRACTICE #6. Best Available Science

Adaptive management is embedded within SGMA and provides a process to work toward sustainability over time by beginning with the best available information to make initial decisions, monitoring the results of those decisions, and using the data collected through monitoring programs to revise decisions in the future. In many situations, the hydrologic connection of NC dataset polygons will not initially be clearly understood if site-specific groundwater monitoring data are not available. If sufficient data are not available in time for the 2020/2022 plan, The Nature Conservancy strongly advises that questionable polygons from the NC dataset be included in the GSP until data gaps are reconciled in the monitoring network. Erring on the side of caution will help minimize inadvertent impacts to GDEs as a result of groundwater use and management actions during SGMA implementation.

KEY DEFINITIONS

Groundwater basin is an aquifer or stacked series of aquifers with reasonably well-defined boundaries in a lateral direction, based on features that significantly impede groundwater flow, and a definable bottom. *23 CCR §341(g)(1)*

Groundwater dependent ecosystem (GDE) are ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface. *23 CCR §351(m)*

Interconnected surface water (ISW) 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. *23 CCR §351(o)*

Principal aquifers are aquifers or aquifer systems that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems. *23 CCR §351(aa)*

ABOUT US

The Nature Conservancy is a science-based nonprofit organization whose mission is *to conserve the lands and waters on which all life depends*. To support successful SGMA implementation that meets the future needs of people, the economy, and the environment, TNC has developed tools and resources (www.groundwaterresourcehub.org) intended to reduce costs, shorten timelines, and increase benefits for both people and nature.

Listening Session Notes

Chowchilla Subbasin
Wednesday, October 23, 2019
2:00 – 4:00pm
Chowchilla Water District

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1. GSP Presentation

Doug W presented a summary/overview of the GSP for the Chowchilla Subbasin (GSP Highlights). He then stated that the deadline to submit comments regarding this plan is November 9, 2019.

2. Listening Session – the public is invited to comment on the Chowchilla Subbasin GSP The following comments were made:

- What does the hydrology mean on Figure 3-3A?

- In the plan do you have any idea of what the timing of the two sides of supply enhancement and groundwater enhancement? – How does that roll out in 20 years?

- On the project side – starting right now on the reduction and demand side – when do you expect that to kick in in any meaningful way?

- One question not clear to landowners – The 2%, is that a target for the whole GSA or is it a target for each individual to reach?

- The longer we could avoid allocating the better for farmers – see how the projects and other things will make it happen without out the farmers having to cut back. Maybe the projects and other things will take care of the problem.

- Merced County is suggesting 2% voluntary per year – they are probably not going to do anything for 5 years. Can we wait? (Correction from Merced member - They are still going to work out what is going to happen during the first 5 years – it will be voluntary in the beginning because there is no enforcement action now.)

- A lot of what is being talked about are management strategies - Triangle T just changed their management strategies and if you check the DWR website you can see maps that show the change in groundwater, just from the change of management policies. Farmers need to just work on their farm management strategies. The Madera/Chowchilla RCD is going to help farmers do some of this – farmers can do a lot on their own property, without asking permission. They can take out 5% of their land and it won't be the worst farming decision they will ever make.

- I hope that allocating and pumping to individual farmer is a long way off. I think there should be some way for the farmers to receive credit for the water they are putting into the ground. With a credit it will give farmers incentive to put more water into the ground.

- Merced is proposing a pumping fee on the growers - How many growers didn't take surface water this year when it was available because they can still pump? The frustration is our neighbors that are not helping and are pumping when they don't take surface water when it is available.

- I didn't know what recharge was until recharge happened. Neighbors are pumping and not using surface water – it is the need of education – people don't know – you have to always educate because the wheels of agriculture turns slow. All of this technology is going to change over time, but what we do on our farms we can do now without technology. We just need to educate farmers.

- We can't accomplish this without your cooperation (pointing at the Committee at the head table). We have two canals that drain water to the southern state – they cut the water off from the south side of the valley. Somehow or another we need to put enough clout in the system. We are proposing to set those limits not as a tomorrow morning demand – but every time we have a wet year – we have to do it now – we have to be able to send it into our water districts, not south or to the ocean. Kings River sends ½ of their water to LA and San Diego, we need to put a stop to that and put the water in the ground here and now. It is up to you and I – we have deep wells. Draw a line in the middle of Madera County, use highway 99 or the airport as a goal, and get the water up at least 50 feet if not 100 feet – we are currently below sea level. We have run our limit out so we have to all give a little up. We have to do something – we can't keep on doing what we are doing.

- The GSA had to be formed quickly, the GSP had to be formed quickly – there is no thought to what other GSAs are charging.

3. Adjournment
   November 20 is the next Advisory Committee meeting, here (Chowchilla Water District) at 2:00.

APPENDIX 2.D. HYDROGEOLOGIC CONCEPTUAL MODEL

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

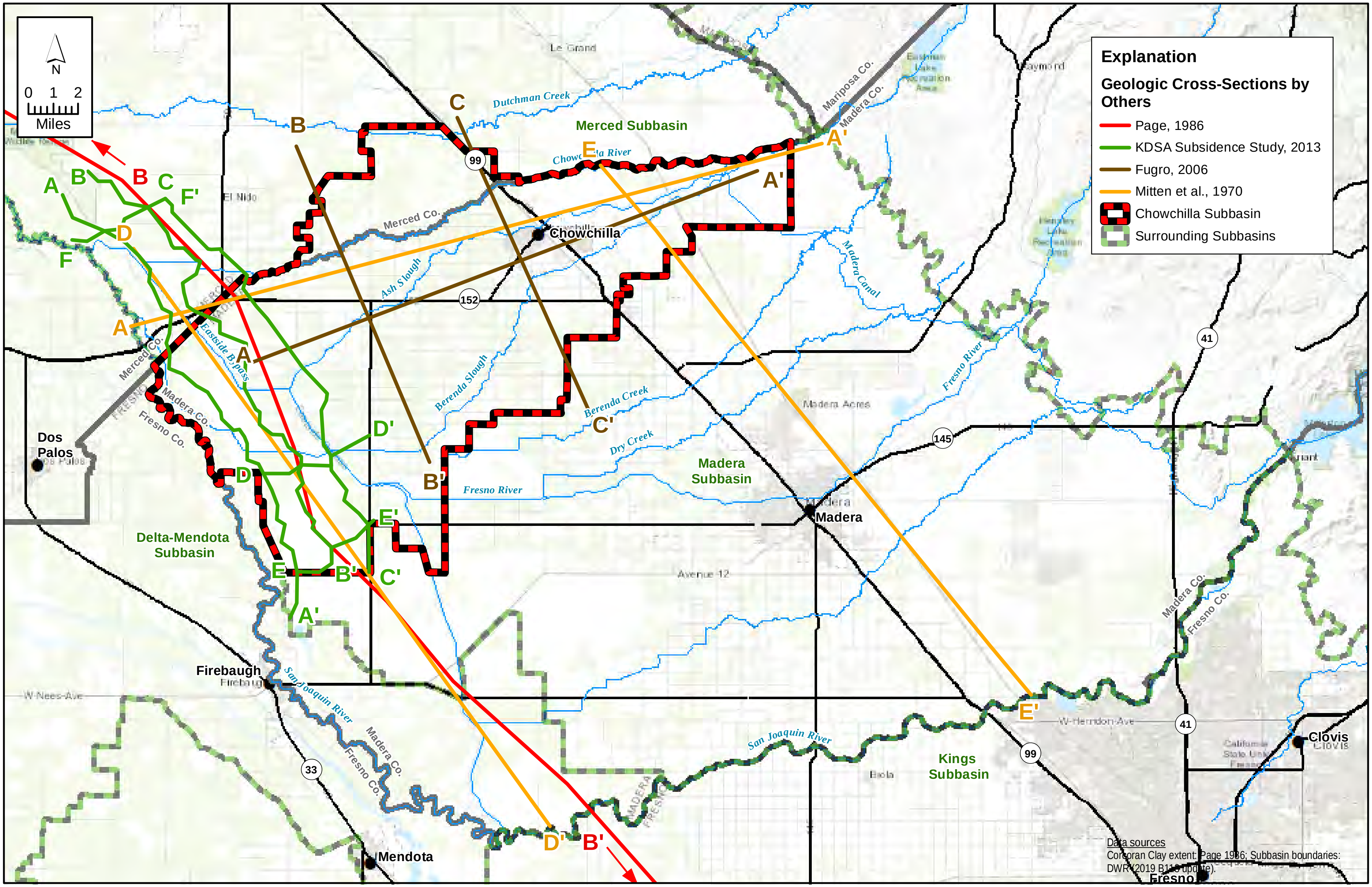
January 2020

GSP Team:

Davids Engineering, Inc
Luhdorff & Scalmanini
ERA Economics
Stillwater Sciences and
California State University, Sacramento

Existing Geologic

Cross-Sections



X:\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Appendix 2.F Chowchilla Subbasin CrossSection Location Map.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

APPENDIX 2.D

Existing Geologic Cross-Section Location Map

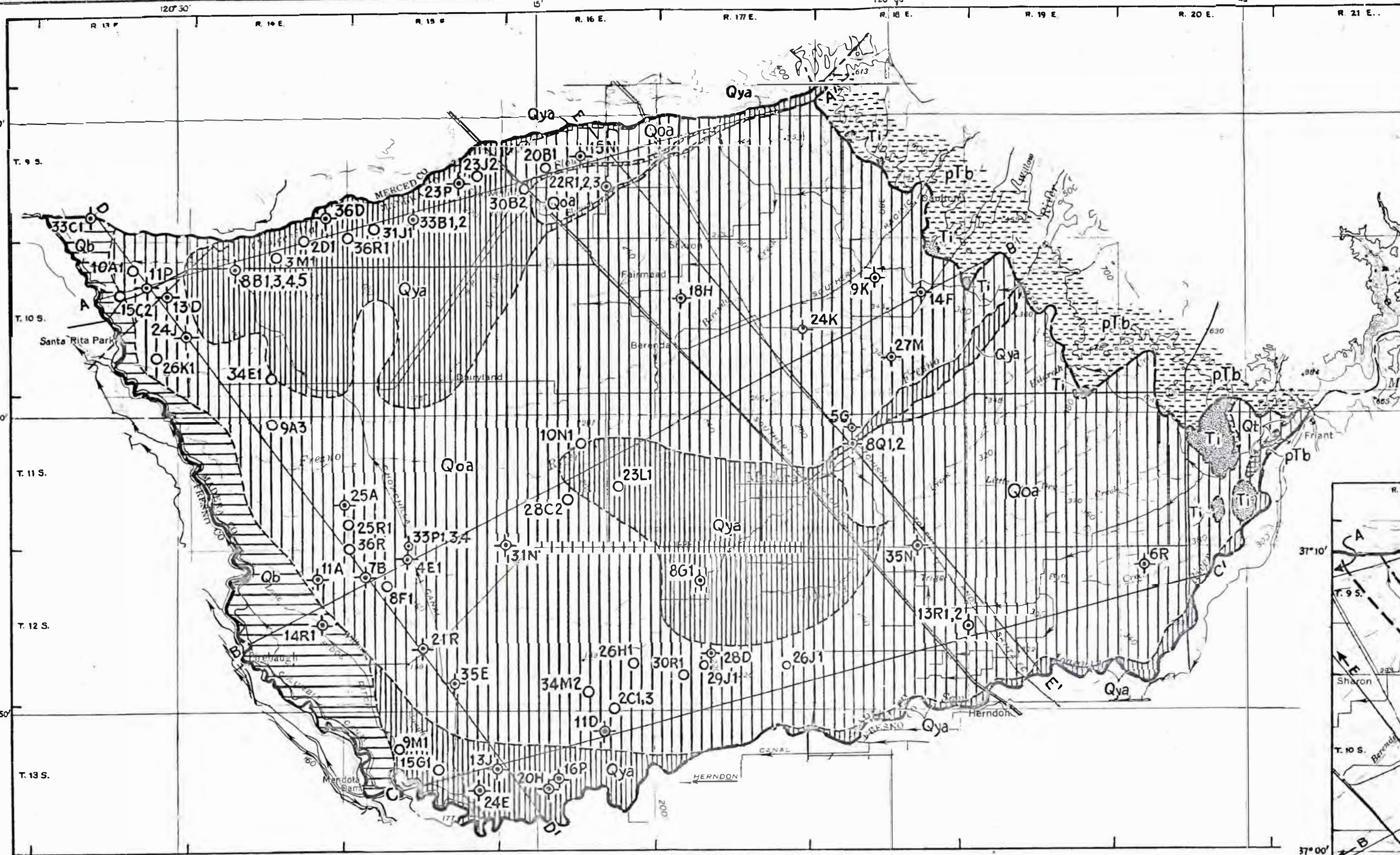
Mitten et al., 1970

70-228

U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
CALIFORNIA DEPARTMENT OF WATER RESOURCES

PLATE 1



GEOLOGIC MAP

EXPLANATION

UNCONSOLIDATED DEPOSITS

Qb Flood-basin deposits

Qya Younger alluvium

Qt Terrace deposits

Qoa Older alluvium

Pleistocene and Holocene(?) / Holocene — QUATERNARY

UNCONFORMITY

CONSOLIDATED ROCKS

Ti Ione Formation — Eocene — TERTIARY

UNCONFORMITY

pTb Basement complex — PRE-TERTIARY

Geologic contact

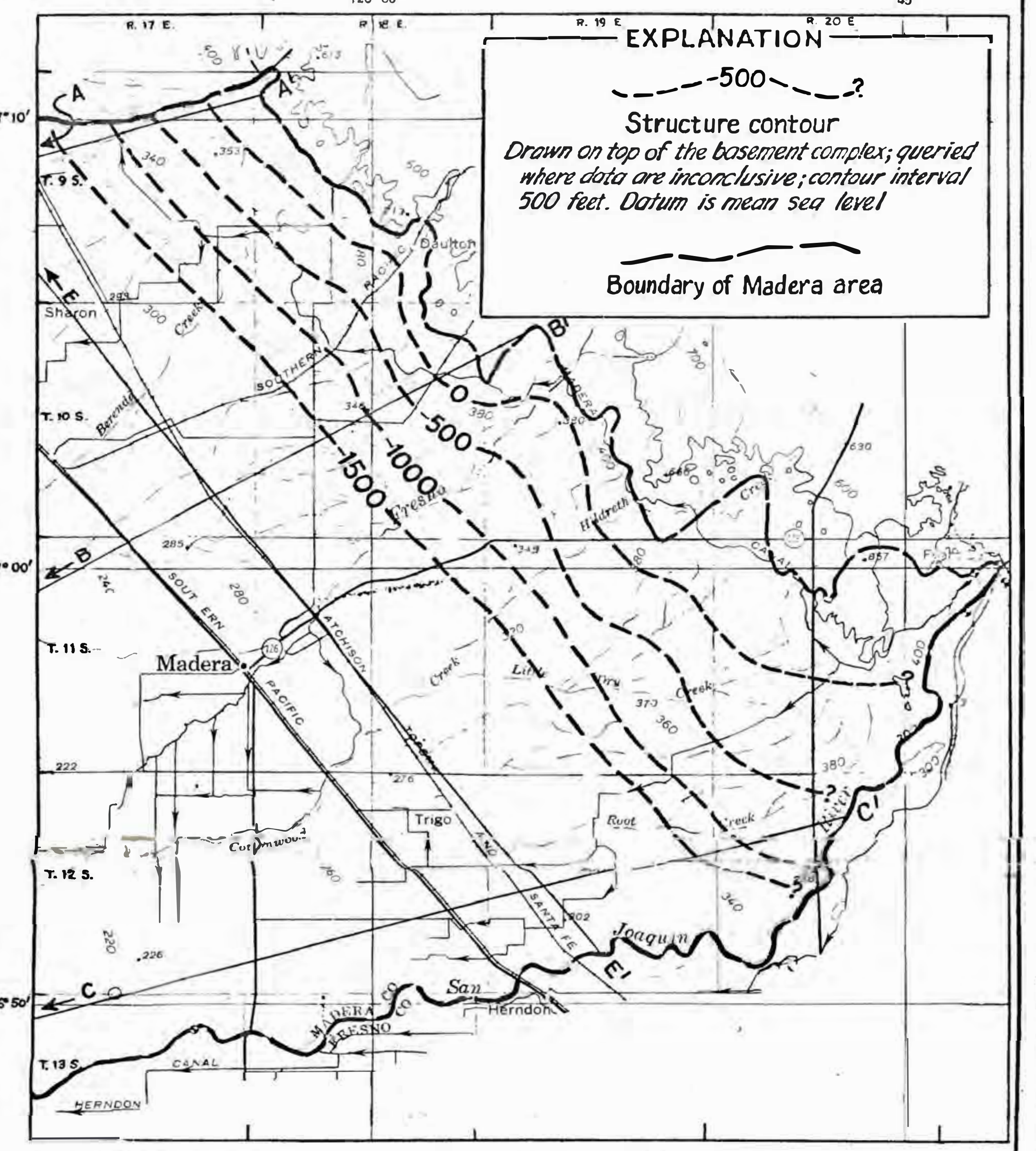
13D1 Water well and number

33B1 Test well and number

Oil well or oil-test well and number

A — A' Line of geologic section

Boundary of Madera area



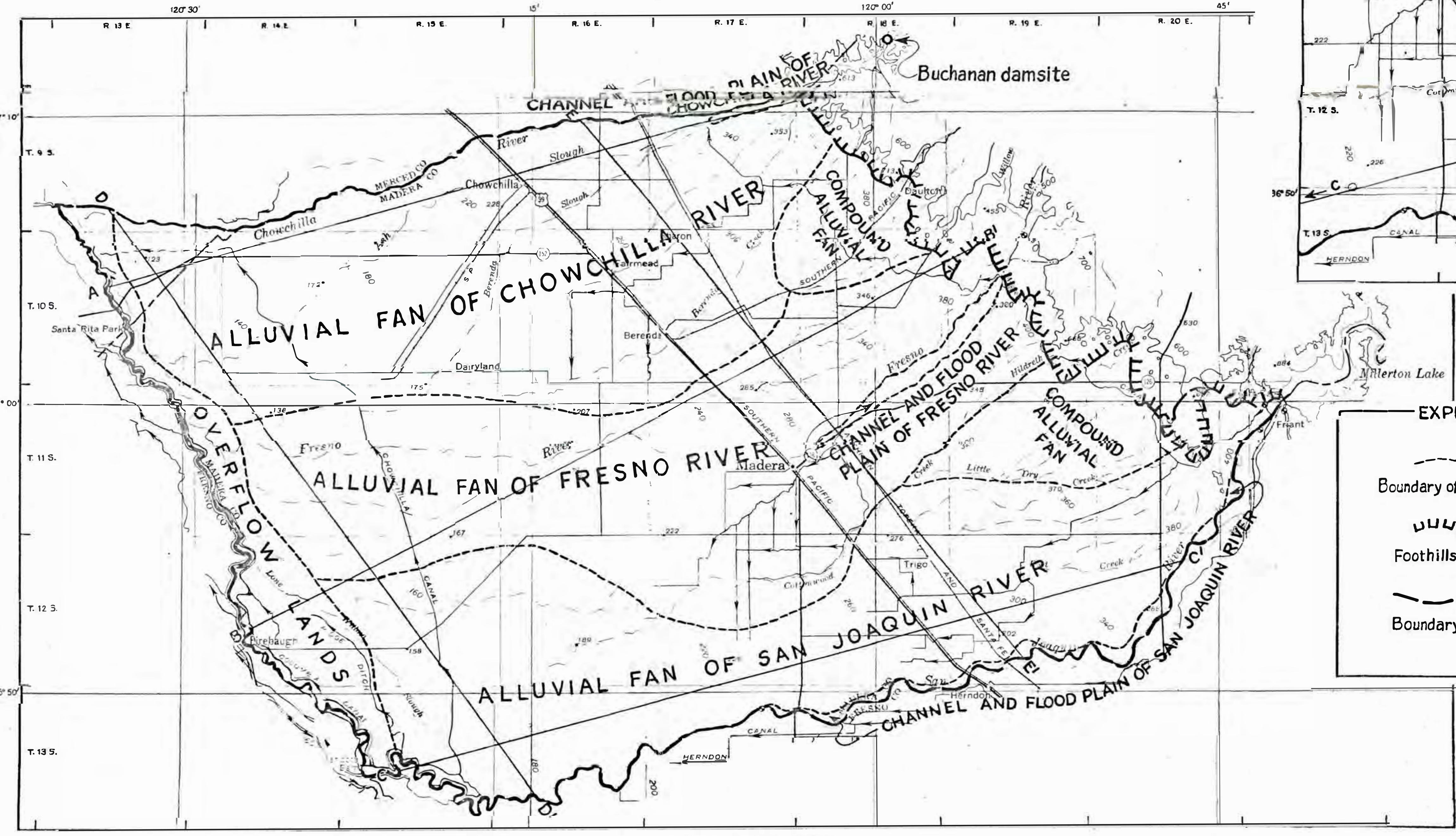
EXPLANATION

-500 Structure contour

Drawn on top of the basement complex; queried where data are inconclusive; contour interval 500 feet. Datum is mean sea level

Boundary of Madera area

CONTOURS ON BASEMENT COMPLEX



EXPLANATION

Boundary of geomorphic units

Foothills of Sierra Nevada

Boundary of Madera area

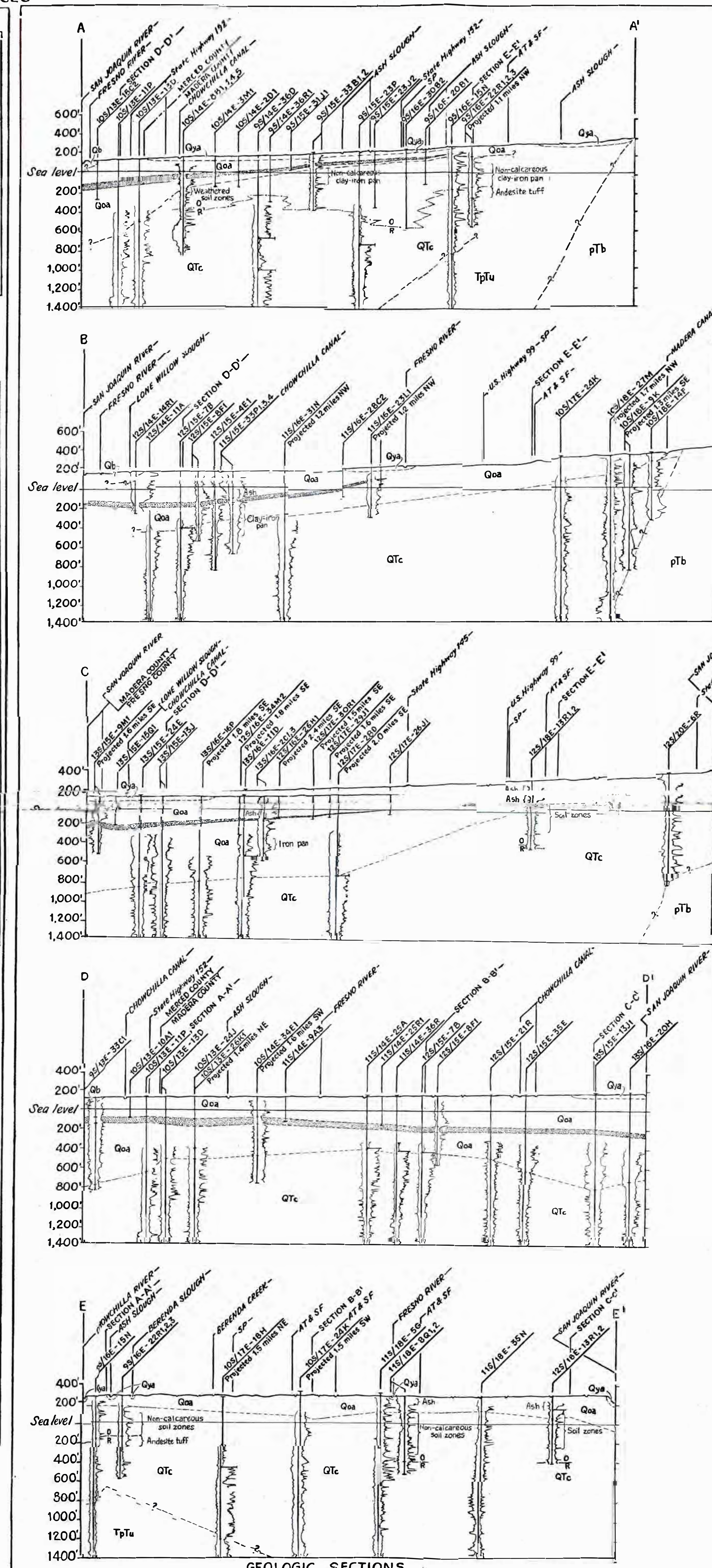
GEOMORPHIC MAP

Base from U.S. Geological Survey Central Valley, California, Delta Area, 1958 1:250,000

5 0 5 10 MILES

Contour interval 100 feet
Contours at 20 foot interval are shown in valley area where space permits
Datum is mean sea level

TRUE NORTH — MAGNETIC NORTH — APPROXIMATE MEAN DECLINATION, 1970



GEOLOGIC SECTIONS

EXPLANATION

UNCONSOLIDATED DEPOSITS

Qb Flood-basin deposits

Qya Younger alluvium

Ql Lacustrine and marsh deposits

Qoa Older alluvium

Pleistocene(?) Holocene(?) Holocene — QUATERNARY

QTc Continental deposit of Tertiary and Quaternary (?) age — TERTIARY AND QUATERNARY

UNCONFORMITY

CONSOLIDATED ROCKS

TpTu Marine and continental sedimentary rocks, undifferentiated — PRE-TERTIARY AND TERTIARY

UNCONFORMITY

pTb Basement complex — PRETERTIARY

Contact
Queried where evidence is inconclusive

Contact between oxidized (O) and reduced (R) deposits

E-clay (Ql)

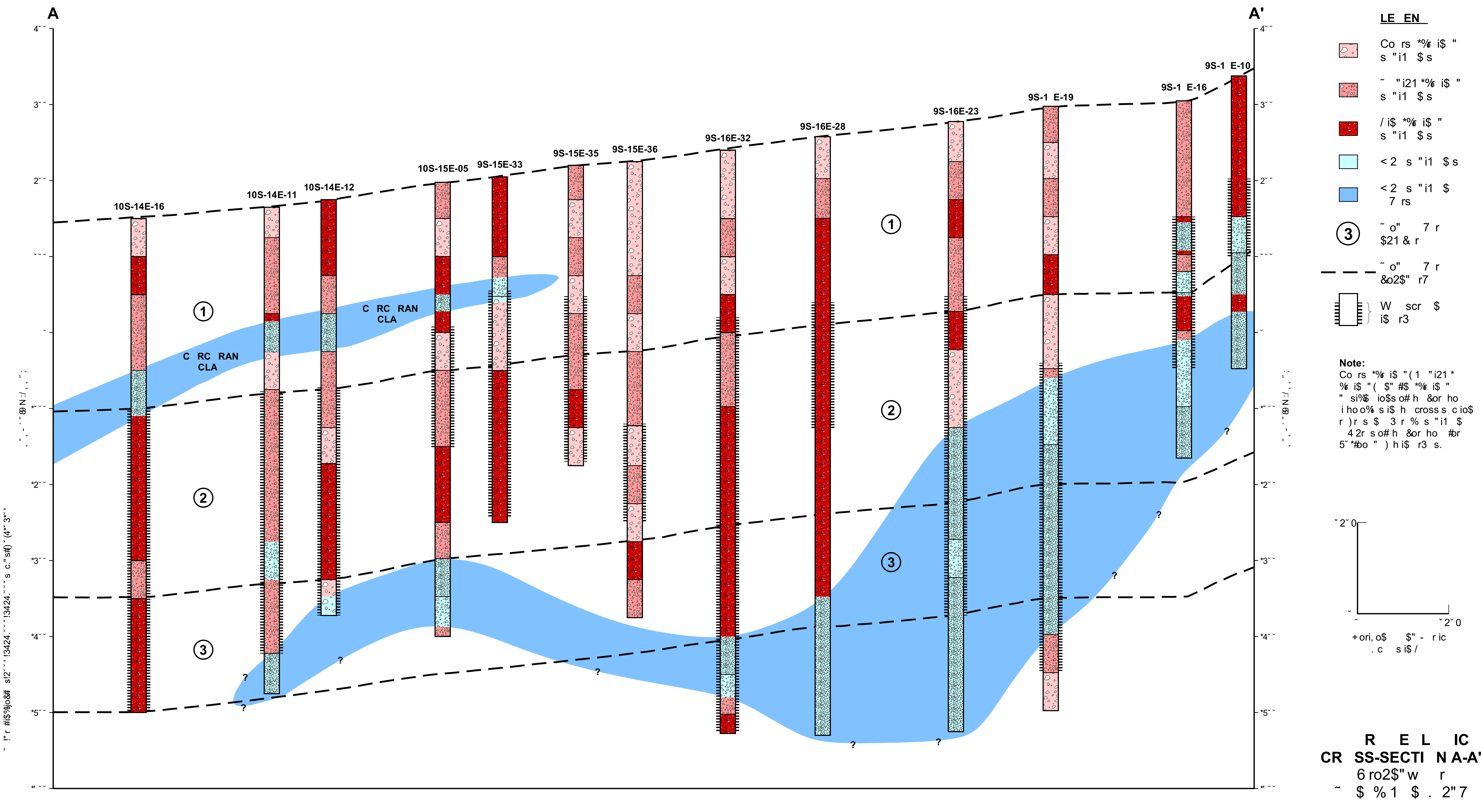
TOP OF WELL — BOTTOM OF WELL
Well symbol

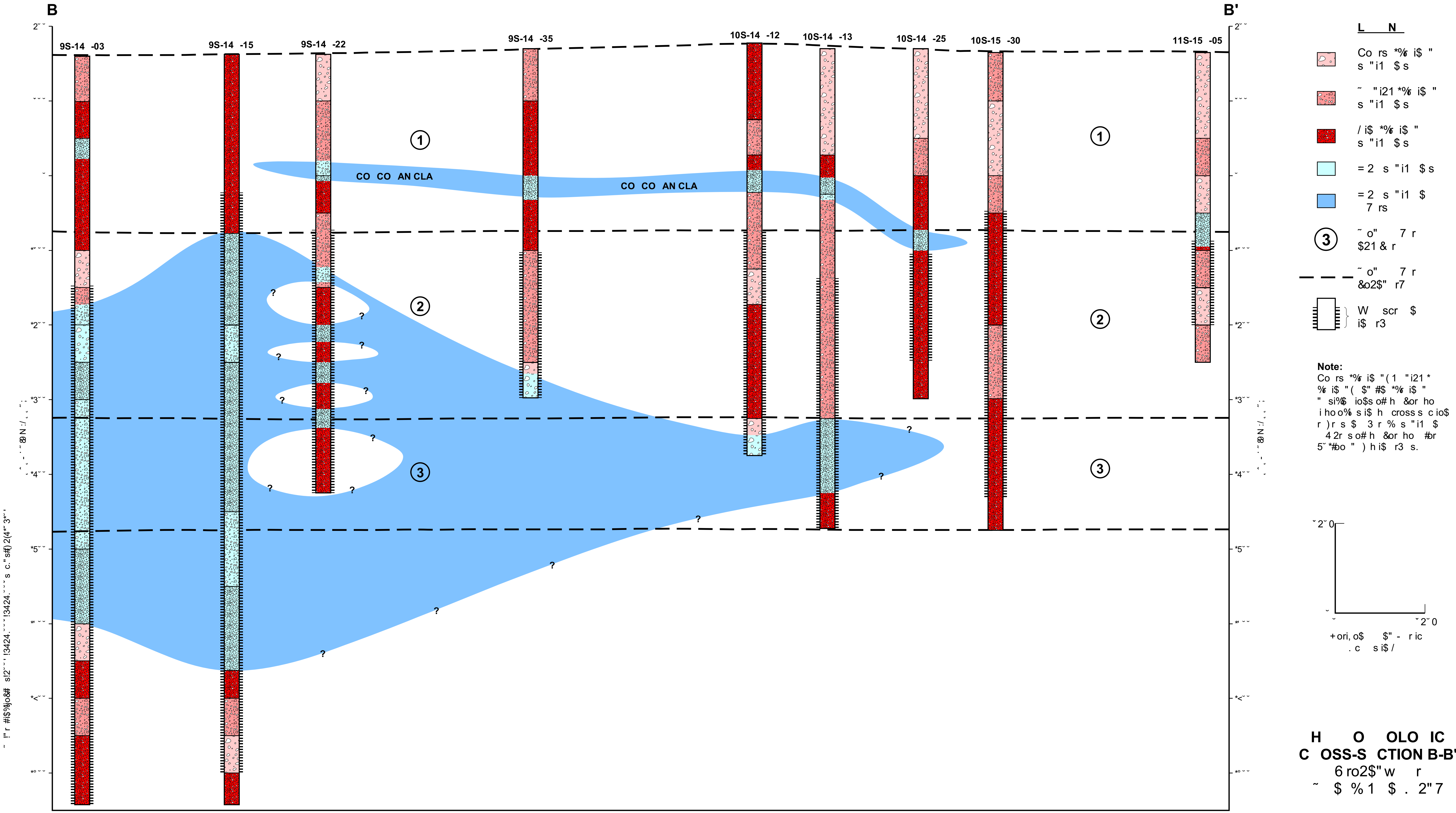
CHANGE IN RESISTIVITY SCALE
Well with electric log

Horizontal scale same as scale of maps; vertical scale X 26.4. Datum is mean sea level

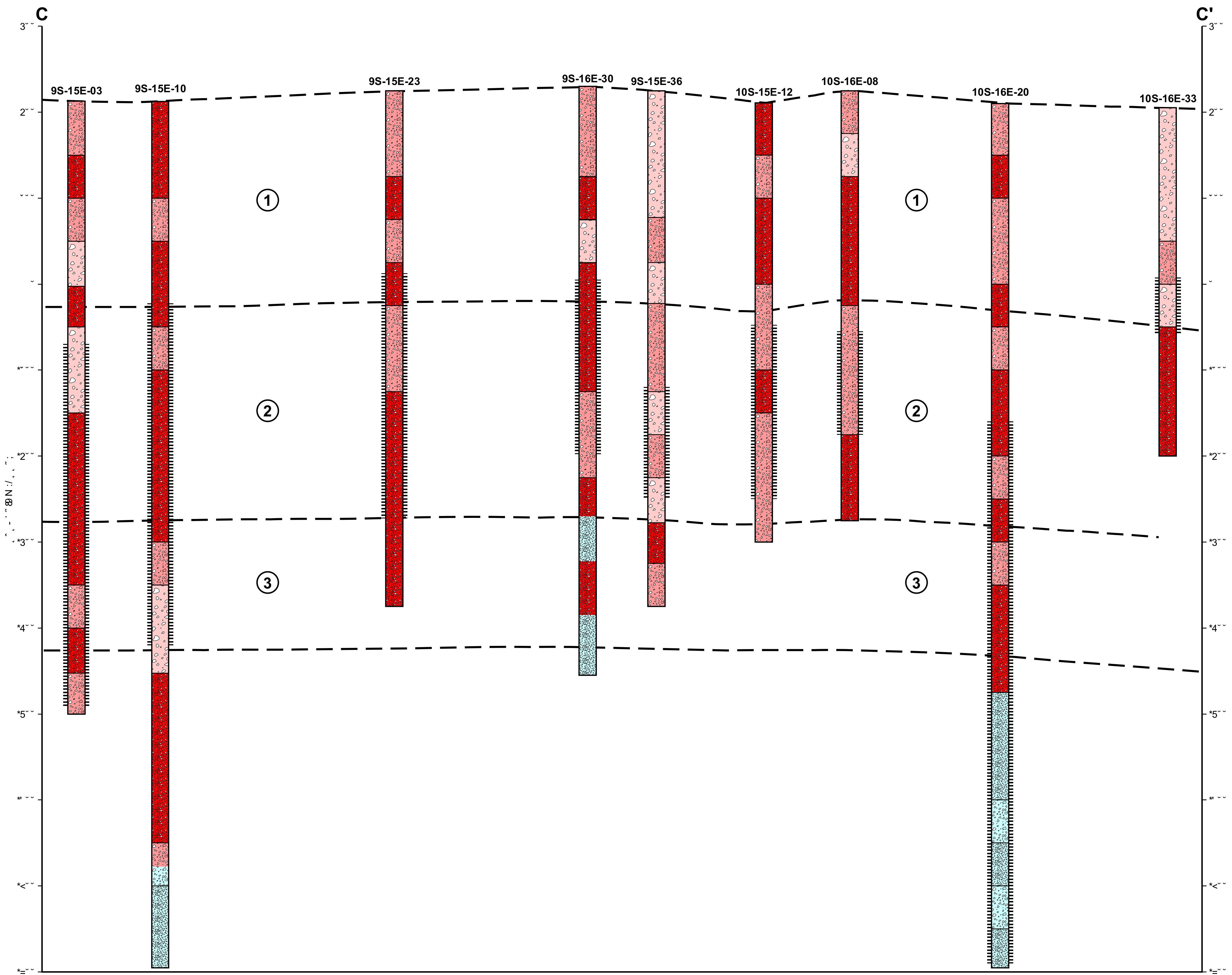
GEOMORPHIC AND GEOLOGIC MAPS AND SECTIONS, AND CONTOURS ON BASEMENT COMPLEX, MADERA AREA, SAN JOAQUIN VALLEY, CALIFORNIA

A2.D-3


A
A'
10S-14E-16
10S-14E-11
10S-14E-12
10S-15E-05
9S-15E-33
9S-15E-35
9S-15E-36
9S-16E-32
9S-16E-28
9S-16E-23
Note:
?



H O OLO IC
C OSS-S CTION B-B'



LEGEND

Coars

W ll scr

Note:

HYDROGEOLOGIC CROSS-SECTION C-C'

A2.D-6

FIGURE 2 - SUBSURFACE GEOLOGIC CROSS SECTION A - A'

FIGURE 3 - SUBSURFACE GEOLOGIC CROSS SECTION B - B'

FIGURE 4 - SUBSURFACE GEOLOGIC CROSS SECTION C - C'

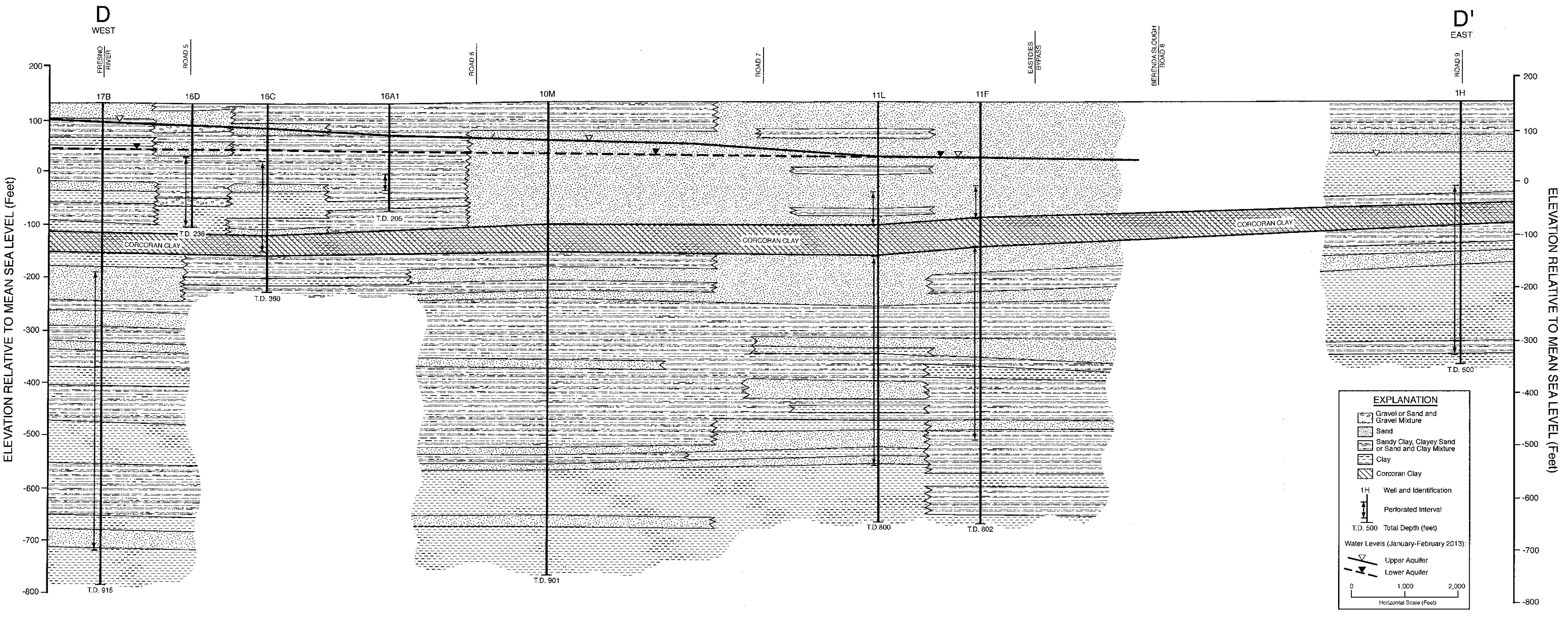


FIGURE 5 - SUBSURFACE GEOLOGIC CROSS SECTION D - D'

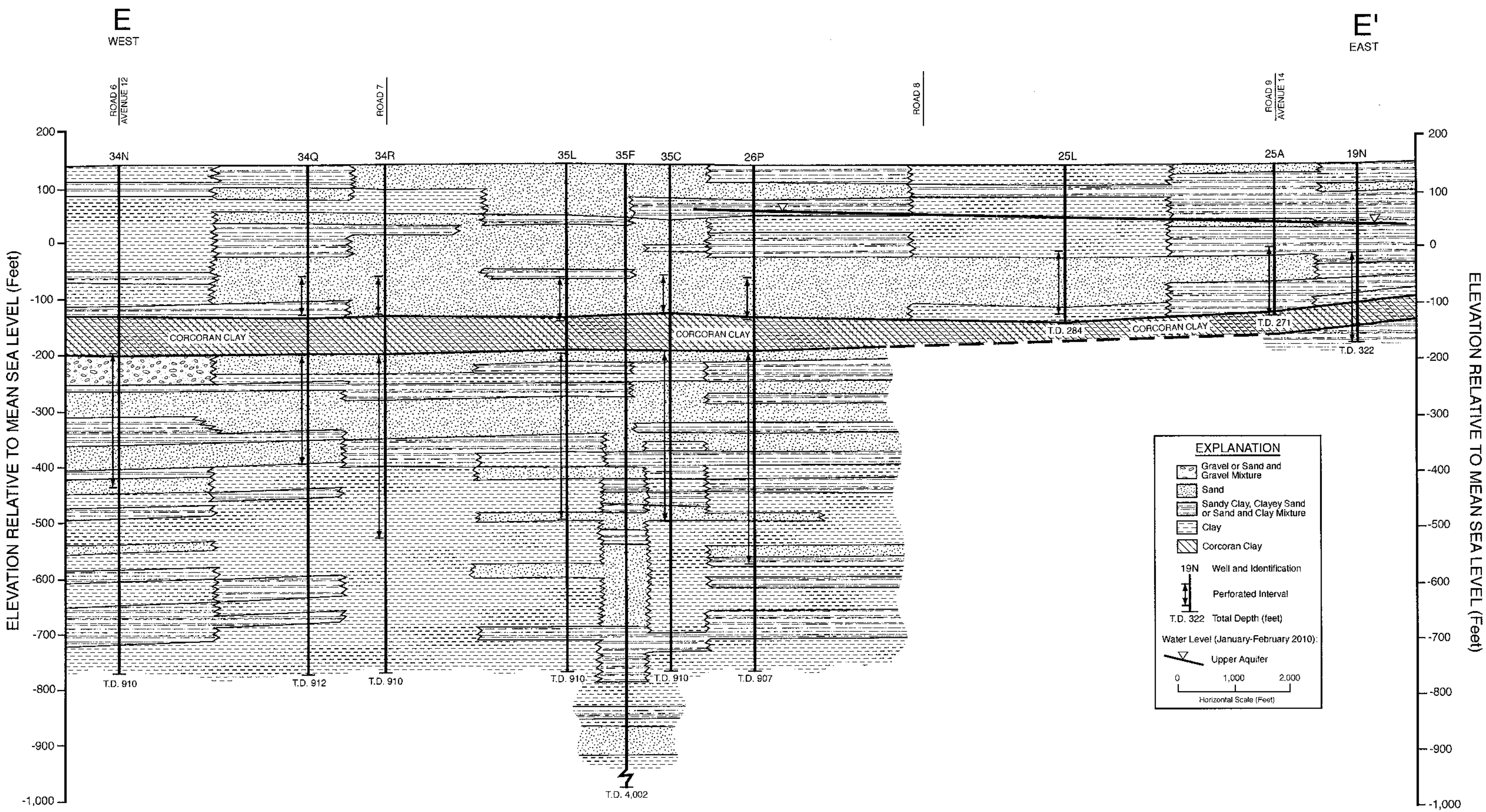


FIGURE 6 - SUBSURFACE GEOLOGIC CROSS SECTION E - E'

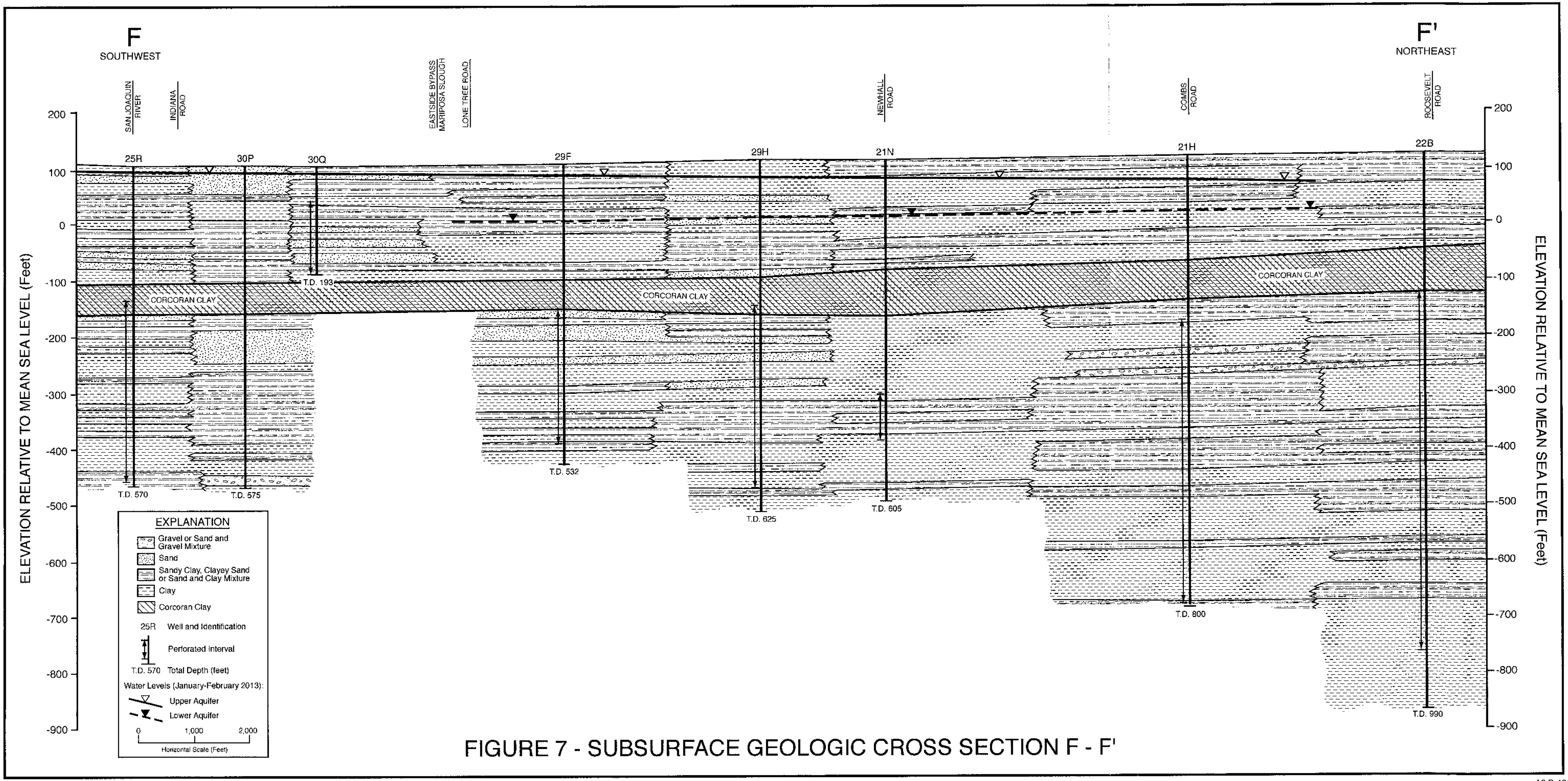
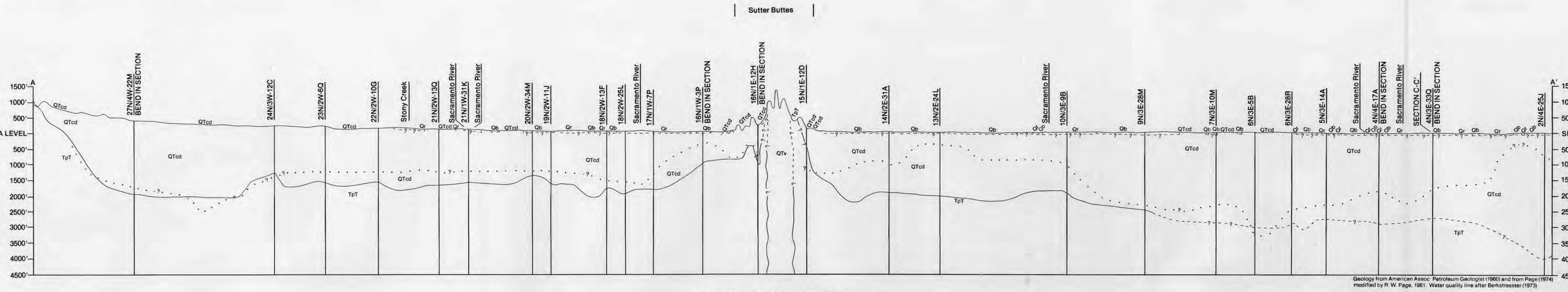


FIGURE 7 - SUBSURFACE GEOLOGIC CROSS SECTION F - F'



Geologic section A - A', Sacramento Valley, California
(See Plate 1 for location of section)

EXPLANATION OF SYMBOLS

Stratigraphic unit contact Approximately located; queried where data are inconclusive

Water quality line Below line dissolved - solids concentration greater than about 2,000 milligrams per liter; queried where data are inconclusive

205/15E - 18K **Well and number**

SCALE

0 1 2 3 4 5 6 MILES

VERTICAL EXAGGERATION x 21

Geologic section B - B', San Joaquin Valley, California
(See Plate 2 for location of section)

CORRELATION OF SECTION UNITS

SACRAMENTO VALLEY

Units	Age	Period
Qb, Qr	Holocene	QUATERNARY
QTcd	Oligocene to Holocene	TERTIARY AND QUATERNARY
QTv	Pliocene and Pleistocene	TERTIARY
TpT	Pre-Tertiary to Eocene	TERTIARY AND PRE-TERTIARY

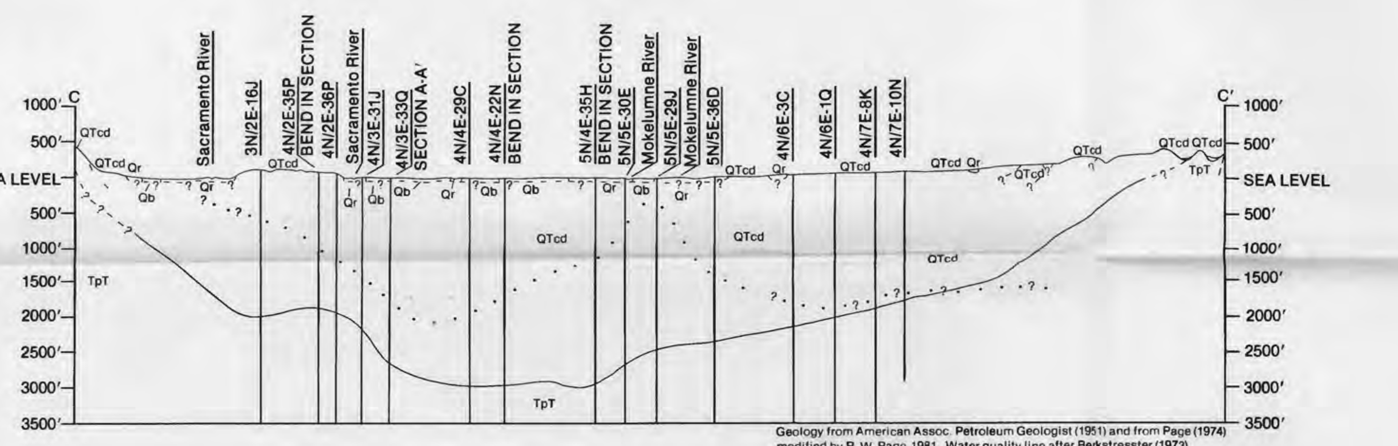
SAN JOAQUIN VALLEY

Units	Age	Period
Qs, Qb, Qr	Holocene	QUATERNARY
QTl	Pliocene to Holocene	TERTIARY AND QUATERNARY
QTcd	Oligocene to Holocene	TERTIARY AND QUATERNARY
Tm	Eocene, Oligocene, Miocene, and Pliocene	TERTIARY
TpT	Pre-Tertiary to Oligocene	TERTIARY AND PRE-TERTIARY
pTgm	Pre-Tertiary	PRE-TERTIARY

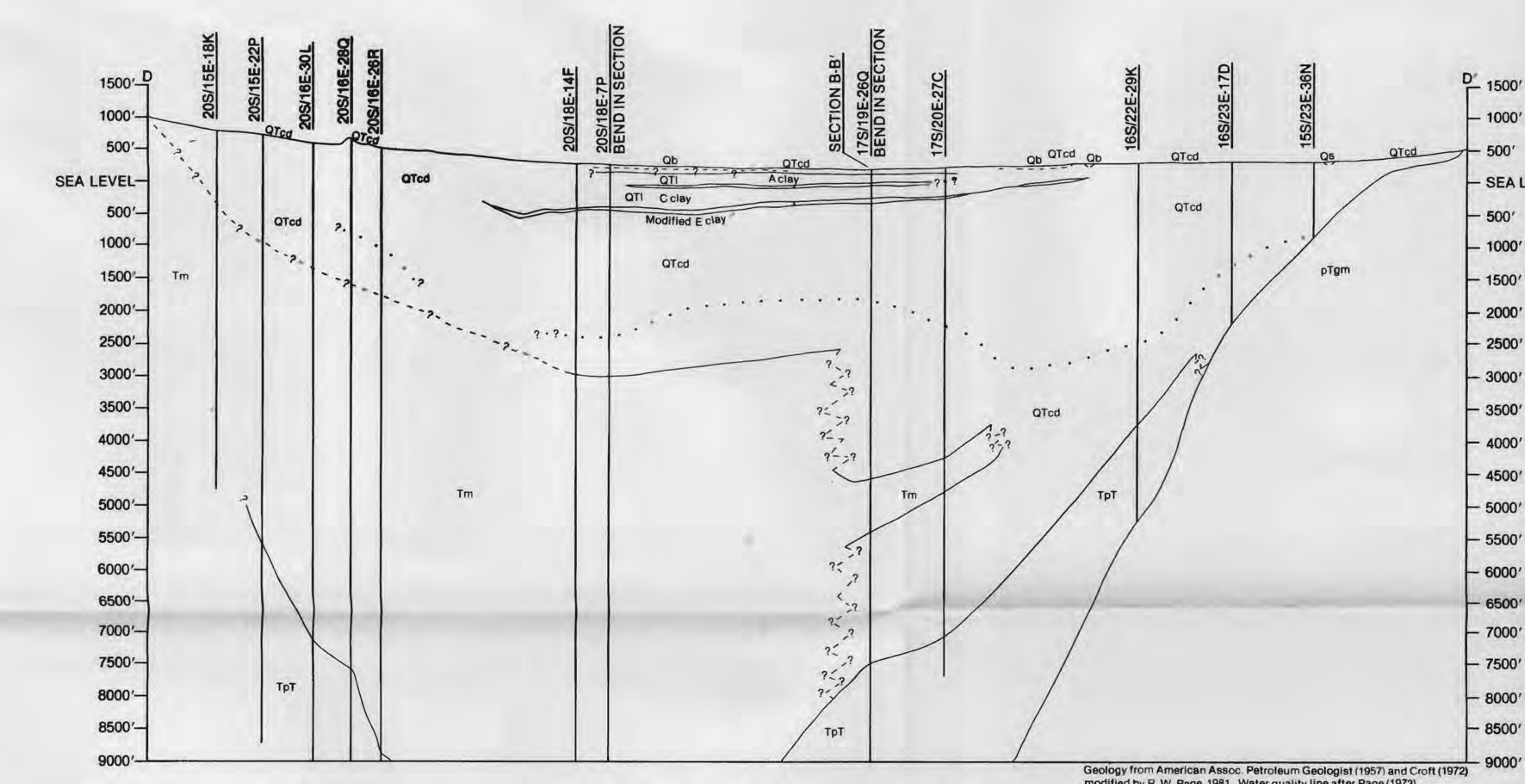
DESCRIPTION OF SECTION UNITS

SACRAMENTO VALLEY SECTION A - A' and C - C'	A - A'	C - C'
Qb **Flood-basin deposits (Holocene)** Clay, silt, and some sand;	In southern part of section consist of muck, peat, and other organic soils. In places may include part of the Modesto Formation (Pleistocene)	In western part of section consist of muck, peat, and other organic soils. In places may include part of the Modesto Formation (Pleistocene)
Qr **River deposits (Holocene)** Gravel, sand, silt, and minor amounts of clay deposited along channels, flood plains, and natural levees of major streams. In places may include part of the Modesto Formation (Pleistocene)	Description at left	Description at left
QTcd **Continental rocks and deposits (Oligocene to Holocene)** Chiefly heterogeneous mix of gravel, sand, silt, and clay, some cobbles and boulders, sandstone, breccia, and conglomerate. Principal unit, continental rocks and deposits (Pliocene to Holocene)...	On this section include volcanic rocks and deposits at Sutter Buttes (Pliocene and Pleistocene) of tuff and tuff breccia. Also on this section may include volcanic rocks and deposits (Miocene and Pliocene), continental rocks and deposits (Miocene and Pliocene)--mostly Mehrten Formation or an equivalent, and continental rocks and deposits (Oligocene and Miocene)--mostly Valley Springs Formation or an equivalent	On this section include some volcanic rocks and deposits (Miocene and Pliocene) near western side, continental rocks and deposits (Miocene and Pliocene)--mostly Mehrten Formation on eastern side, and may include Mehrten or an equivalent near central part, and continental rocks and deposits (Oligocene and Miocene)--mostly Valley Springs Formation on eastern side, and may include Valley Springs or an equivalent near central part
QTv **Volcanic rocks (Pliocene and Pleistocene)** Andesitic and rhyolitic porphyry and tuff at core of Sutter Buttes	Description at left	Not present
TpT **Continental and marine rocks and deposits (Pre-Tertiary to Eocene)** Continental rocks and deposits, chiefly sandstone with some conglomerate and shale; marine rocks and deposits of clay, shale, siltstone, and sandstone...	On this section include continental rocks and deposits (Eocene)--mostly Ione Formation or an equivalent, marine rocks and deposits (Paleocene and Eocene), and marine rocks (Pre-Tertiary)	On this section include continental rocks and deposits (Eocene)--mostly Ione Formation on eastern side, and Ione or an equivalent near central part, marine rocks and deposits (Paleocene to Oligocene), and marine rocks (Pre-Tertiary)

SAN JOAQUIN VALLEY SECTION B - B' and D - D'	B - B'	D - D'
Qs **Sand dunes (Holocene)** Windblown sand and dune sand	Description at left	Description at left
Qb **Flood-basin deposits (Holocene)** Clay, silt, and some sand;	Near northern end of section consist of muck, peat, and other organic soils	Description at left
Qr **River deposits (Holocene)** Gravel, sand, silt, and minor amounts of clay; deposited along channels, flood plains, and natural levees of main streams.	Description at left	Not present
QTl **Lacustrine and marsh deposits (Pliocene to Holocene)** Clay, silt, and some sand; in subsurface include three widespread clays: A clay (Pleistocene and Holocene?), C clay (Pleistocene); and modified E clay (Pleistocene), includes Corcoran Clay Member of Tulare Formation	Description at left	Description at left
QTcd **Continental rocks and deposits (Oligocene to Holocene)** Heterogeneous mix of generally poorly sorted clay, silt, sand, and gravel, some beds of claystone, siltstone, sandstone, and conglomerate...	On this section, principal unit, continental rocks and deposits (Miocene to Holocene); in northern part of section may include continental rocks and deposits (Miocene and Pliocene)--mostly Mehrten Formation or an equivalent, and continental rocks and deposits (Oligocene and Miocene) -mostly Valley Springs Formation or an equivalent. Include continental rocks and deposits (Miocene and Pliocene)--chiefly the Chanac Formation (Miocene) at extreme southern end of section, and the Zilch Formation of informal subsurface usage, which is considered to be the continental equivalent of the Marine Temblor Formation (Oligocene and Miocene)	On this section, principal unit continental rocks and deposits (Miocene to Holocene); at depth include the Zilch formation of informal subsurface usage, which is considered to be the continental equivalent of the marine Temblor Formation (Oligocene and Miocene)
Tm **Marine rocks and deposits (Eocene, Oligocene, Miocene, and Pliocene)** Sand, clay, silt, sandstone, shale, mudstone, and siltstone. On these section include marine rocks and deposits of Miocene and Pliocene age only	Description at left	Description at left
TpT **Continental and marine rocks and deposits (Pre-Tertiary to Oligocene)** Continental rocks and deposits of clay, shale, sand, sandstone and conglomerate; marine rocks and deposits of clay, shale, sandstone, and conglomerate...	On this section include marine rocks and deposits of Eocene and Oligocene age, also include some Paleocene marine rocks. Include continental rocks and deposits (Eocene to Miocene)-- chiefly Walker Formation (Eocene to Miocene) at depths off the section - greater than 13,000ft, where the Walker Formation underlies Eocene, marine sediments. Include marine rocks (Pre-Tertiary)	On this section include marine rocks and deposits of Eocene and Oligocene age, some Paleocene marine rocks, some unnamed continental rocks (Pre-Tertiary age) on eastern end of section, and marine rocks (Pre-Tertiary)
pTgm **Granitic and metamorphic rocks (Pre-Tertiary)** Granitic rocks with some mafic intrusive rocks, and metasedimentary and metavolcanic rocks. Include granitic rocks (Pre-Tertiary) and metamorphic rocks (Pre-Tertiary)	Not present	Description at left



Geologic section C - C', Sacramento Valley, California
(See Plate 1 for location of section)



Geologic section D - D', San Joaquin Valley, California
(See Plate 2 for location of section)

GEOLOGIC SECTIONS A - A' THROUGH D - D', SACRAMENTO VALLEY AND SAN JOAQUIN VALLEY, CALIFORNIA

Table of Aquifer Property Data

Well_ID	Data Source	Subbasin	Latitude	Longitude	Town-ship	Range	Sec	Depth Zone	Well Type	Total Depth (ft)	Top of Perforations (ft)	Bottom of Perforations (ft)	Well Casing Diameter (in)	Test Date	Test Discharge rate (gpm)	Test Duration (hr)	Well Specific Capacity (gpm/ft)	Transmissivity from Aquifer Test (gpd/ft)	Transmissivity from Well Specific Capacity (x1500) (gpd/ft)	Transmissivity from Well Specific Capacity (x2000) (gpd/ft)	Note
10S/16E-24H01	USGS-Mitten et al., 1970	Chowchilla	37.04771	-120.175				Composite		183						15.8		18,000			Hantush method
13S/17E-01L01	USGS-Mitten et al., 1970	Chowchilla	36.82996	-120.06942				Upper Aquifer		345						20.8		50,000			Hantush (Jacob T=99,000)
WCR0012267	WCR	Chowchilla	36.995555	-120.413333	11S	14E	11	Composite	Agriculture/Irrigation	260	90	220			900	2	50.0		75,000	100,000	
WCR0017472	WCR	Chowchilla	37.16371	-120.35615	09S	15E	8	Lower Aquifer	Agriculture/Irrigation	700	215	690	16		4,192	26	127.0		190,545	254,061	
WCR0017473	WCR	Chowchilla	37.16372	-120.31987	09S	15E	10	Lower Aquifer	Agriculture/Irrigation	540	320	530	16		4,408	30	32.9		49,343	65,791	
WCR0056165	WCR	Chowchilla	37.01816	-120.46457	10S	14E	32	Composite	Agriculture/Irrigation	260	150	250	16		6,000	24	77.9		116,883	155,844	
WCR0062850	WCR	Chowchilla	37.01816	-120.46457	10S	14E	32	Upper Aquifer	Agriculture/Irrigation	204	120	153	18		3,900	12	150.0		225,000	300,000	
WCR0068892	WCR	Chowchilla	37.09098	-120.26566	10S	16E	6	Lower Aquifer	Agriculture/Irrigation	559	277	540	16		900	8	32.1		48,214	64,286	
WCR0103900	WCR	Chowchilla	37.16362	-120.37416	09S	15E	7	Lower Aquifer	Agriculture/Irrigation	1032	220	585	16		4,500	15	66.2		99,265	132,353	
WCR0120517	WCR	Chowchilla	37.108333	-120.271944	09S	16E	31	Lower Aquifer	Municipal/Public Supply	795	475	795	16		1,500	6	24.6		36,885	49,180	
WCR0127074	WCR	Chowchilla	37.07621	-120.46439	10S	14E	8	Lower Aquifer	Agriculture/Irrigation	847	230	847	16		1,500	24	8.9		13,393	17,857	
WCR0152919	WCR	Chowchilla	36.94566	-120.35483	11S	15E	29	Composite	Agriculture/Irrigation	300	150	300	16		4,000	21	93.0		139,535	186,047	
WCR0161027	WCR	Chowchilla	36.98908	-120.46436	11S	14E	8	Upper Aquifer	Agriculture/Irrigation	186	120	173	18		3,600	10	90.0		135,000	180,000	
WCR0165177	WCR	Chowchilla	37.149	-120.17487	09S	16E	13	Lower Aquifer	Agriculture/Irrigation	790	290	790	16		600	12	10.7		16,071	21,429	
WCR0169808	WCR	Chowchilla	37.06171	-120.41003	10S	14E	14	Lower Aquifer	Agriculture/Irrigation	800	200	800	16		2,800	10	15.6		23,464	31,285	
WCR0228666	WCR	Chowchilla	37.04729	-120.28349	10S	15E	24	Lower Aquifer	Agriculture/Irrigation	650	425	645			1,800	5	20.5		30,682	40,909	
WCR0238216	WCR	Chowchilla	37.141833	-120.252083	09S	16E	14	Lower Aquifer	Agriculture/Irrigation	810	385	800	36		2,000	10	52.6		78,947	105,263	
WCR0242828	WCR	Chowchilla	37.14719	-120.28342	09S	15E	13	Lower Aquifer	Agriculture/Irrigation	444	238	438	16		3,670	14	23.8		35,747	47,662	
WCR0250233	WCR	Chowchilla	37.149	-120.17487	09S	16E	13	Lower Aquifer	Agriculture/Irrigation	700	275	275	30		700	12	10.8		16,154	21,538	
WCR0250335	WCR	Chowchilla	37.03273	-120.50163	10S	13E	25	Upper Aquifer	Agriculture/Irrigation	192			16		4,500		68.2		102,273	136,364	
WCR0254211	WCR	Chowchilla	37.07608	-120.39182	10S	14E	12	Lower Aquifer	Agriculture/Irrigation	780	210	760			1,850	1	22.6		33,841	45,122	
WCR0256821	WCR	Chowchilla	37.076635	-120.22939	10S	16E	9	Lower Aquifer	Agriculture/Irrigation	955	270	935	36		2,800	6	46.7		70,000	93,333	
WCR0277636	WCR	Chowchilla	37.047279	-120.501508	10S	13E	24	Lower Aquifer	Other/Unknown	600	300	600	30		2,100	12	8.5		12,702	16,935	
WCR0282593	WCR	Chowchilla	37.07608	-120.39182	10S	14E	12	Composite	Agriculture/Irrigation	750					2,000	18	12.8		19,231	25,641	
WCR0291776	WCR	Chowchilla	37.149027	-120.244944	09S	16E	17	Lower Aquifer	Agriculture/Irrigation	770	372	750	36		2,000	10	58.8		88,235	117,647	
WCR0310201	WCR	Chowchilla	37.06172	-120.30158	10S	15E	14	Lower Aquifer	Agriculture/Irrigation	665	375	660			1,200	5	14.3		21,429	28,571	
WCR2017-001038	WCR	Chowchilla	37.00813	-120.4909	11S	14E	6	Upper Aquifer	Agriculture/Irrigation	280					1,600	14	11.6		17,391	23,188	
WCR2017-001090	WCR	Chowchilla	36.99508	-120.42827	11S	14E	10	Upper Aquifer	Agriculture/Irrigation	270					1,200	10	16.4		24,658	32,877	
WCR2017-003791	WCR	Chowchilla	36.98672	-120.46425	11S	14E	8	Upper Aquifer	Agriculture/Irrigation	280					1,800	8	14.3		21,429	28,571	

APPENDIX 2.E. CURRENT AND HISTORICAL GROUNDWATER CONDITIONS

Prepared as part of the

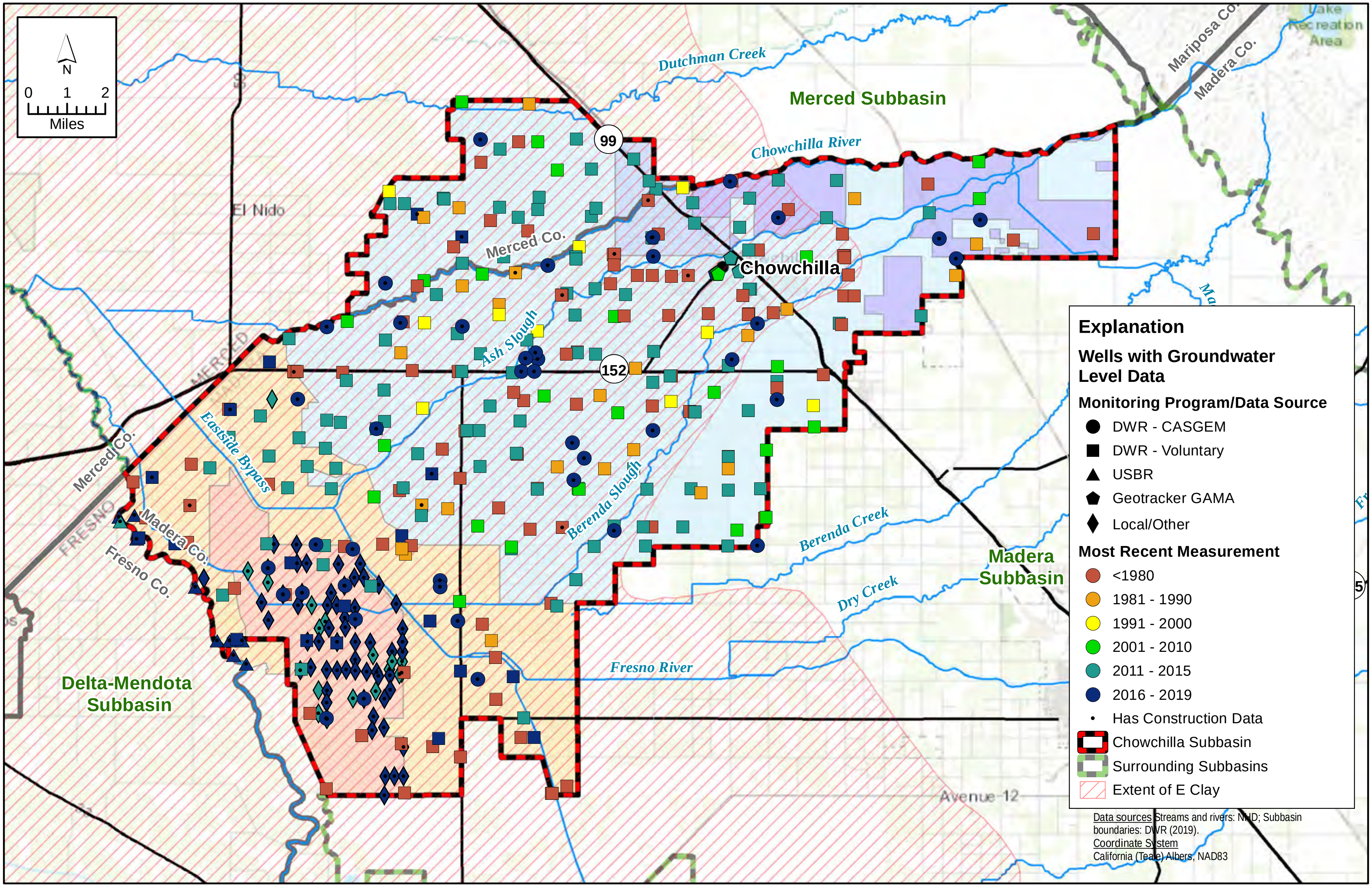
Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020

GSP Team:

Davids Engineering, Inc
Luhdorff & Scalmanini
ERA Economics
Stillwater Sciences and
California State University, Sacramento

Existing and Historical Groundwater Monitoring Programs



X:\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Appendix 2.E Chowchilla Subbasin Existing and Historical Groundwater Level Monitoring.mxd

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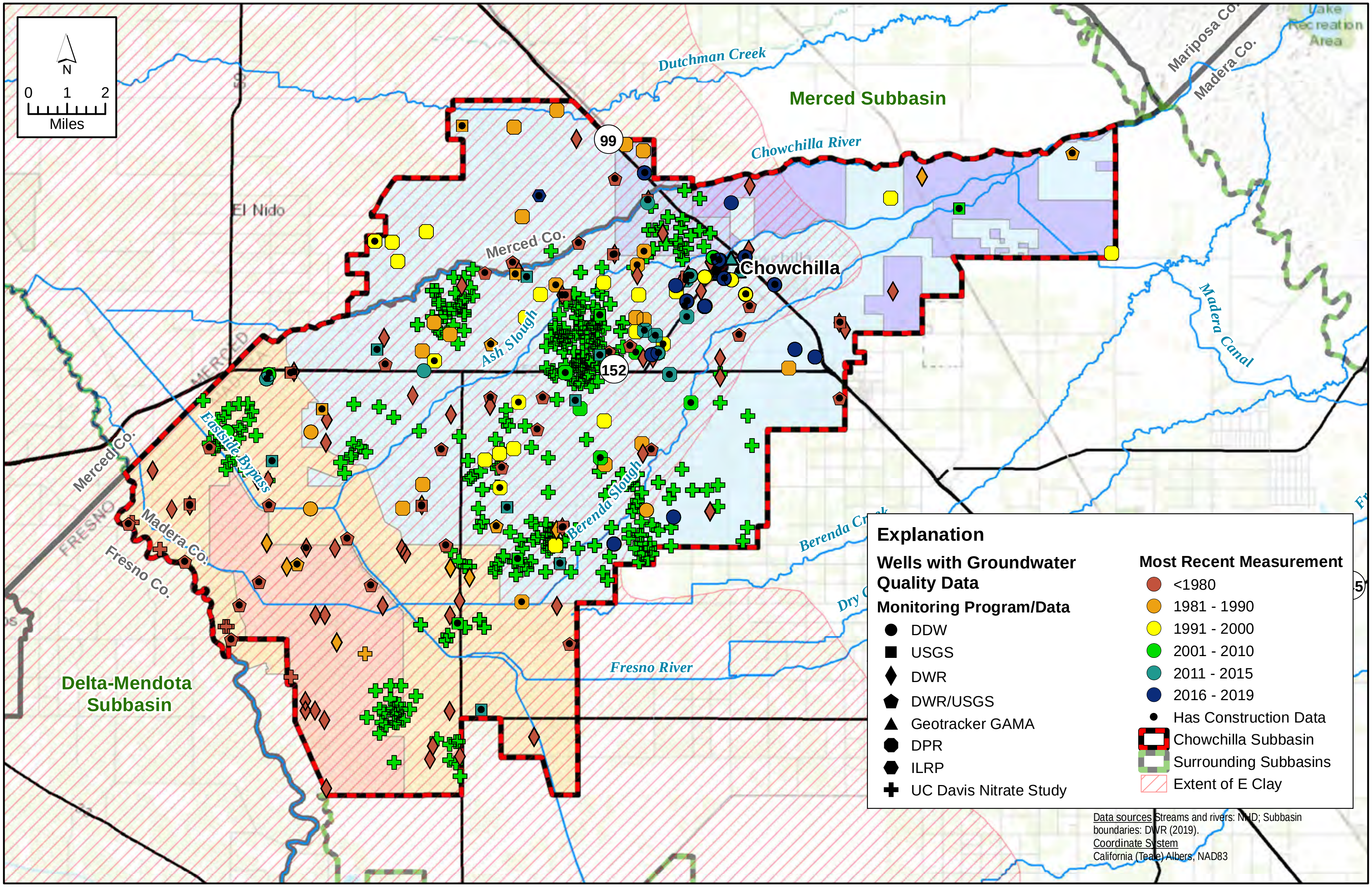
Luhdorff & Scalmanini Consulting Engineers

APPENDIX 2.E
Existing and Historical Groundwater Level Monitoring Programs

Chowchilla Subbasin A2.E-2
Groundwater Sustainability Plan



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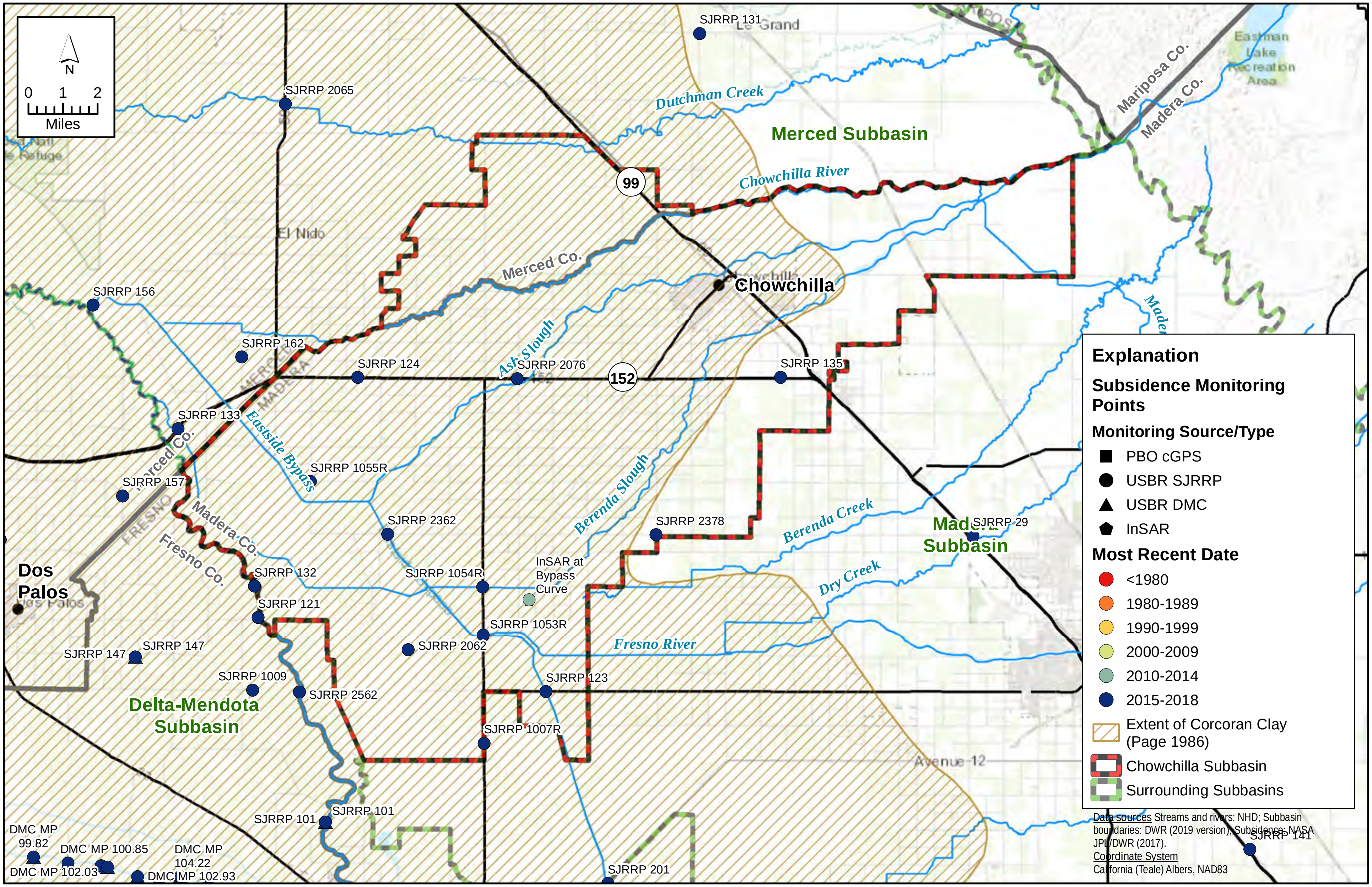
APPENDIX 2.E
Existing and Historical Groundwater Quality Monitoring Programs

Chowchilla Subbasin Groundwater Sustainability Plan



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APPENDIX 2.E

Existing and Historical Land Subsidence Monitoring

Groundwater Elevation Contour Maps

Base from map prepared by W. C. Mendenhall. Corrected from U.S.G.S. topographic atlas sheets

Artesian areas and ground-water levels by W. C. Mendenhall. Pumping plants by Herman Stabler

MAP OF SAN JOAQUIN VALLEY, CALIFORNIA

SHOWING ARTESIAN AREAS, GROUND-WATER LEVELS AND LOCATION OF PUMPING PLANTS

Scale $\frac{1}{500,000}$

5 0 5 10 15 20 Miles

10 0 10 20 Kilometers

1915

A2.E-6

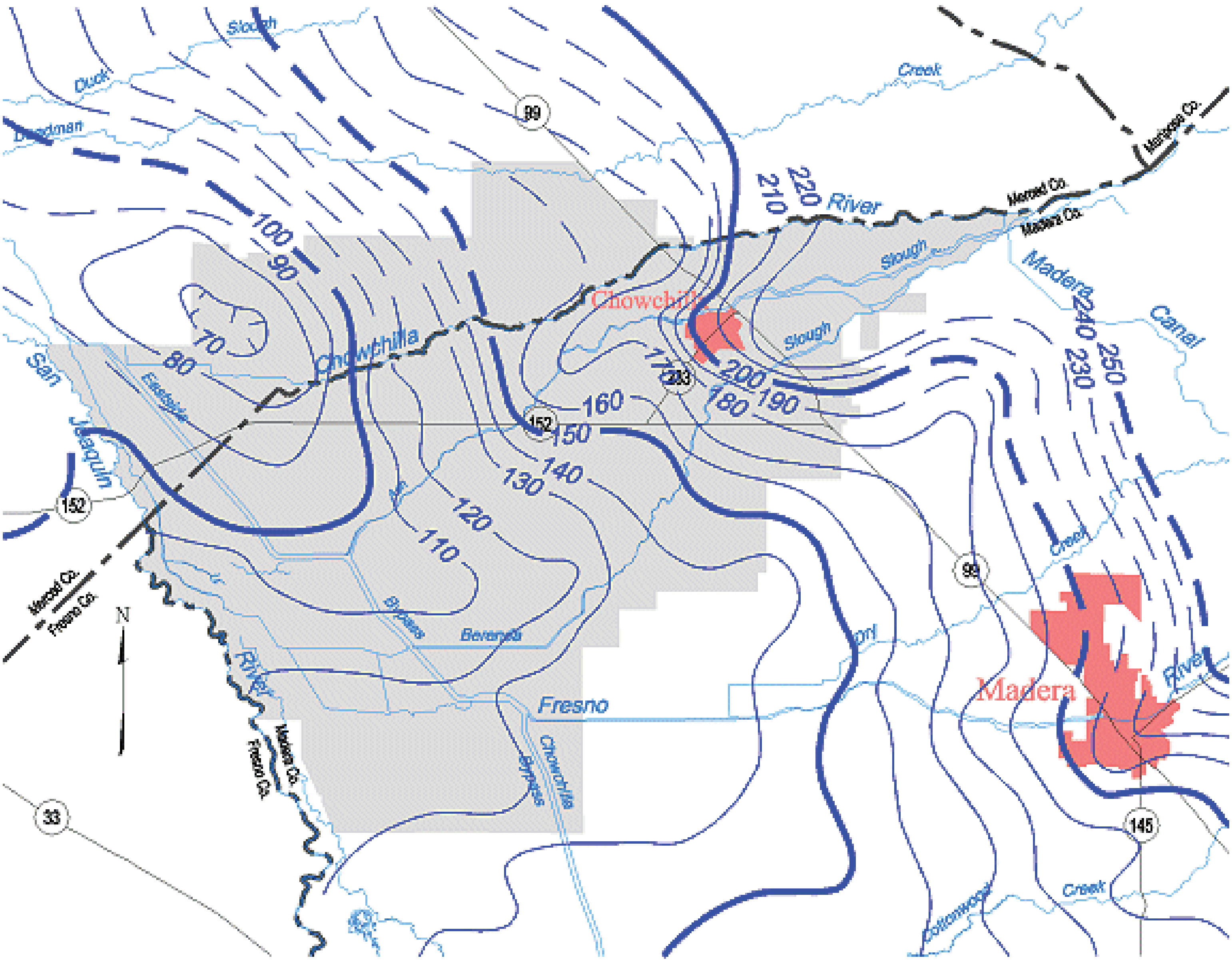
Chowchilla Groundwater Basin

Spring 1958, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Scale of Miles

2 0 2 4 6

Disclaimer: Base map created from current USGS 1:24,000 and 1:100,000 maps. Some base map features may not have been present (i.e. roads, canals, reservoirs) for the water year shown.



Contours are dashed where inferred. Contour interval is 10 feet.

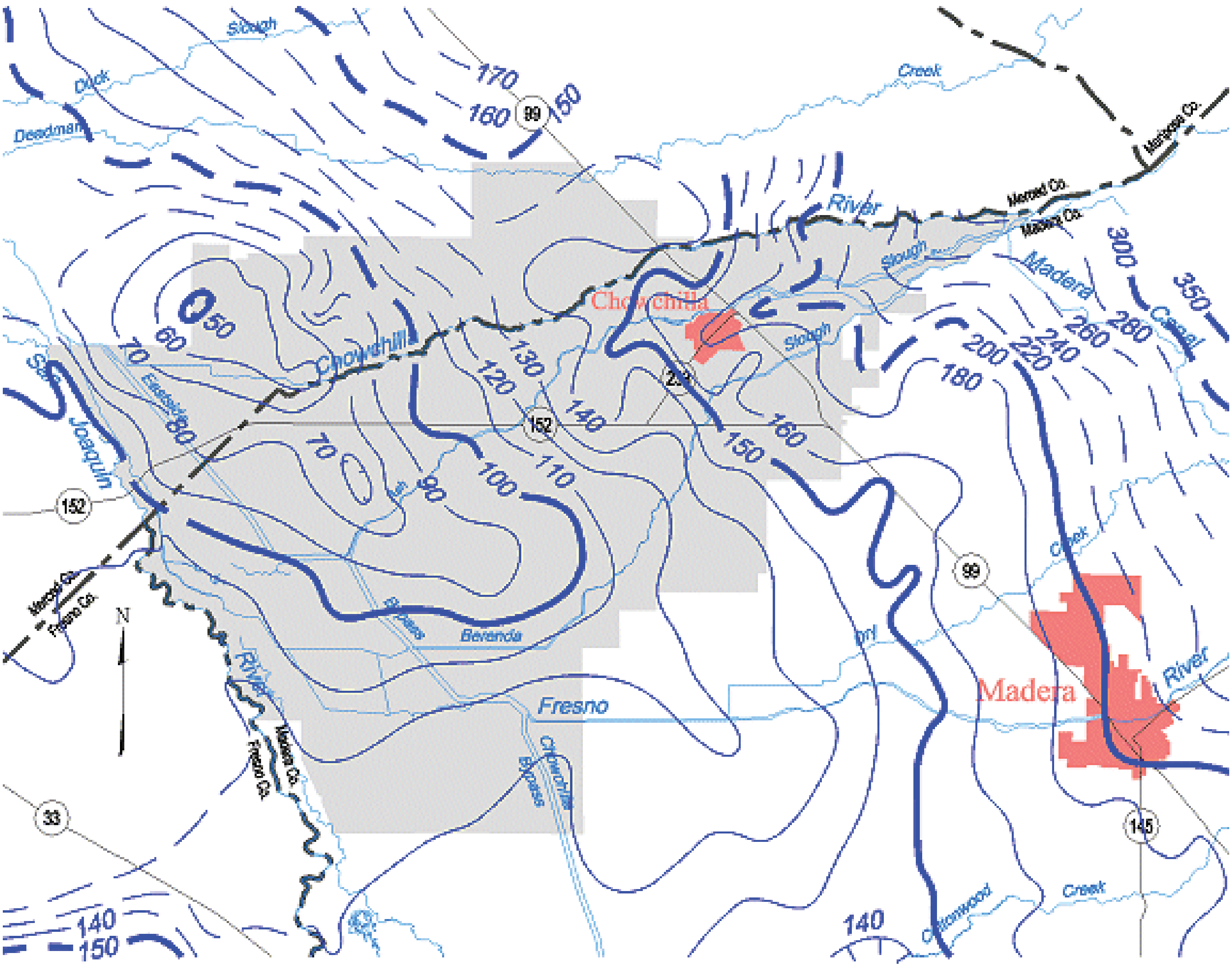
Chowchilla Groundwater Basin

Spring 1962, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Scale of Miles

2 0 2 4 6

Disclaimer: Base map created from current USGS 1:24,000 and 1:100,000 maps. Some base map features may not have been present (i.e. roads, canals, reservoirs) for the water year shown.



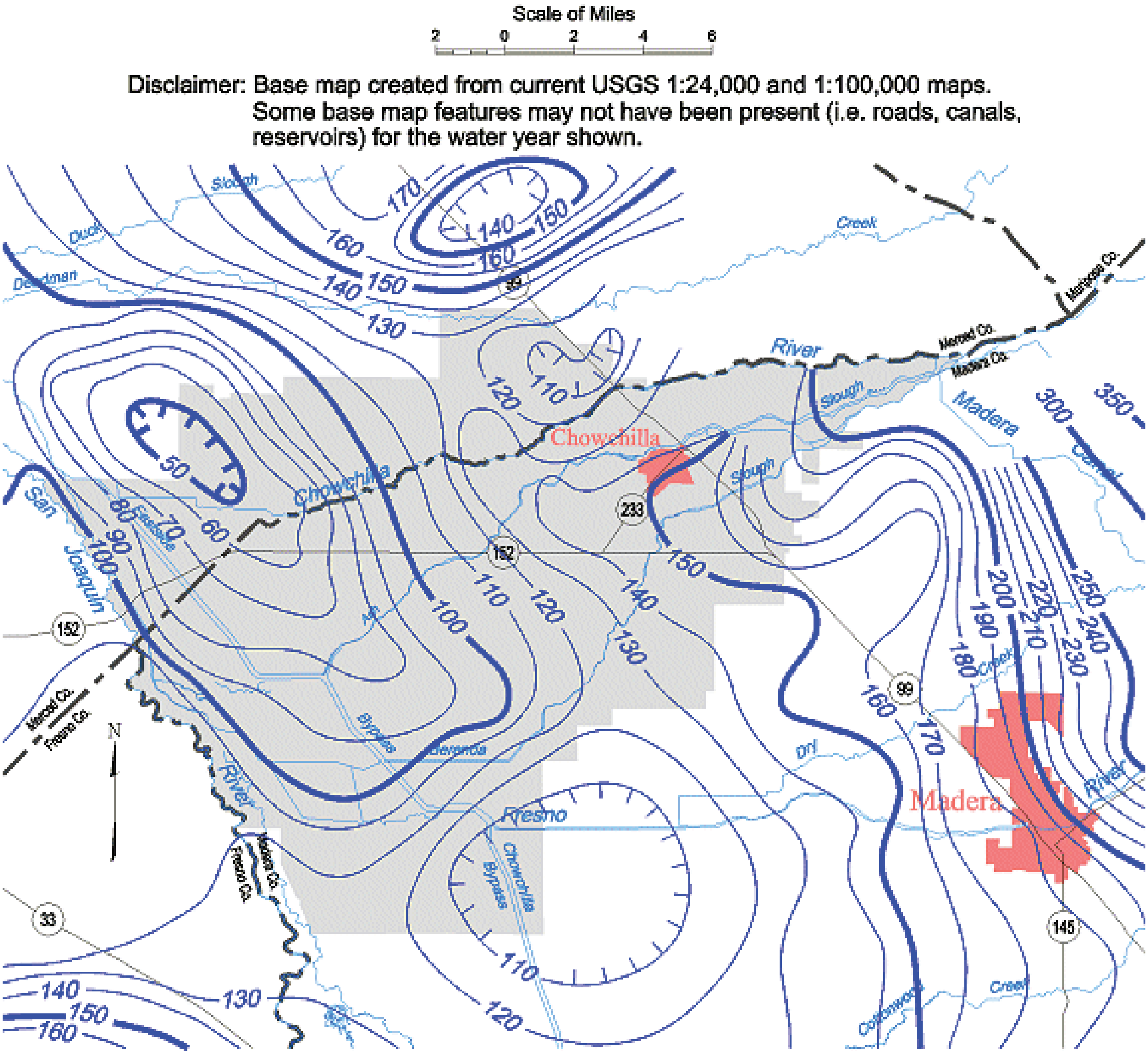
Contours are dashed where inferred. Contour interval is 10, 20 and 50 feet.

Chowchilla Groundwater Basin

Spring 1969, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Scale of Miles

Disclaimer: Base map created from current USGS 1:24,000 and 1:100,000 maps. Some base map features may not have been present (i.e. roads, canals, reservoirs) for the water year shown.



Contours are dashed where inferred. Contour interval is 10 and 50 feet.

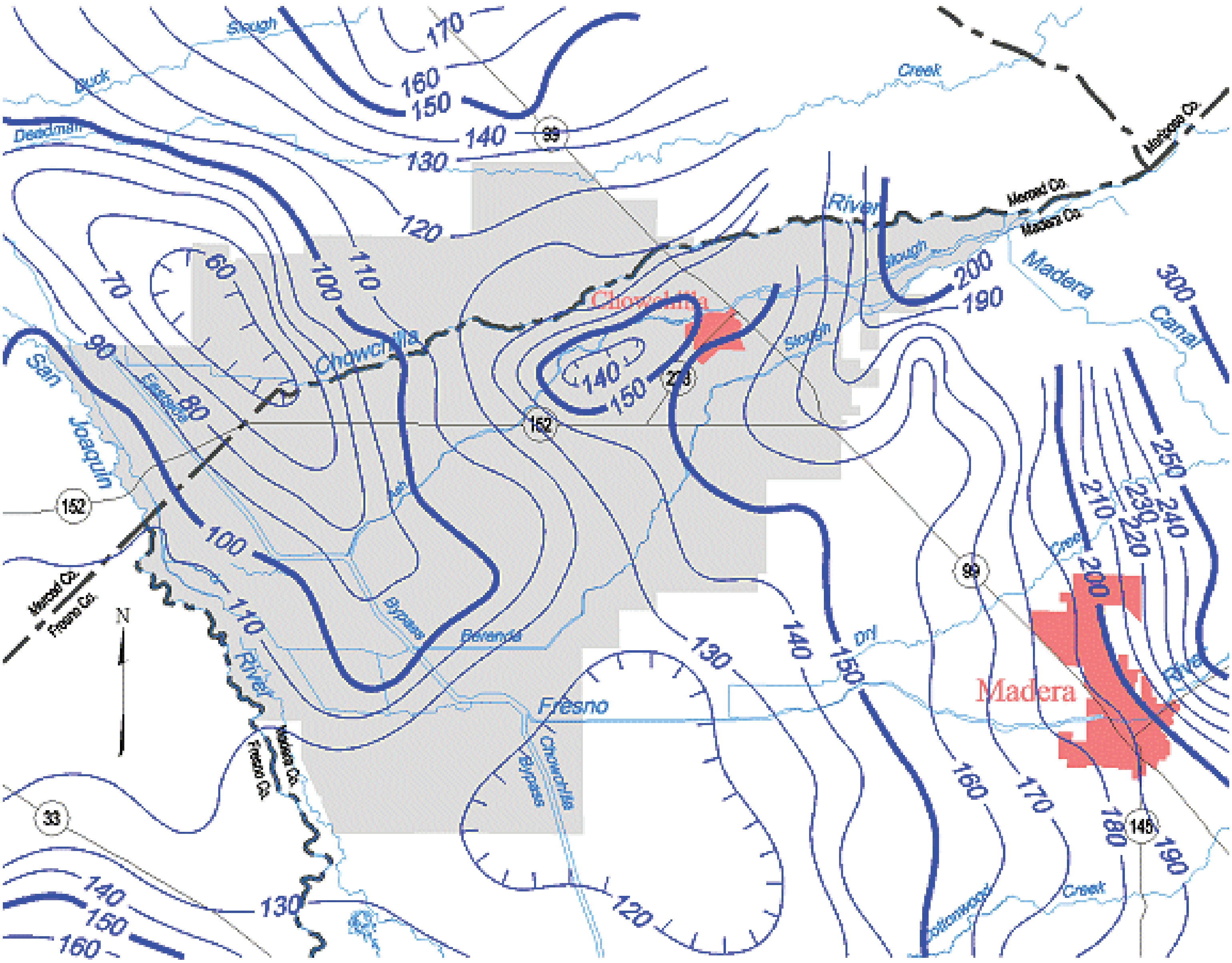
Chowchilla Groundwater Basin

Spring 1970, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Scale of Miles

2 0 2 4 6

Disclaimer: Base map created from current USGS 1:24,000 and 1:100,000 maps. Some base map features may not have been present (i.e. roads, canals, reservoirs) for the water year shown.



Contours are dashed where inferred. Contour interval is 10 and 50 feet.

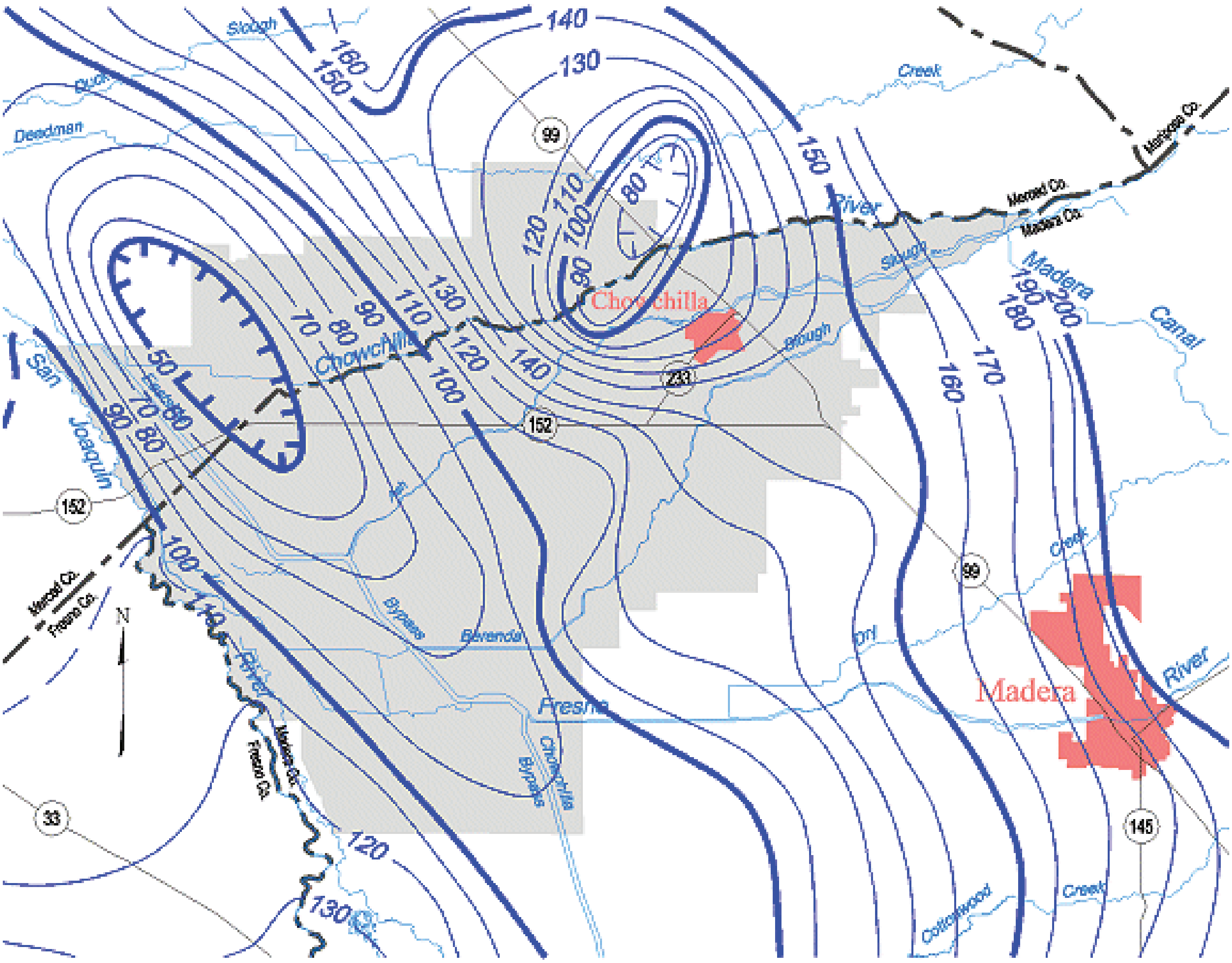
Chowchilla Groundwater Basin

Spring 1976, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Scale of Miles

2 0 2 4 6

Disclaimer: Base map created from current USGS 1:24,000 and 1:100,000 maps. Some base map features may not have been present (i.e. roads, canals, reservoirs) for the water year shown.



Contours are dashed where inferred. Contour interval is 10 feet.

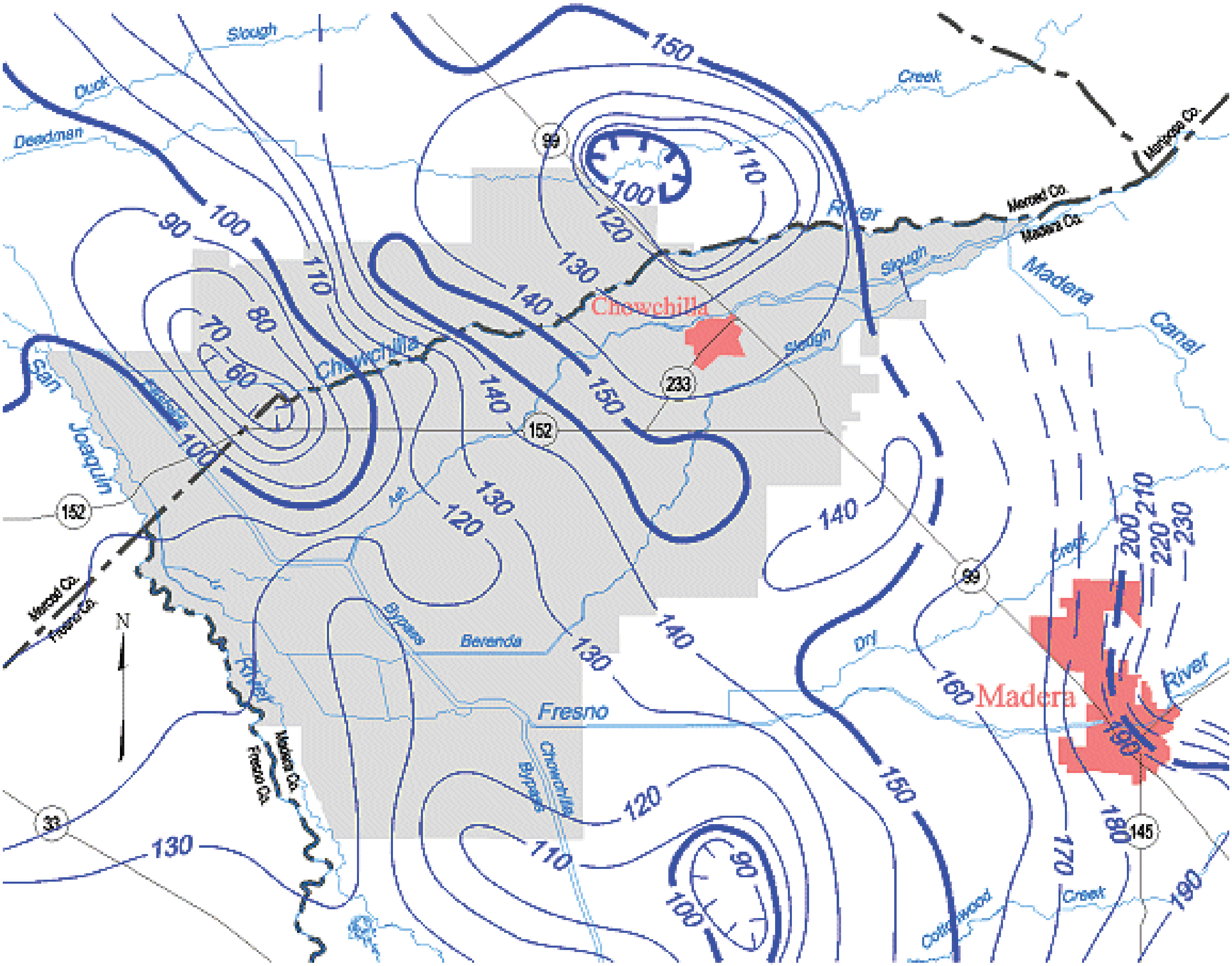
Chowchilla Groundwater Basin

Spring 1984, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Scale of Miles

2 0 2 4 6

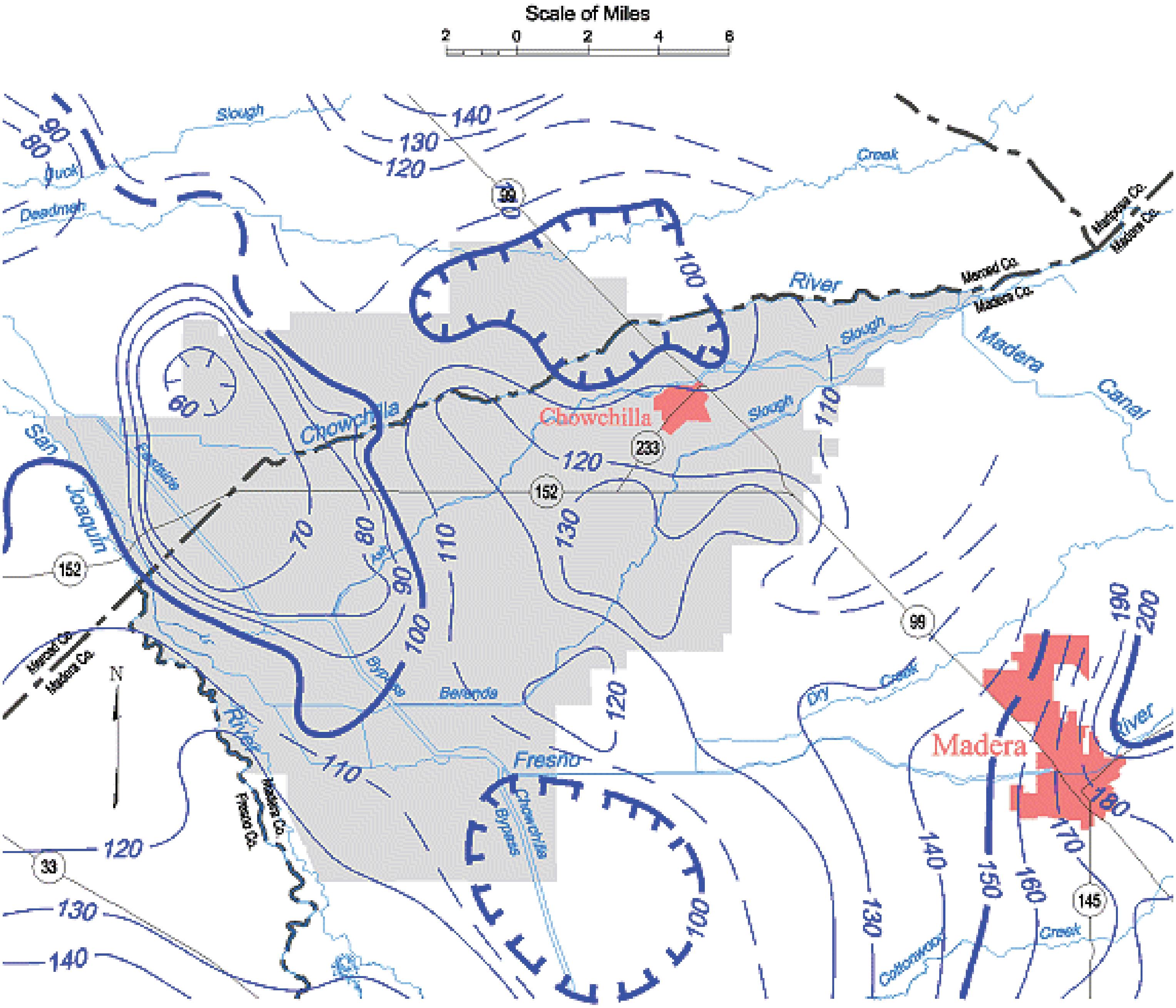
Disclaimer: Base map created from current USGS 1:24,000 and 1:100,000 maps. Some base map features may not have been present (i.e. roads, canals, reservoirs) for the water year shown.



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

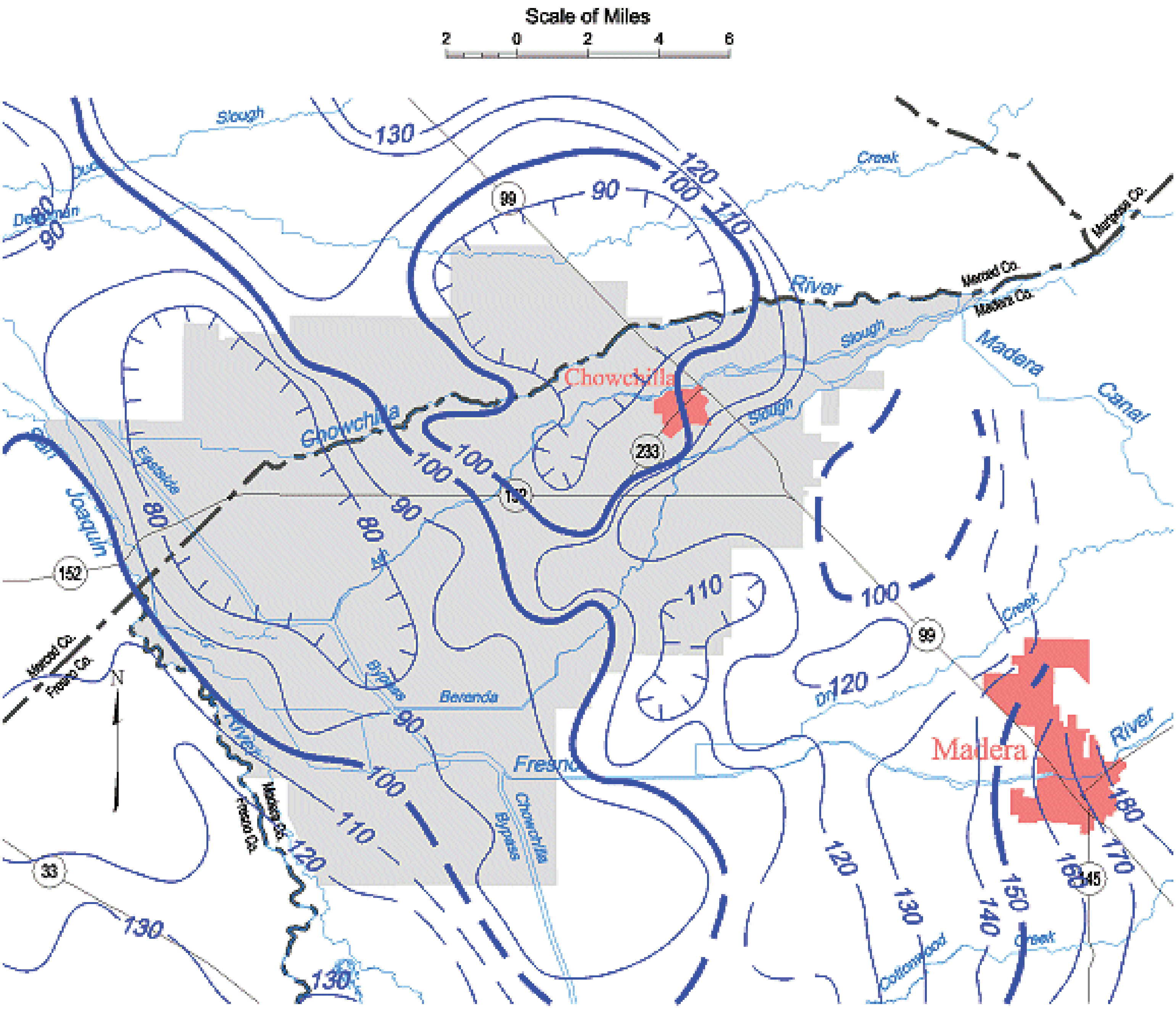
Spring 1989, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

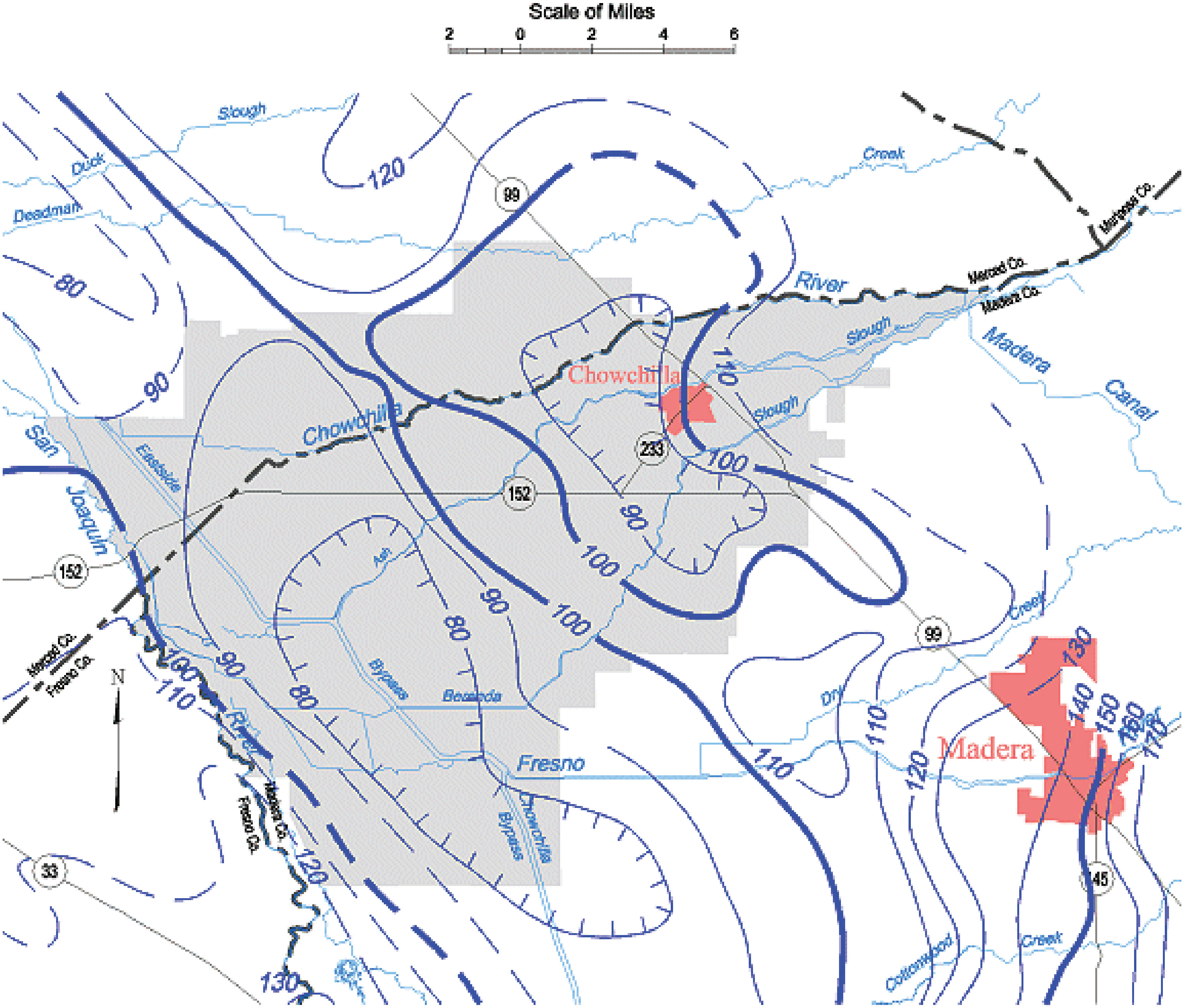
Spring 1990, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

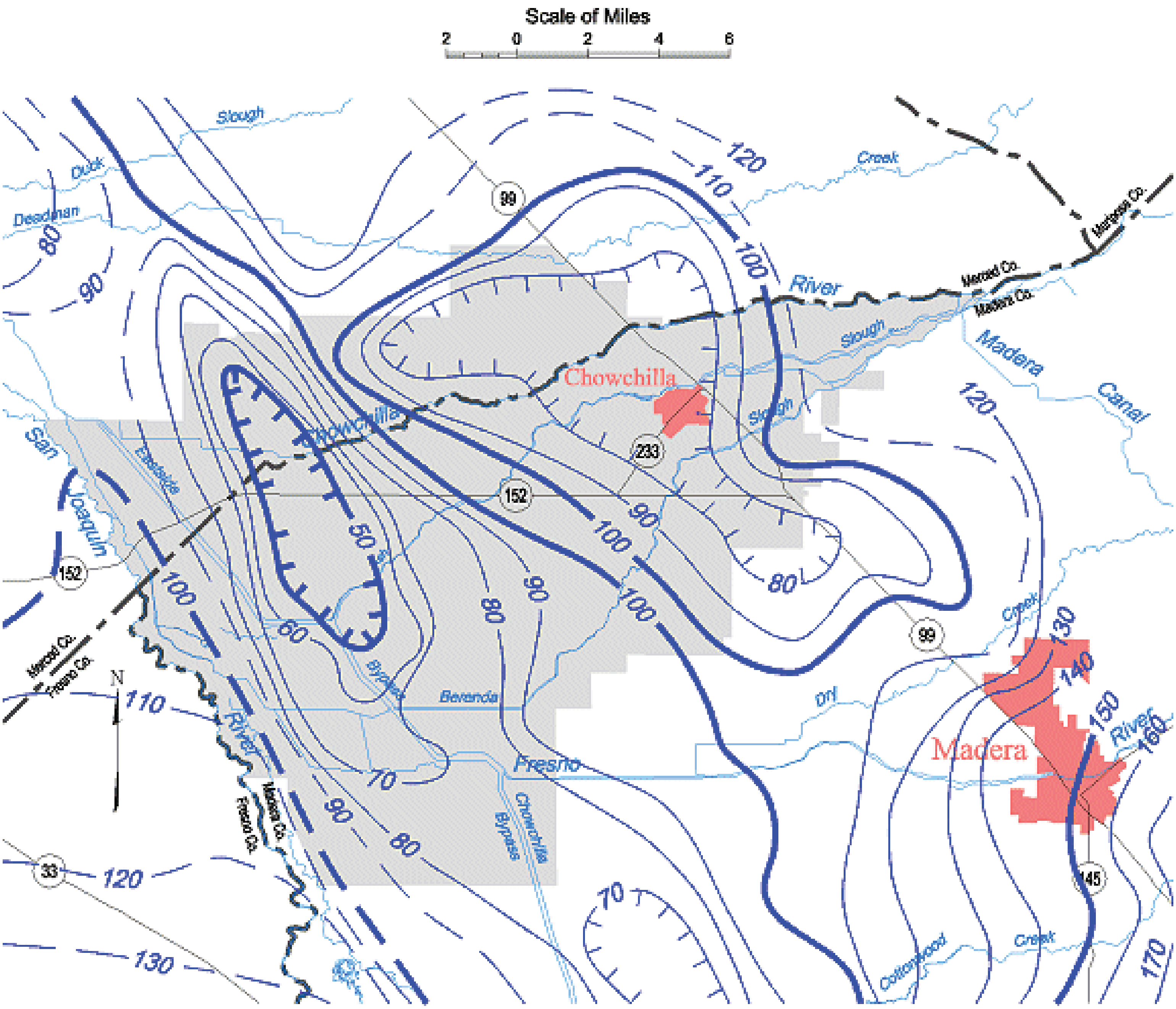
Spring 1991, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

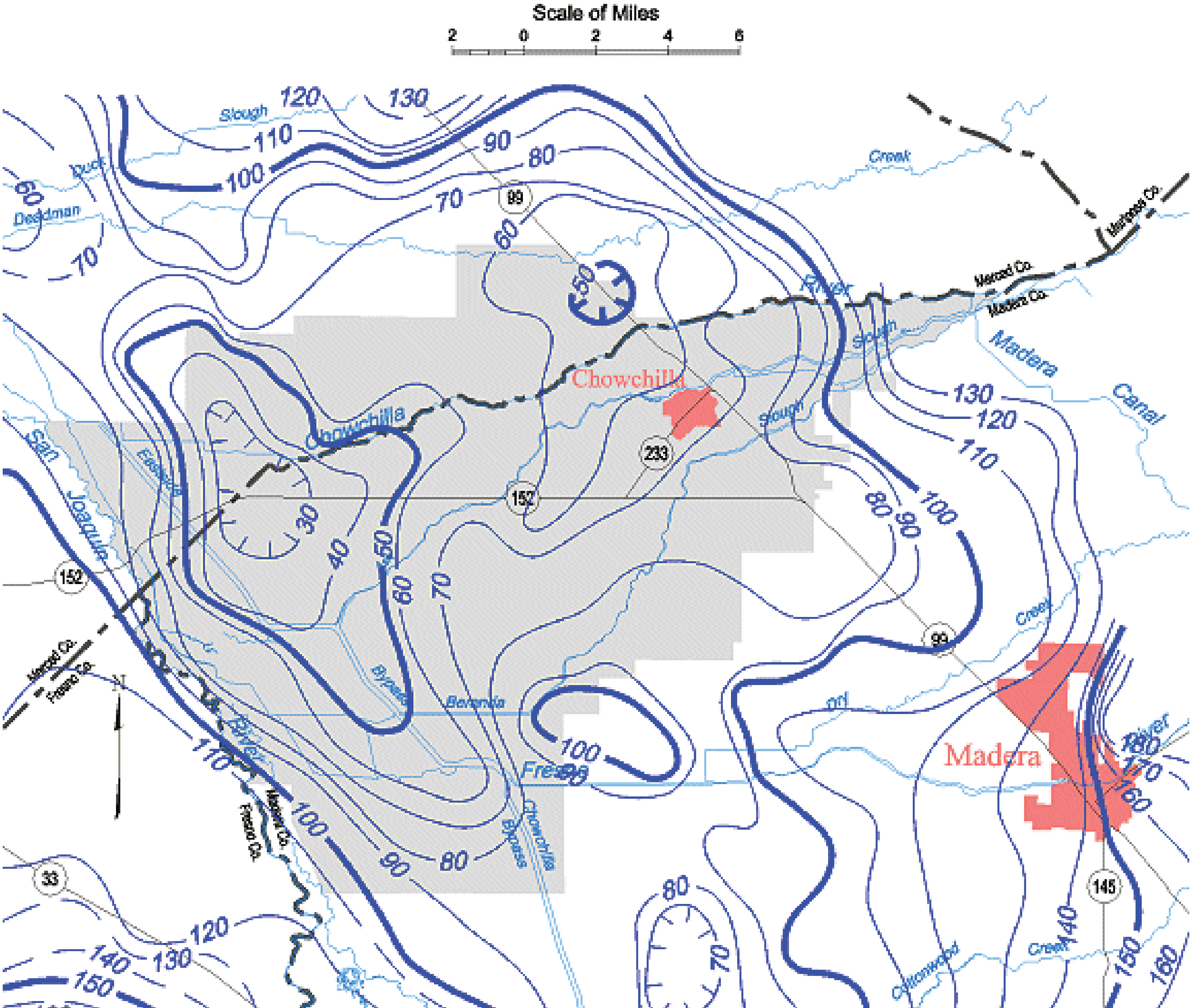
Spring 1992, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

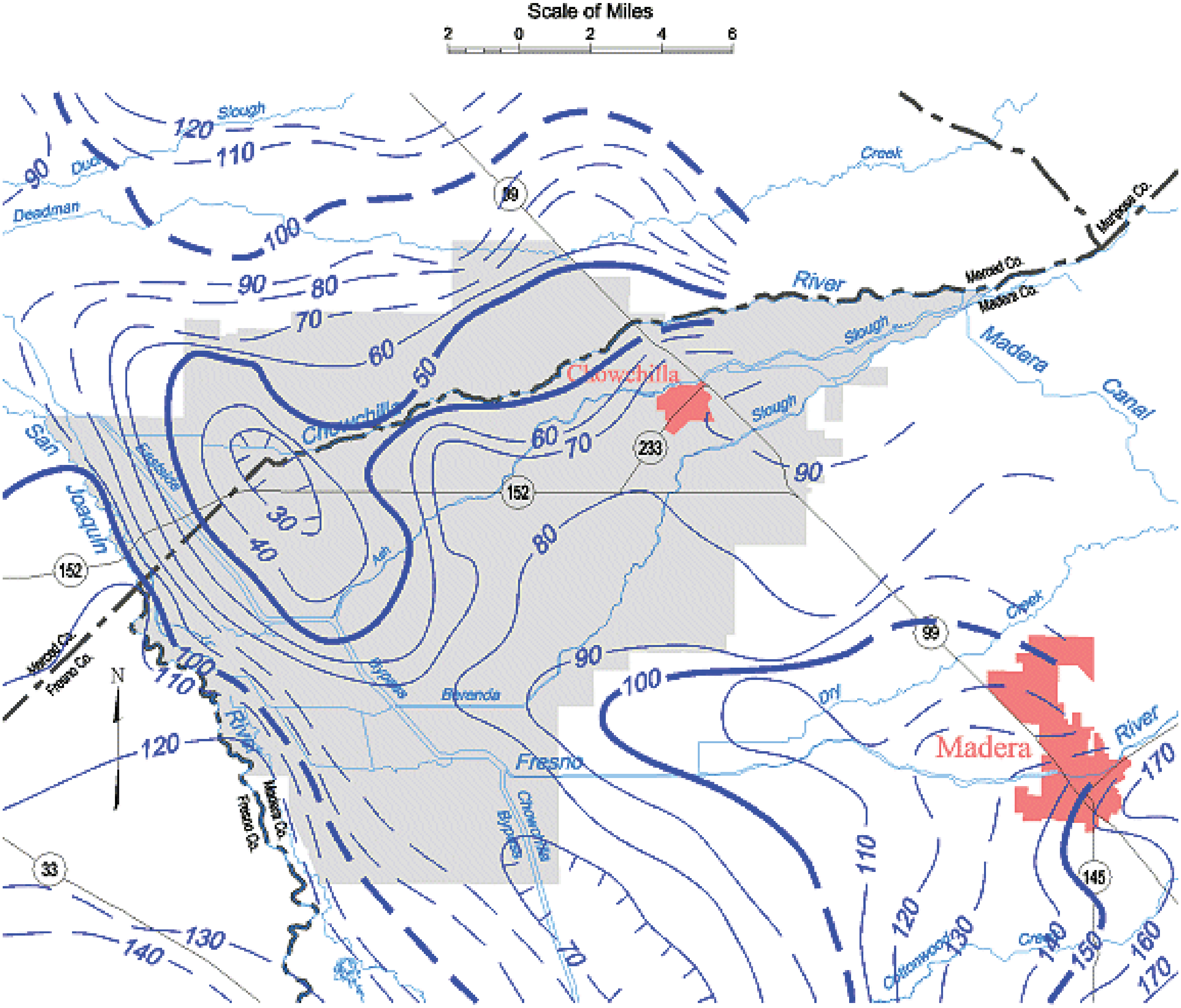
Spring 1993, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

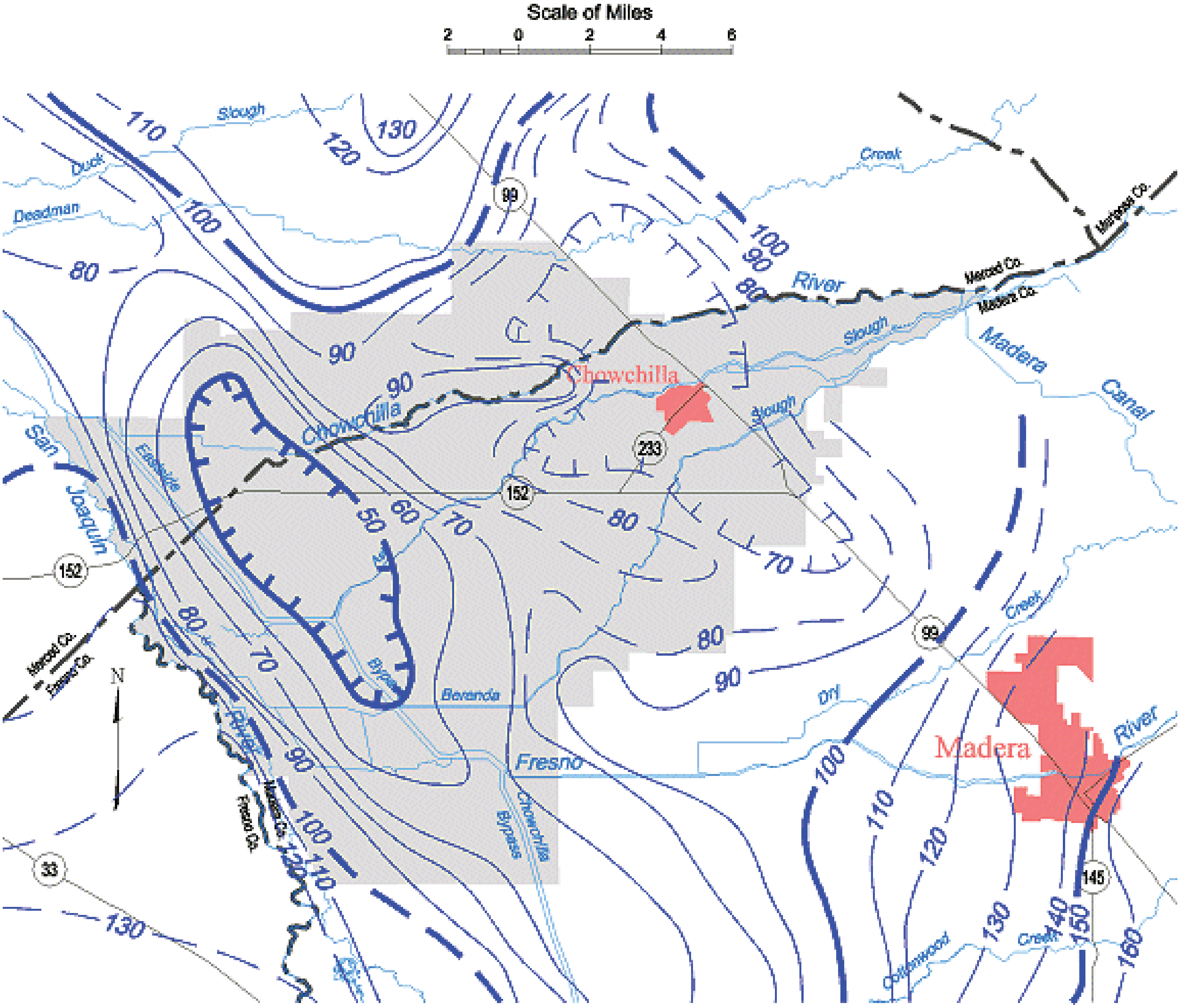
Spring 1994, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

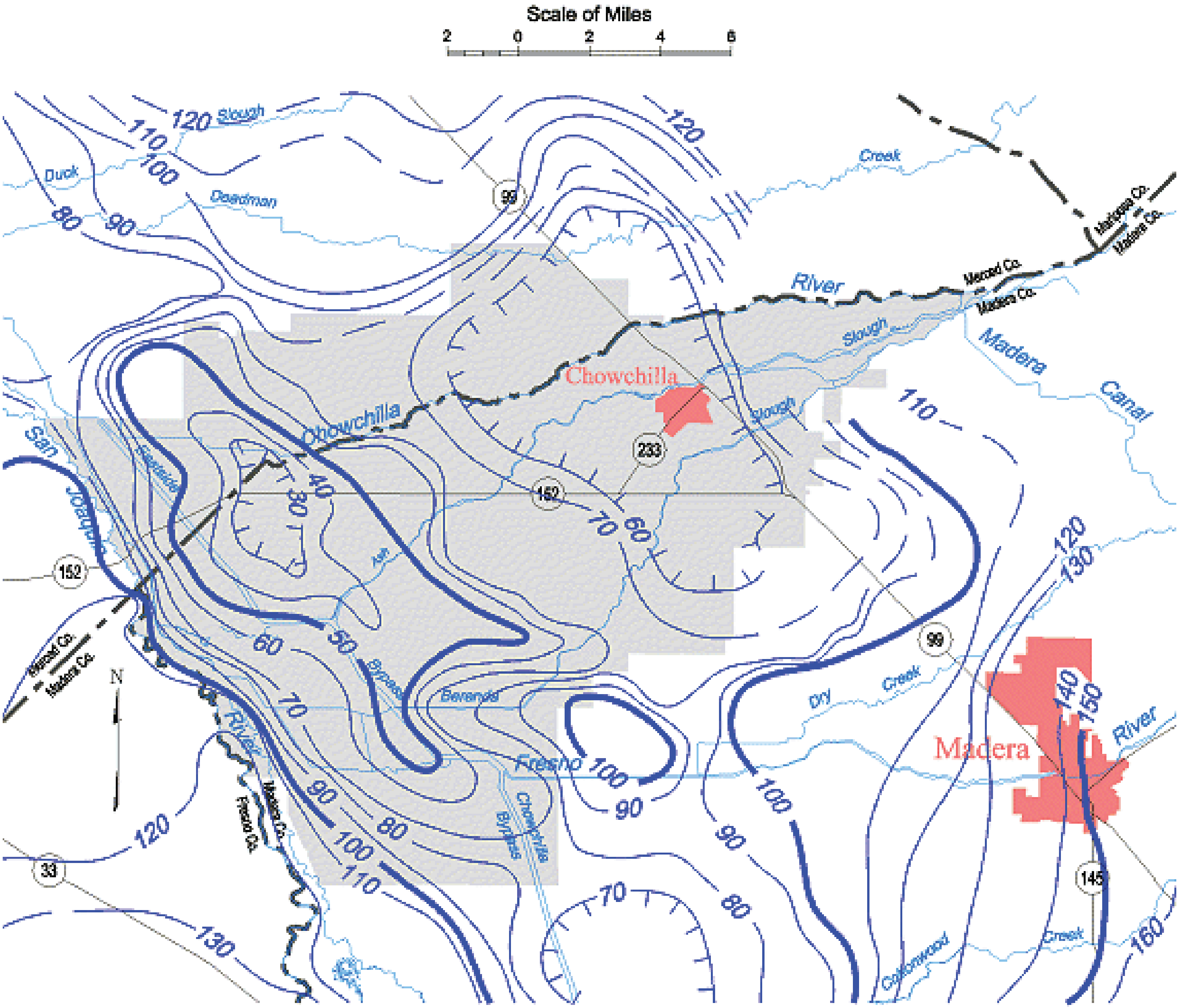
Spring 1995, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

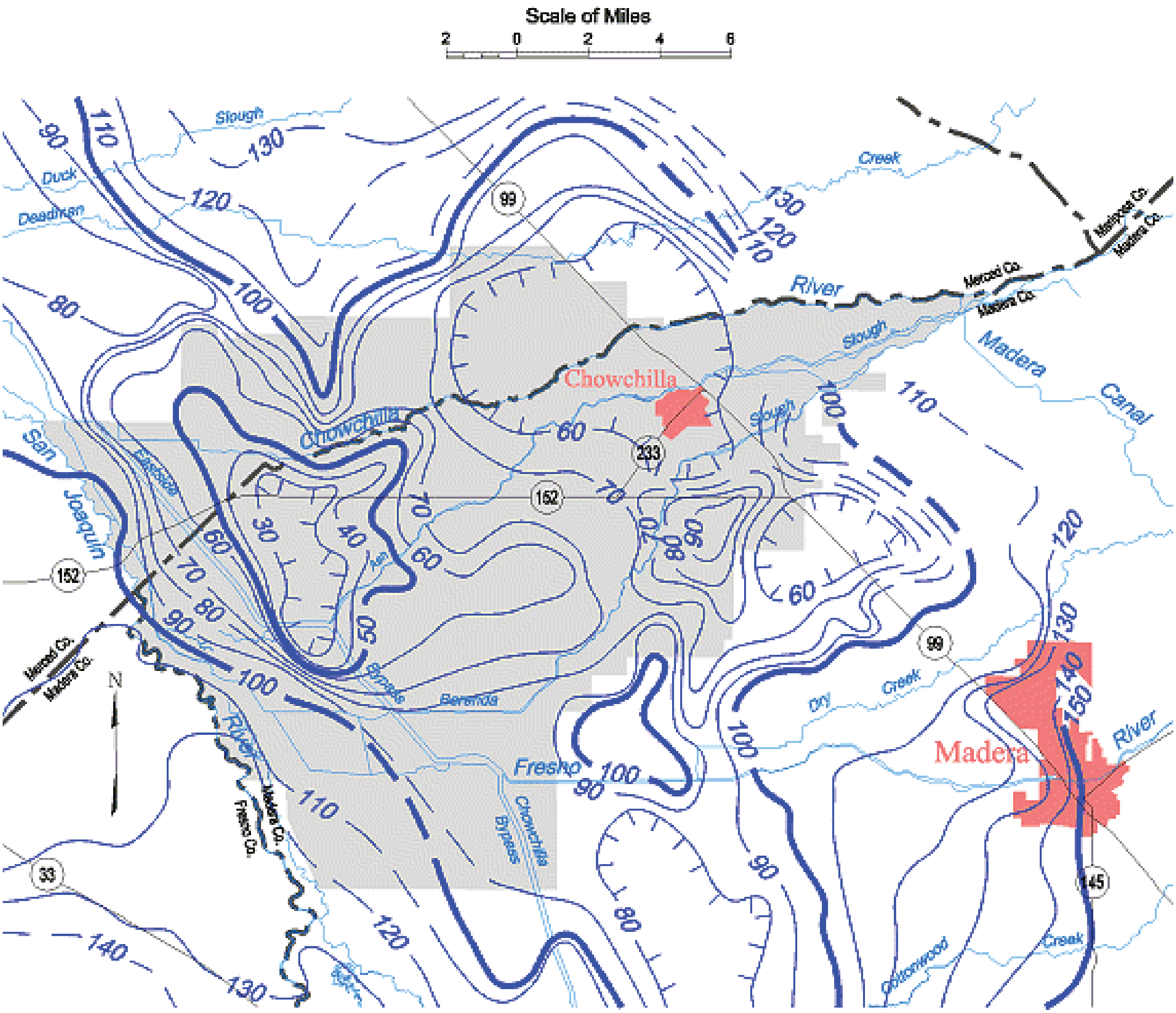
Spring 1996, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

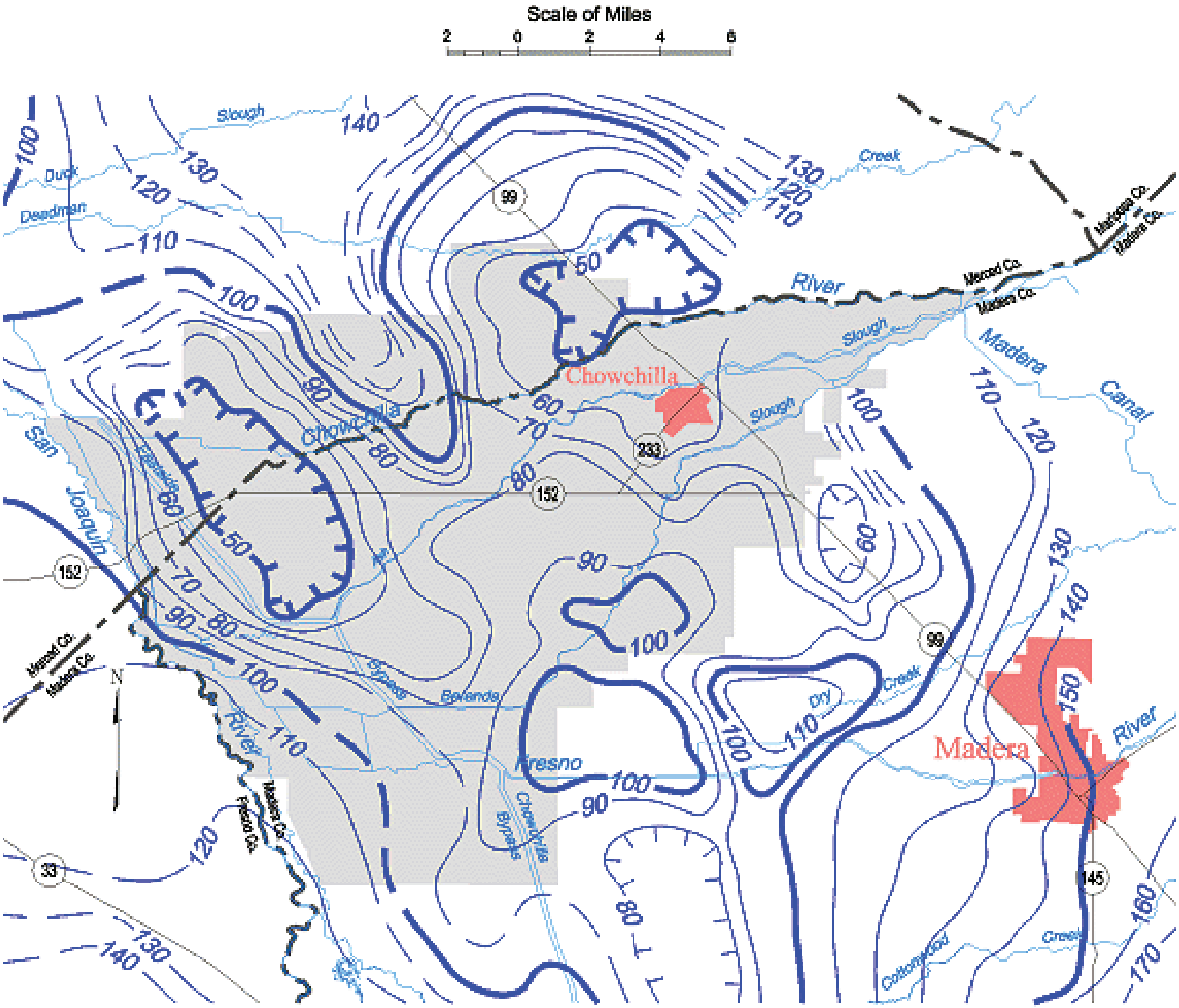
Spring 1997, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

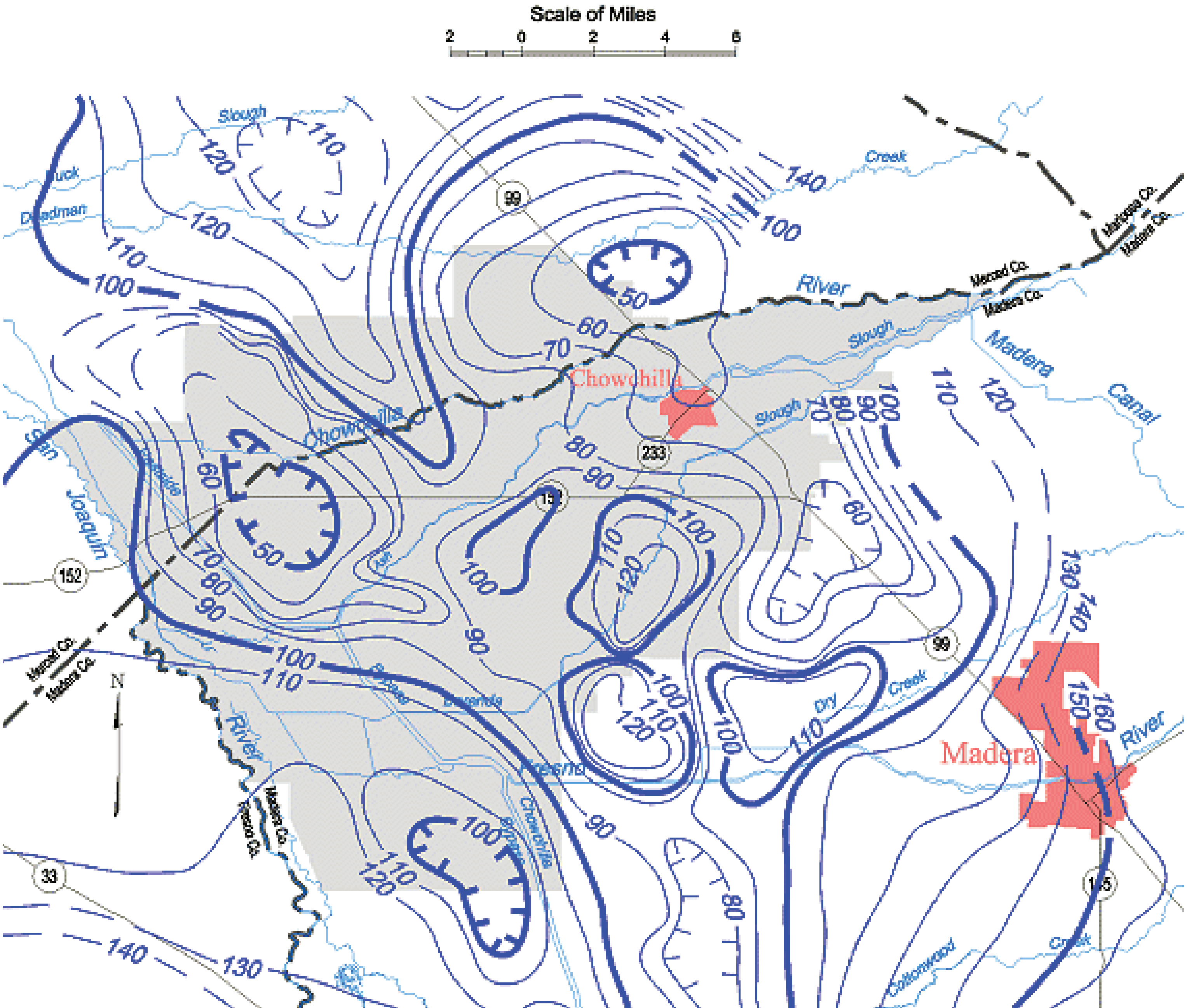
Spring 1998, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

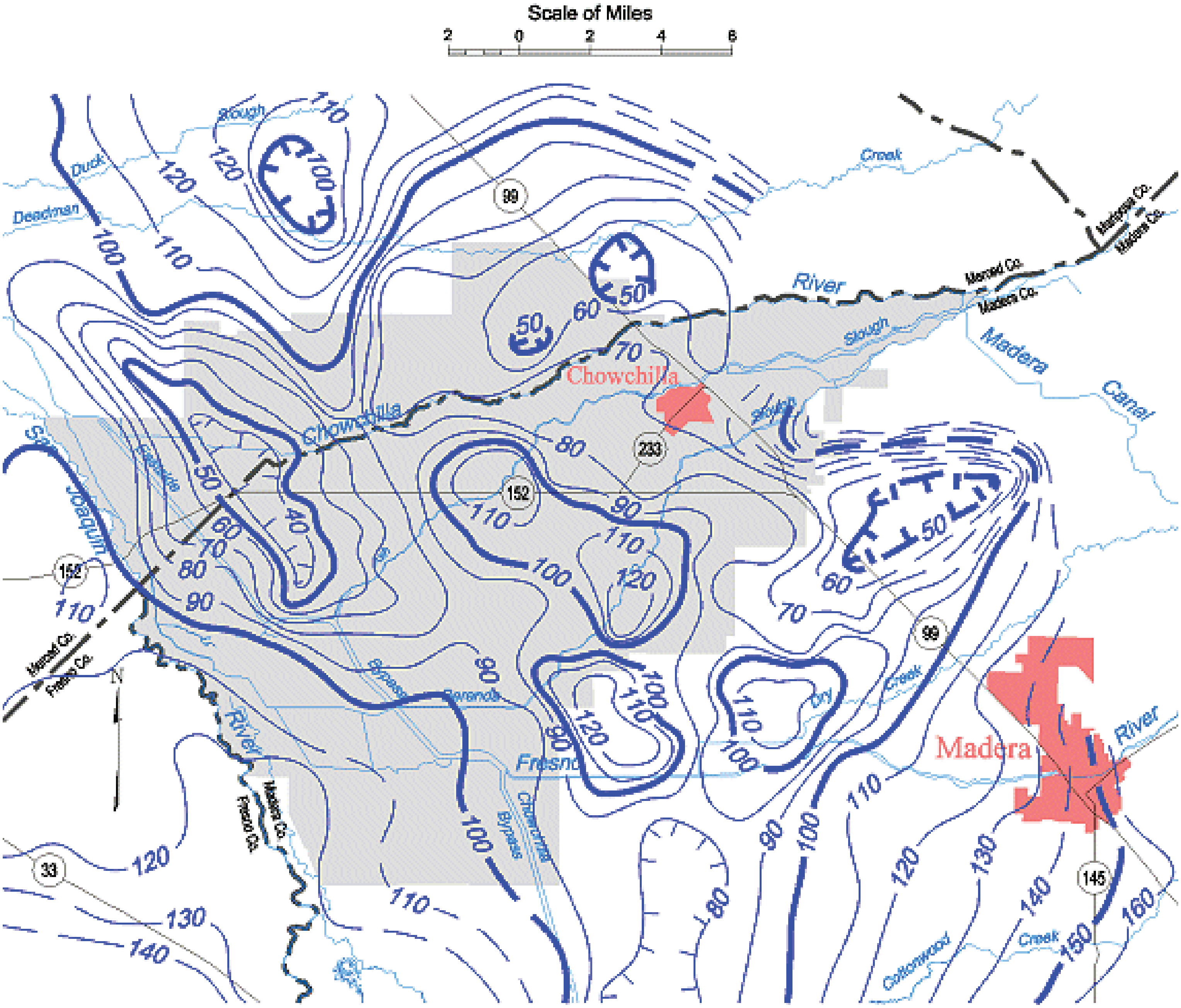
Spring 1999, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

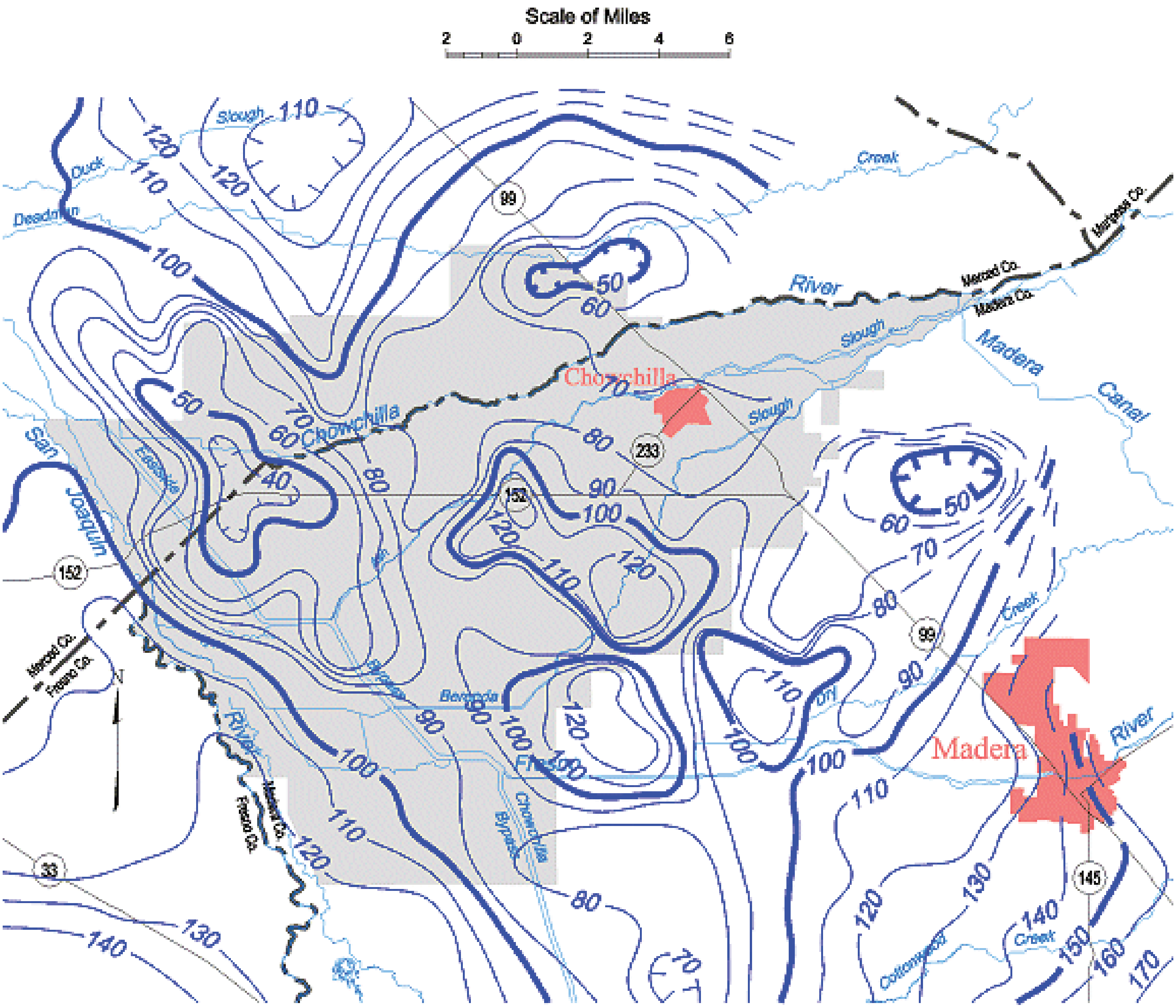
Spring 2000, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

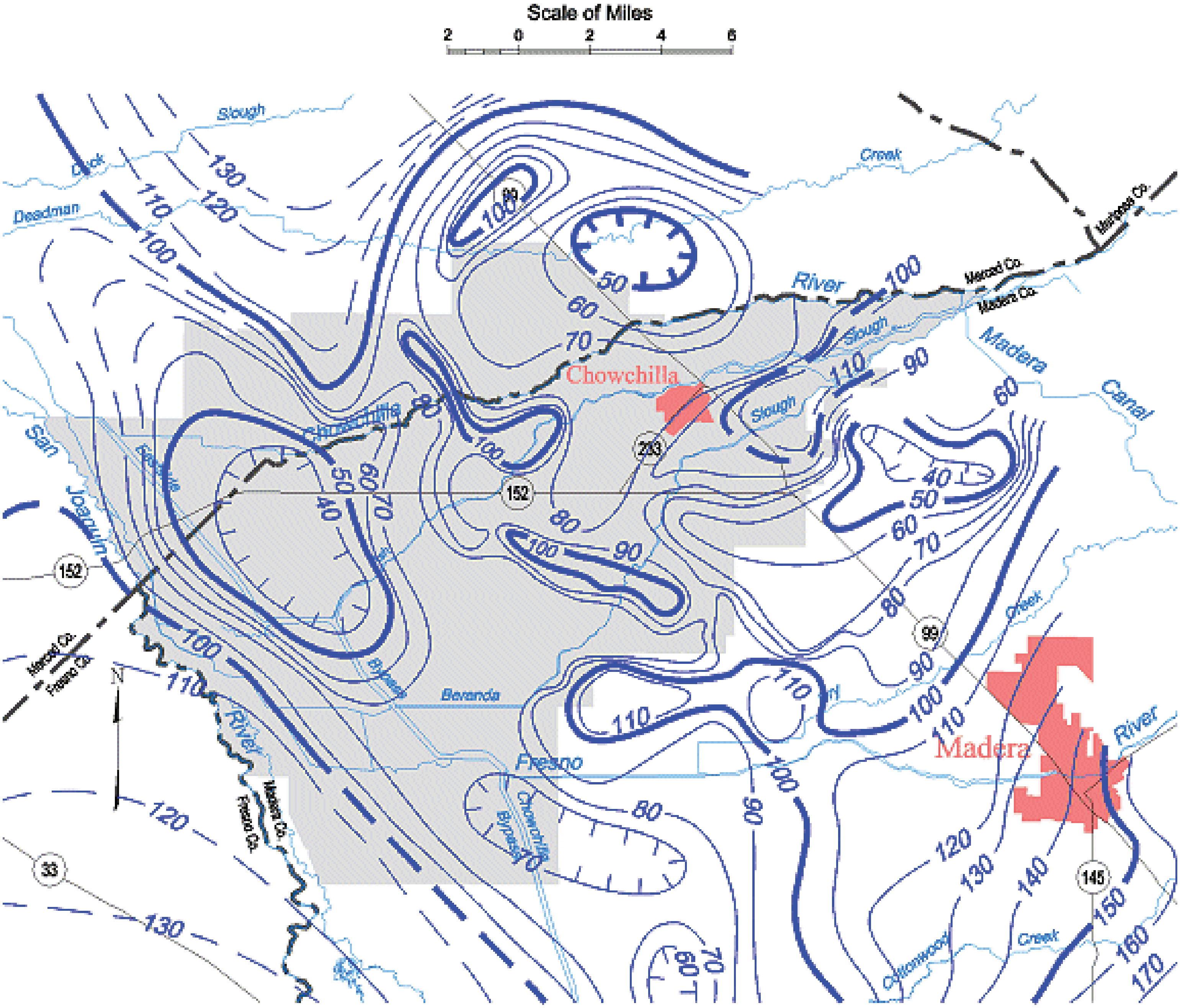
Spring 2001, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

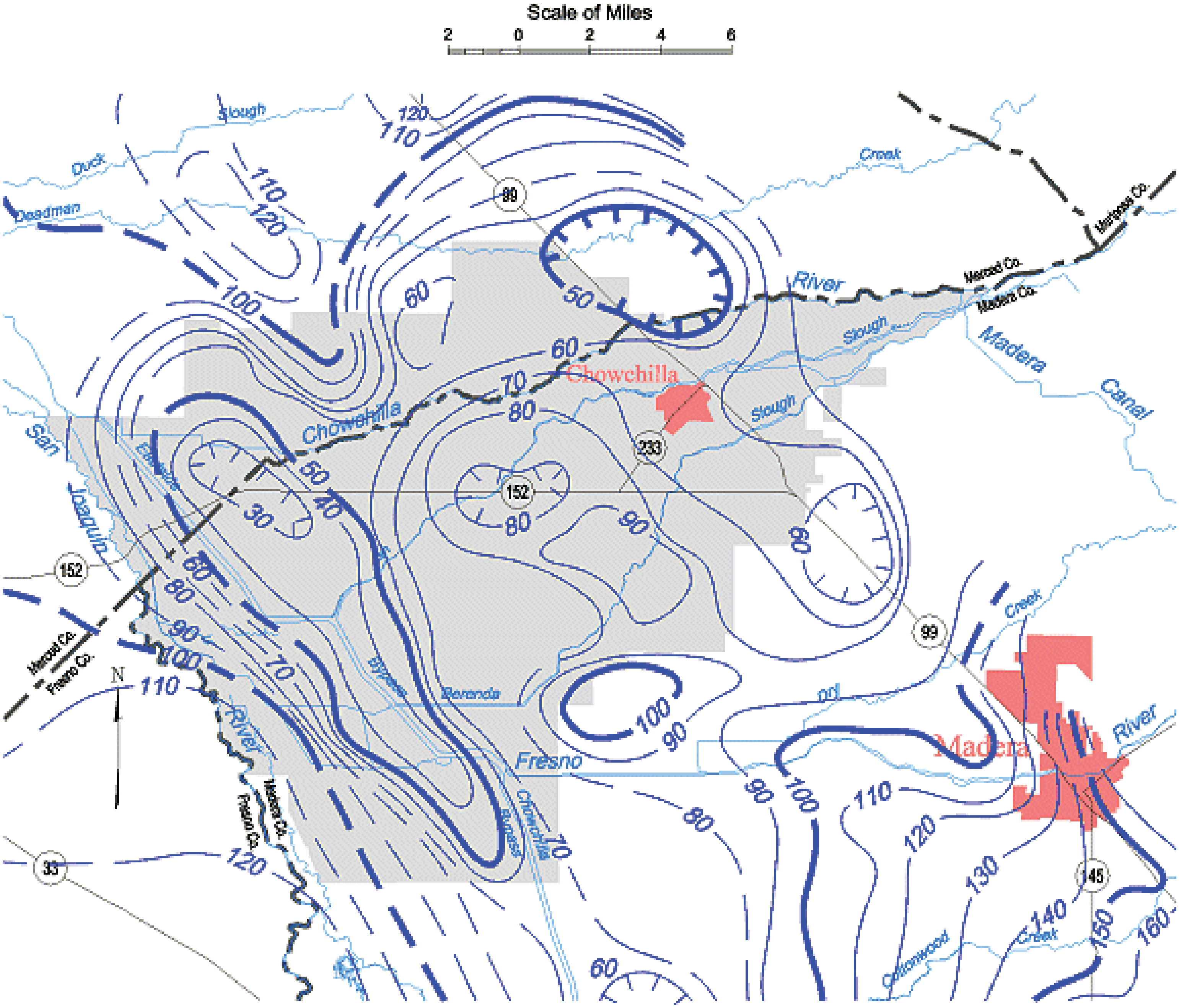
Spring 2002, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

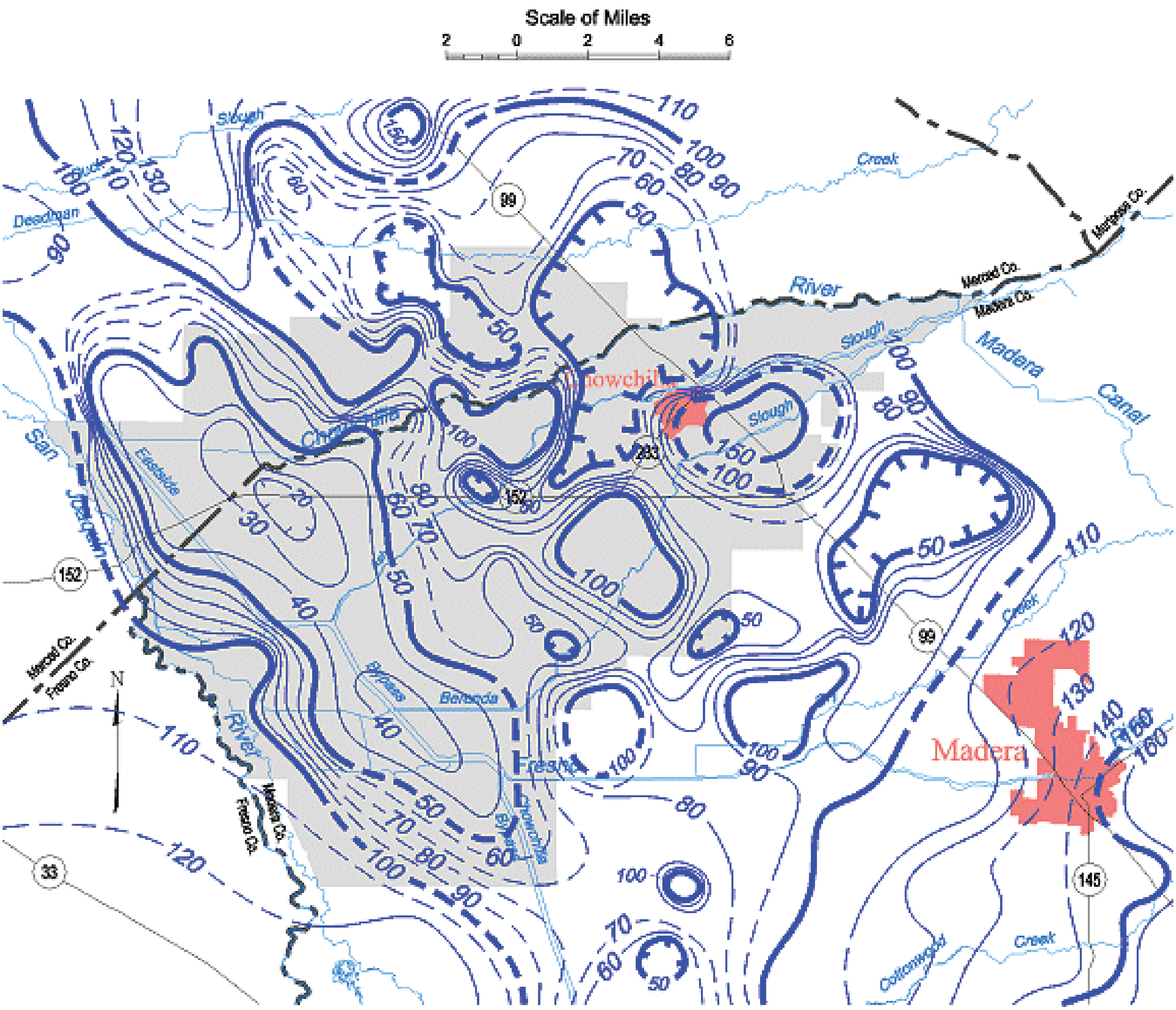
Spring 2003, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

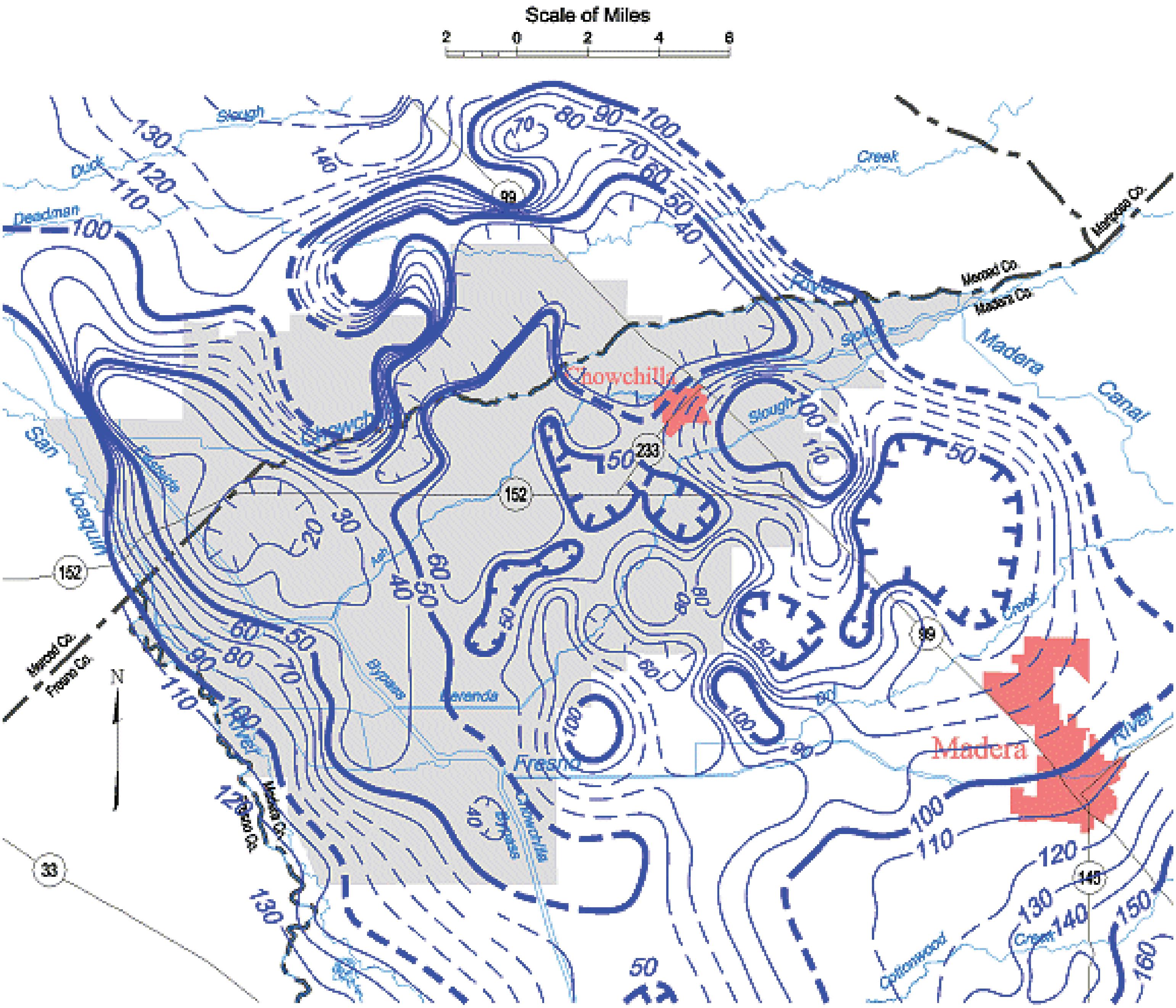
Spring 2004, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 50 feet.

Chowchilla Groundwater Basin

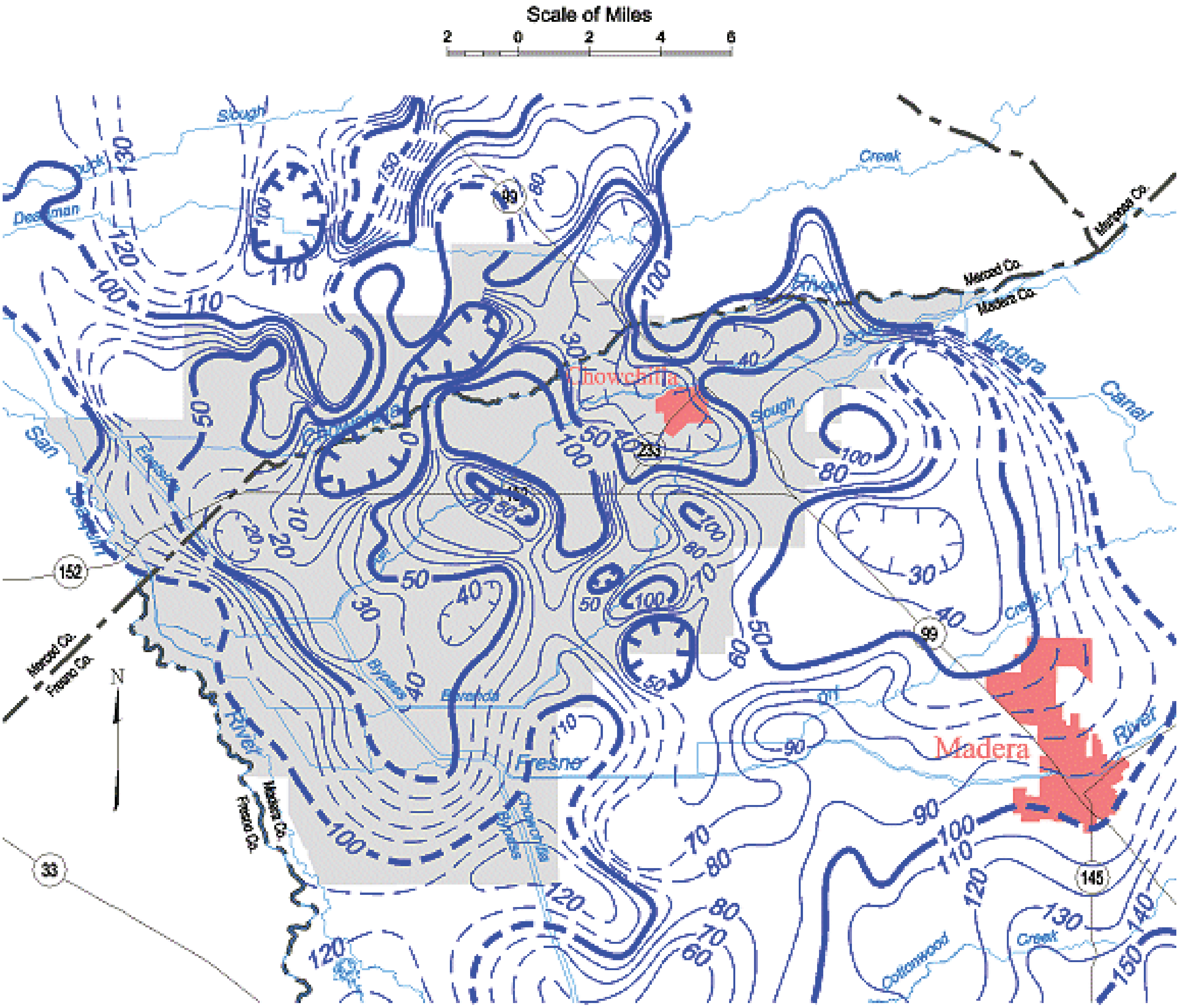
Spring 2005, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

Spring 2006, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



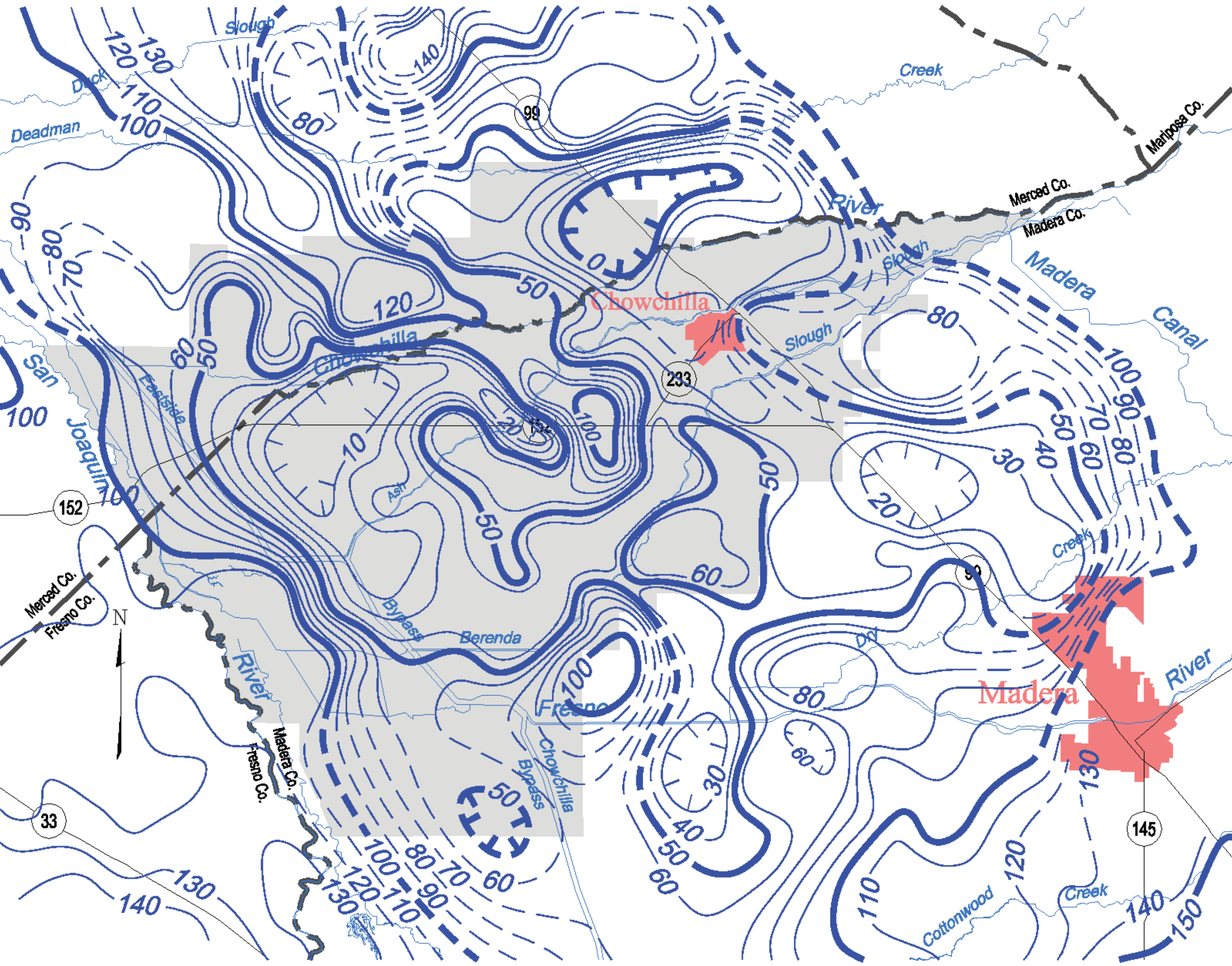
Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Chowchilla Groundwater Basin

Spring 2007, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Scale of Miles

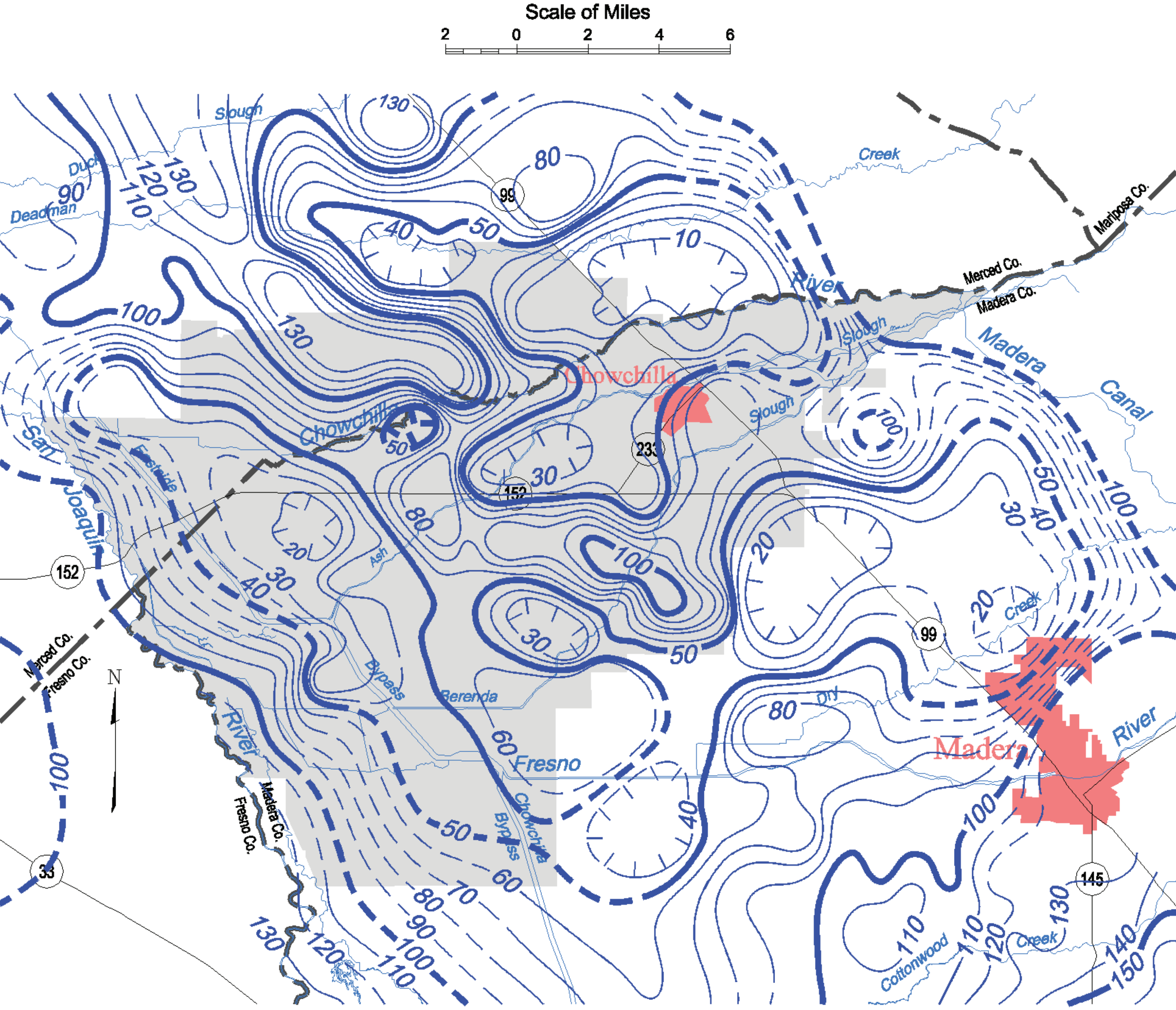
2 0 2 4 6



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

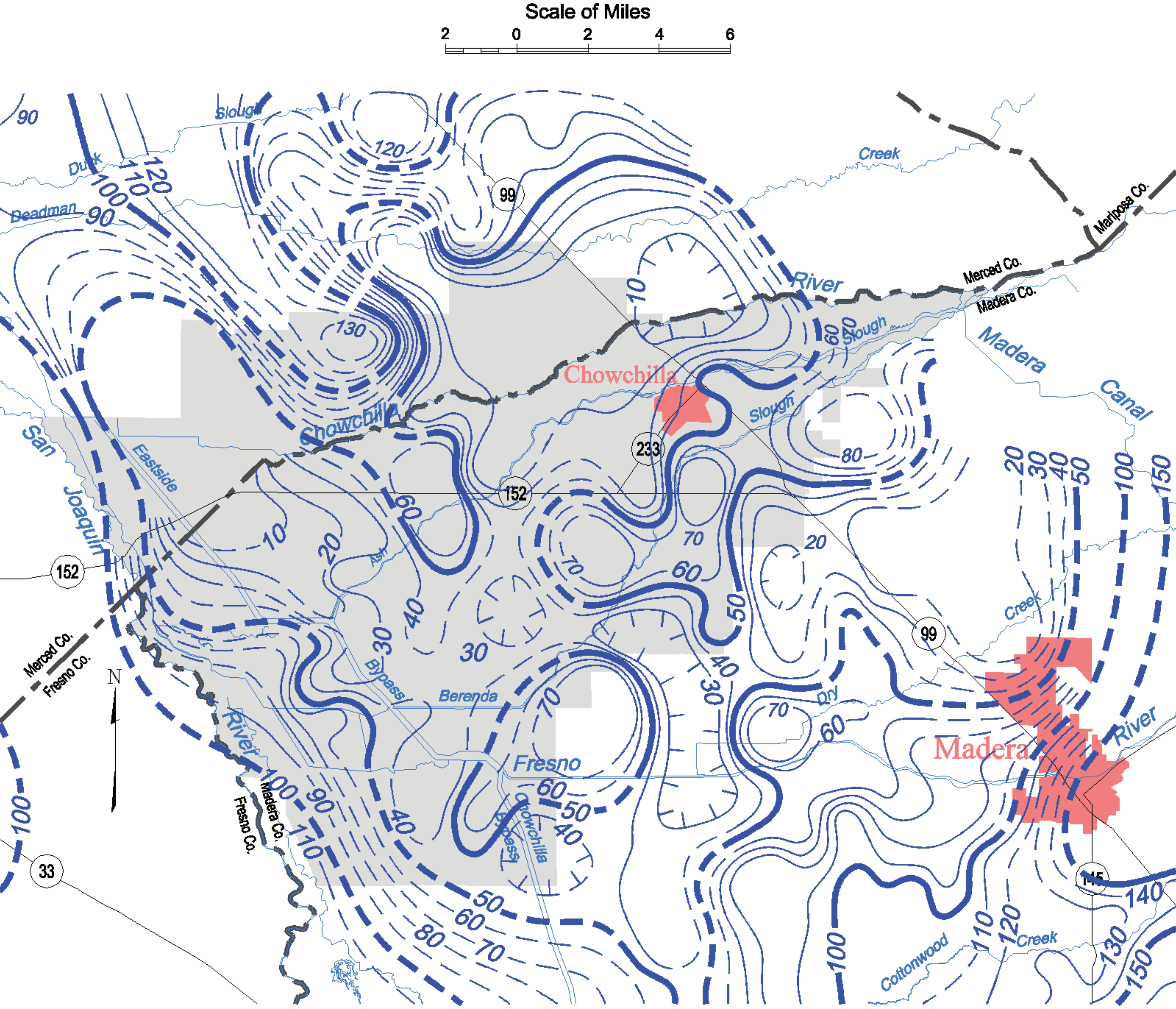
Spring 2008, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

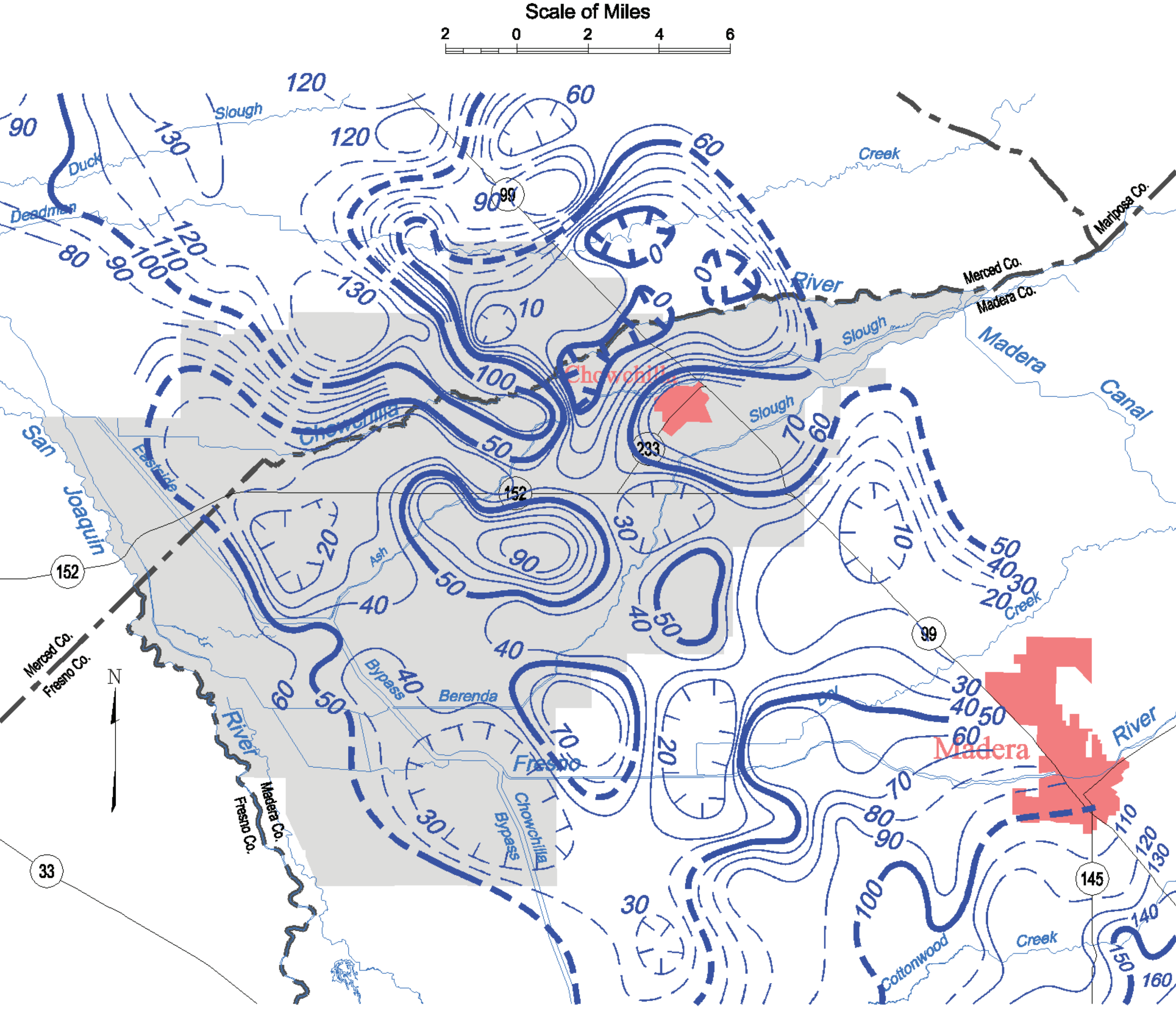
Spring 2009, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin

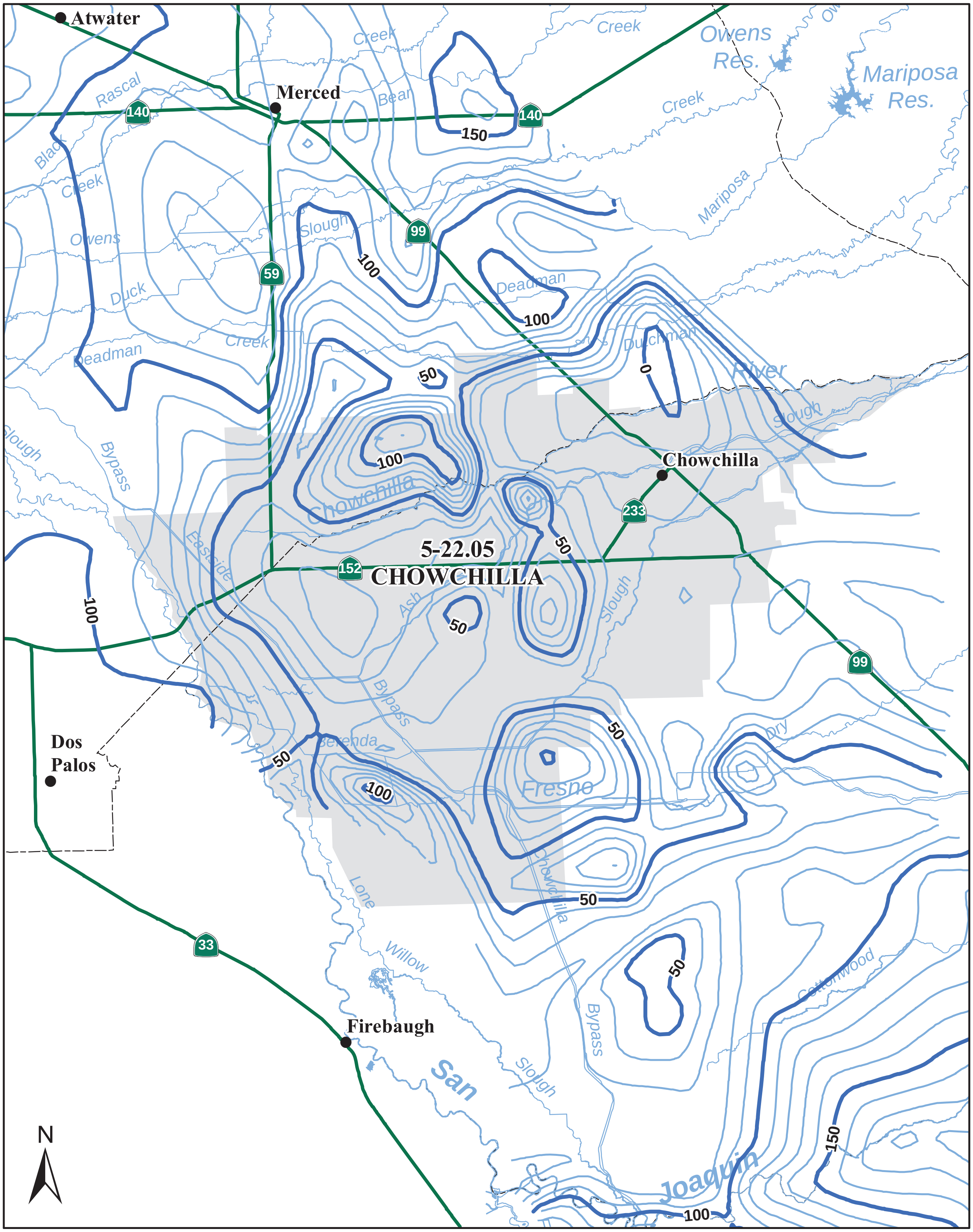
Spring 2010, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Chowchilla Groundwater Basin 5-22.05

Groundwater Elevation Contours - Spring 2011 San Joaquin River Hydrologic Region

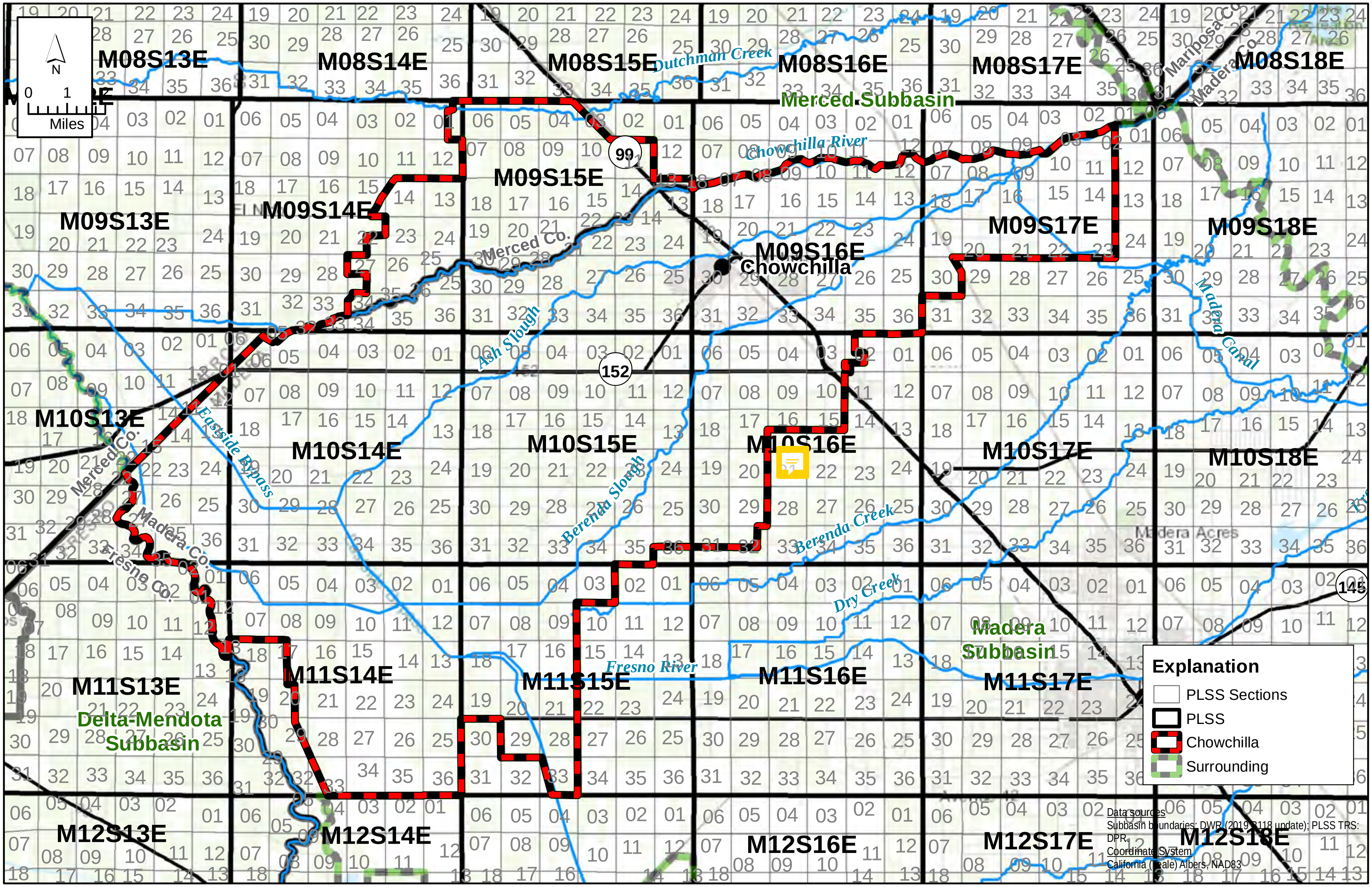


Lines of equal elevation of groundwater in feet above mean sea level.
Groundwater contours are a generalized representation of static water levels interpreted from wells measured in Spring 2011.
Water levels are interpreted to represent unconfined conditions.

0 5 10 Miles

South Central Region Office

Groundwater Elevation Hydrographs

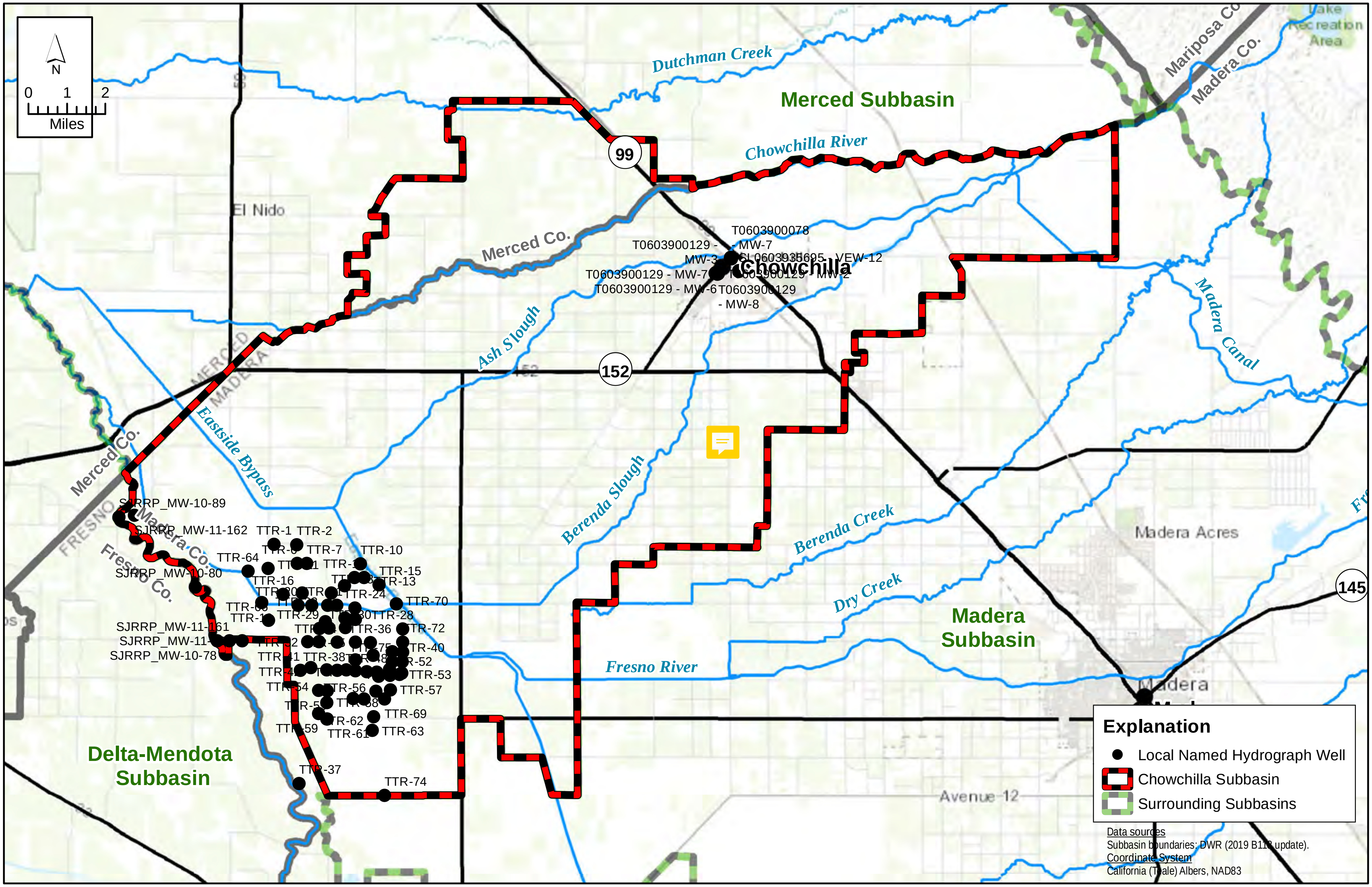


X:\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Appendix 2.E Chowchilla Subbasin Well Hydrograph Locs PLSS.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

APPENDIX 2.E
Groundwater Elevation Hydrograph Location Map: Using PLSS for State Well Numbers



X:\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Appendix 2.E Chowchilla Subbasin Well Hydrograph Locs Entity Wells.mxd

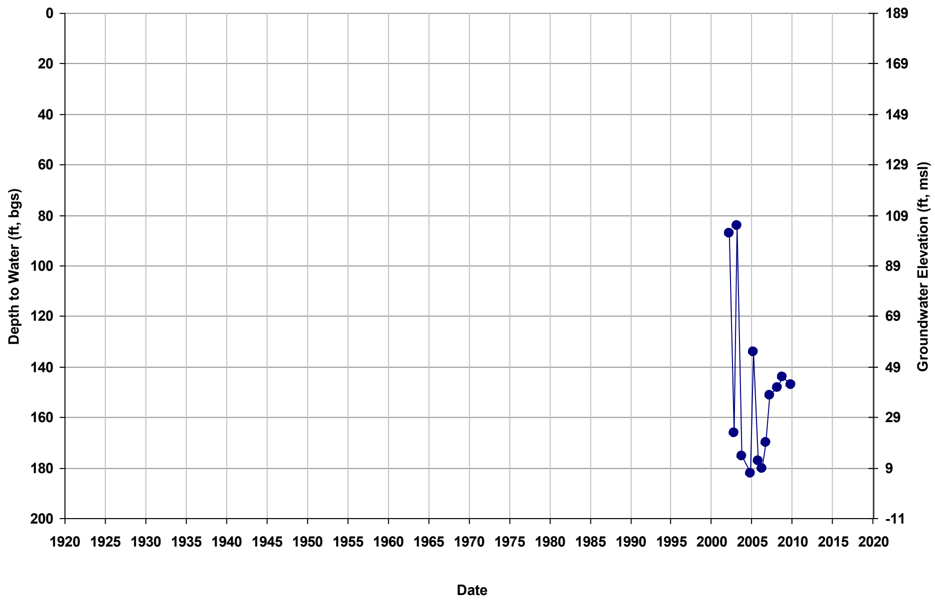
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

APPENDIX 2.E
Groundwater Elevation Hydrograph Location Map: Local Named Well

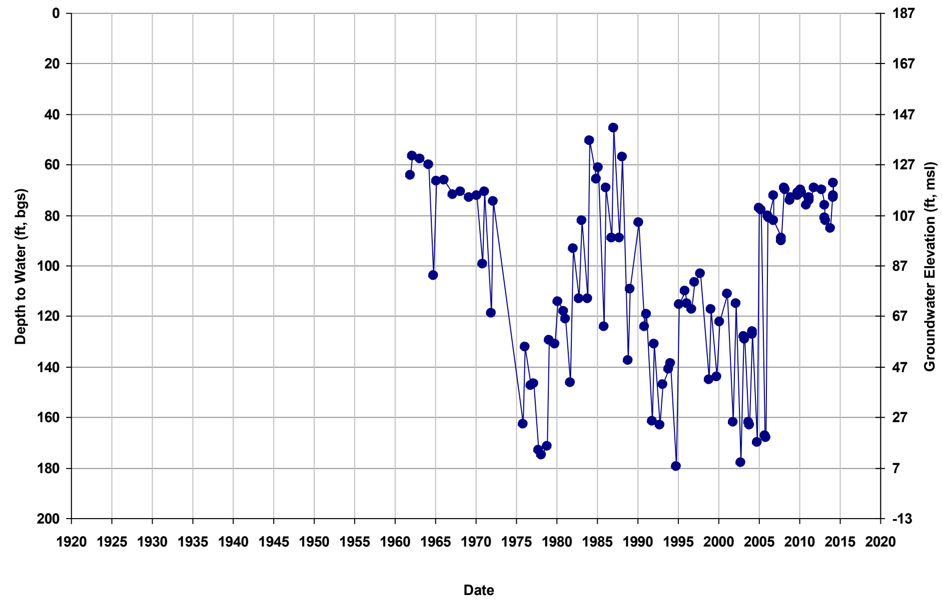
Well ID: 09S14E01A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 189
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



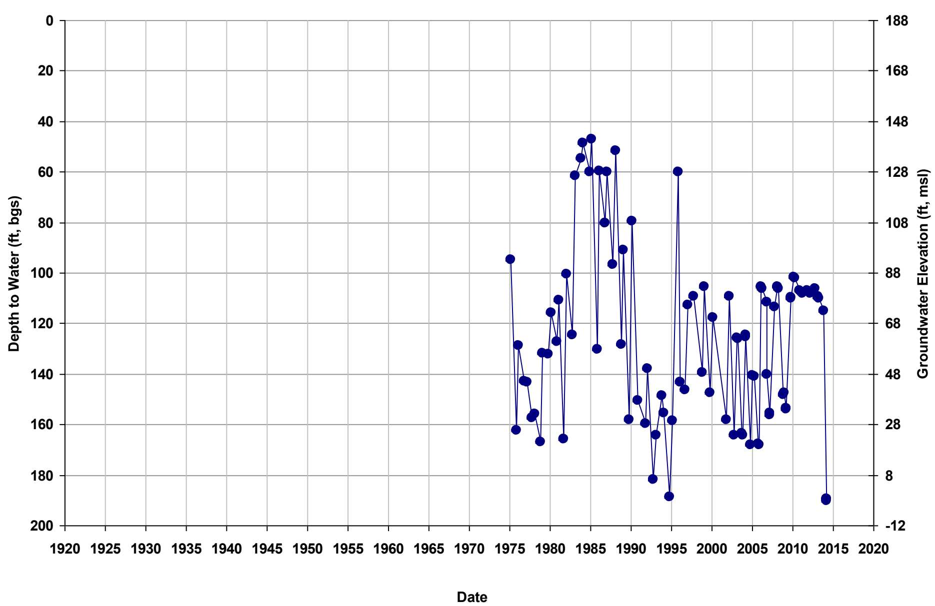
Well ID: 09S14E13J001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 187
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



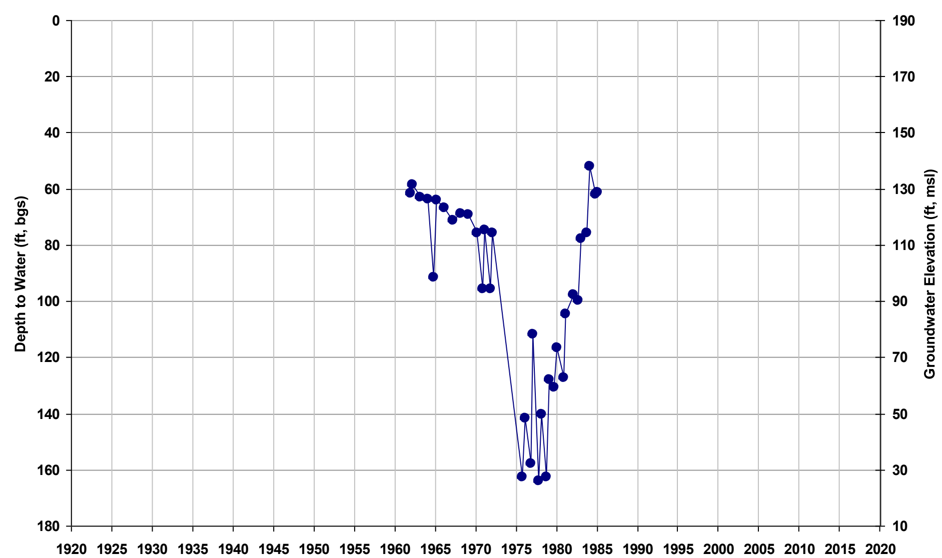
Well ID: 09S14E13K001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 188
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



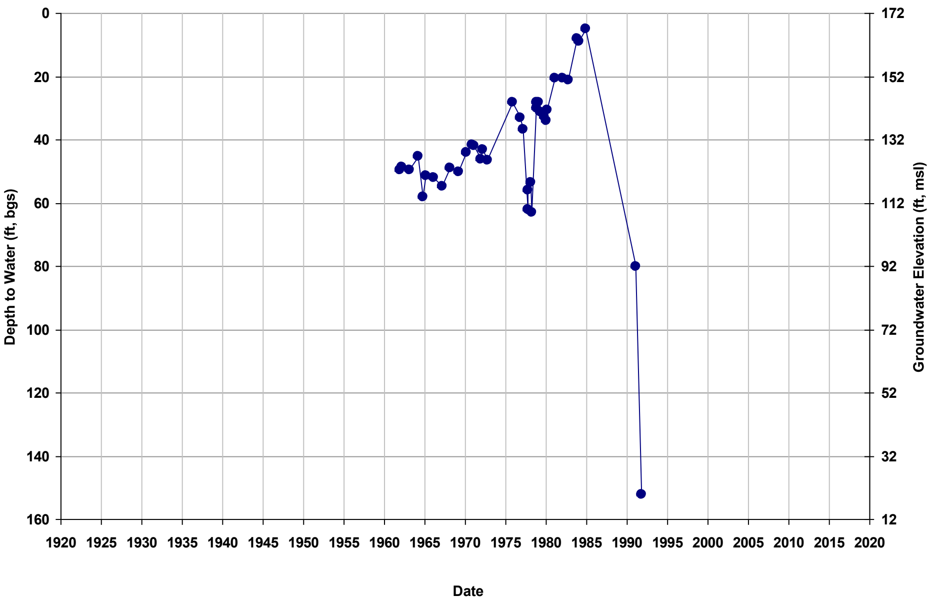
Well ID: 09S14E13R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 190
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



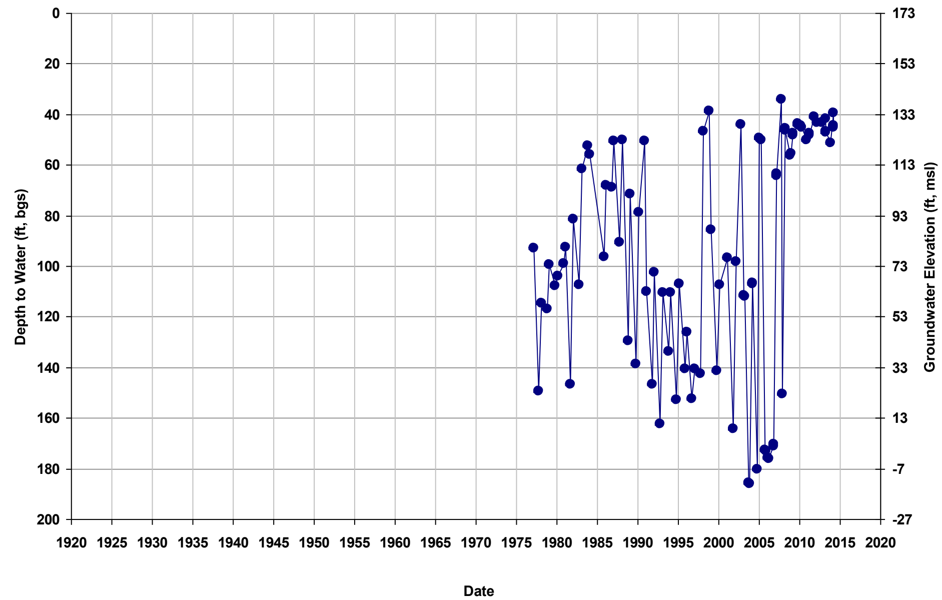
Well ID: 09S14E14E001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 172
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



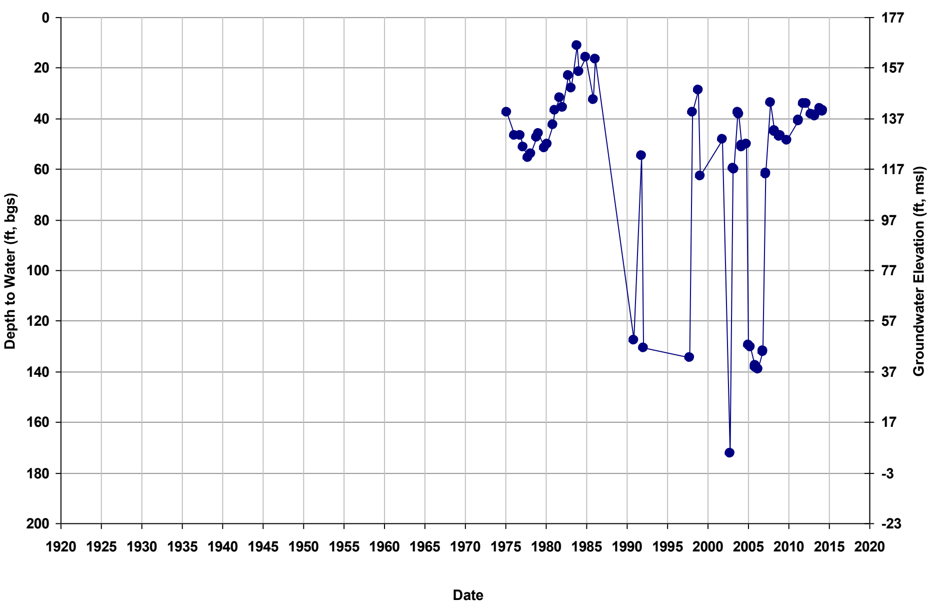
Well ID: 09S14E14K001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 173
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



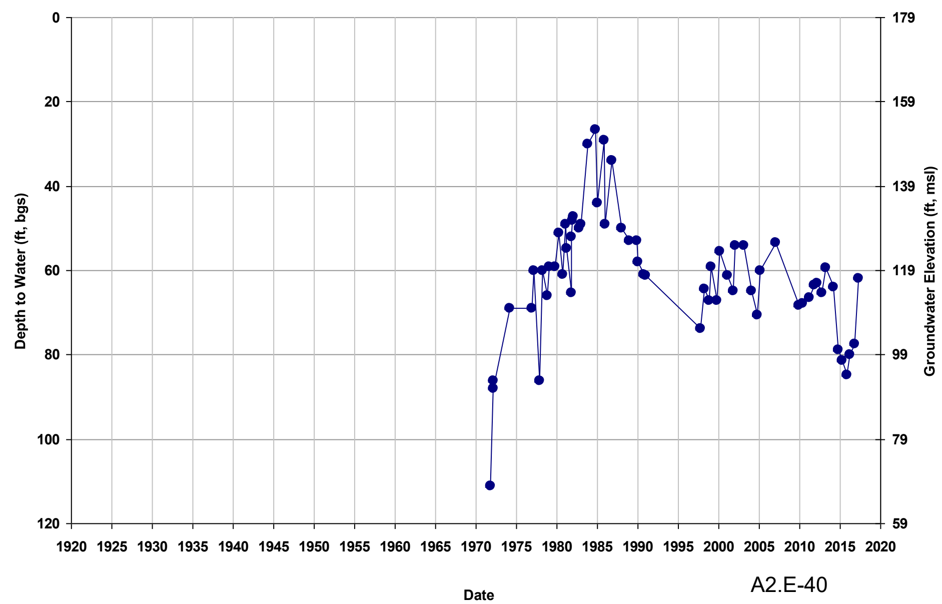
Well ID: 09S14E14L001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 177
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



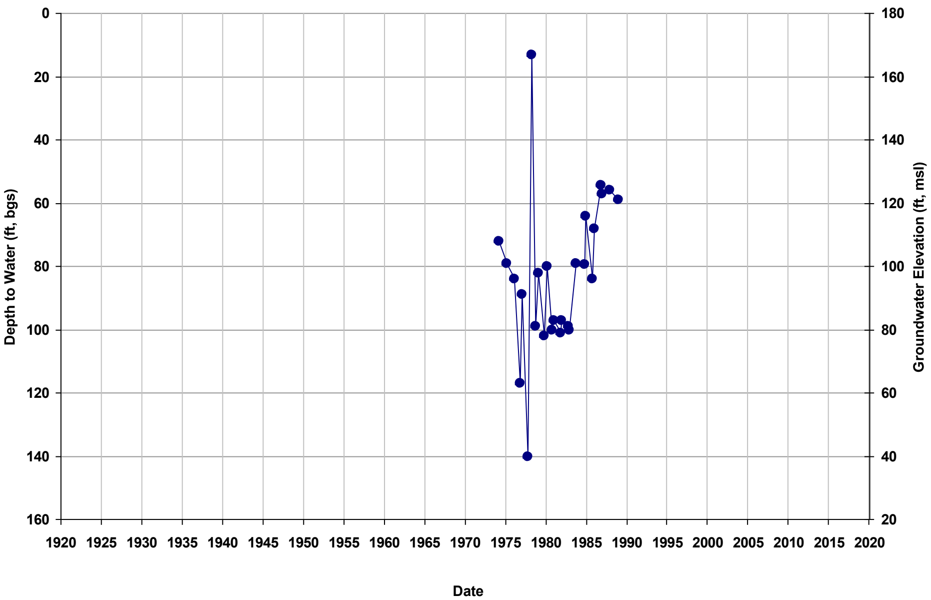
Well ID: 09S14E14R001M
Depth Zone: Composite or Lower; Wi
Subbasin: Chowchilla

GSE (ft, msl): 179
Total Depth (ft): 560
Perf Top (ft): NA
Perf Bottom (ft): NA



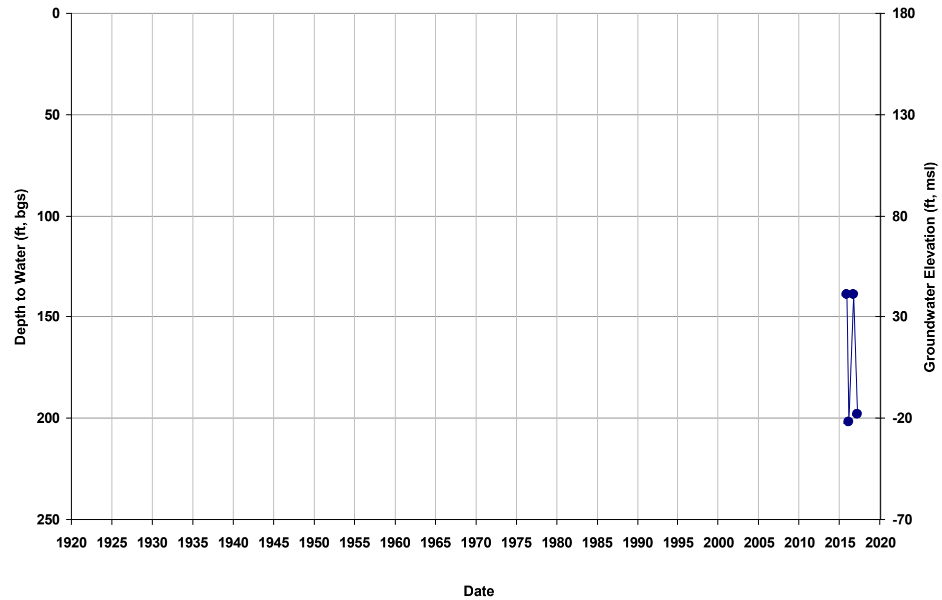
Well ID: 09S14E23A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 180
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



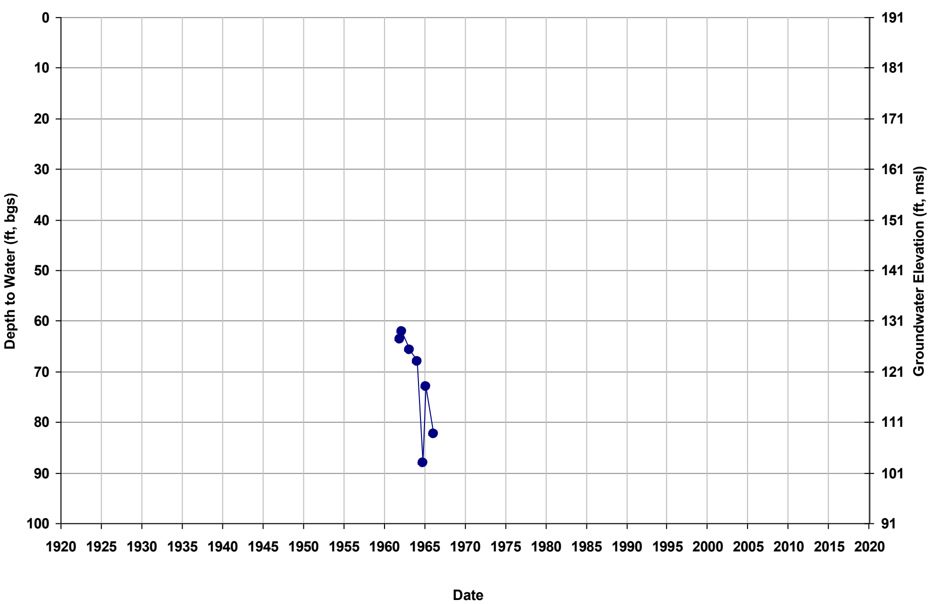
Well ID: 09S14E24H
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 180
Total Depth (ft): 900
Perf Top (ft): 324
Perf Bottom (ft): 828



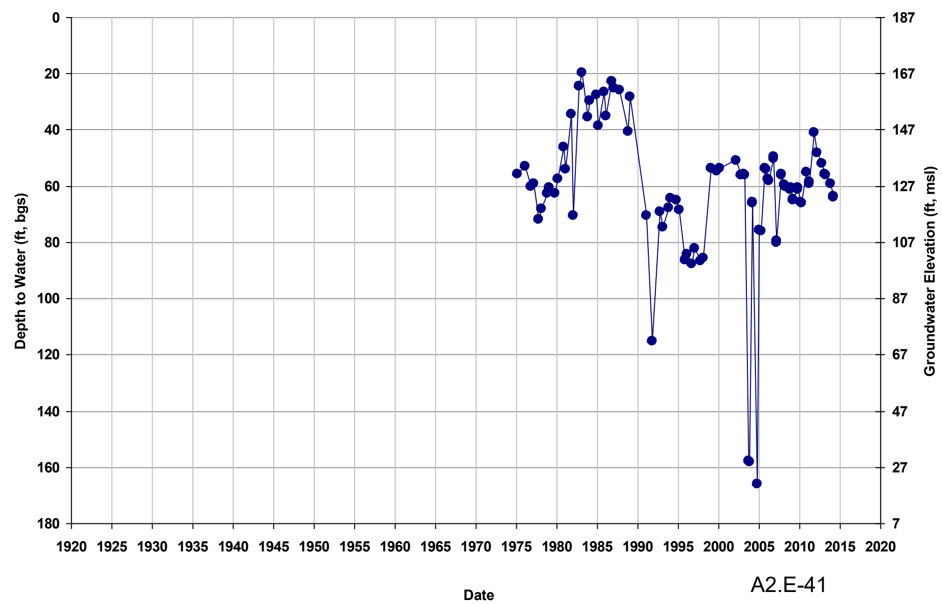
Well ID: 09S14E24R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 191
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



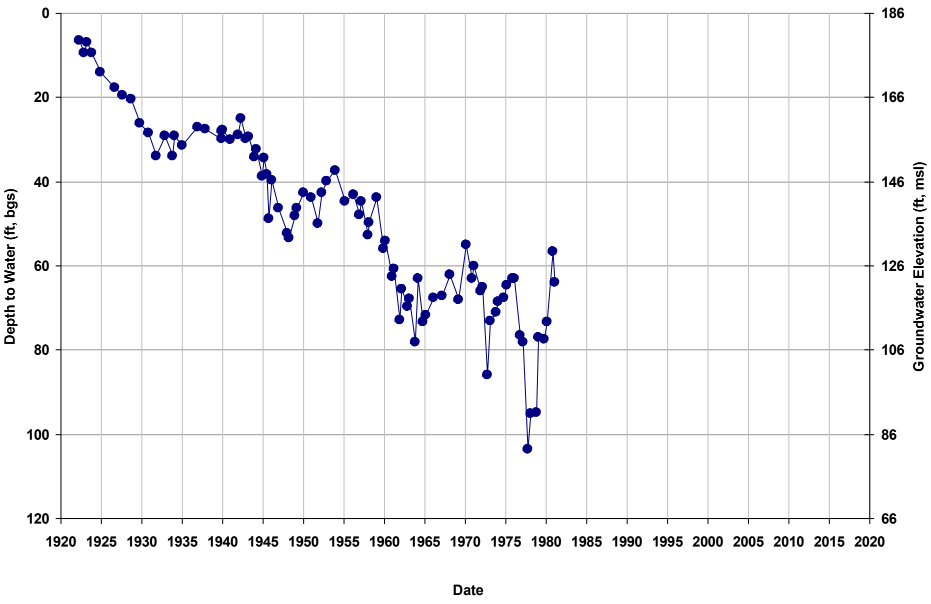
Well ID: 09S14E25A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 187
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



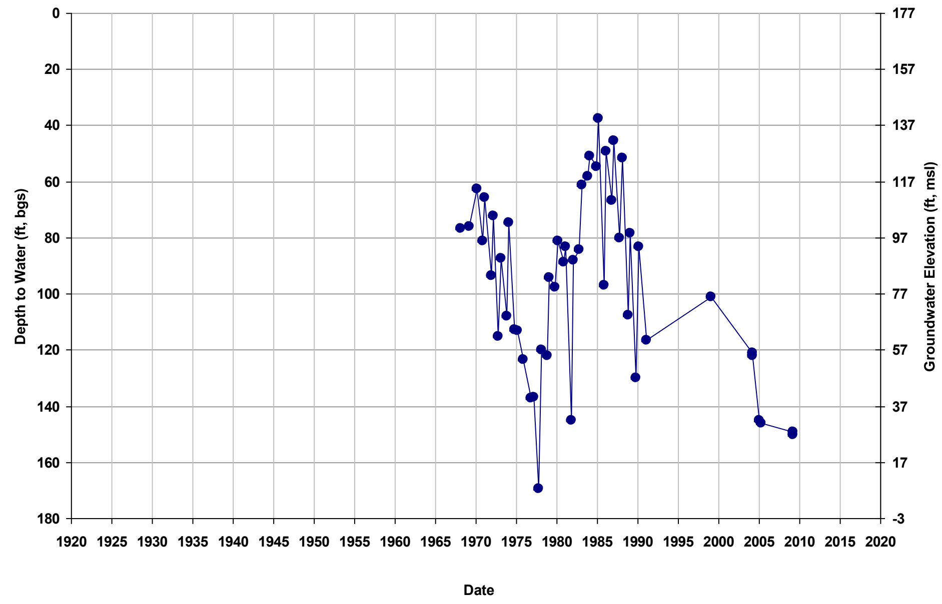
Well ID: 09S14E25R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 186
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



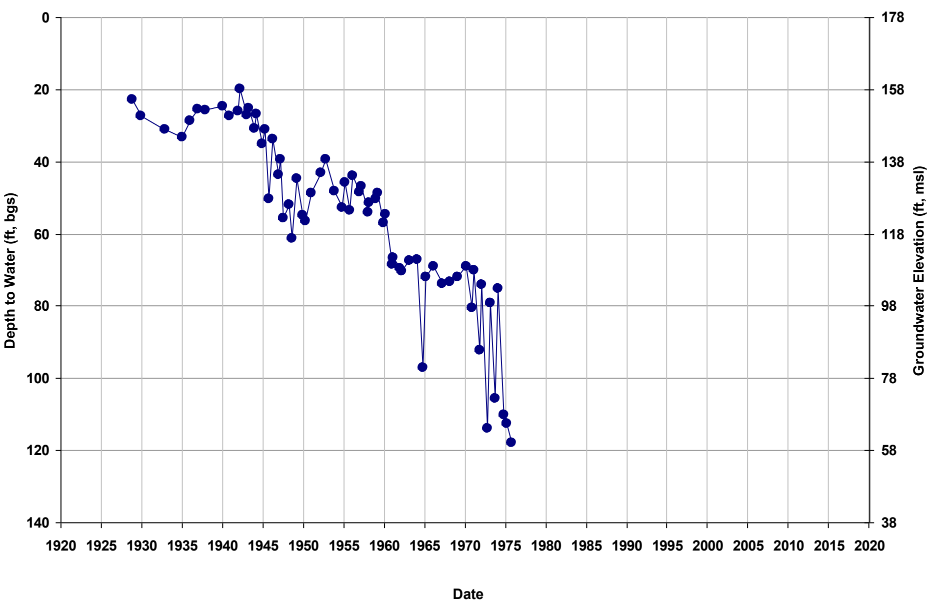
Well ID: 09S14E26J001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 177
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



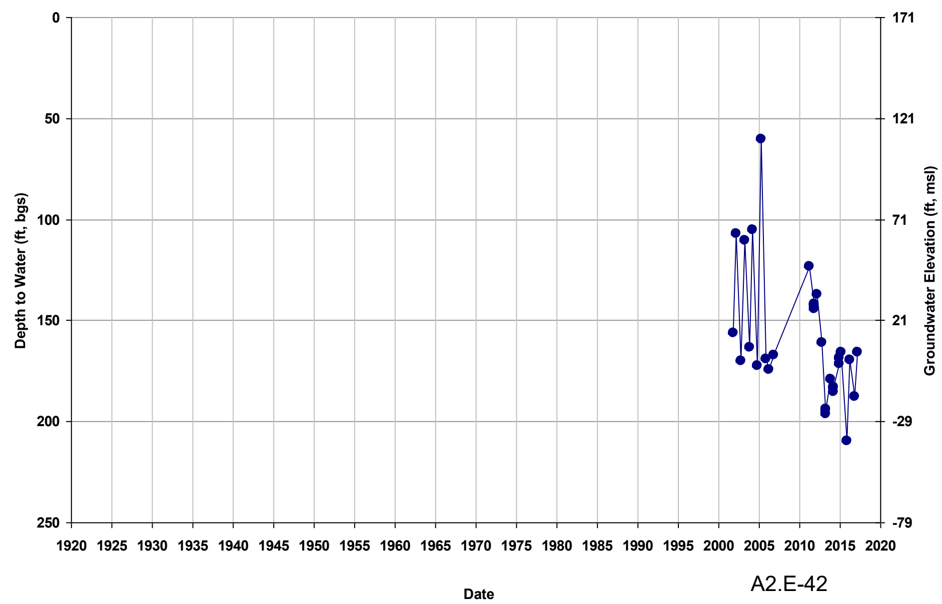
Well ID: 09S14E26R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 178
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



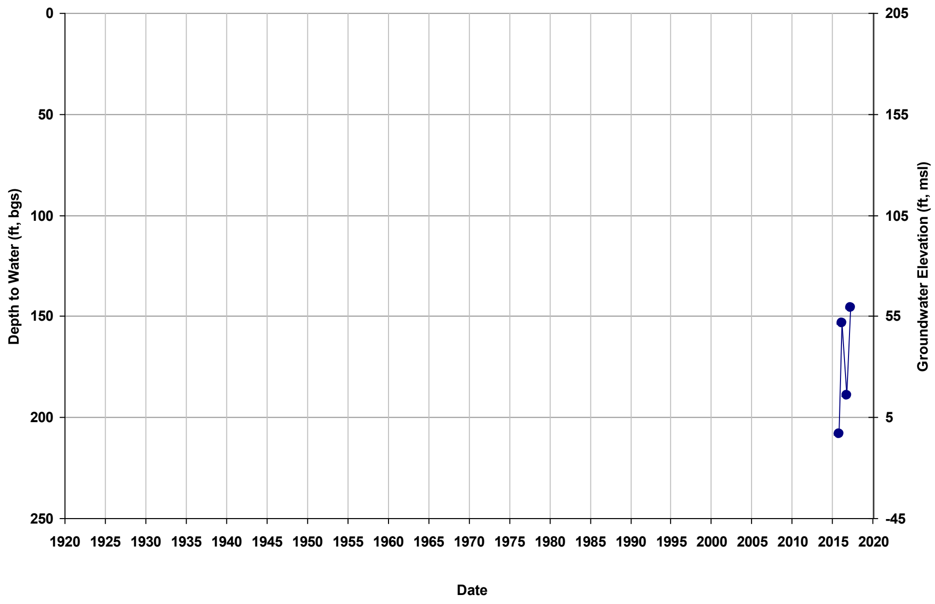
Well ID: 09S14E27R001M
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 171
Total Depth (ft): 275
Perf Top (ft): 160
Perf Bottom (ft): 275



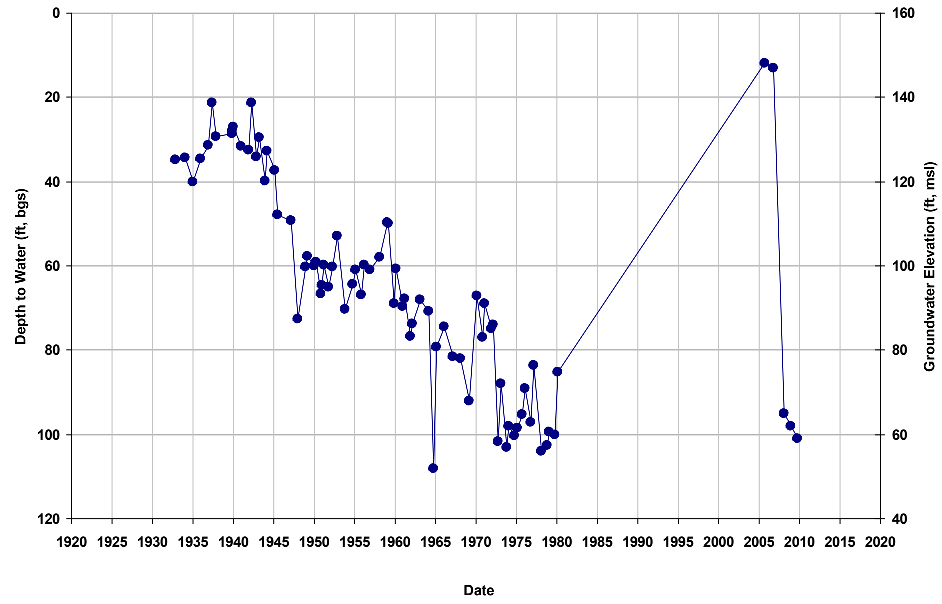
Well ID: 09S14E33L
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 205
Total Depth (ft): 290
Perf Top (ft): 265
Perf Bottom (ft): 285



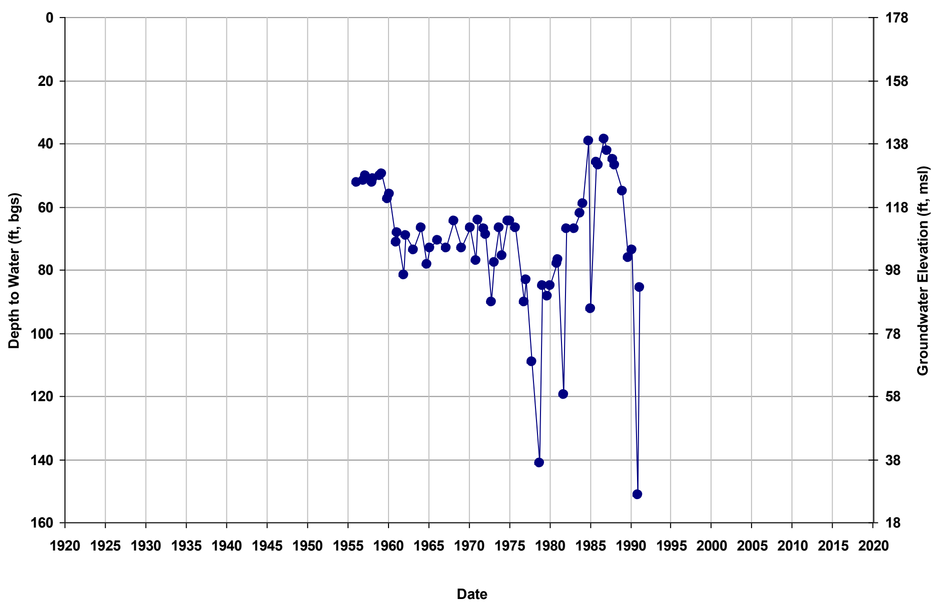
Well ID: 09S14E33R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 159
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



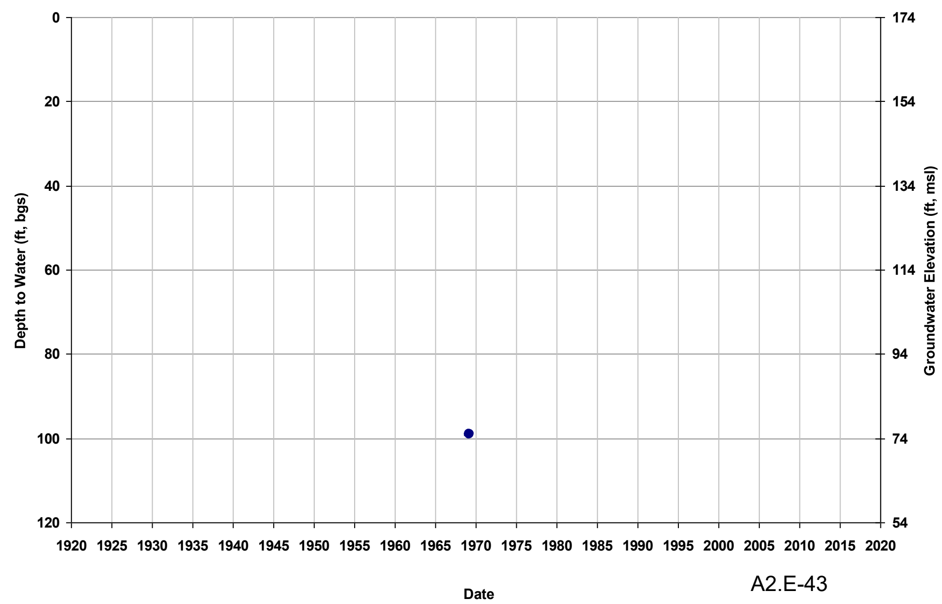
Well ID: 09S14E35J001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 177
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



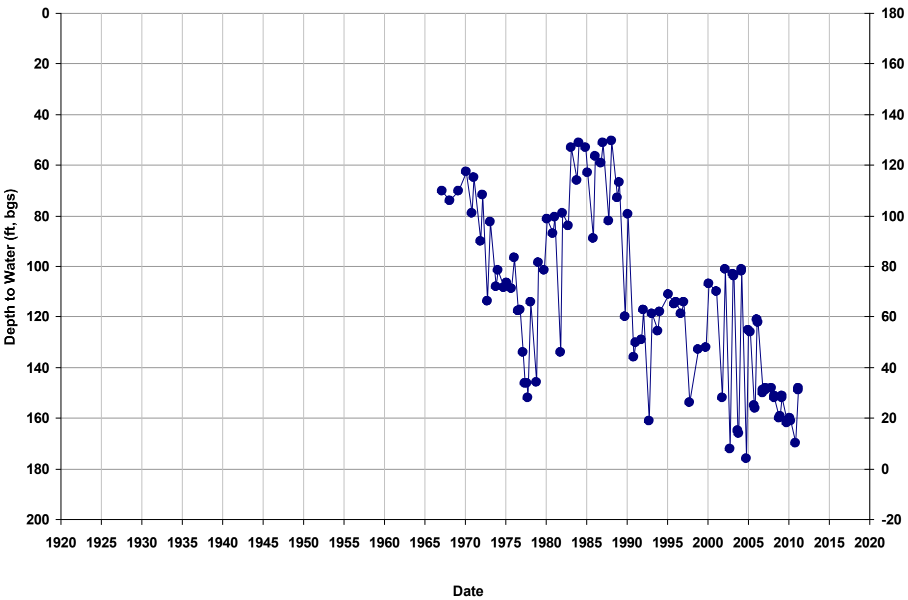
Well ID: 09S14E35L001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 174
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



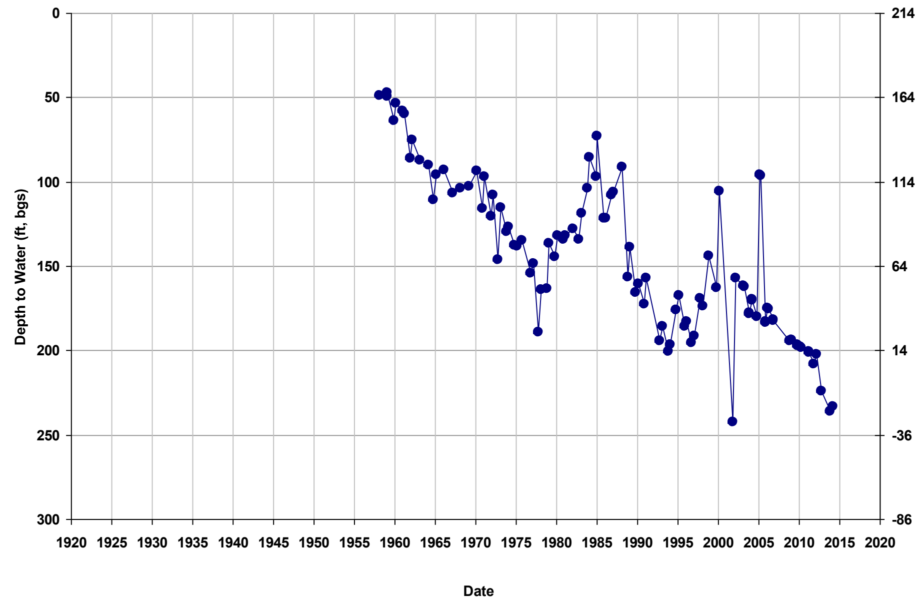
Well ID: 09S14E36C001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 180
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



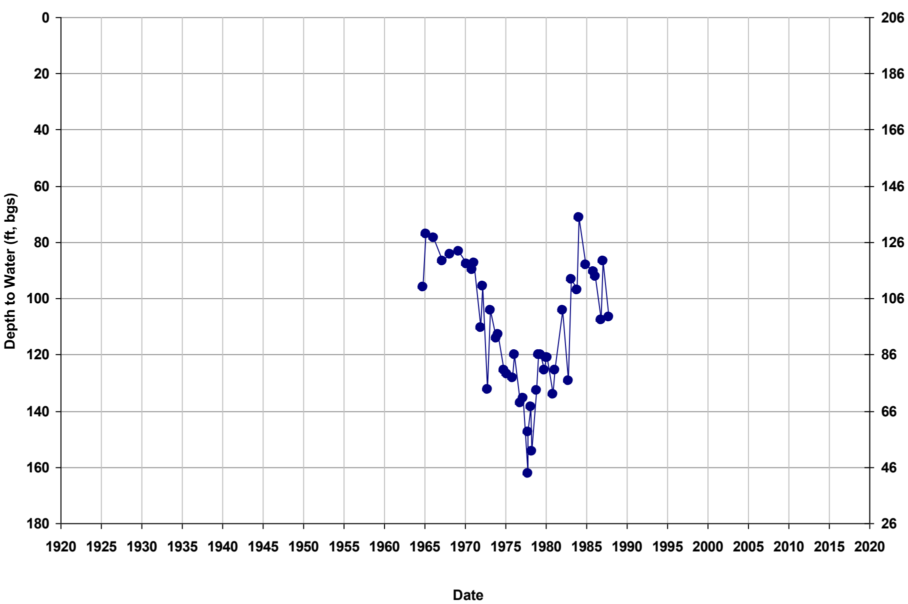
Well ID: 09S15E04R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 214
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



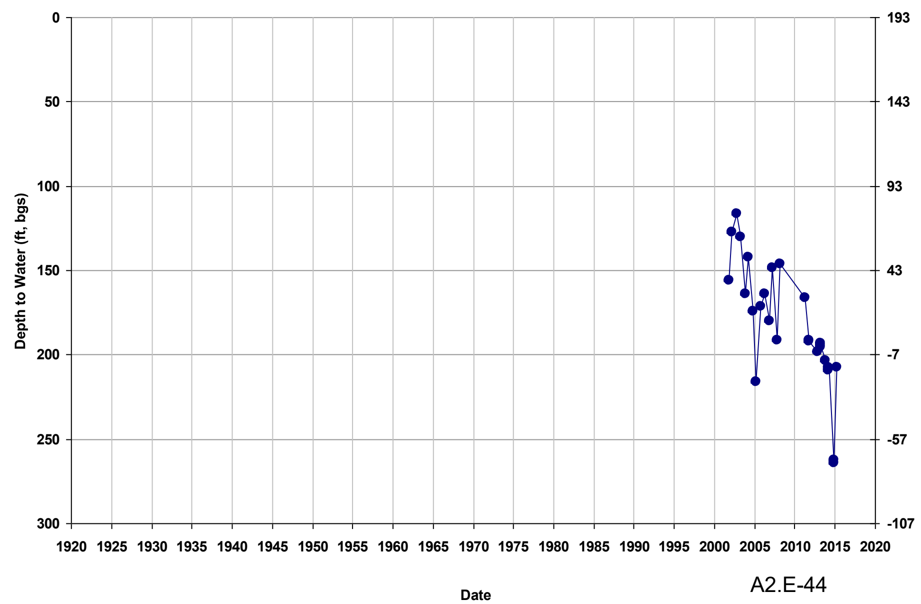
Well ID: 09S15E05A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

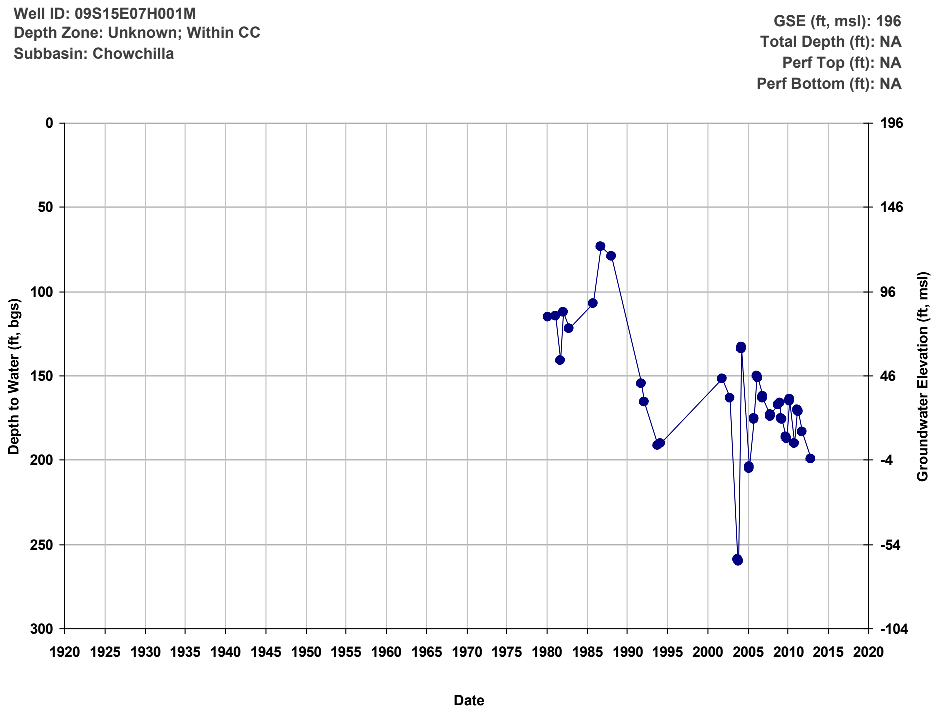
GSE (ft, msl): 206
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



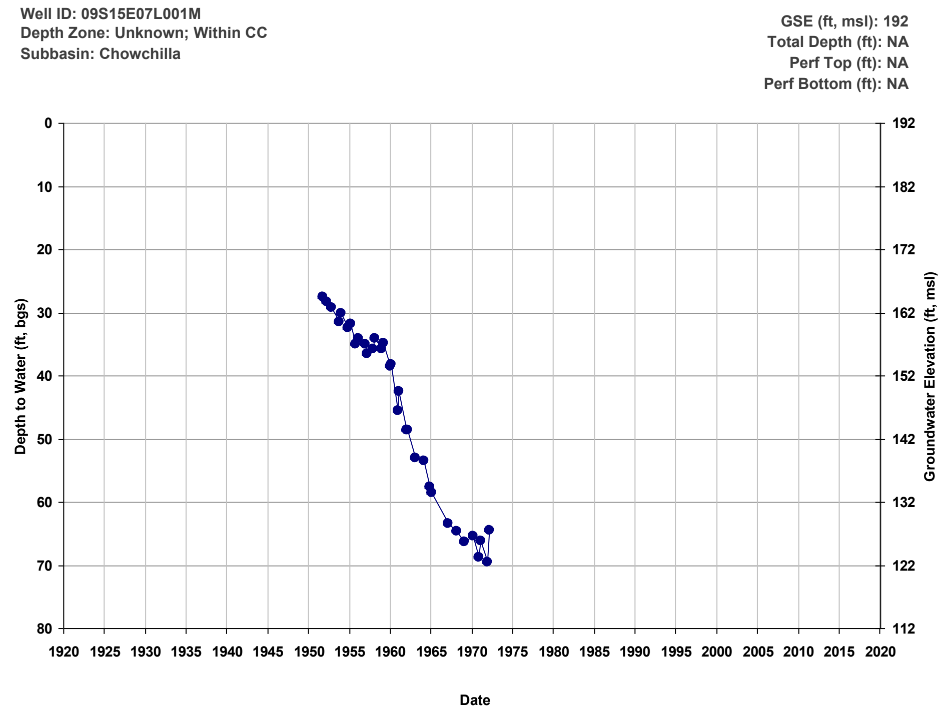
Well ID: 09S15E06P001M
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 193
Total Depth (ft): 780
Perf Top (ft): 230
Perf Bottom (ft): 775

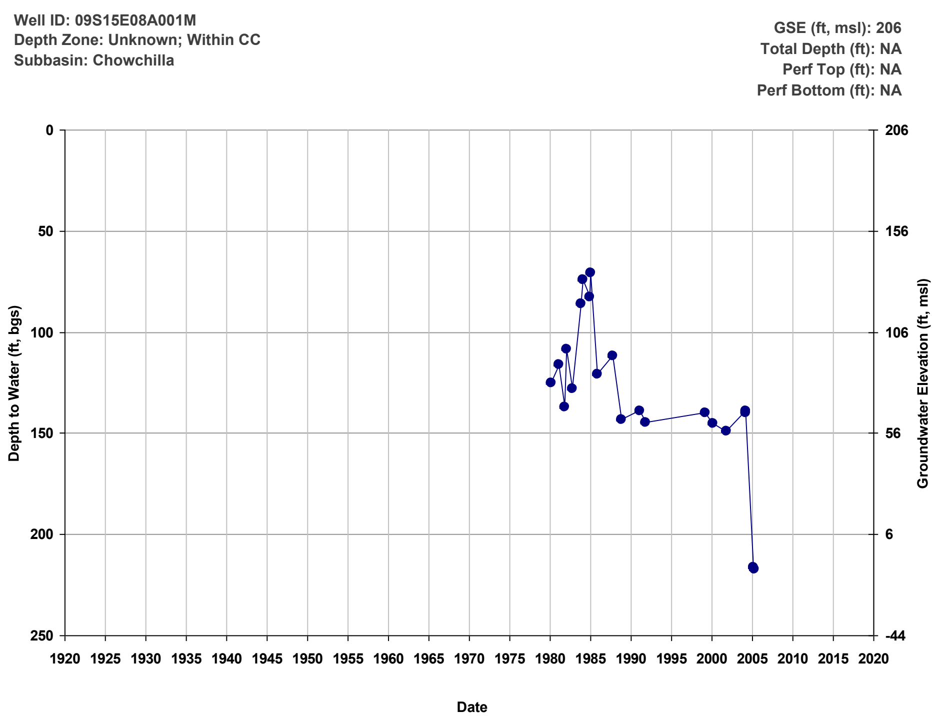




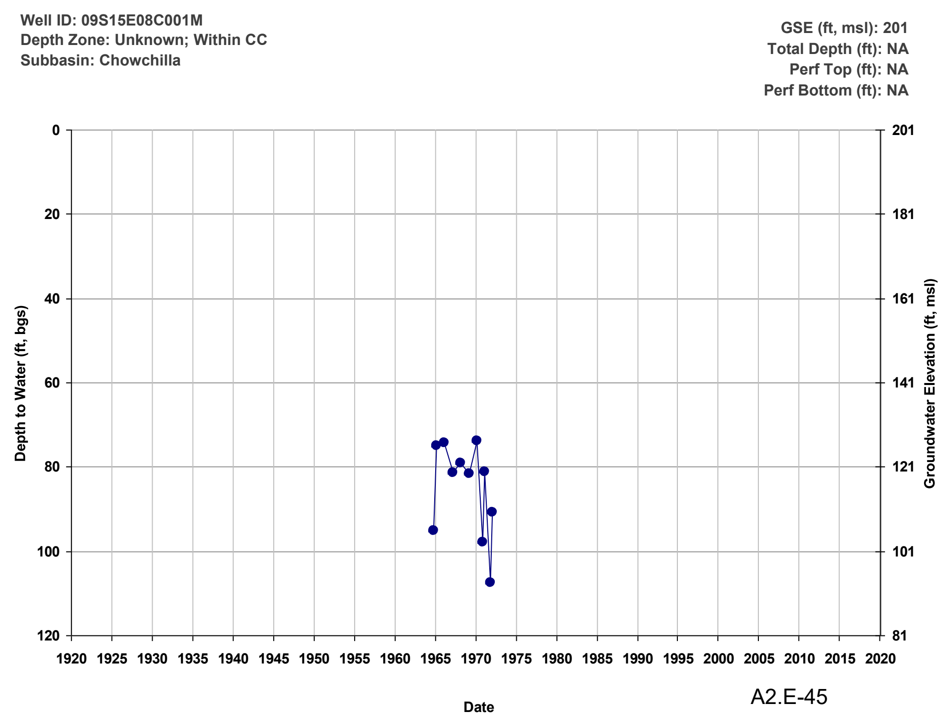
Well ID: 09S15E07H001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 196
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date



Well ID: 09S15E07L001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 192
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date



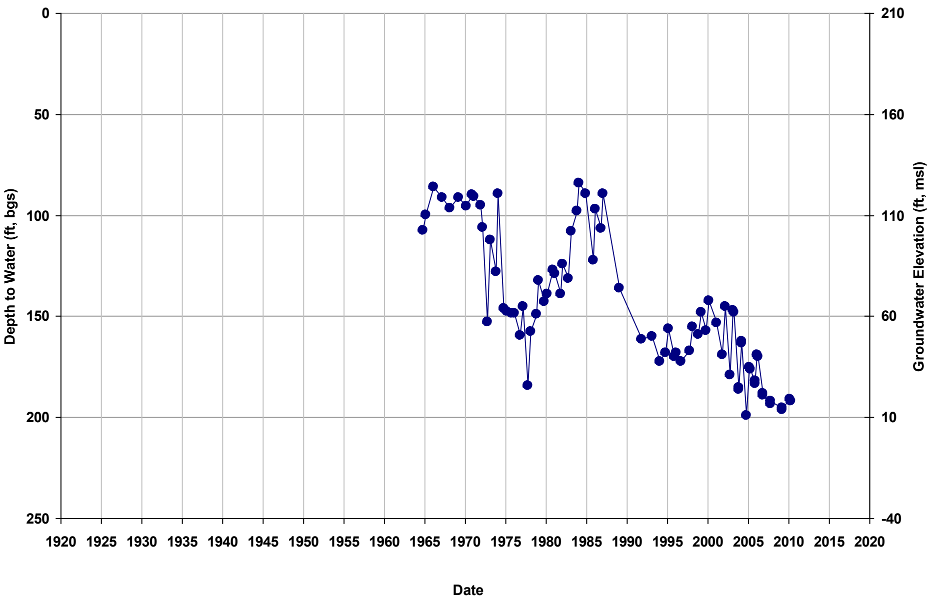
Well ID: 09S15E08A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 206
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date



Well ID: 09S15E08C001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 201
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

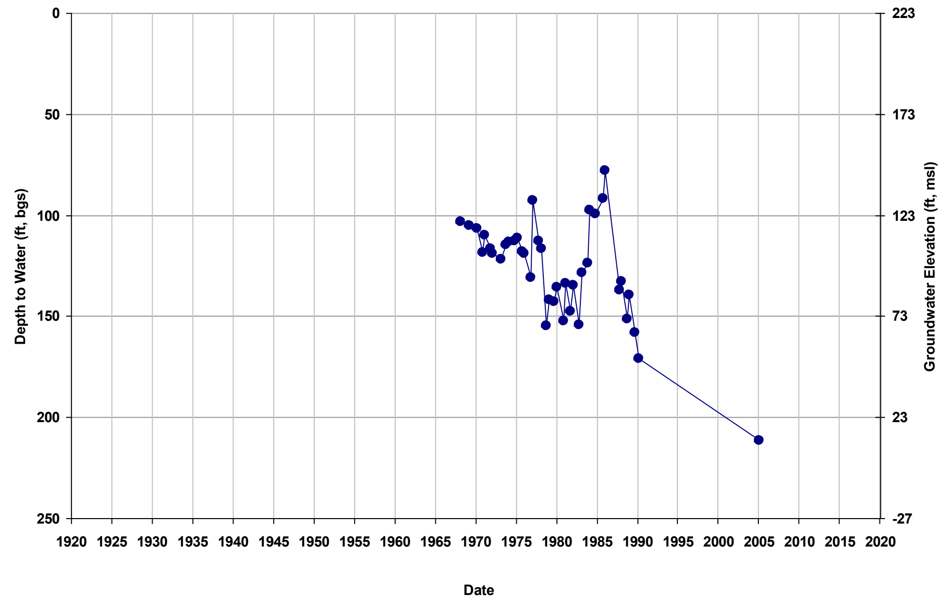
Well ID: 09S15E09P001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 210
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



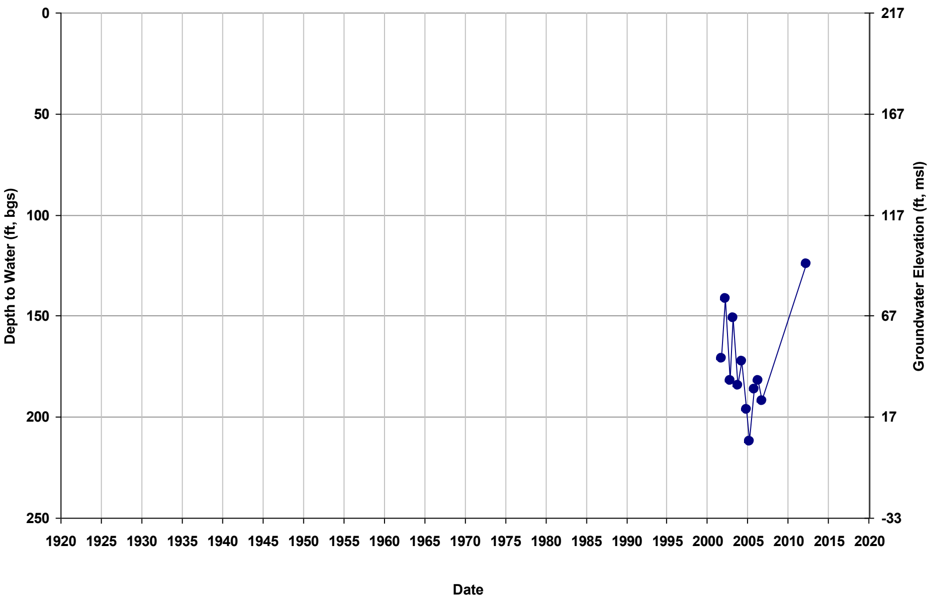
Well ID: 09S15E10A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 223
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



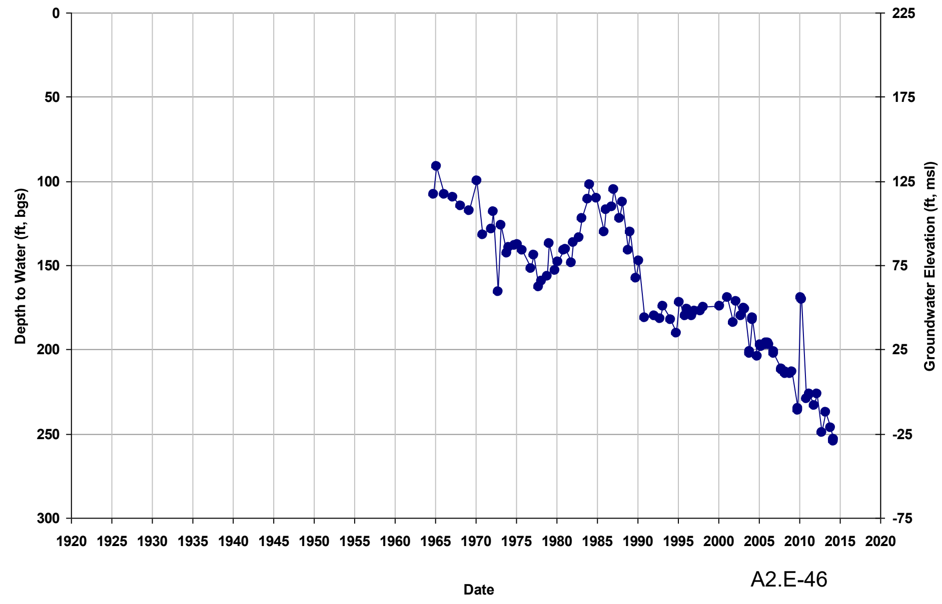
Well ID: 09S15E10P001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

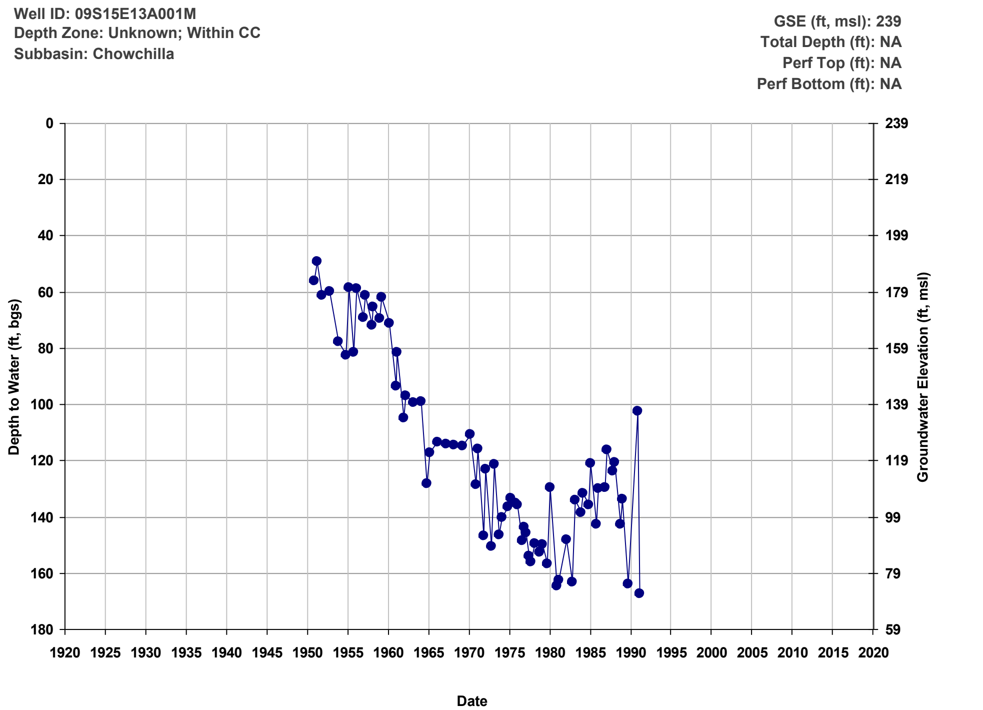
GSE (ft, msl): 217
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA

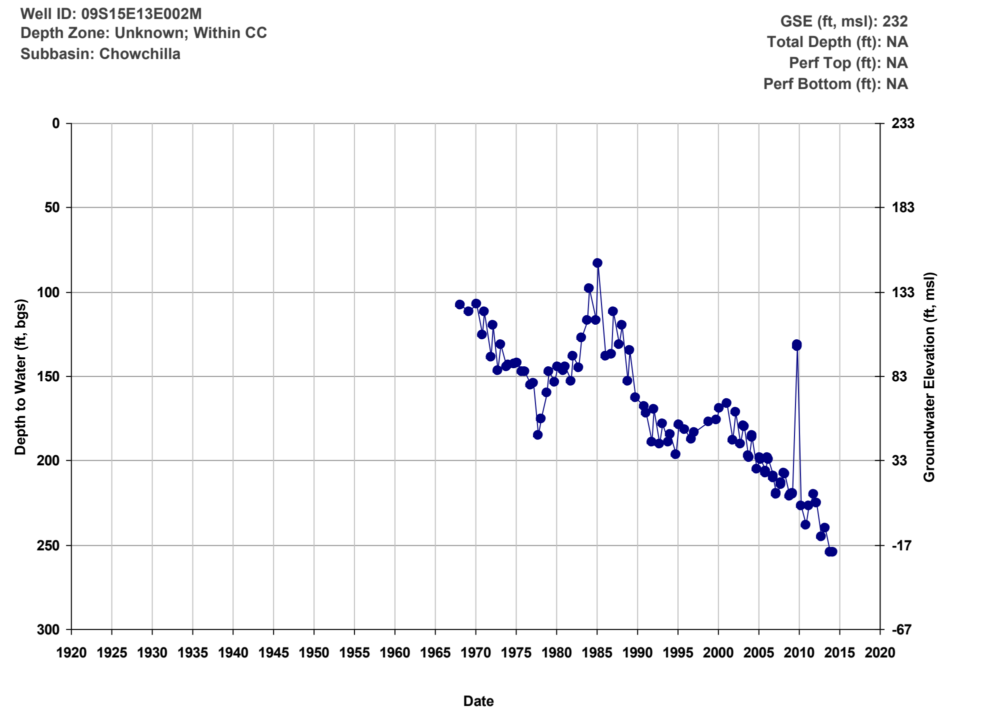


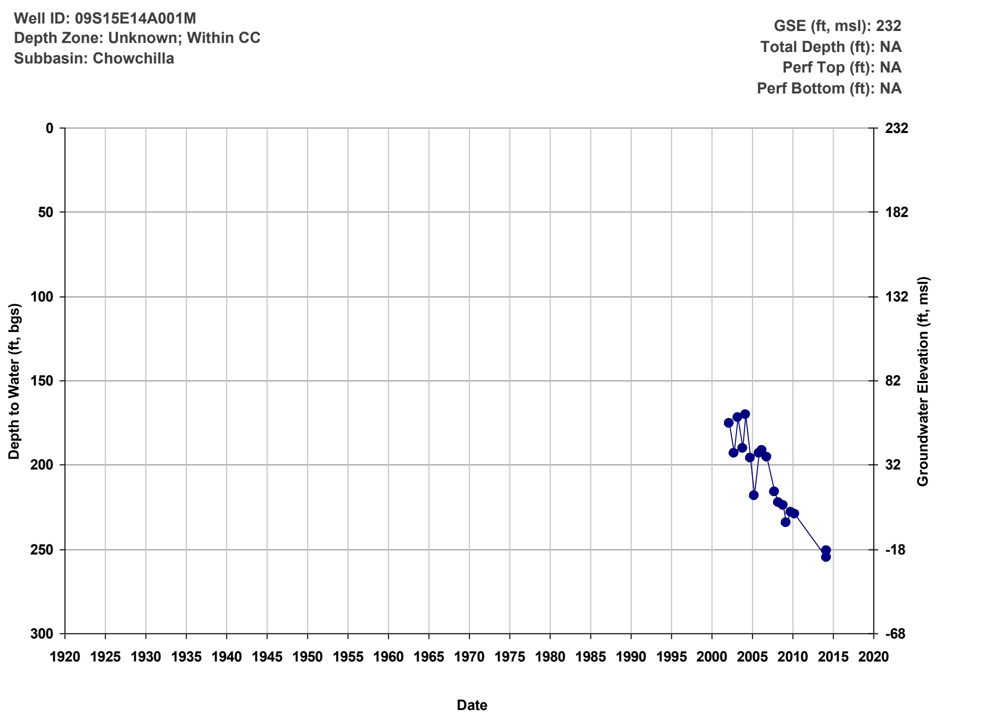
Well ID: 09S15E11F001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

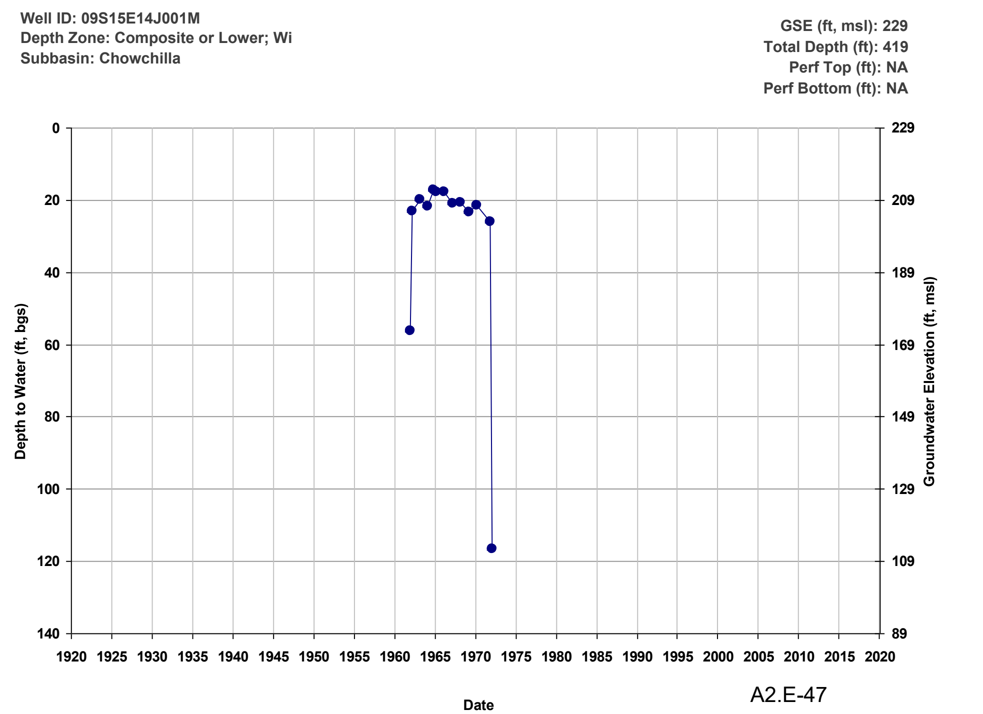
GSE (ft, msl): 225
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA




Well ID: 09S15E13A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 239
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

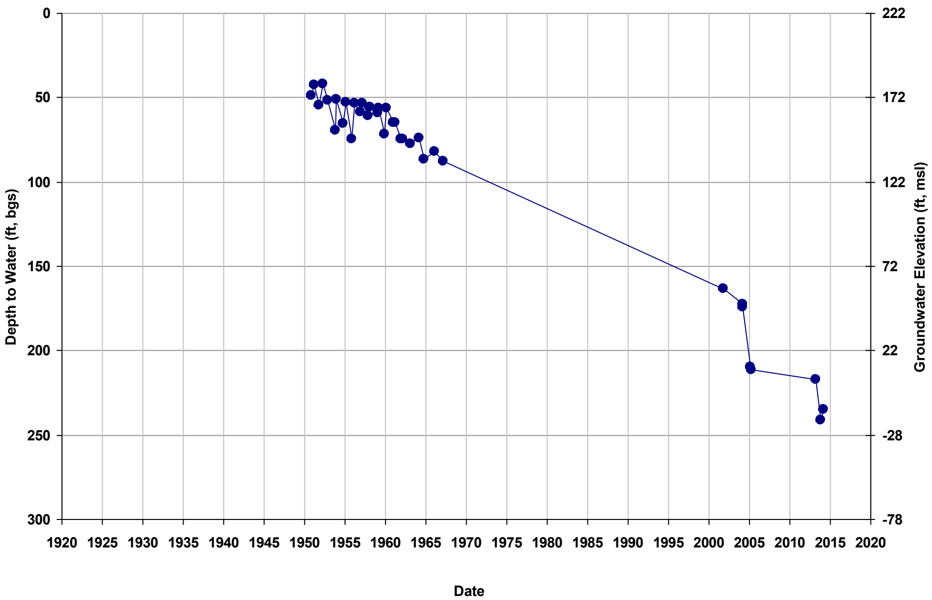

Well ID: 09S15E13E002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 232
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 09S15E14A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 232
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 09S15E14J001M
Depth Zone: Composite or Lower; Wi
Subbasin: Chowchilla
GSE (ft, msl): 229
Total Depth (ft): 419
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

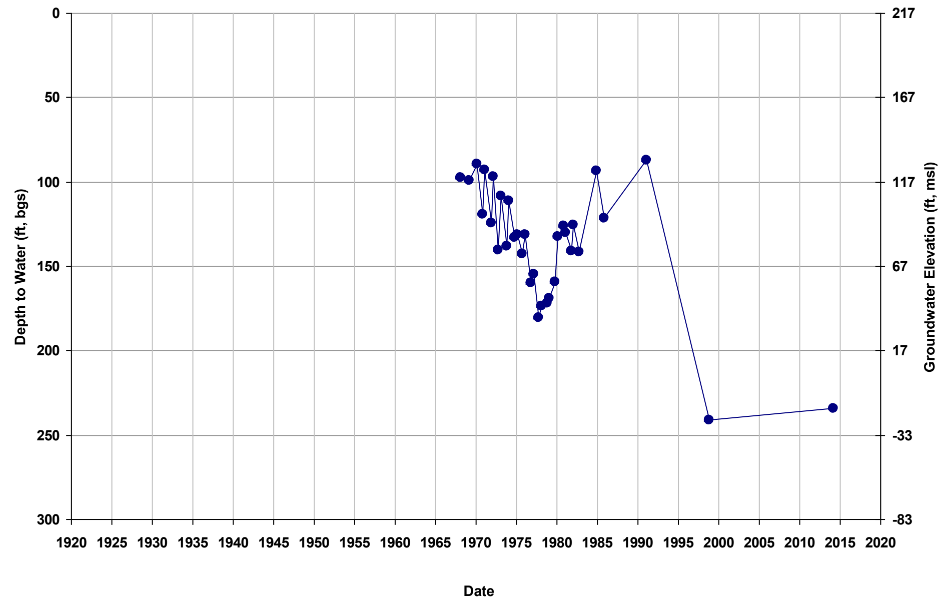
Well ID: 09S15E15P001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 222
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



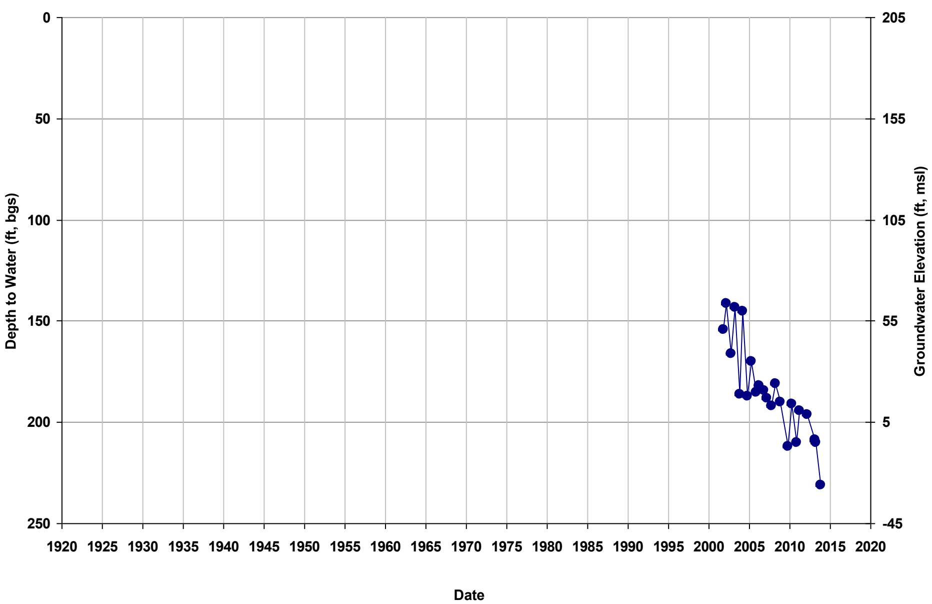
Well ID: 09S15E15P002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 217
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



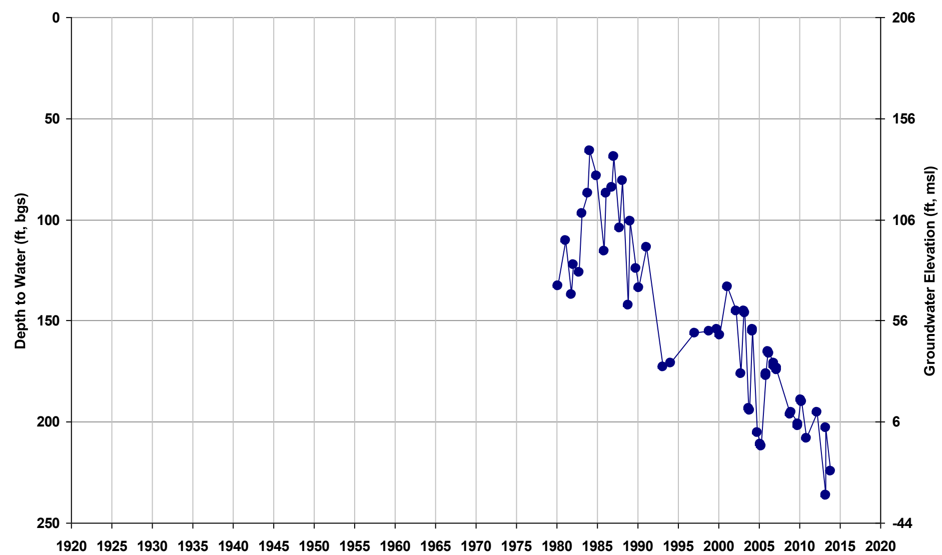
Well ID: 09S15E16E001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 205
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



Well ID: 09S15E17R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

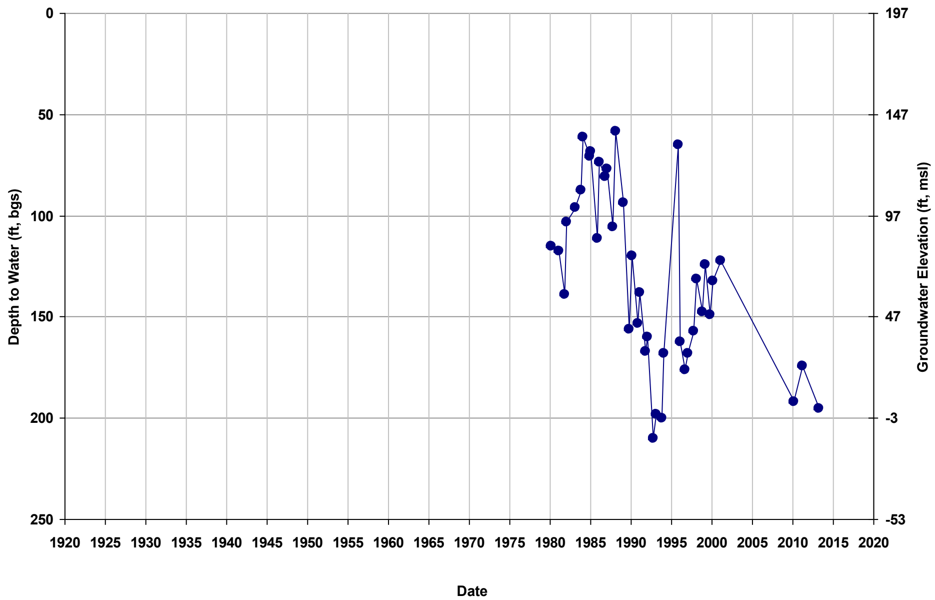
GSE (ft, msl): 206
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



Date

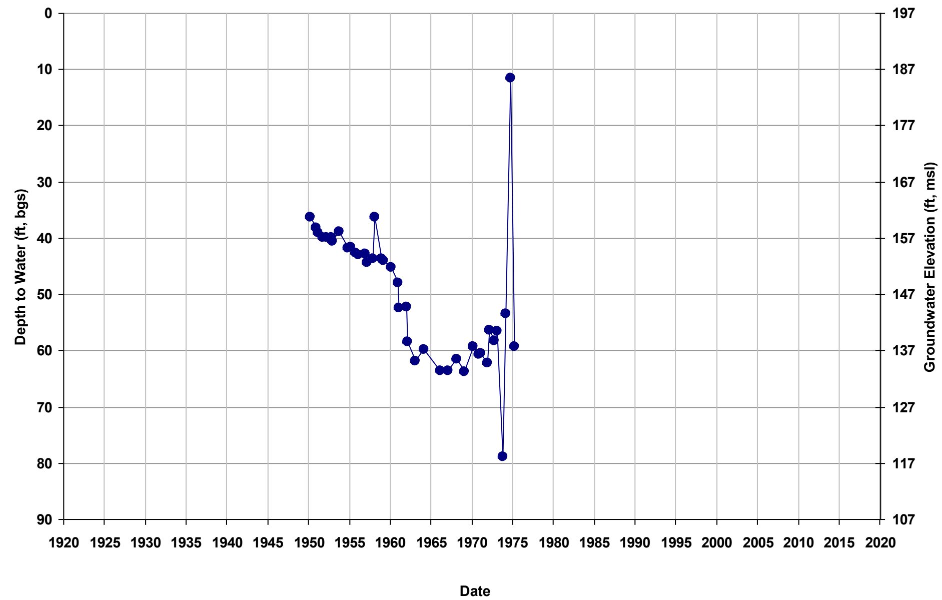
Well ID: 09S15E18J001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 197
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



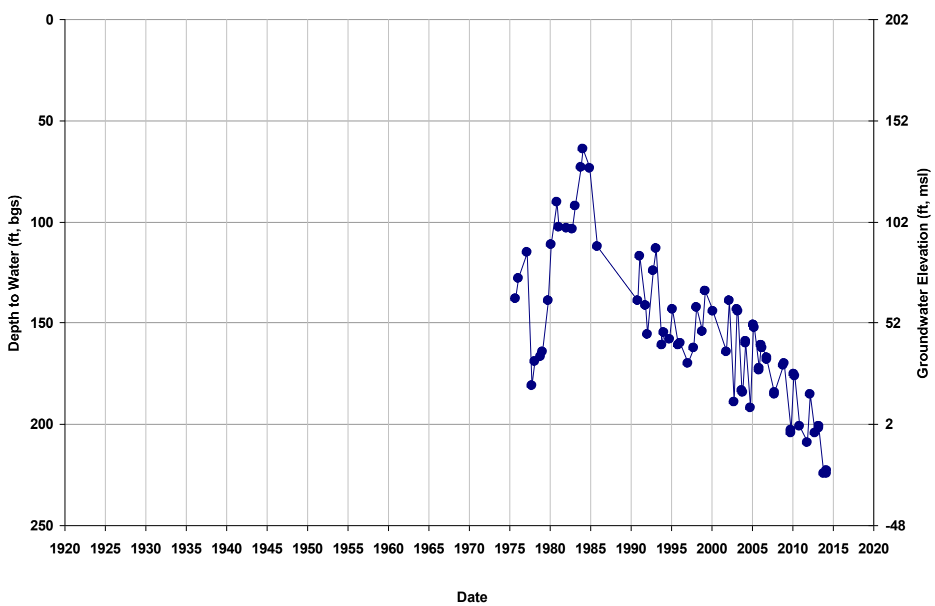
Well ID: 09S15E19A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 197
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



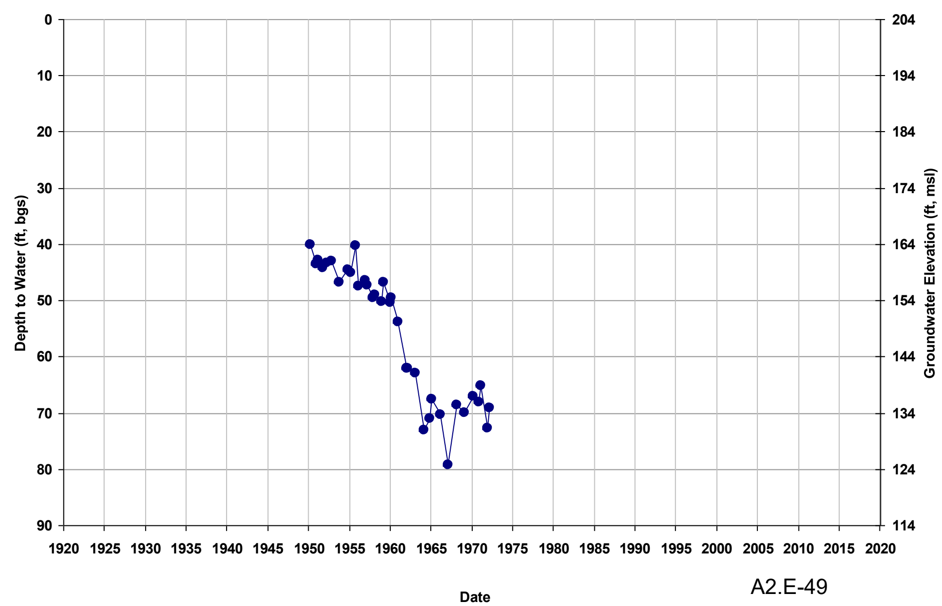
Well ID: 09S15E20C001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 202
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



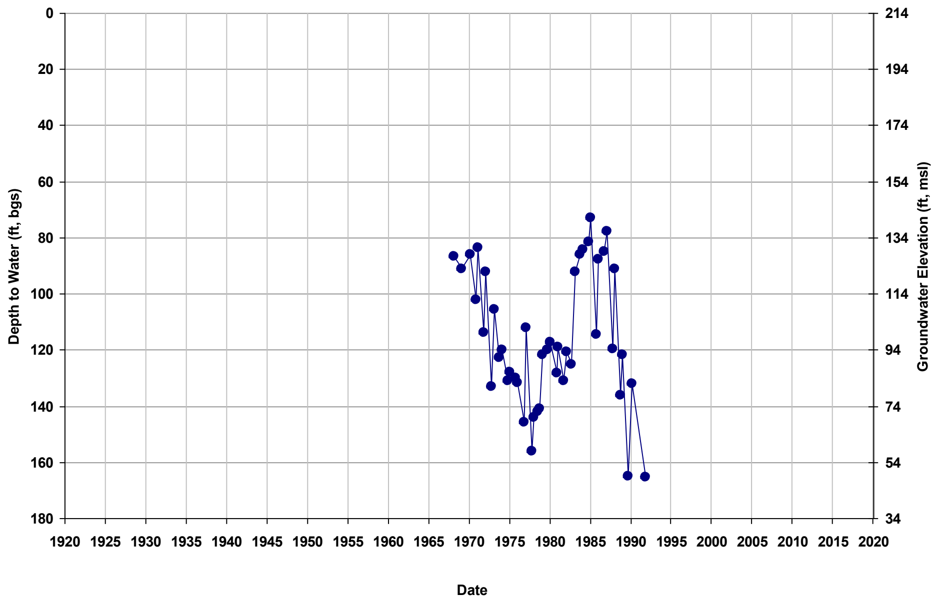
Well ID: 09S15E20G001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 204
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



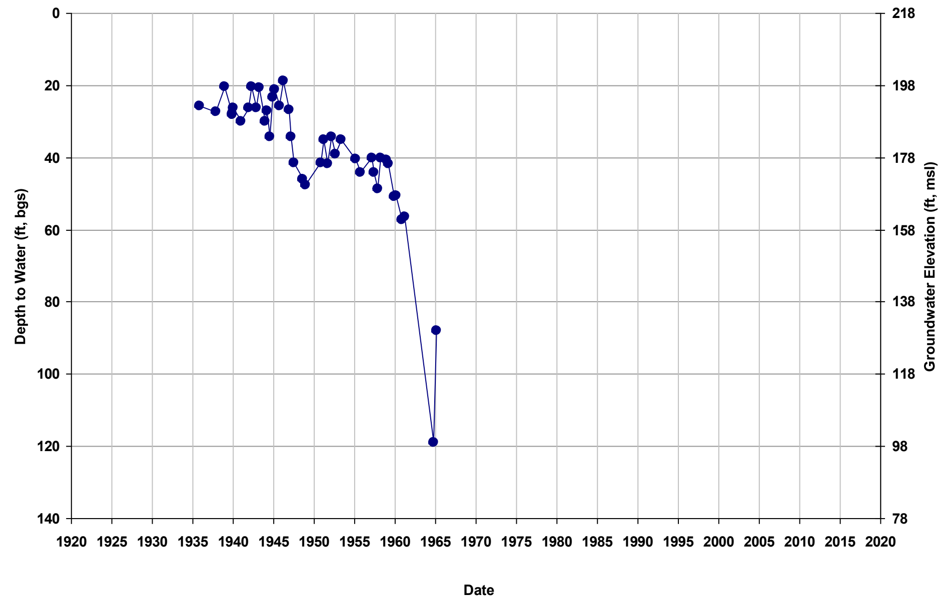
Well ID: 09S15E22N001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 214
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



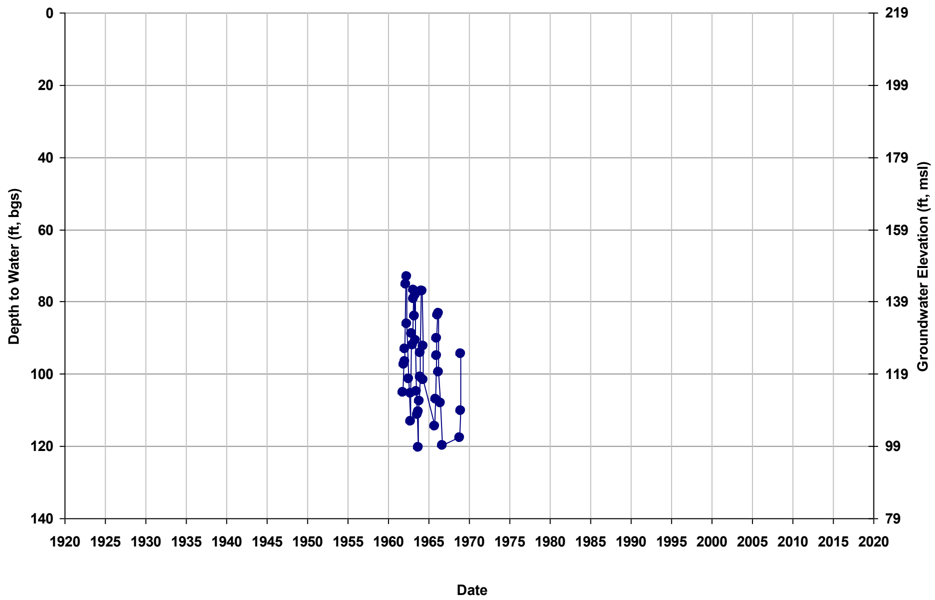
Well ID: 09S15E22R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 218
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



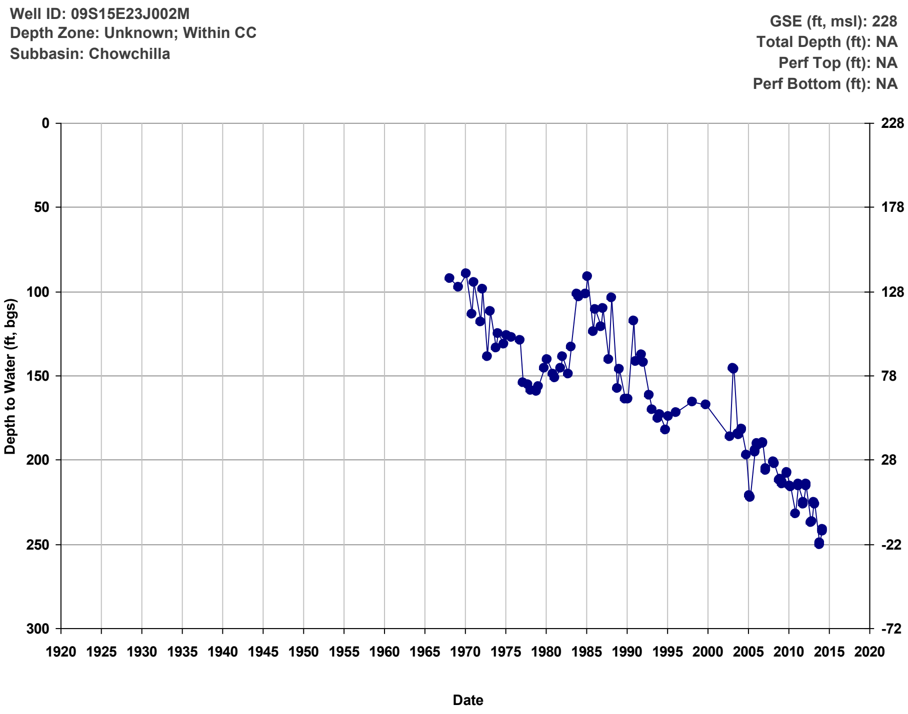
Well ID: 09S15E22R002M
Depth Zone: Composite or Lower; Wi
Subbasin: Chowchilla

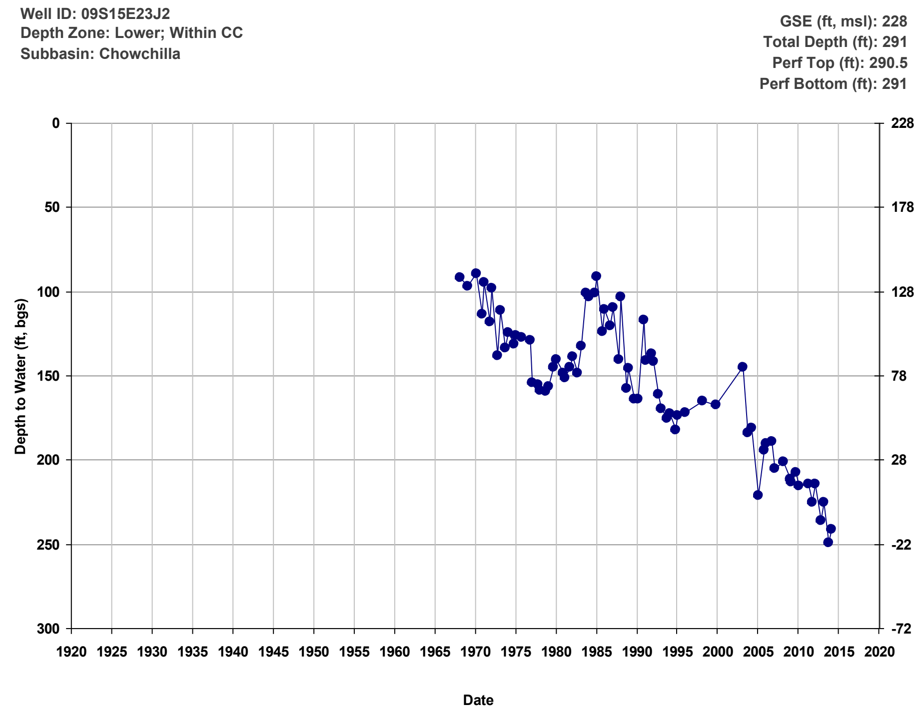
GSE (ft, msl): 218
Total Depth (ft): 190
Perf Top (ft): NA
Perf Bottom (ft): NA

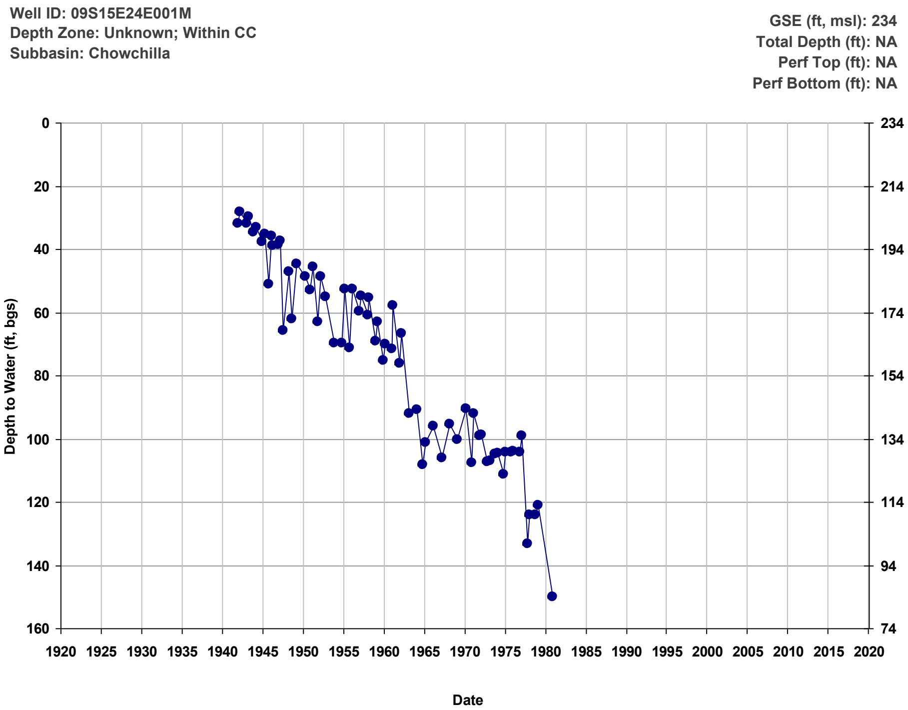


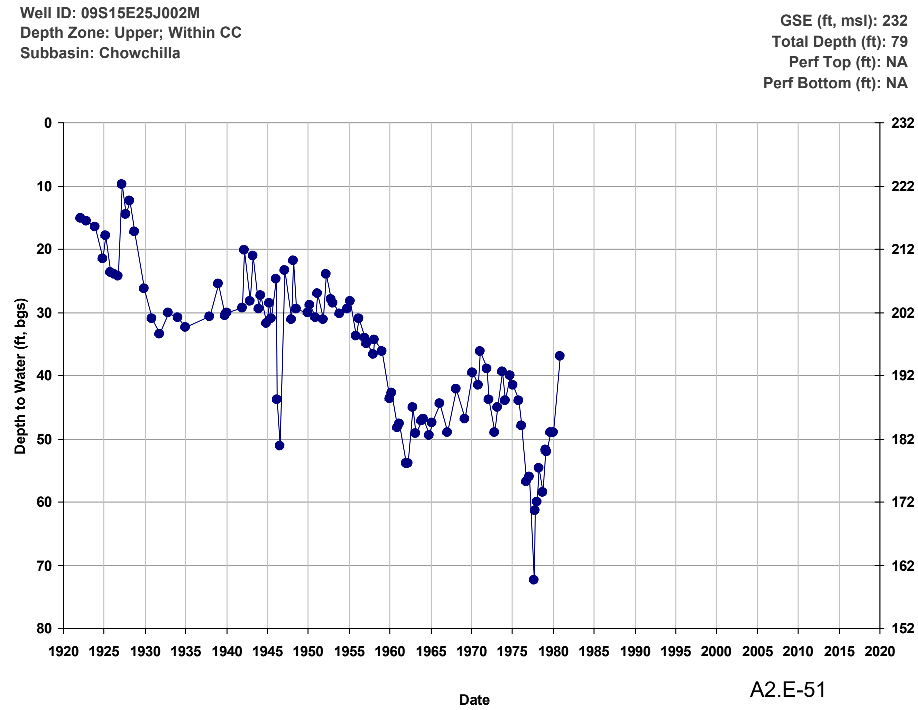
Well ID: 09S15E23J
Depth Zone: Composite or Lower; Wi
Subbasin: Chowchilla

GSE (ft, msl): 204
Total Depth (ft): 291
Perf Top (ft): NA
Perf Bottom (ft): NA


Well ID: 09S15E23J002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 228
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

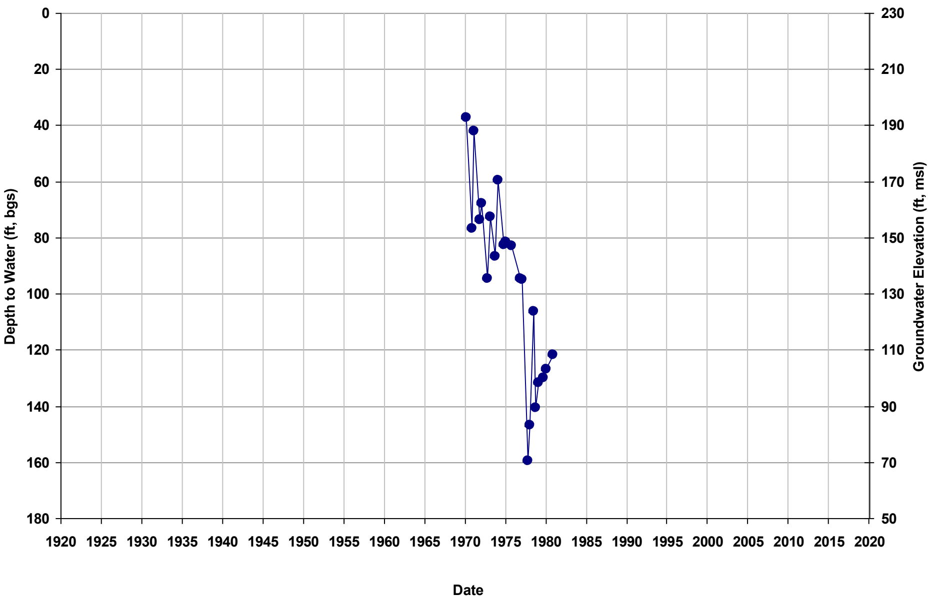

Well ID: 09S15E23J2
Depth Zone: Lower; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 228
Total Depth (ft): 291
Perf Top (ft): 290.5
Perf Bottom (ft): 291
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 09S15E24E001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 234
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 09S15E25J002M
Depth Zone: Upper; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 232
Total Depth (ft): 79
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

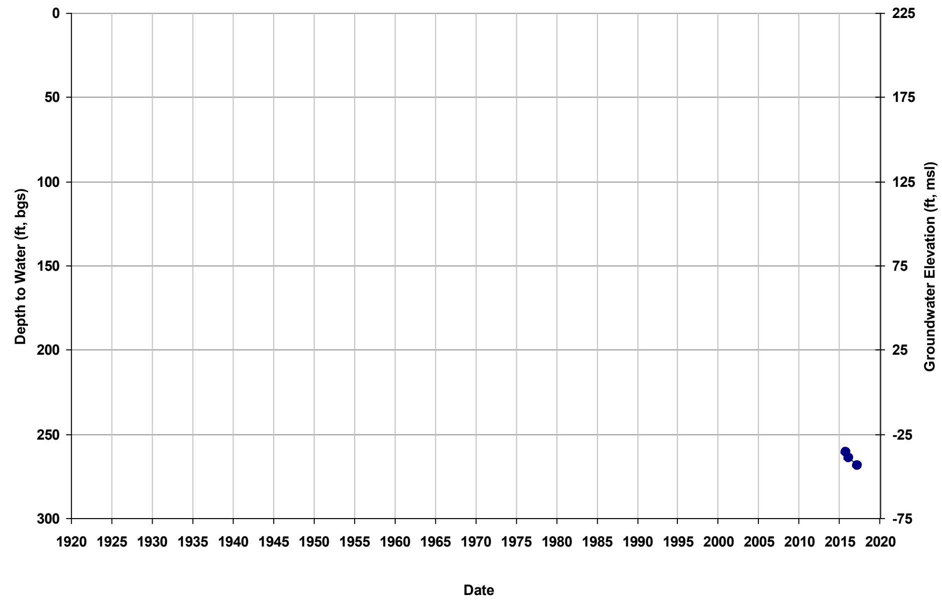
Well ID: 09S15E25L001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 229
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



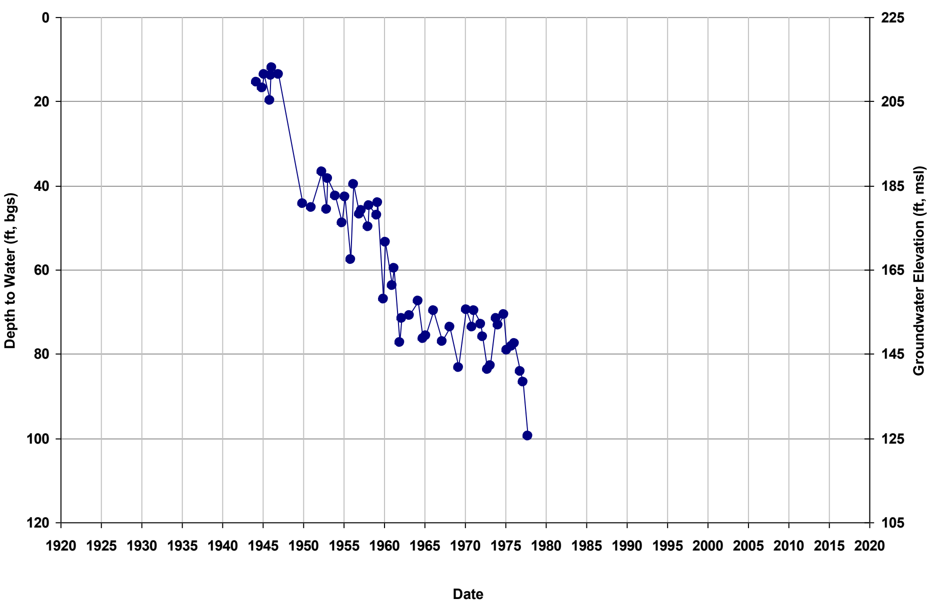
Well ID: 09S15E26A
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 225
Total Depth (ft): 800
Perf Top (ft): 320
Perf Bottom (ft): 800



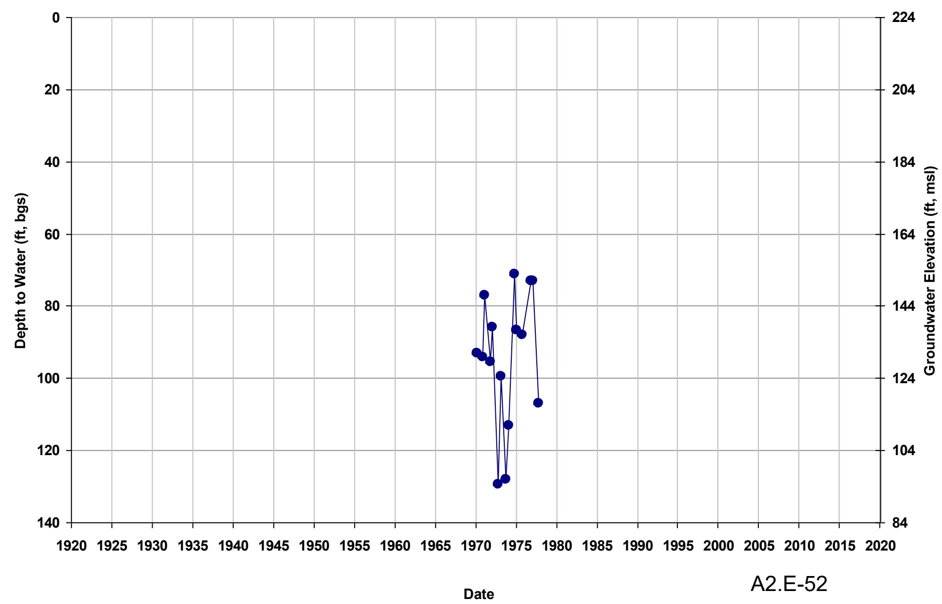
Well ID: 09S15E26J001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 225
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



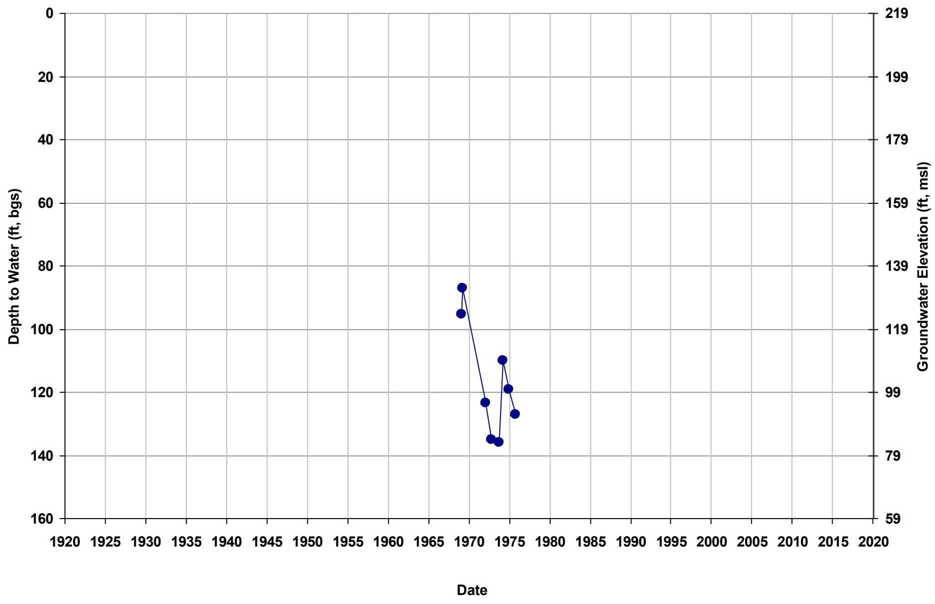
Well ID: 09S15E26K001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 224
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



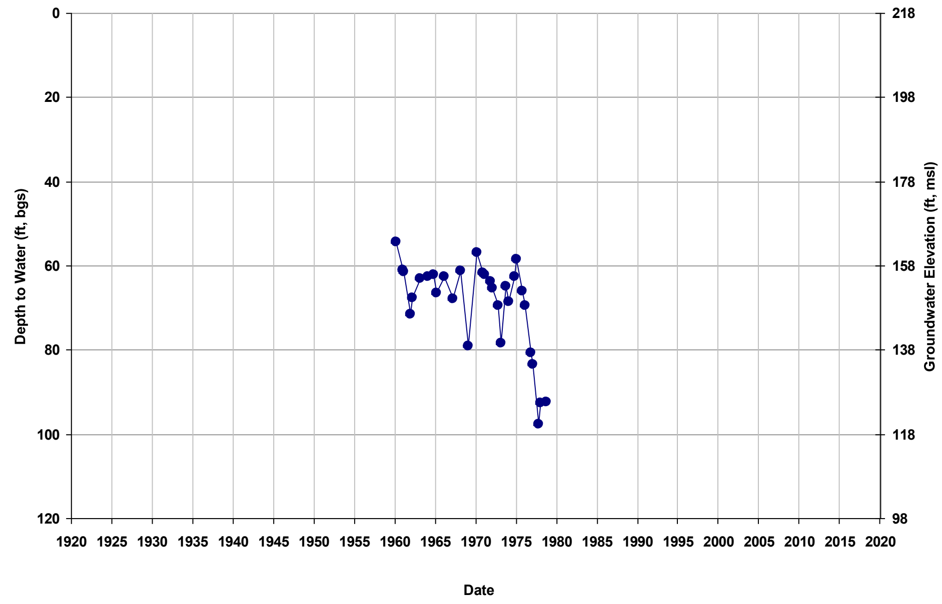
Well ID: 09S15E27A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 219
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



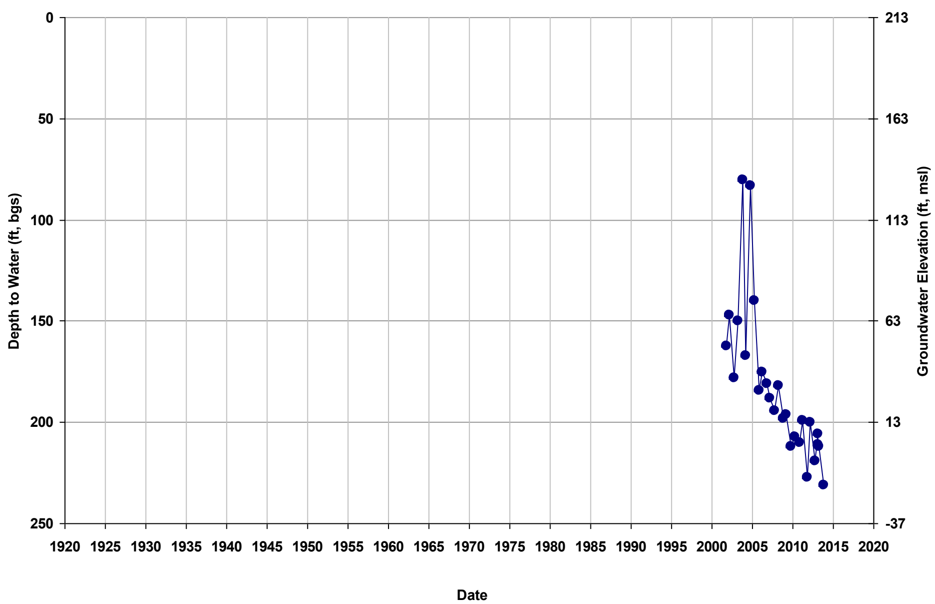
Well ID: 09S15E27J001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 218
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



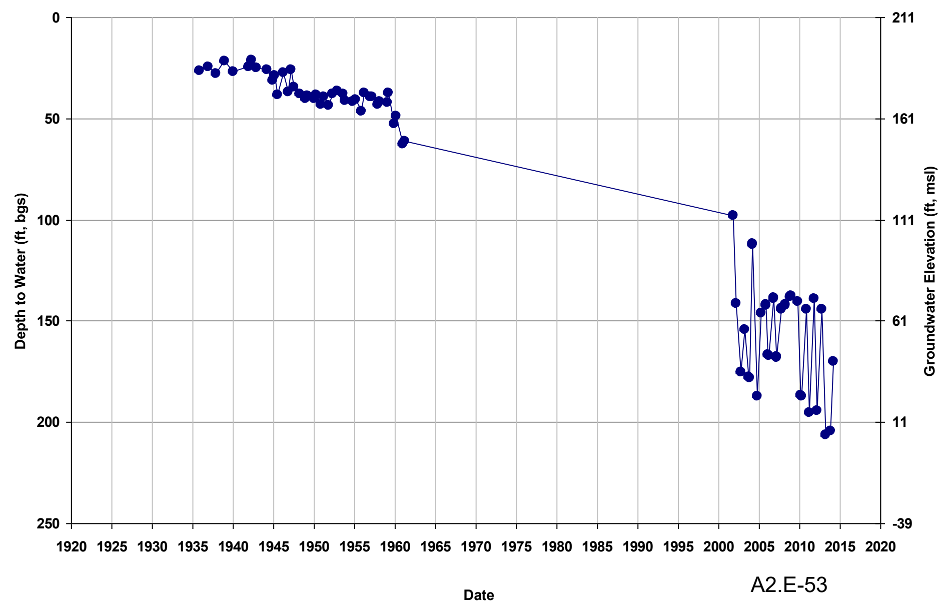
Well ID: 09S15E27Q001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 212
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



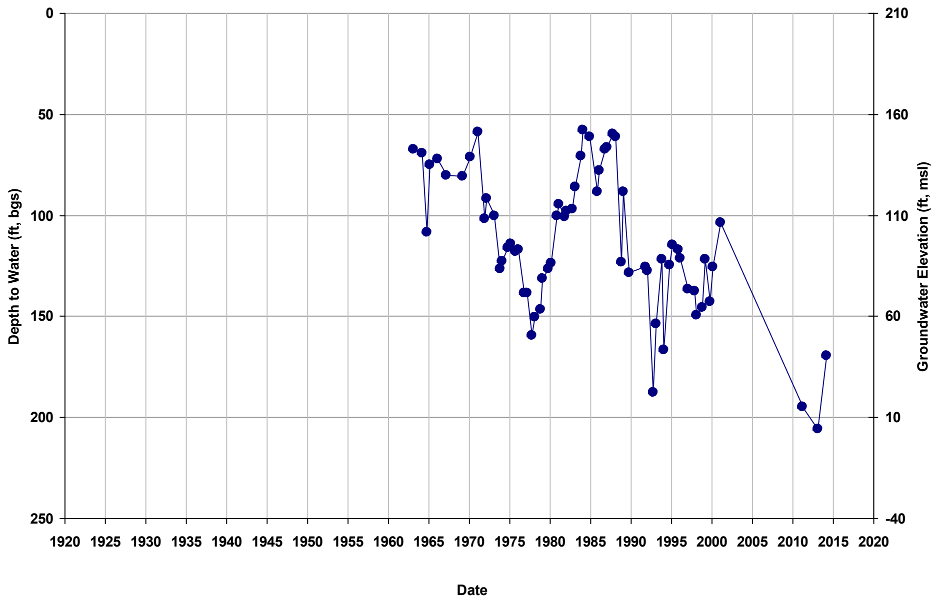
Well ID: 09S15E28A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 210
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



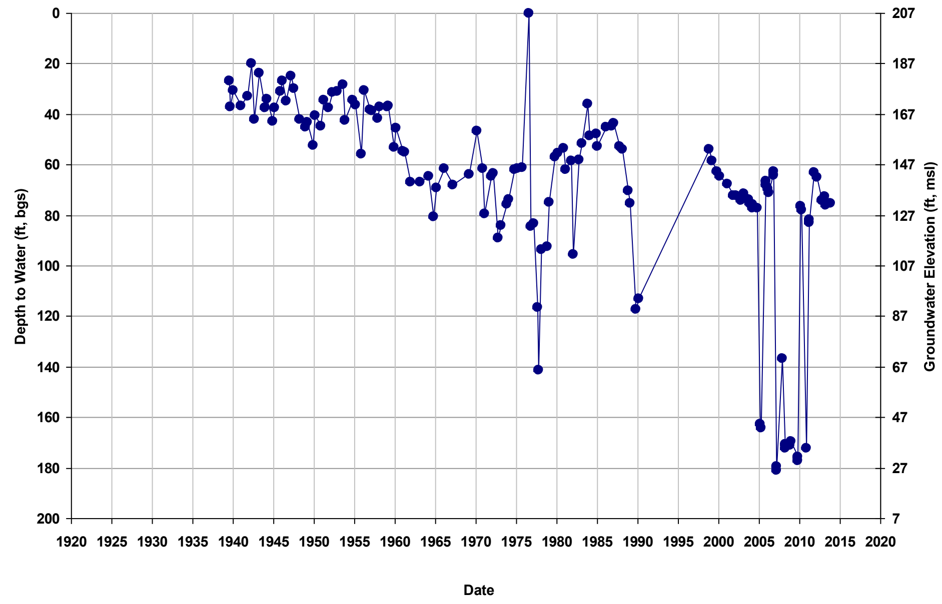
Well ID: 09S15E28A002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 210
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



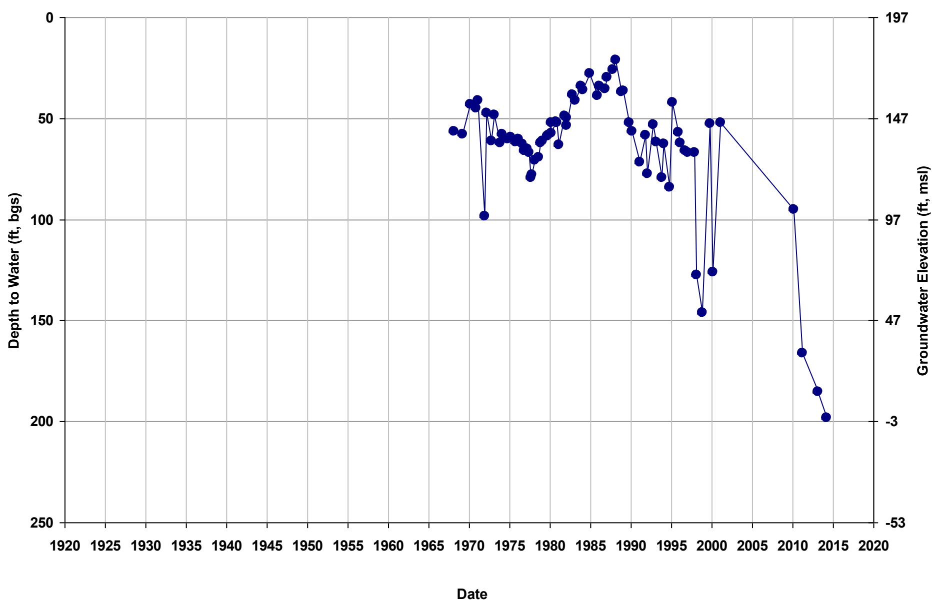
Well ID: 09S15E28R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 207
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



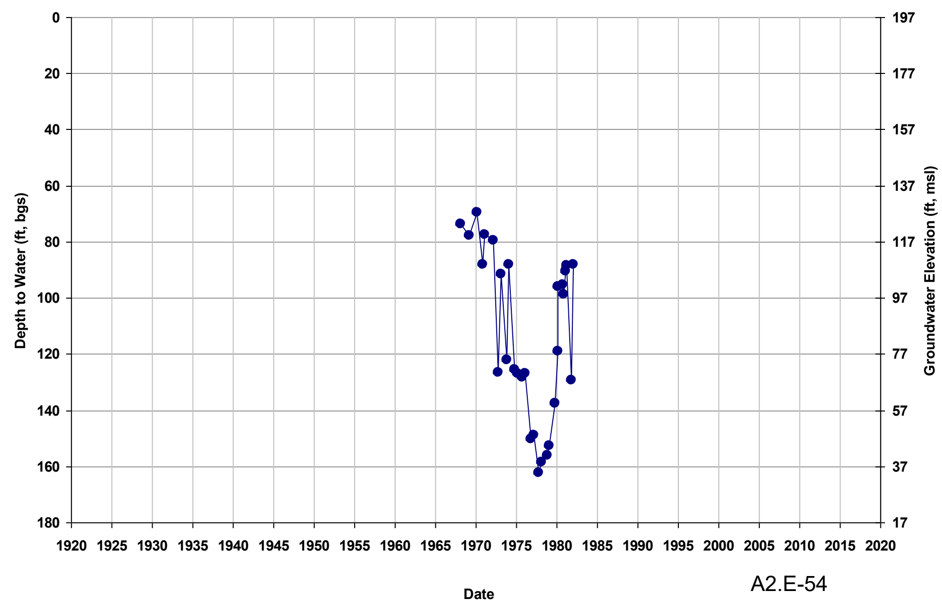
Well ID: 09S15E29D001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 197
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



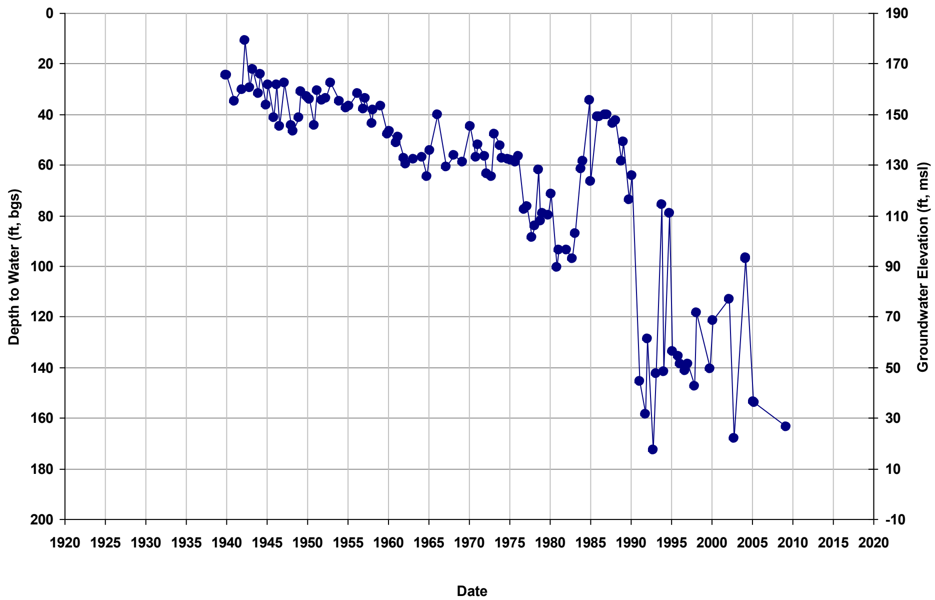
Well ID: 09S15E29F001M
Depth Zone: Composite or Lower; Wi
Subbasin: Chowchilla

GSE (ft, msl): 197
Total Depth (ft): 342
Perf Top (ft): NA
Perf Bottom (ft): NA



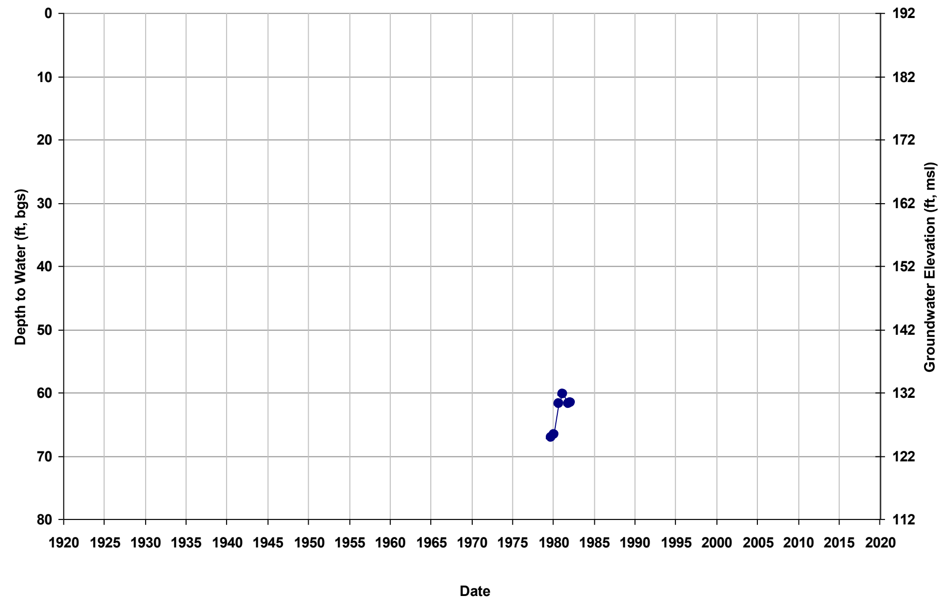
Well ID: 09S15E30G001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 189
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



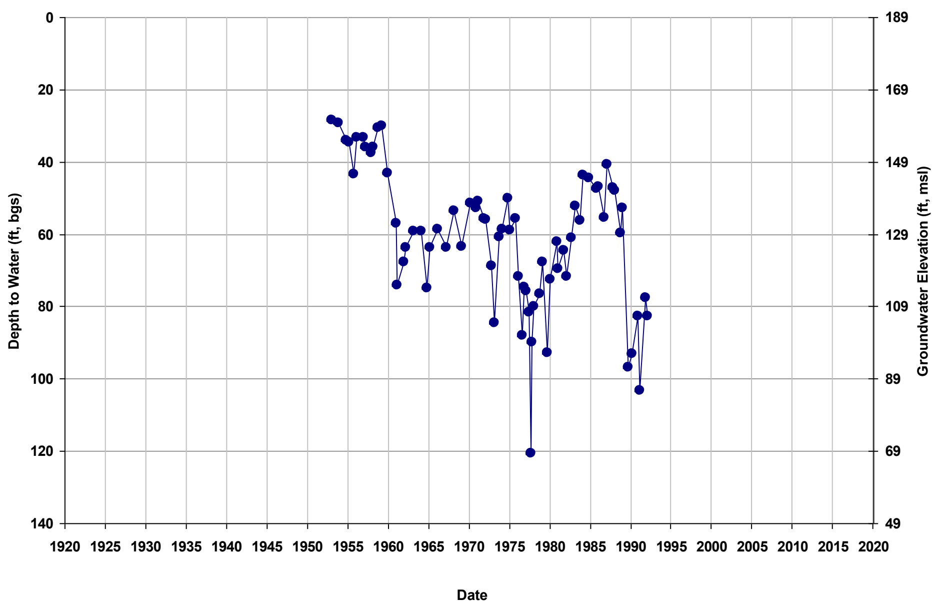
Well ID: 09S15E31H001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 192
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



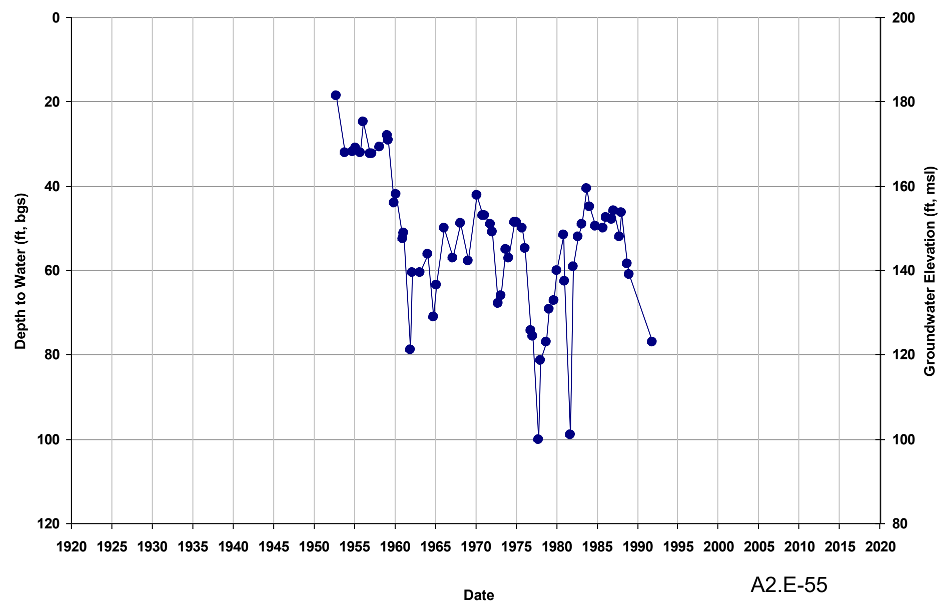
Well ID: 09S15E31J001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 189
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



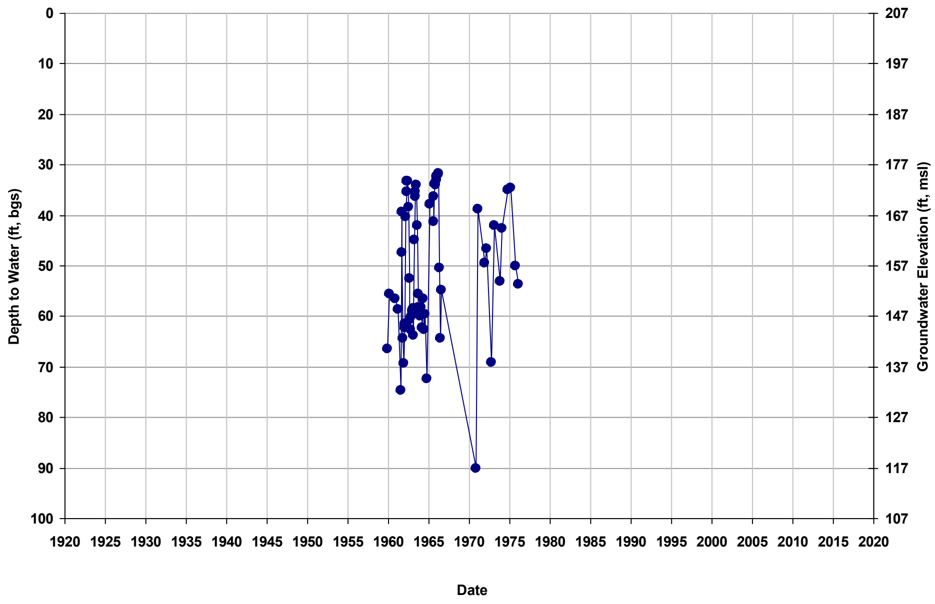
Well ID: 09S15E32R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 200
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



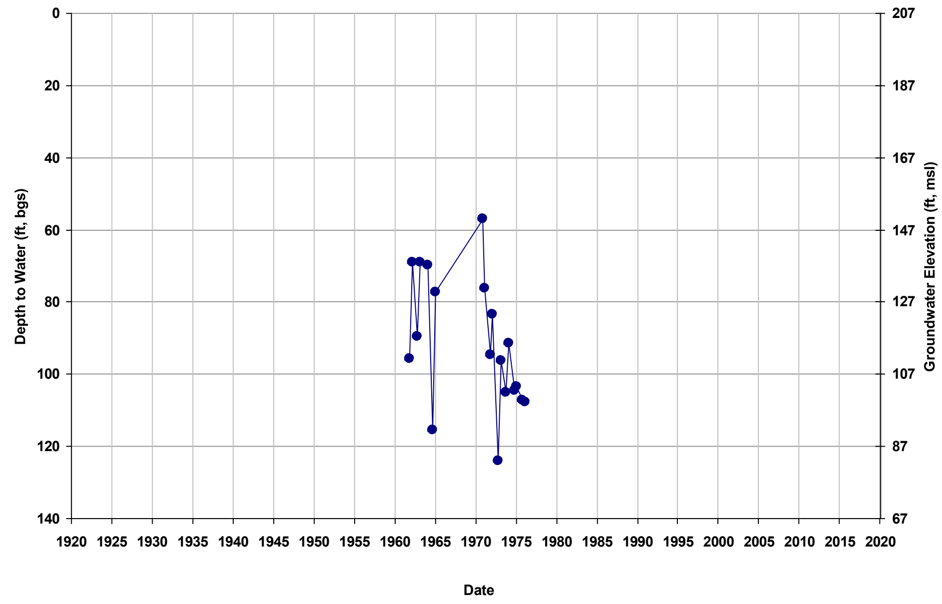
Well ID: 09S15E33B001M
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 207
Total Depth (ft): 110
Perf Top (ft): NA
Perf Bottom (ft): NA



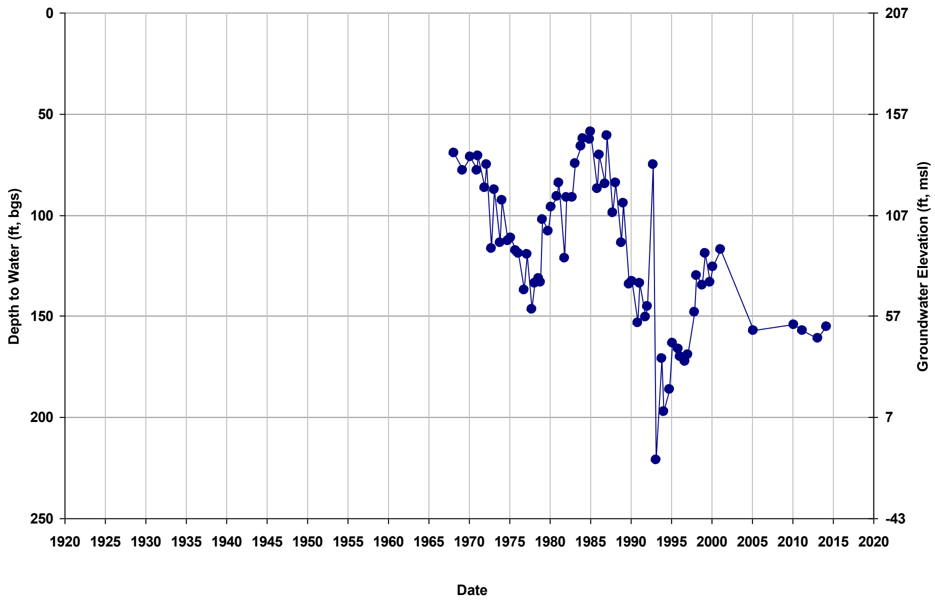
Well ID: 09S15E33B002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 207
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



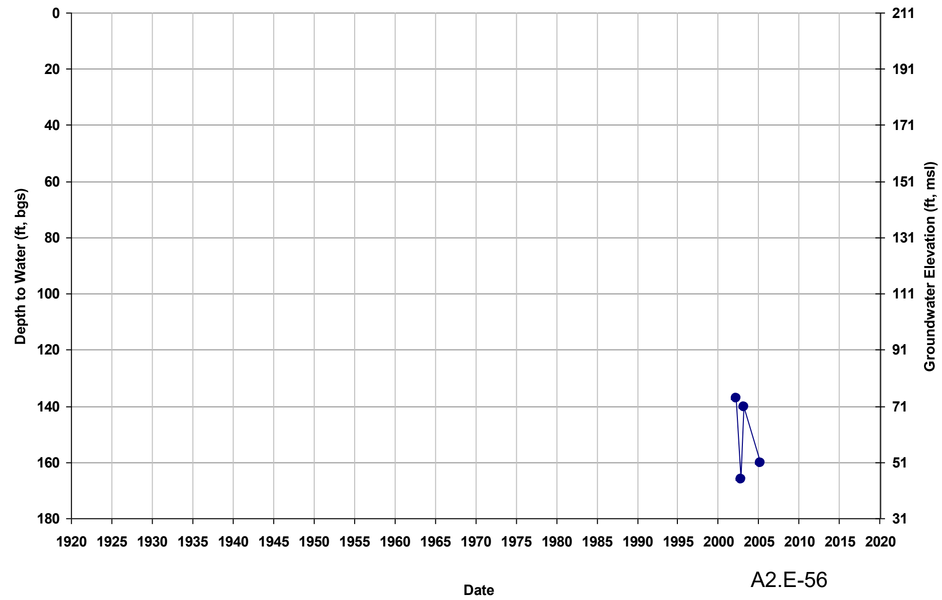
Well ID: 09S15E33J002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 207
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



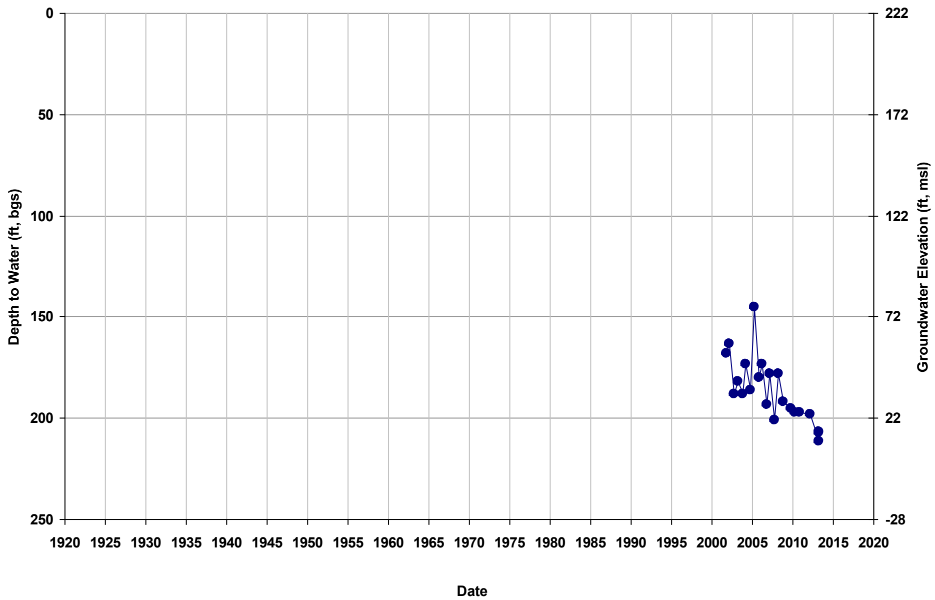
Well ID: 09S15E34J001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 211
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



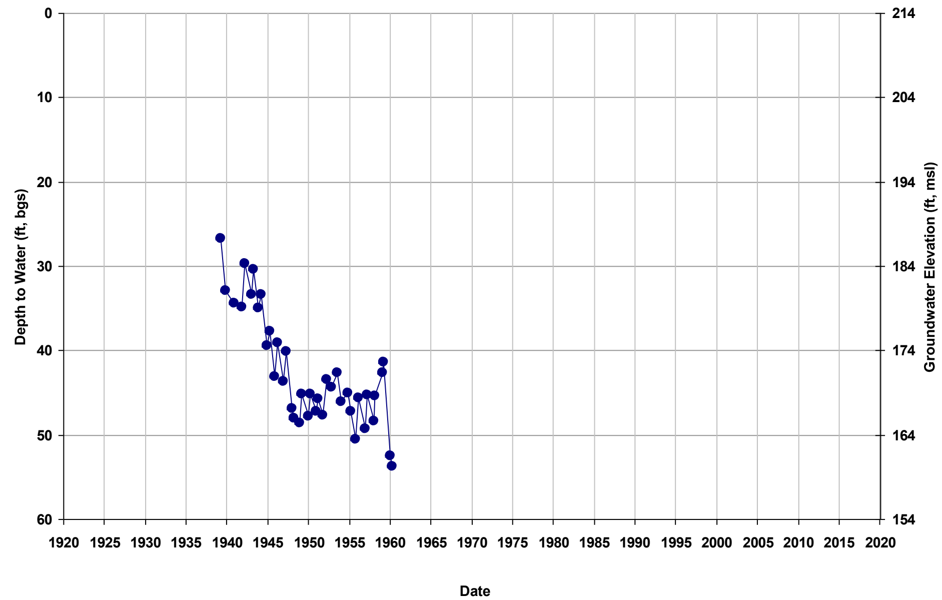
Well ID: 09S15E35C001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 222
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



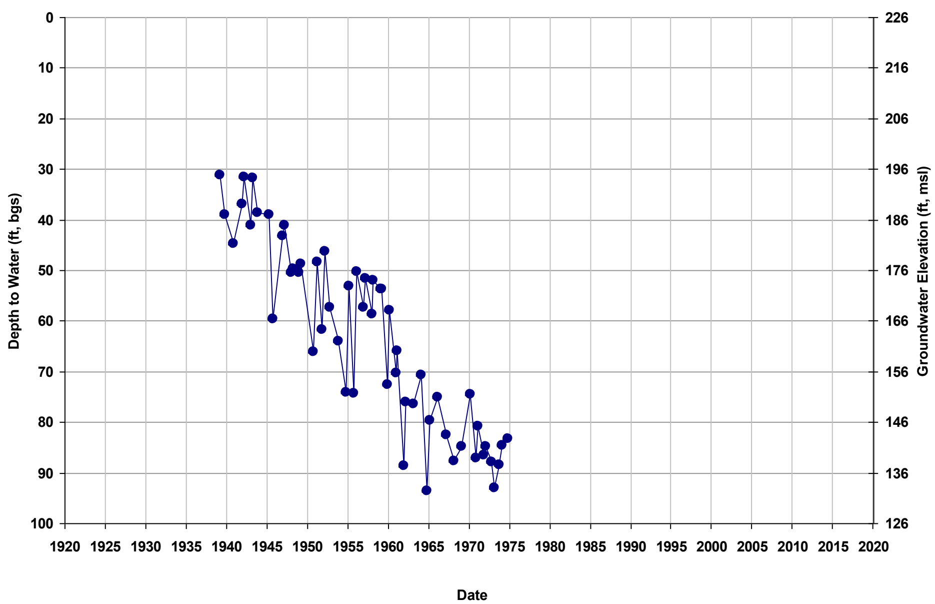
Well ID: 09S15E35M001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 213
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



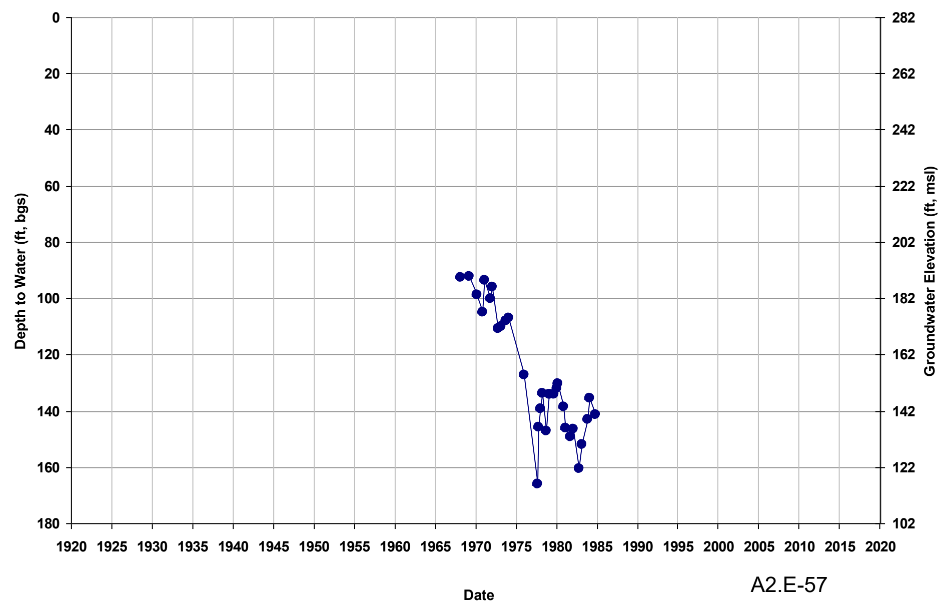
Well ID: 09S15E36L001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 225
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



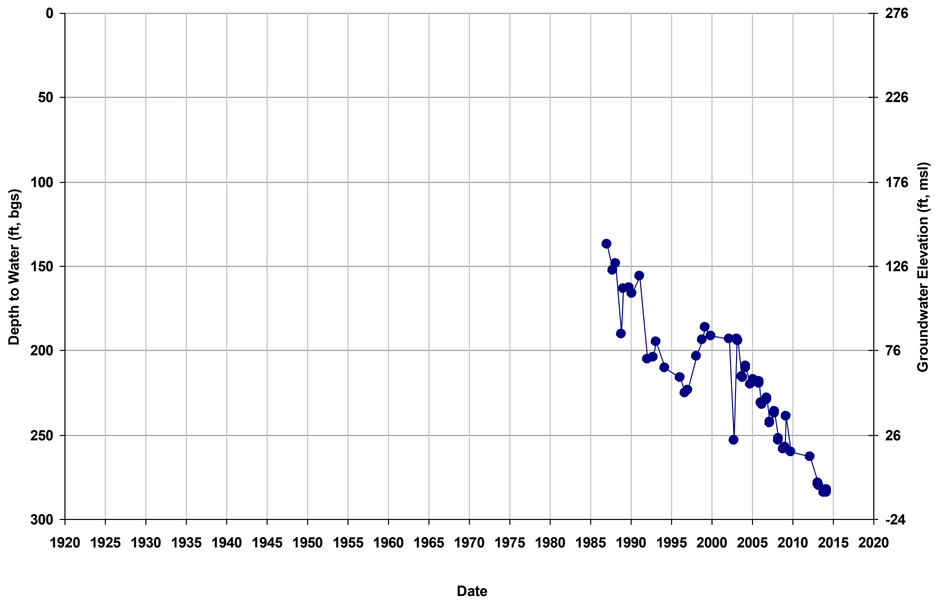
Well ID: 09S16E14M001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 282
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



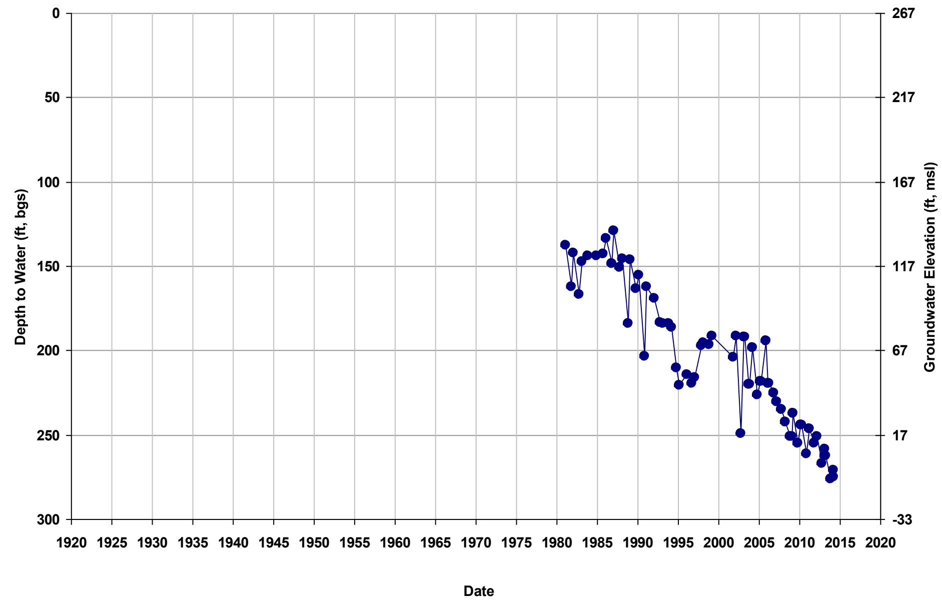
Well ID: 09S16E15B001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 276
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



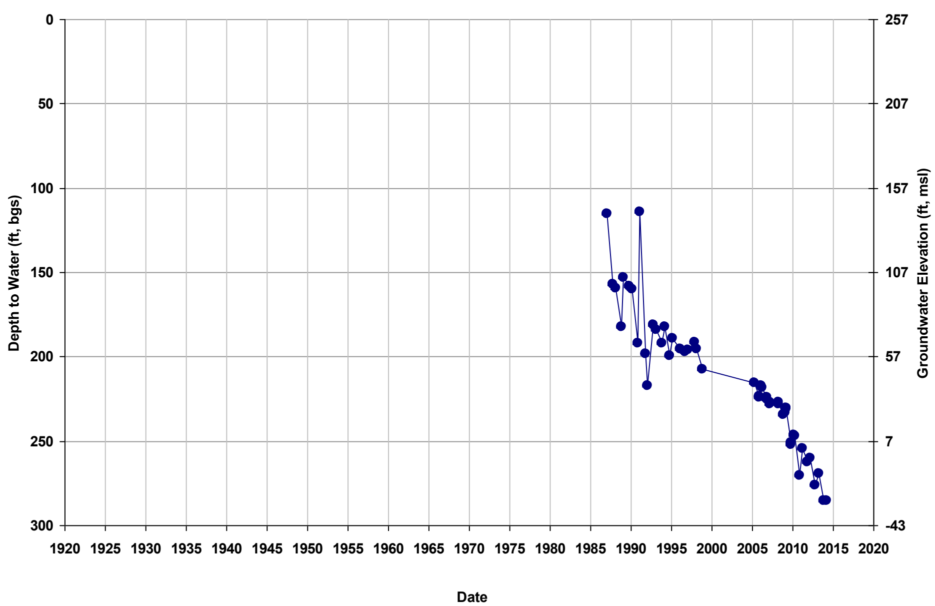
Well ID: 09S16E15Q001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 267
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



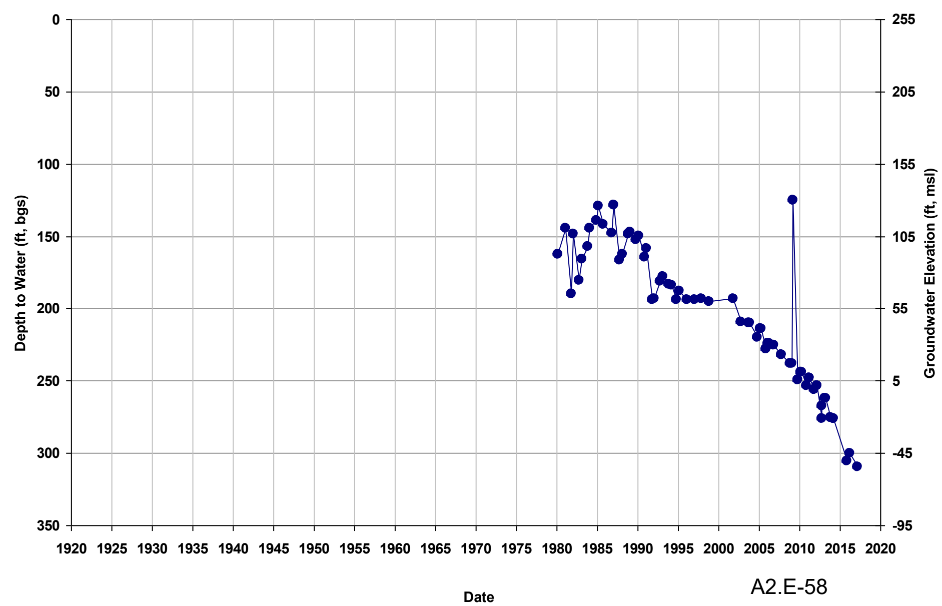
Well ID: 09S16E16D001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 257
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



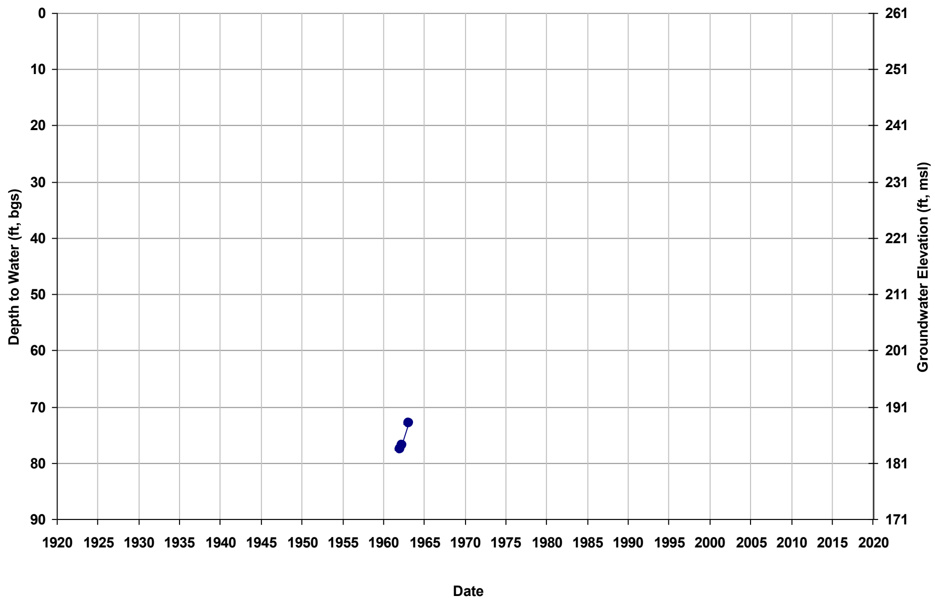
Well ID: 09S16E16N001M
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 255
Total Depth (ft): 466
Perf Top (ft): 218
Perf Bottom (ft): 464



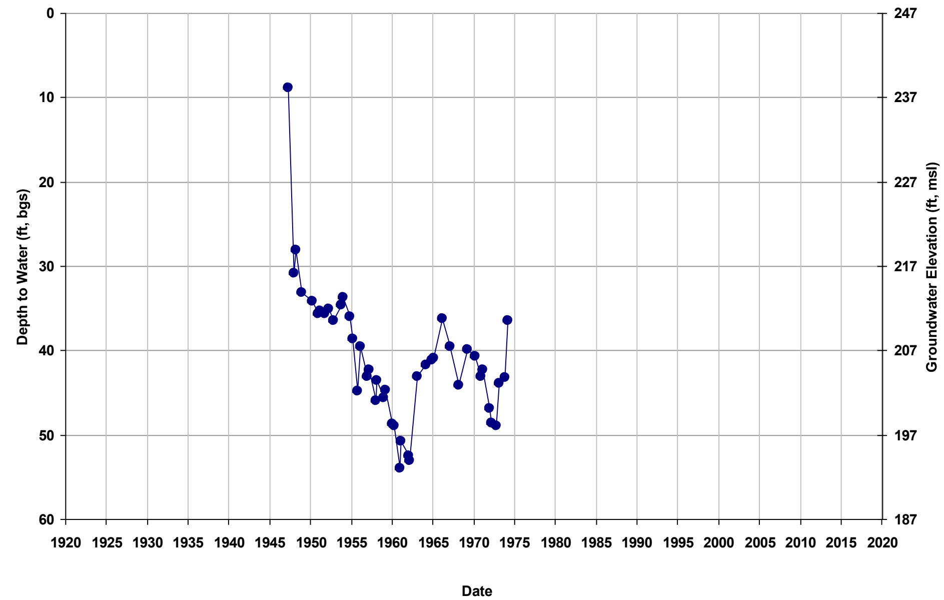
Well ID: 09S16E16Q001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 261
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



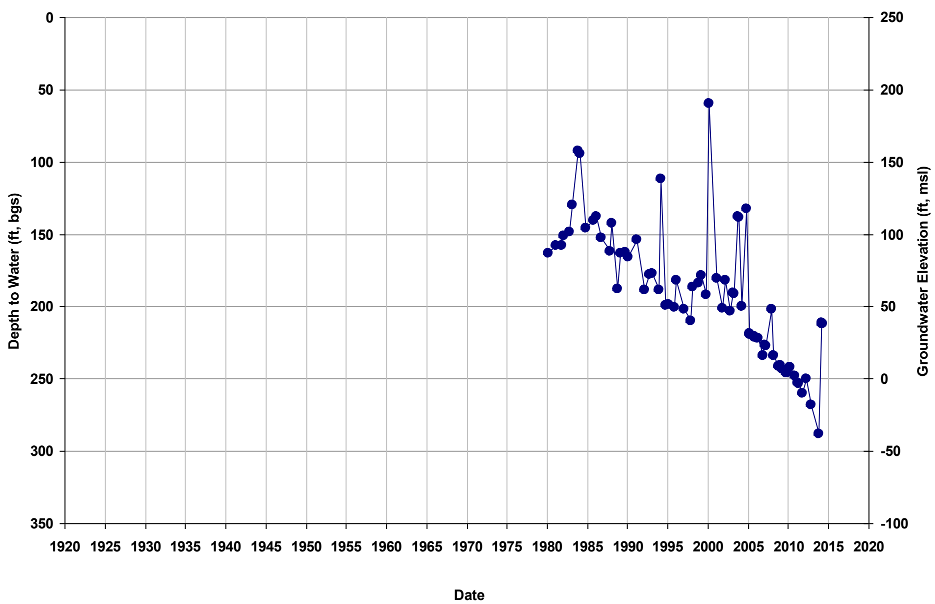
Well ID: 09S16E17D001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 247
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



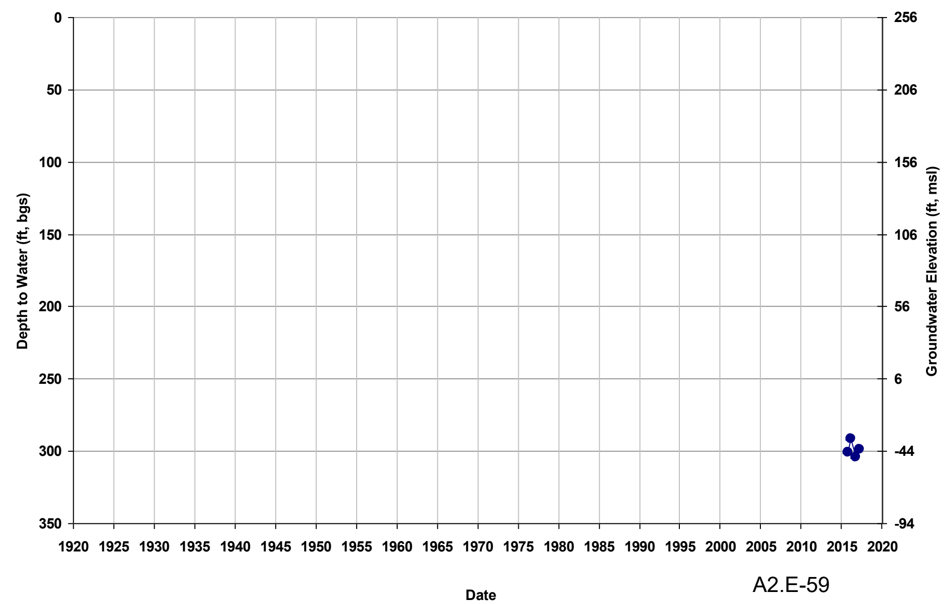
Well ID: 09S16E17F001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 249
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



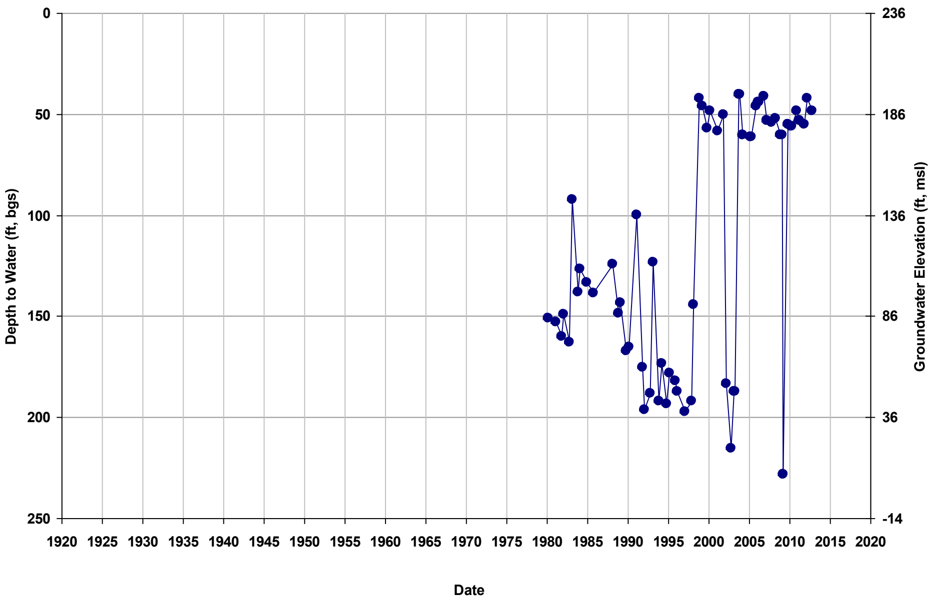
Well ID: 09S16E18A
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 256
Total Depth (ft): 800
Perf Top (ft): 320
Perf Bottom (ft): 762



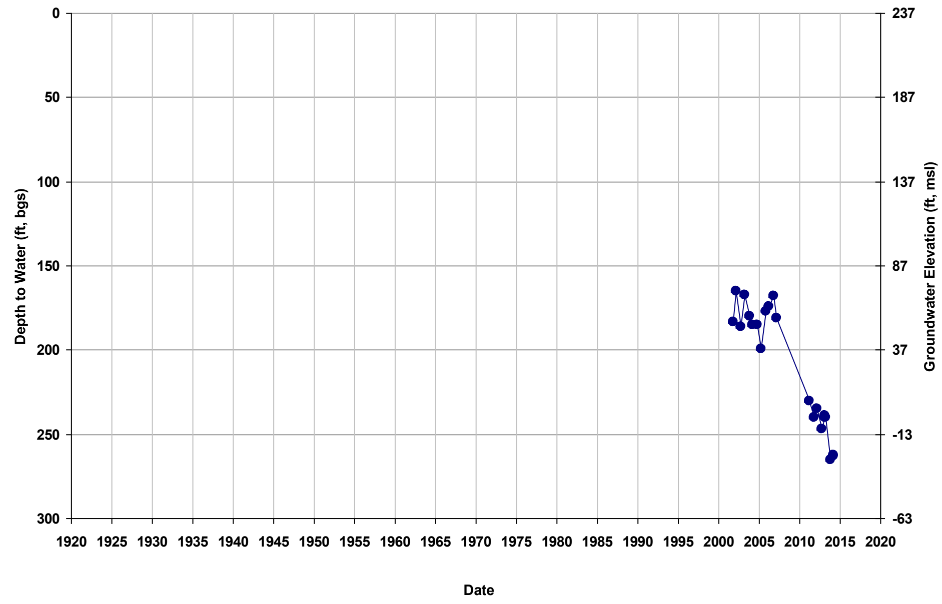
Well ID: 09S16E18M001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 236
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



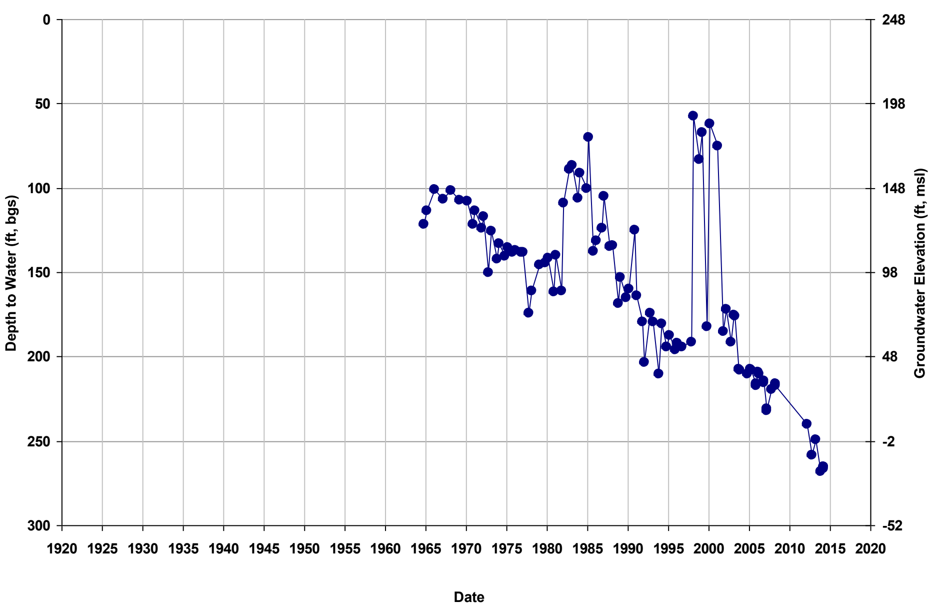
Well ID: 09S16E19D001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 237
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



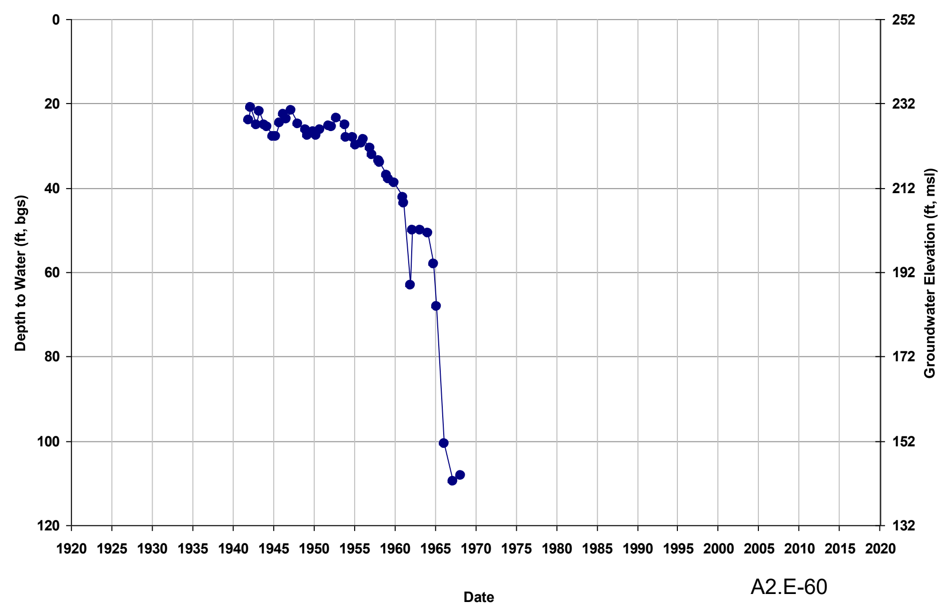
Well ID: 09S16E20E001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

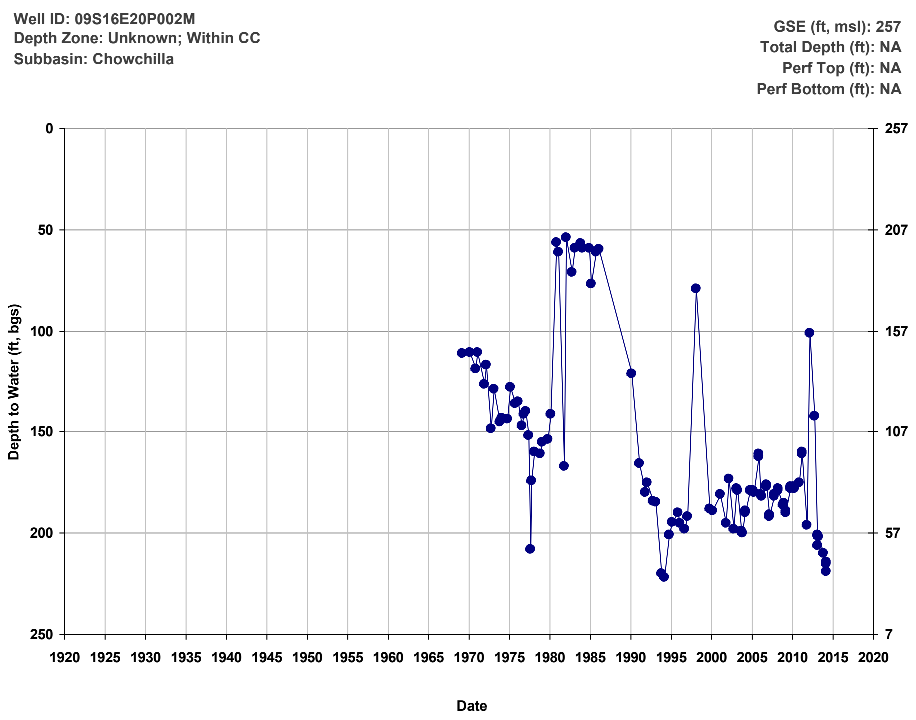
GSE (ft, msl): 248
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA

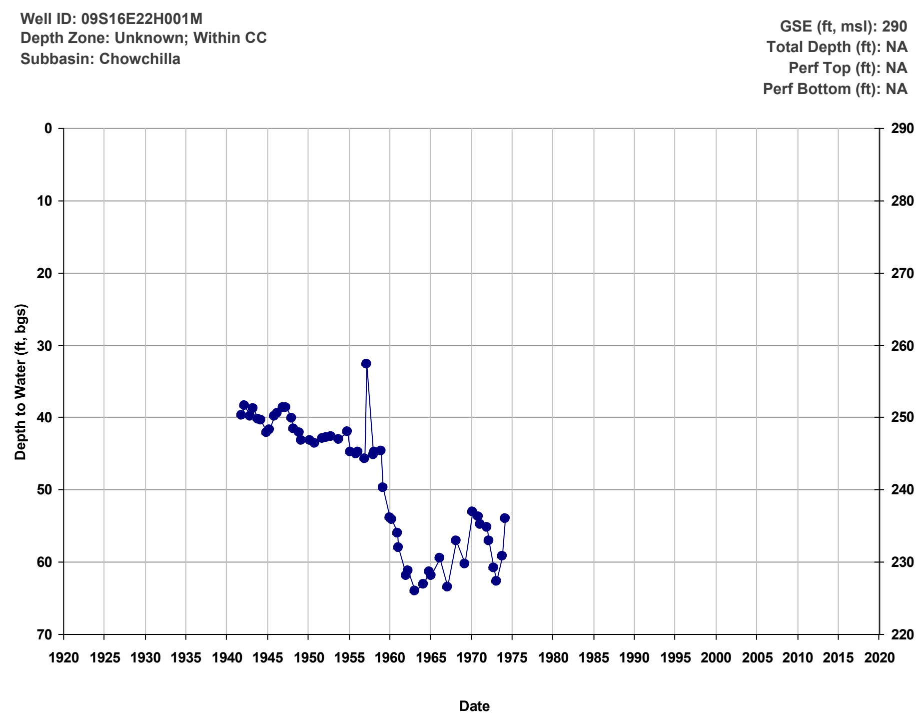


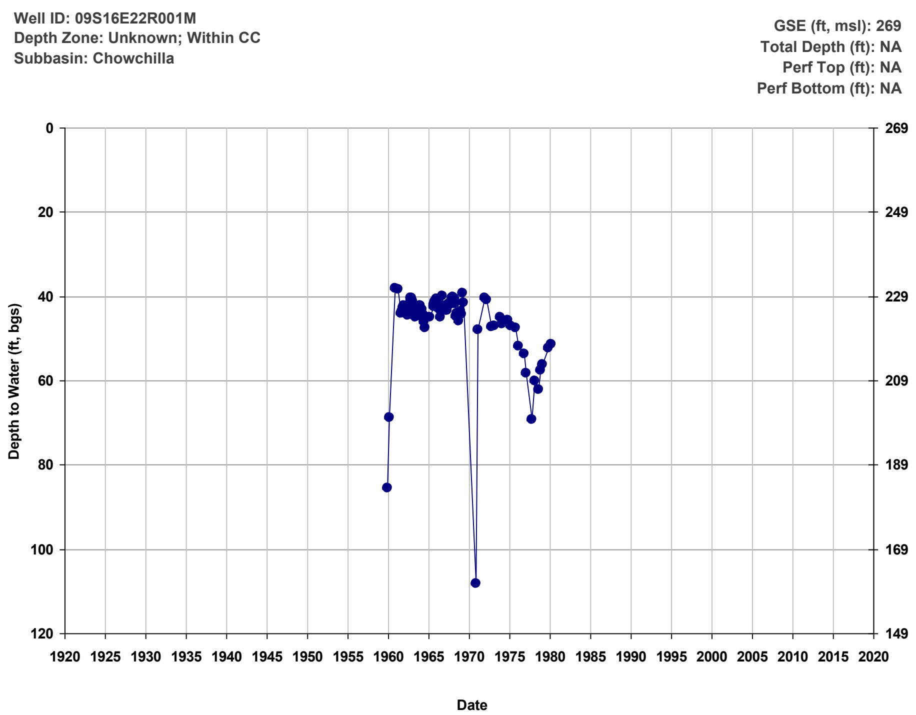
Well ID: 09S16E20P001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

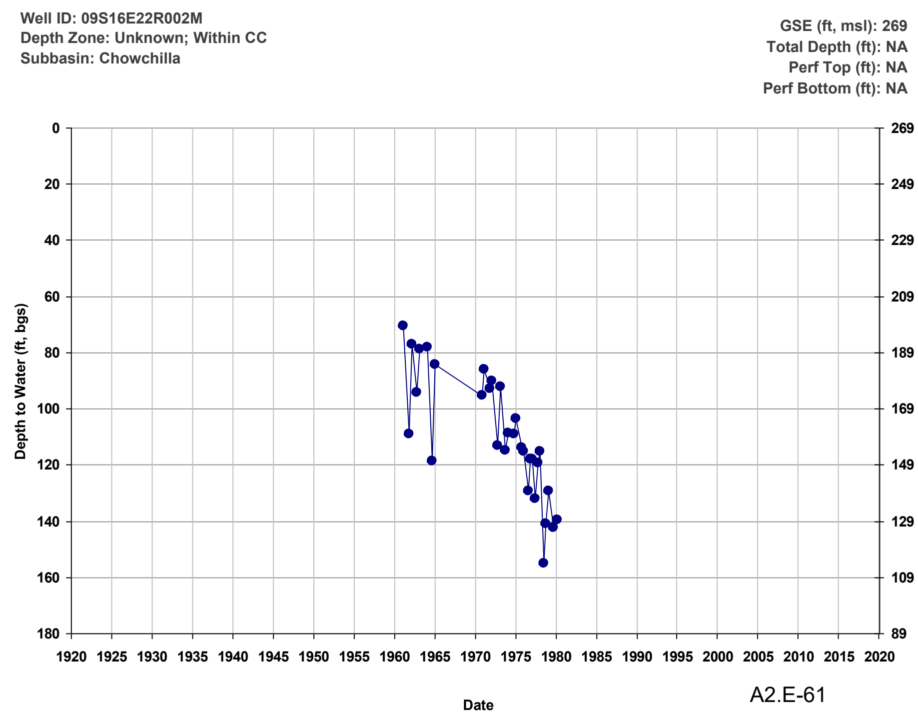
GSE (ft, msl): 252
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA




Well ID: 09S16E20P002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 257
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

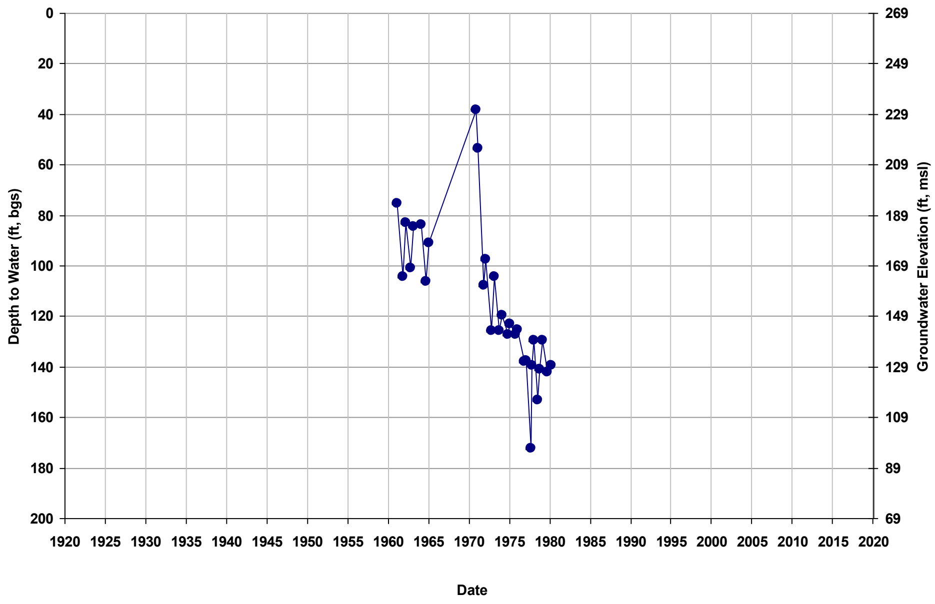

Well ID: 09S16E22H001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 290
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 09S16E22R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 269
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 09S16E22R002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 269
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

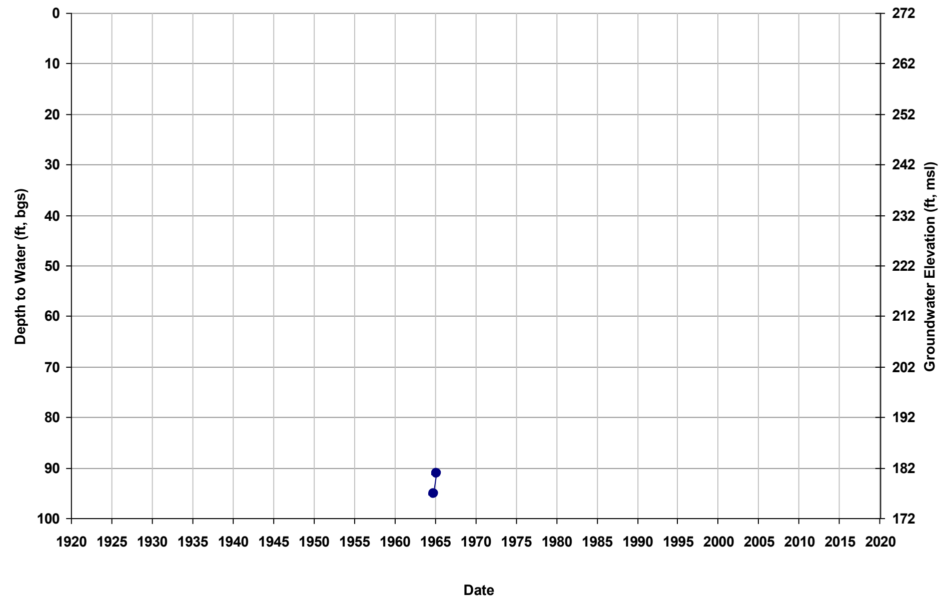
Well ID: 09S16E22R003M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 269
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



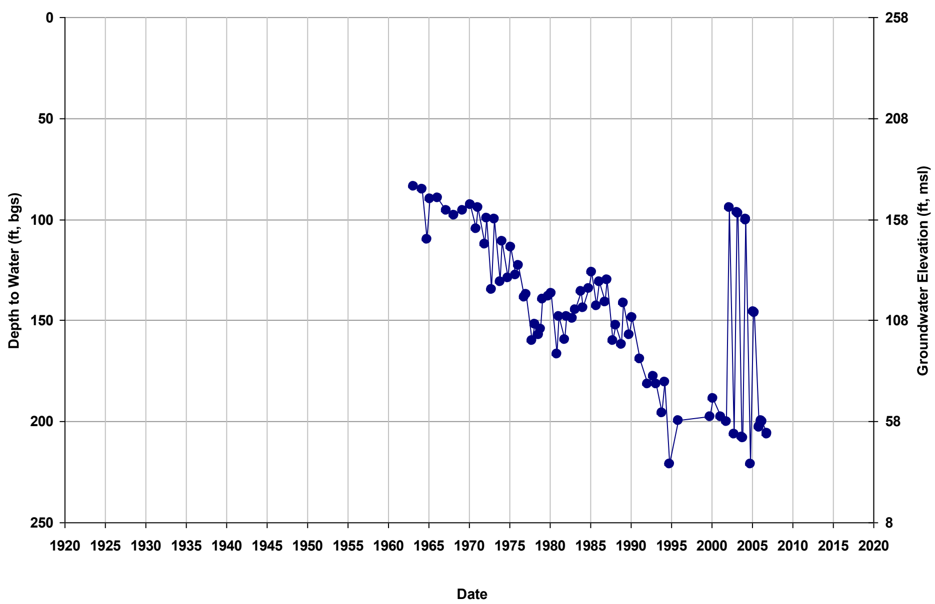
Well ID: 09S16E26E001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 272
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



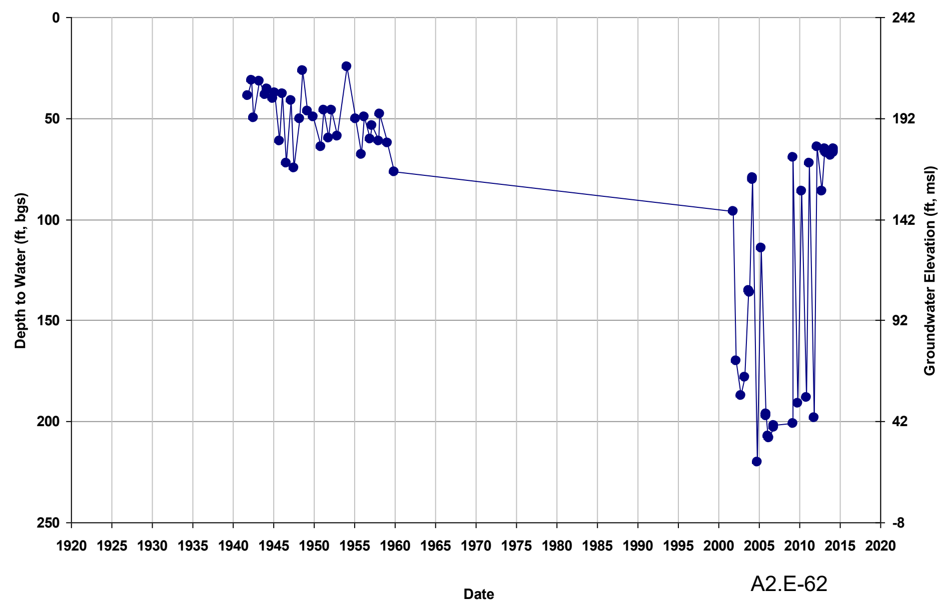
Well ID: 09S16E28A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

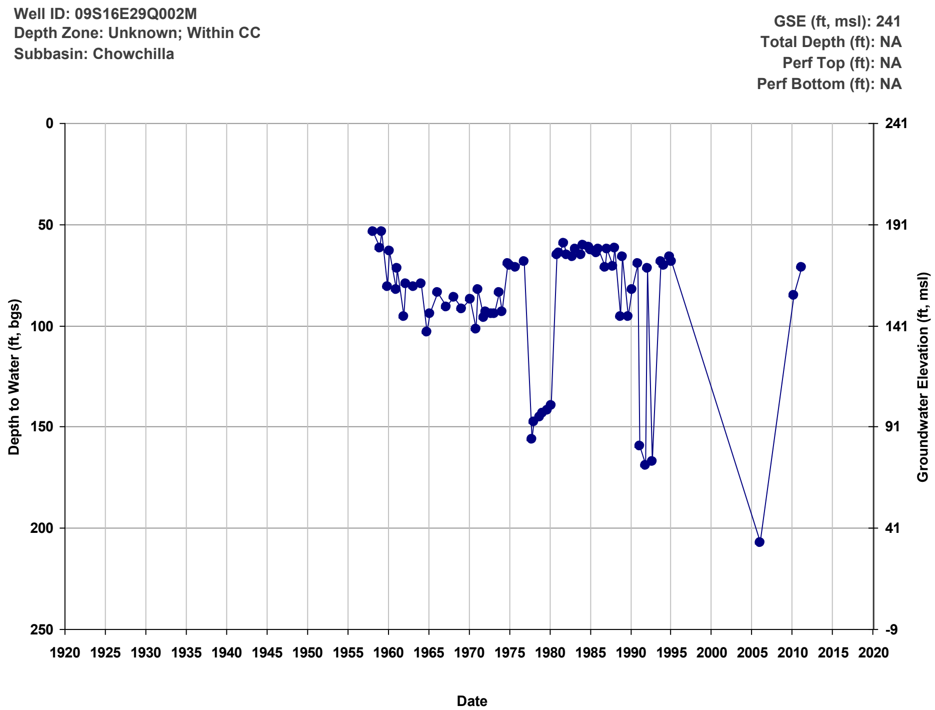
GSE (ft, msl): 258
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA

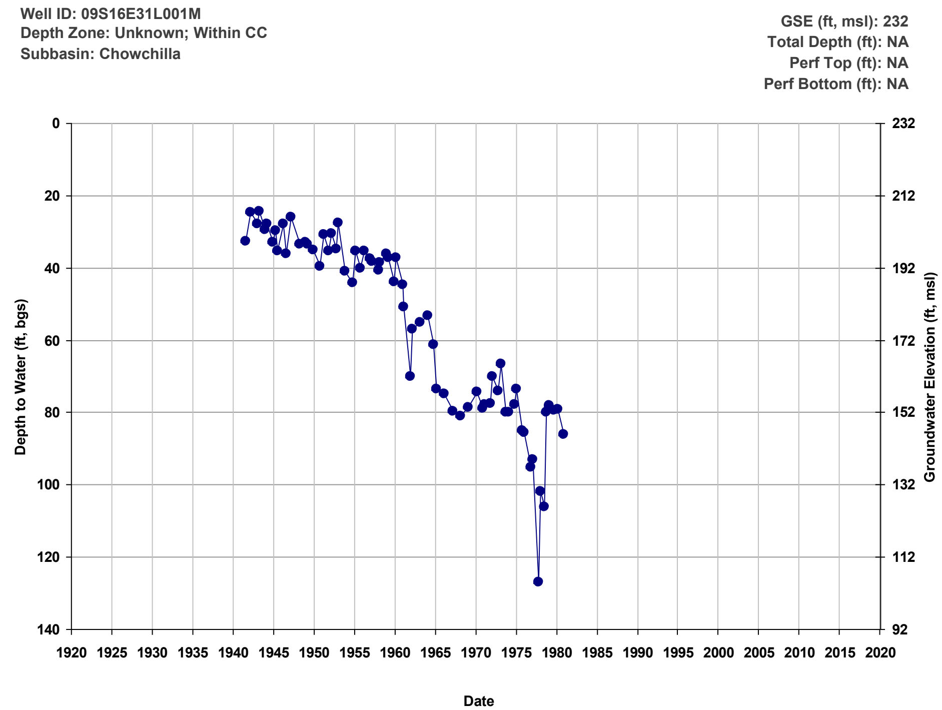


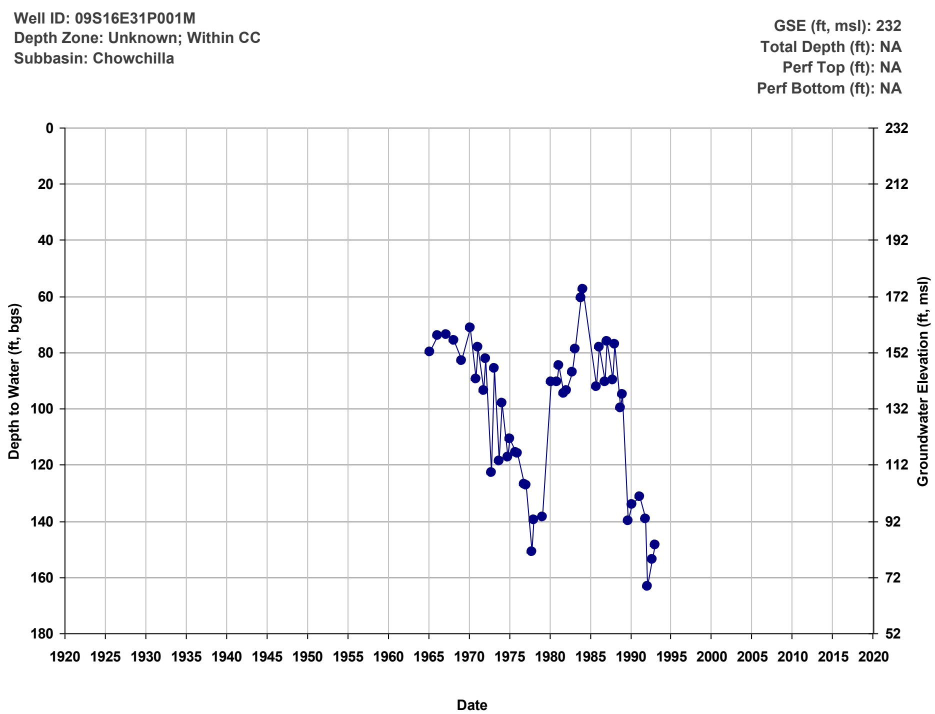
Well ID: 09S16E29Q001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

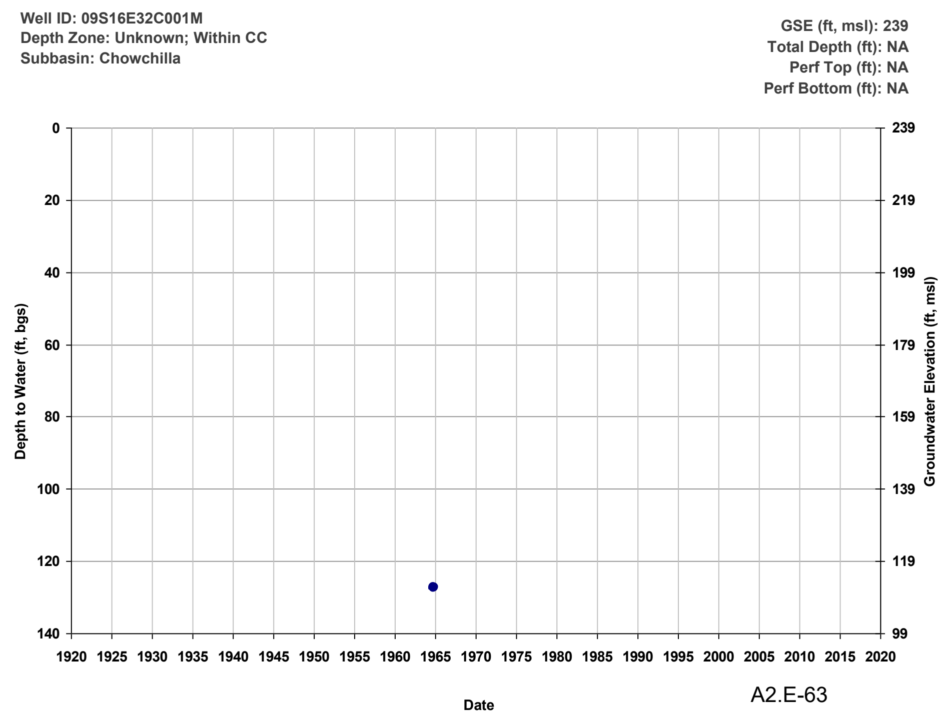
GSE (ft, msl): 242
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA

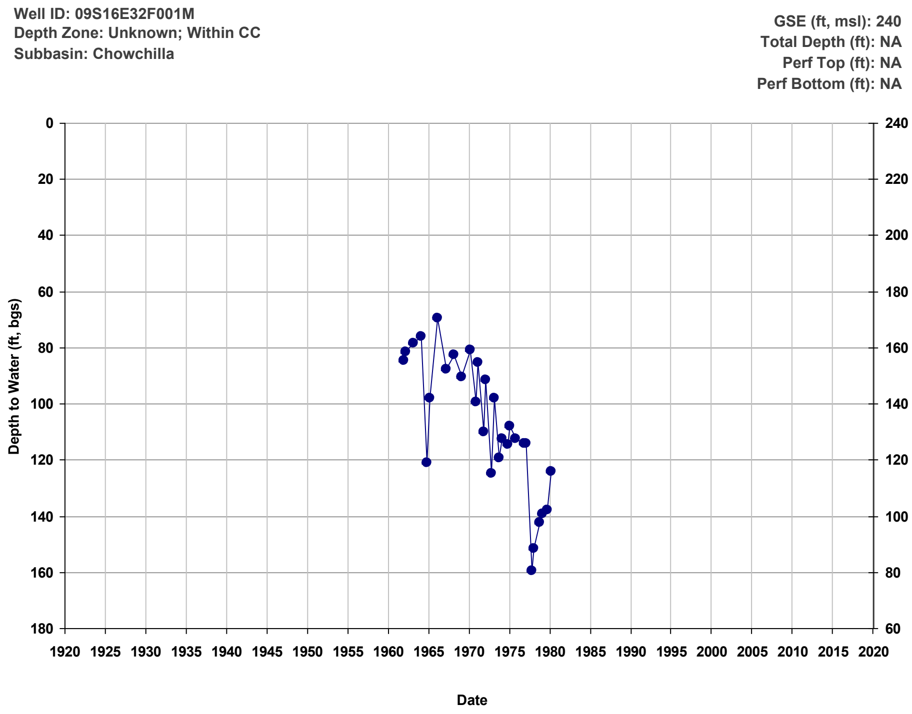


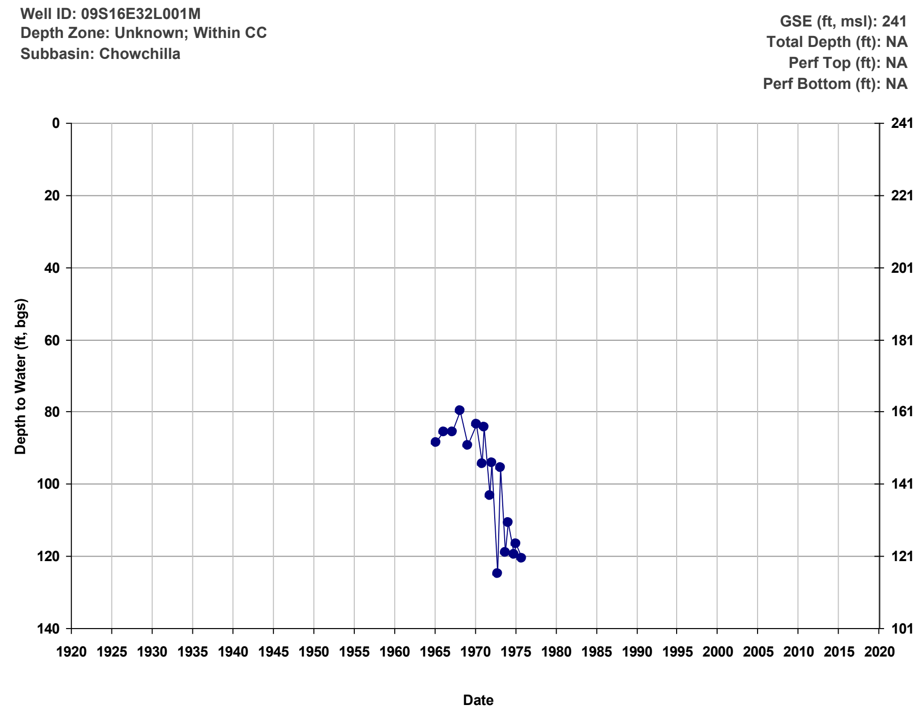

Well ID: 09S16E29Q002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 241
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

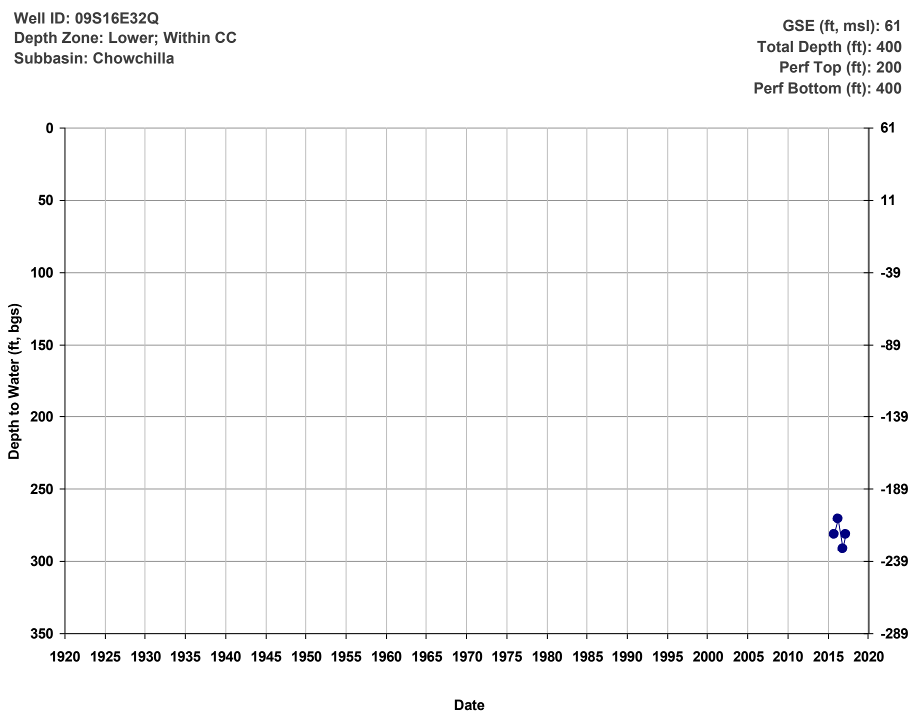

Well ID: 09S16E31L001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 232
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

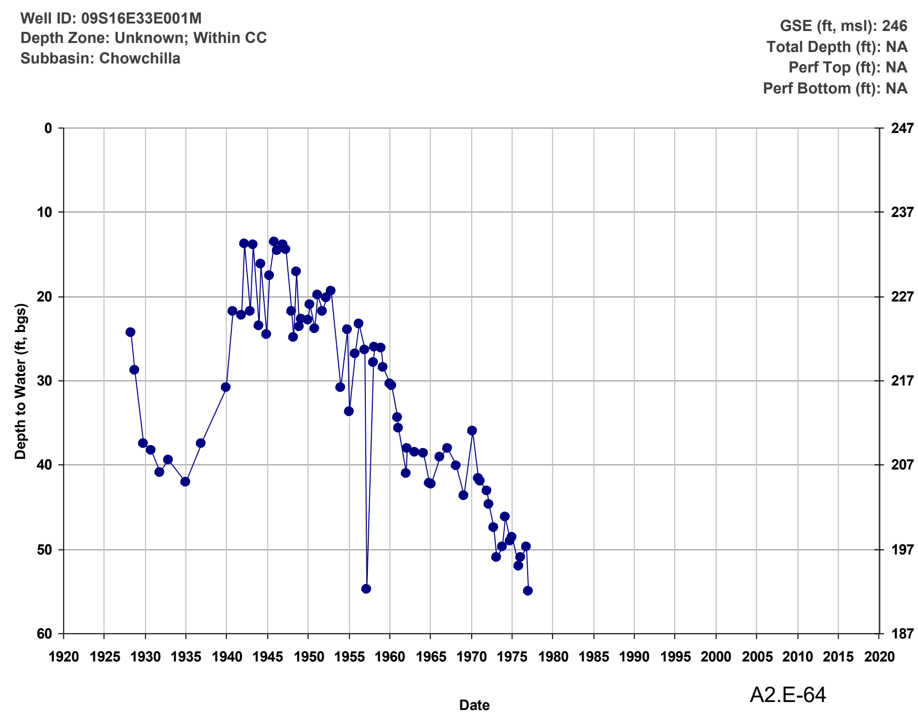

Well ID: 09S16E31P001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 232
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 09S16E32C001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 239
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 09S16E32F001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 240
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

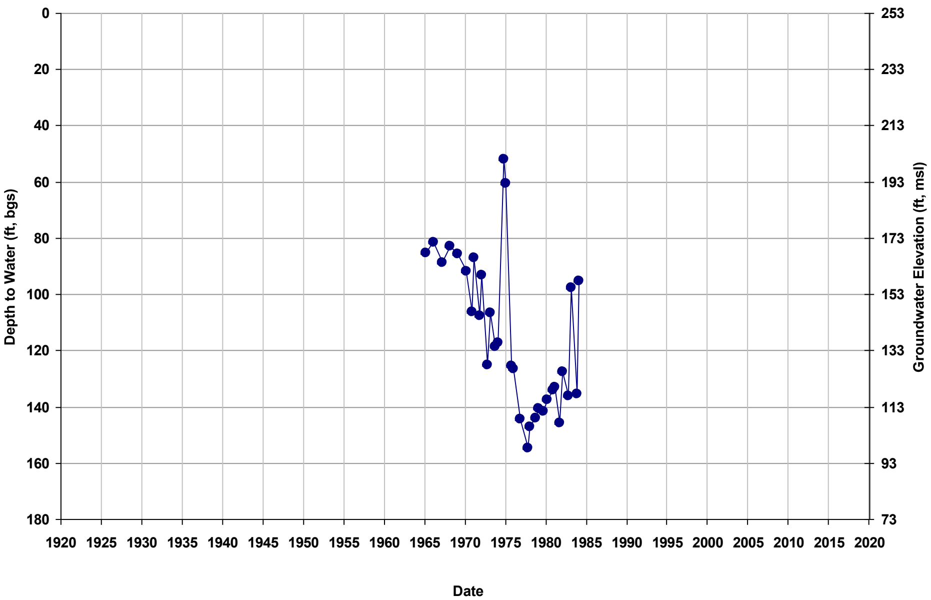

Well ID: 09S16E32L001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 241
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 09S16E32Q
Depth Zone: Lower; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 61
Total Depth (ft): 400
Perf Top (ft): 200
Perf Bottom (ft): 400
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 09S16E33E001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 246
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

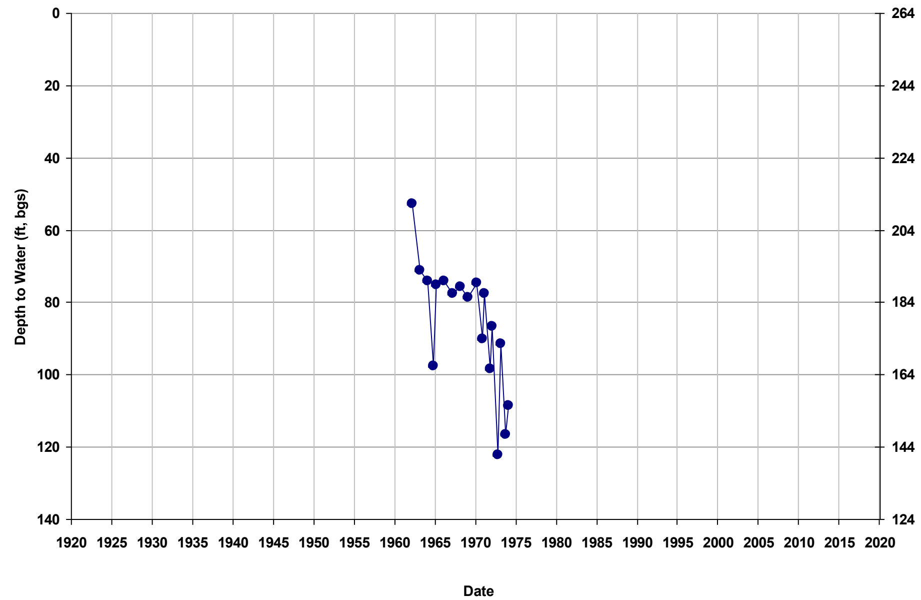
Well ID: 09S16E33F002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 253
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



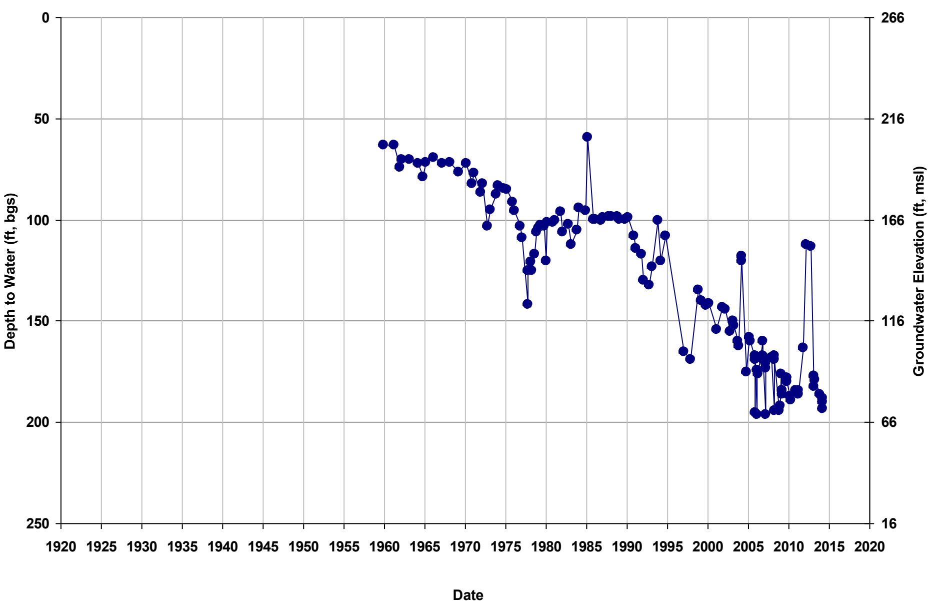
Well ID: 09S16E34A001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 264
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



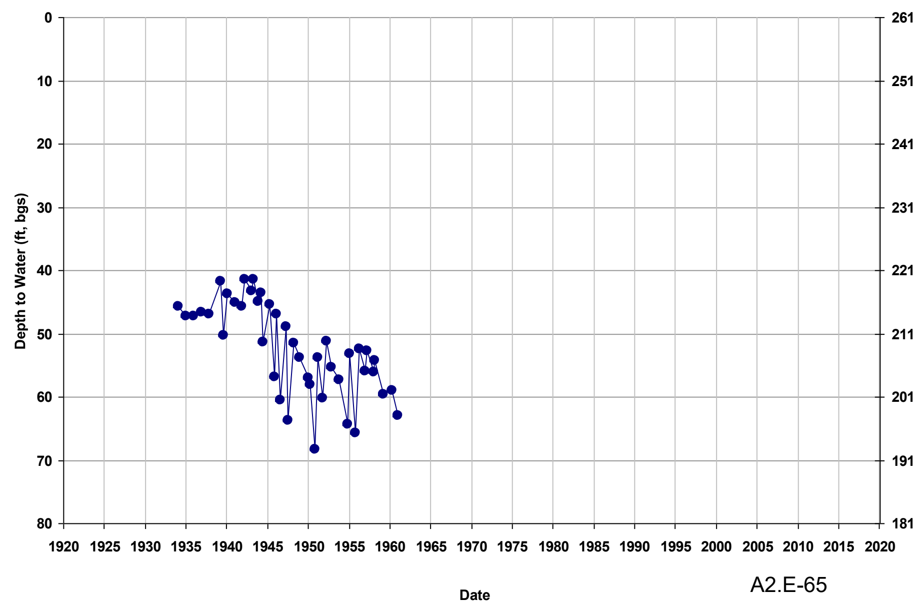
Well ID: 09S16E34J001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

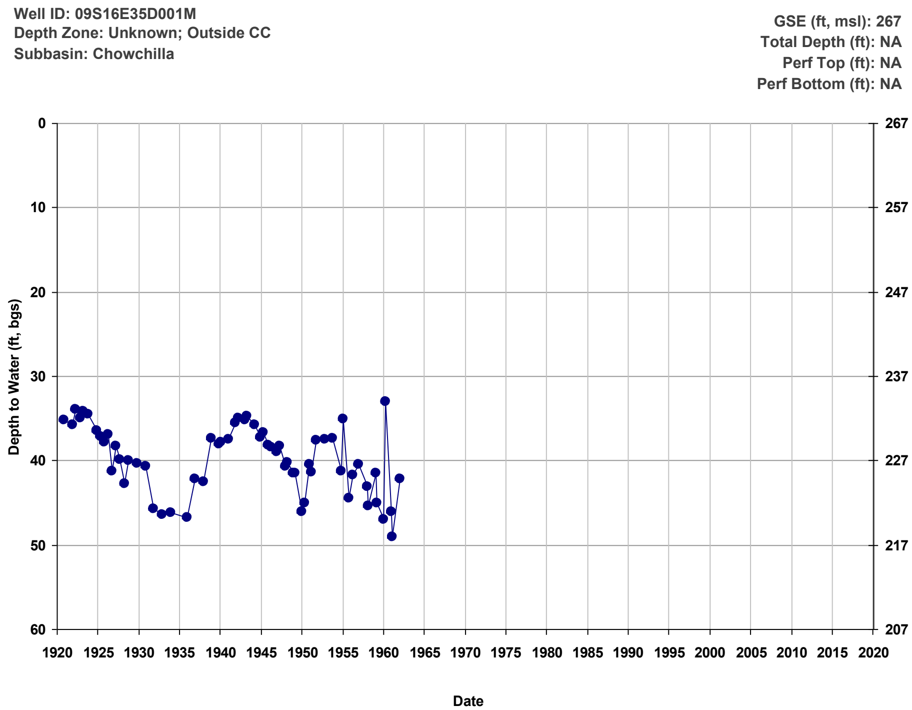
GSE (ft, msl): 266
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA

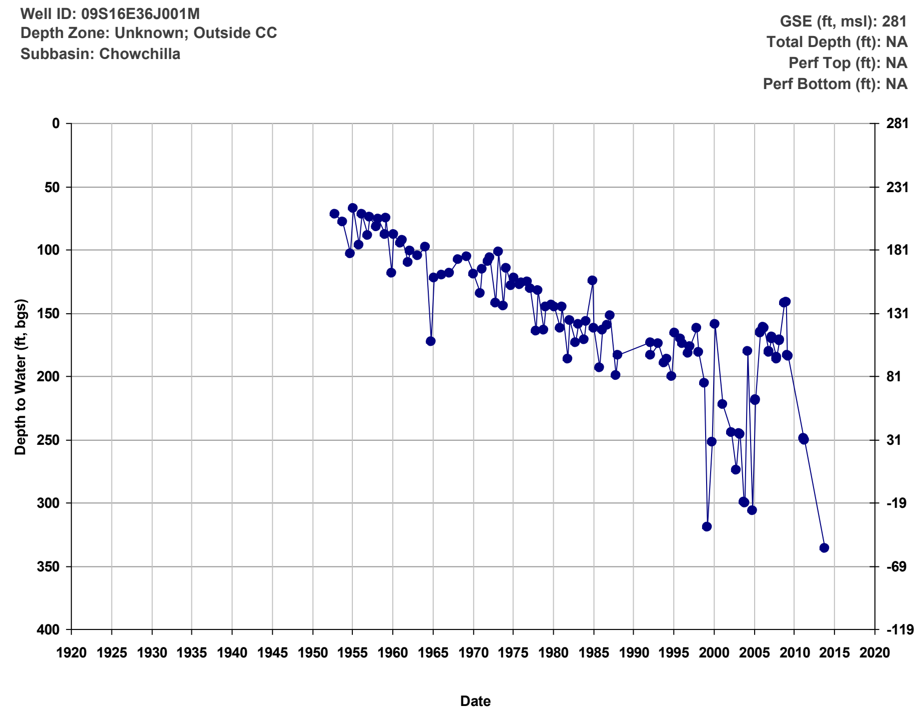


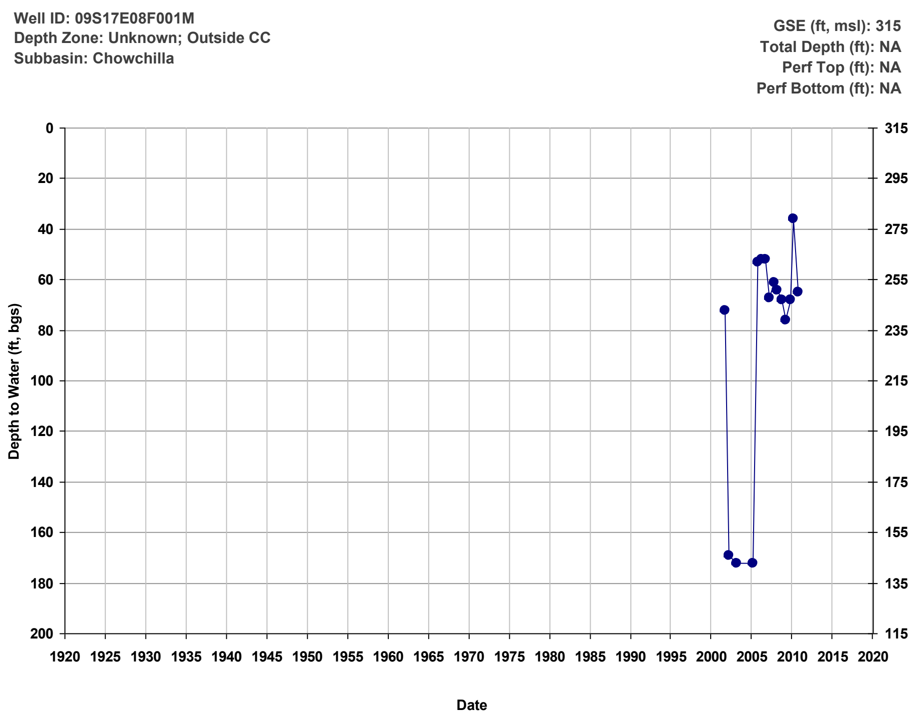
Well ID: 09S16E34R001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

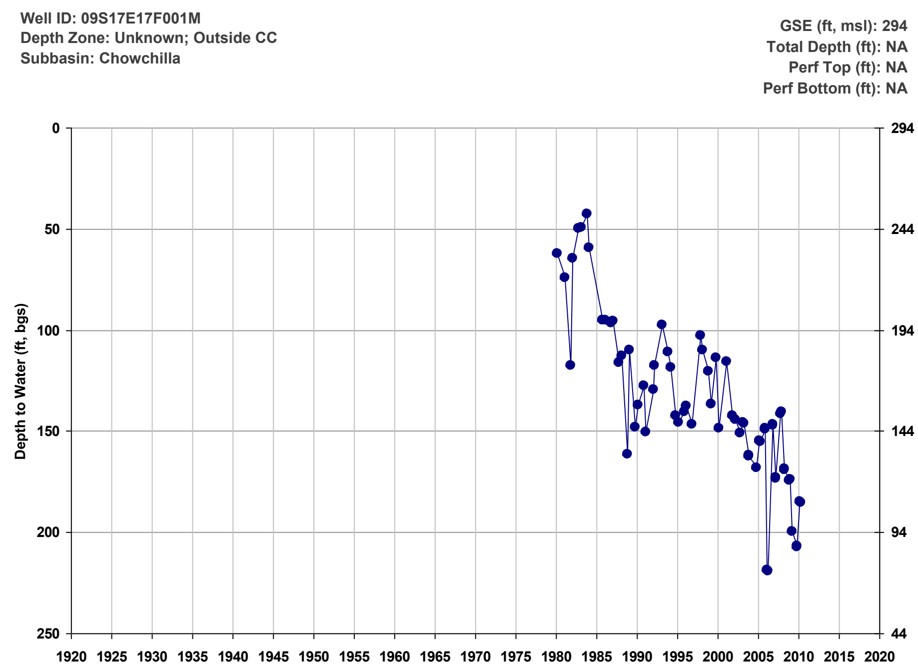
GSE (ft, msl): 261
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA

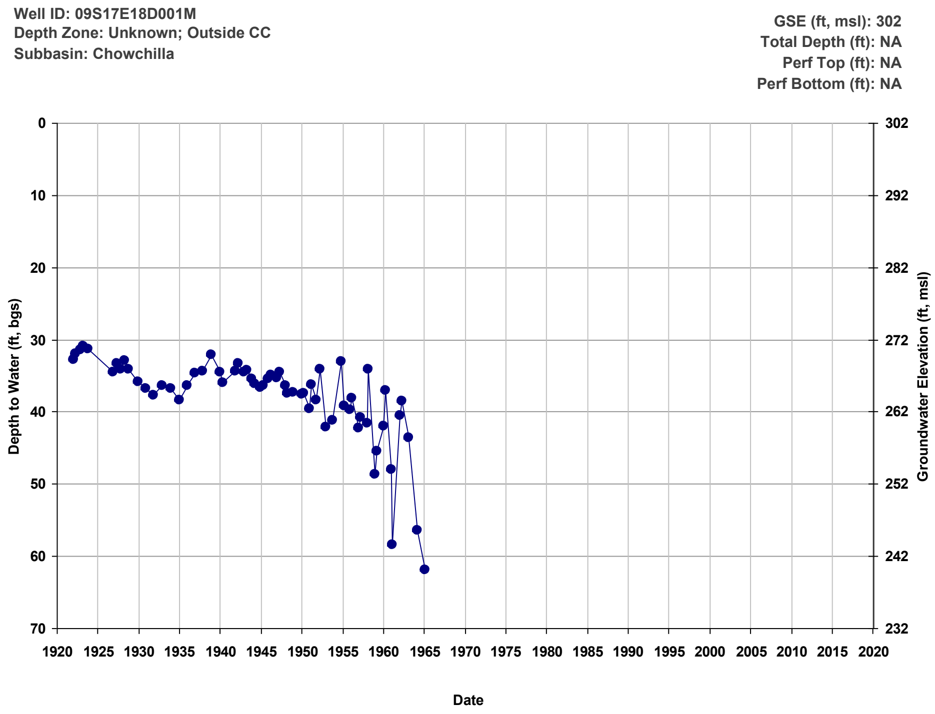


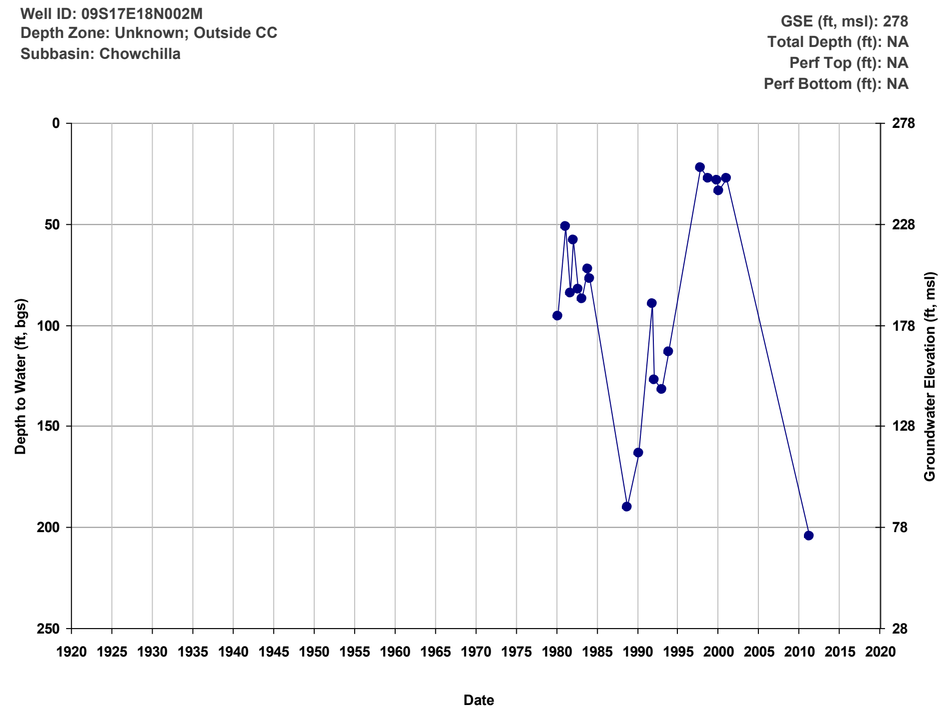

Well ID: 09S16E35D001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla
GSE (ft, msl): 267
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

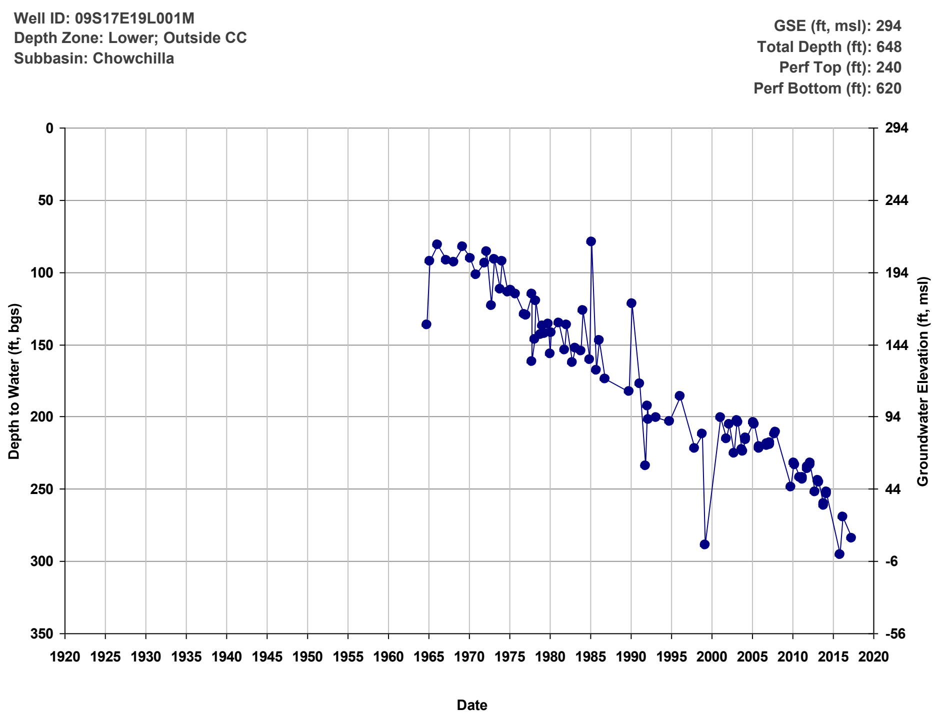

Well ID: 09S16E36J001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla
GSE (ft, msl): 281
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

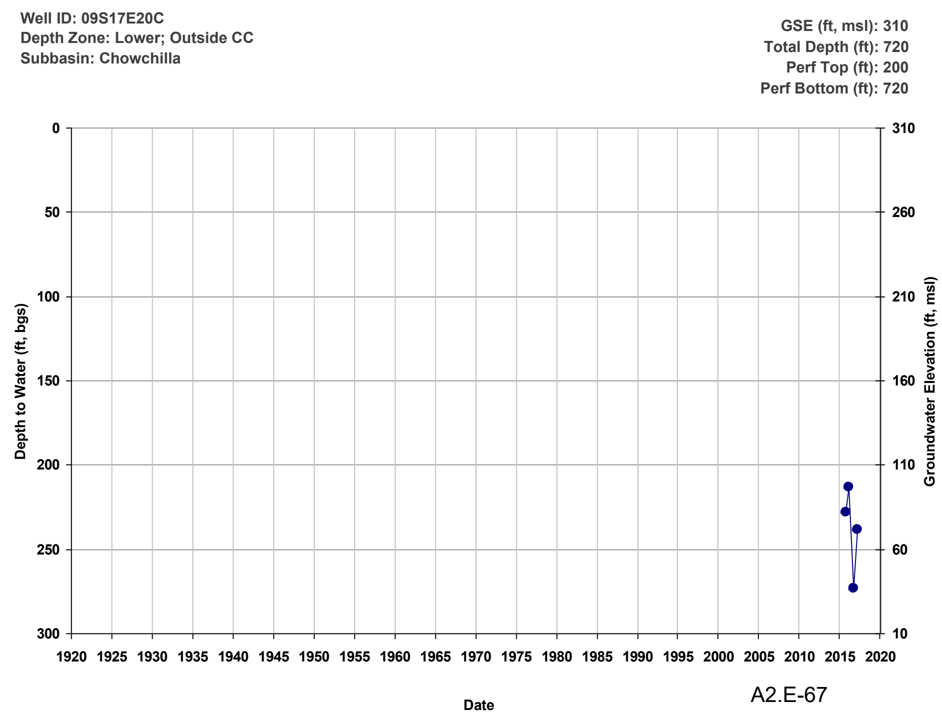

Well ID: 09S17E08F001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla
GSE (ft, msl): 315
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

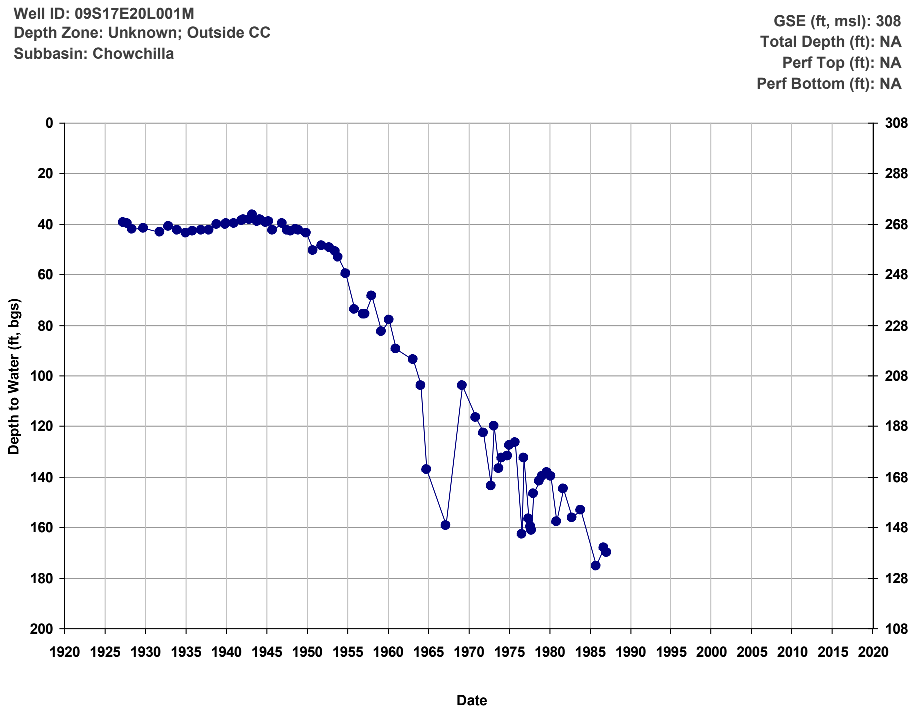

Well ID: 09S17E17F001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla
GSE (ft, msl): 294
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

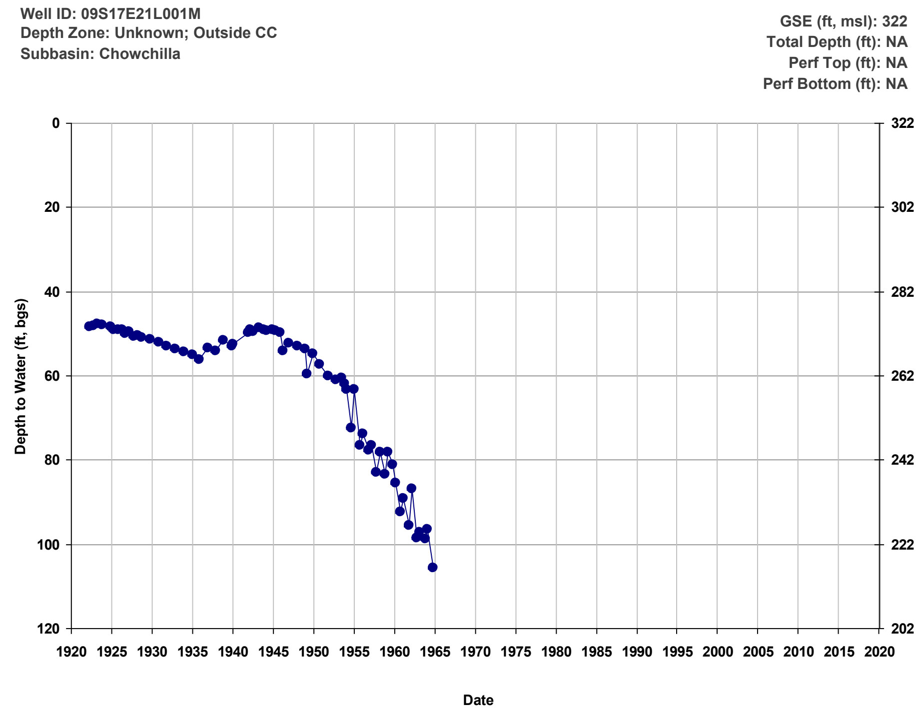

Well ID: 09S17E18D001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla
GSE (ft, msl): 302
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

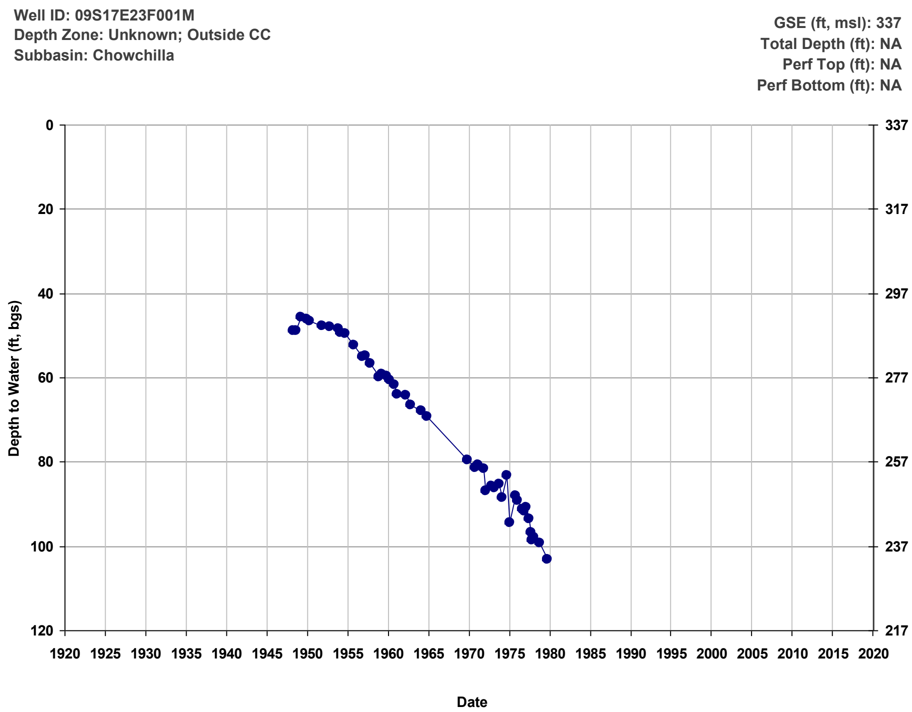

Well ID: 09S17E18N002M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla
GSE (ft, msl): 278
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

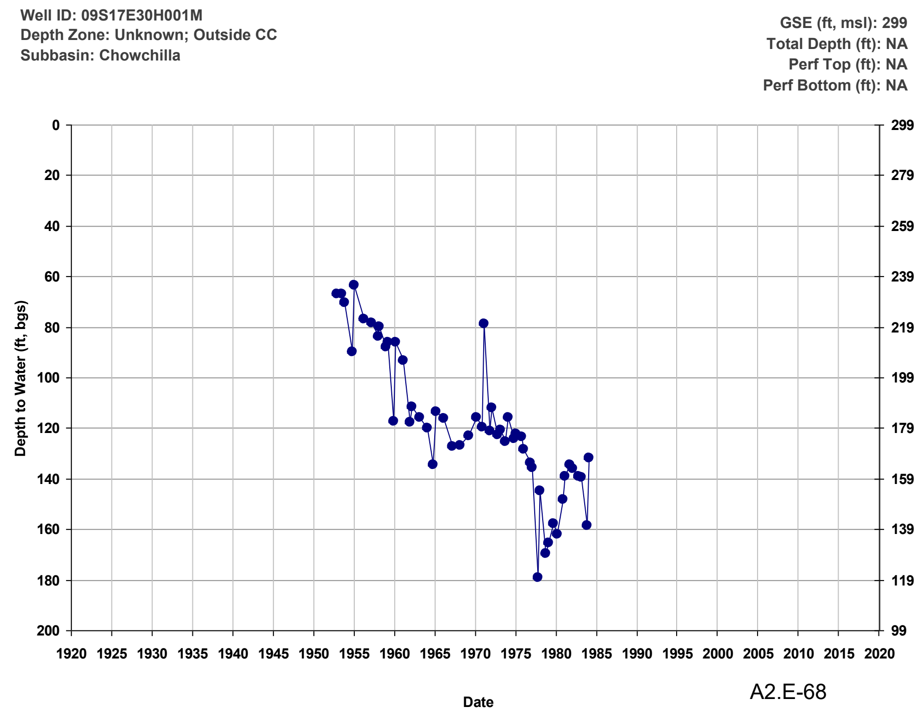

Well ID: 09S17E19L001M
Depth Zone: Lower; Outside CC
Subbasin: Chowchilla
GSE (ft, msl): 294
Total Depth (ft): 648
Perf Top (ft): 240
Perf Bottom (ft): 620
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 09S17E20C
Depth Zone: Lower; Outside CC
Subbasin: Chowchilla
GSE (ft, msl): 310
Total Depth (ft): 720
Perf Top (ft): 200
Perf Bottom (ft): 720
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 09S17E20L001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla
GSE (ft, msl): 308
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

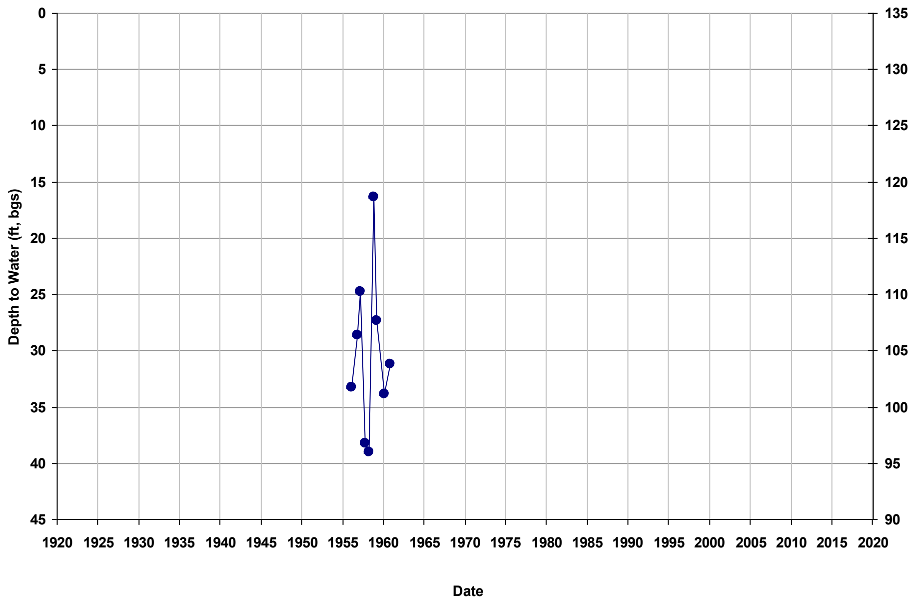

Well ID: 09S17E21L001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla
GSE (ft, msl): 322
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 09S17E23F001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla
GSE (ft, msl): 337
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 09S17E30H001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla
GSE (ft, msl): 299
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

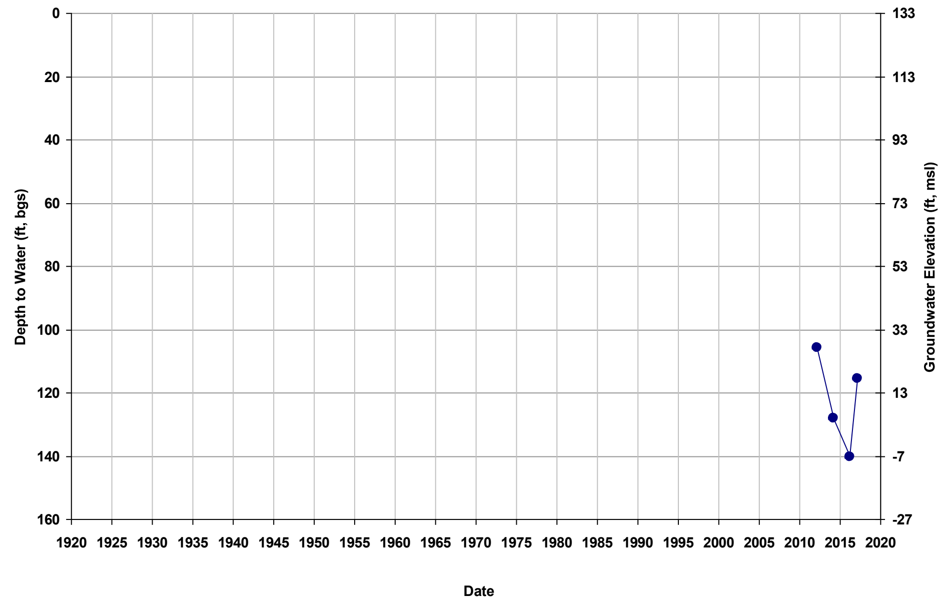
Well ID: 10S13E13A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 134
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



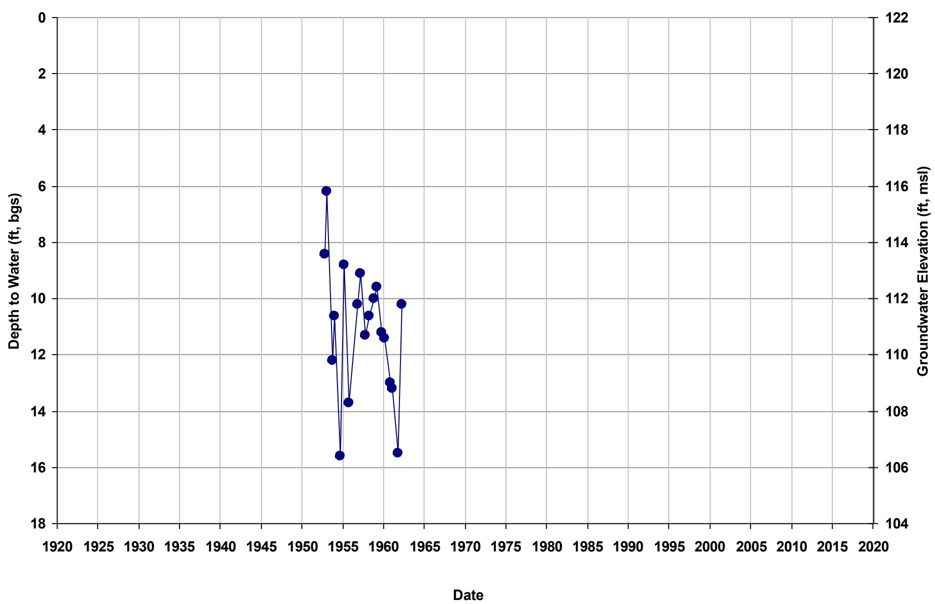
Well ID: 10S13E13J001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 132
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



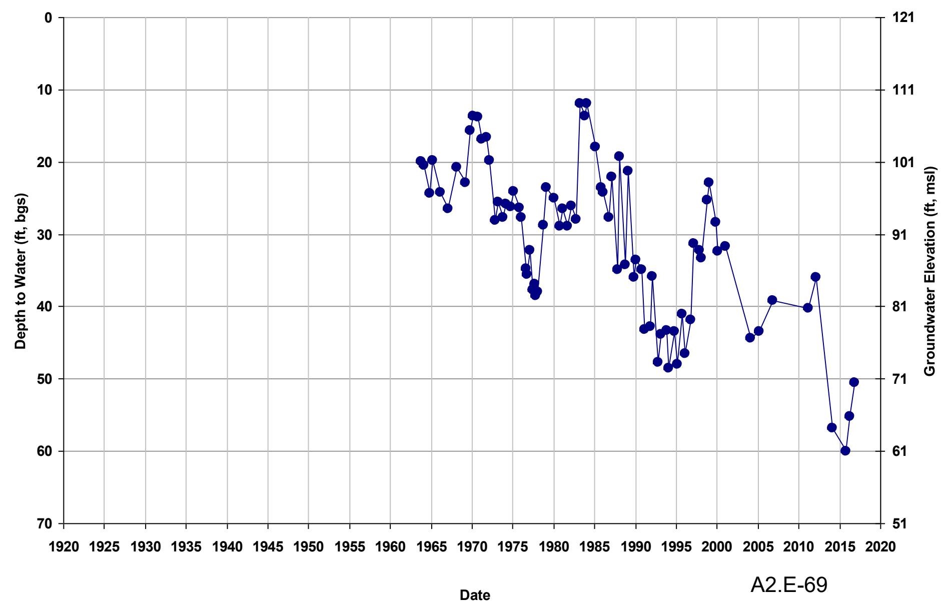
Well ID: 10S13E22Q002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 122
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



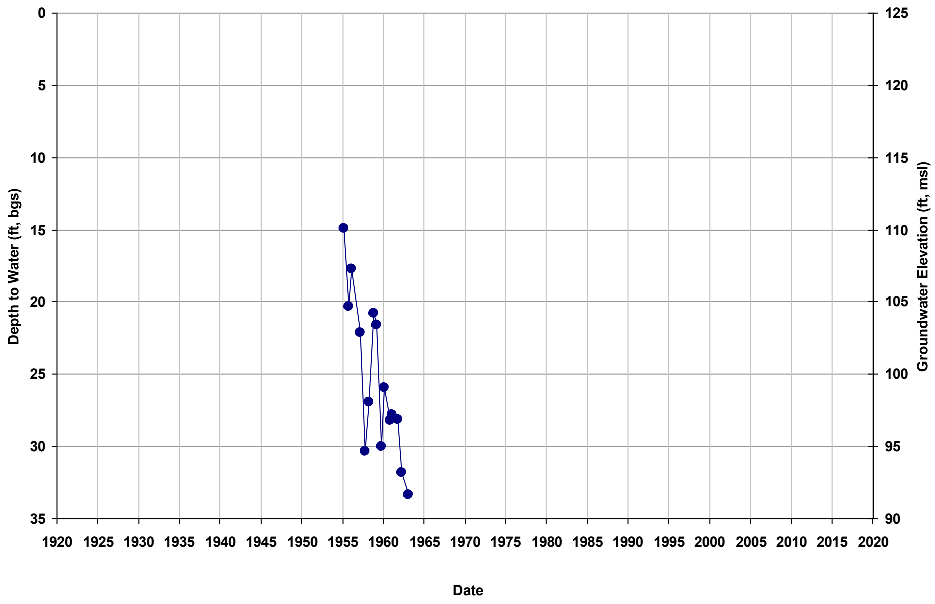
Well ID: 10S13E22R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 121
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



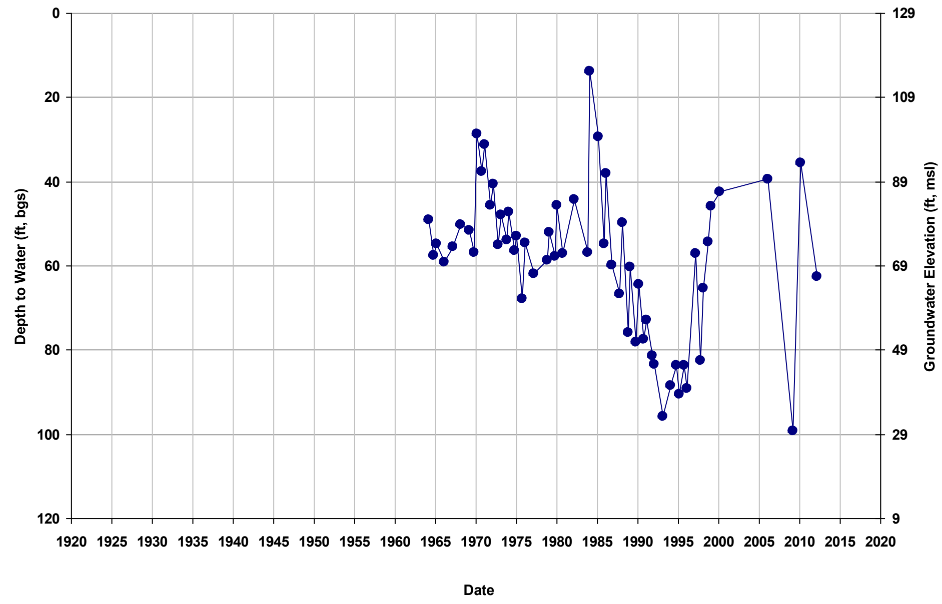
Well ID: 10S13E24E001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 125
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



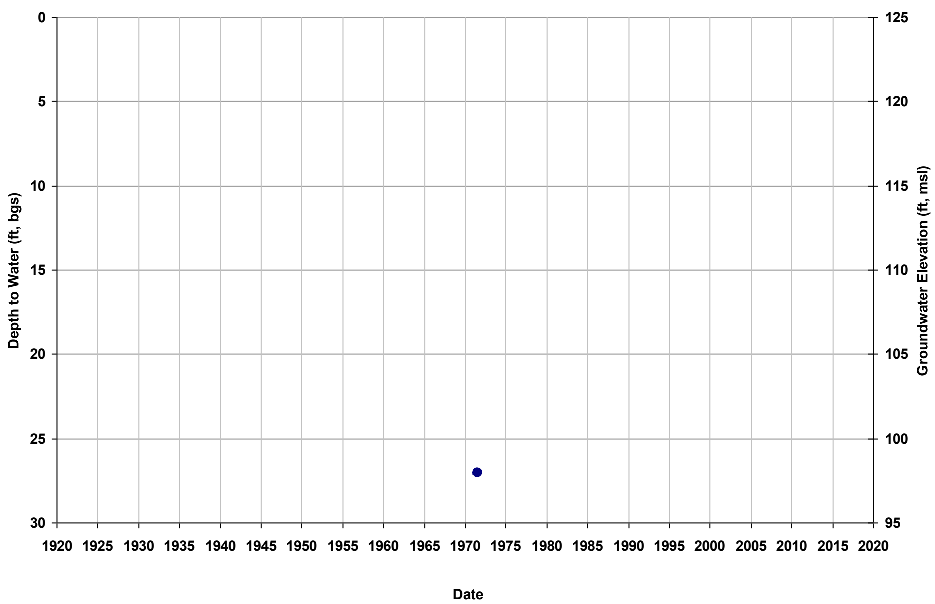
Well ID: 10S13E24L001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 129
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



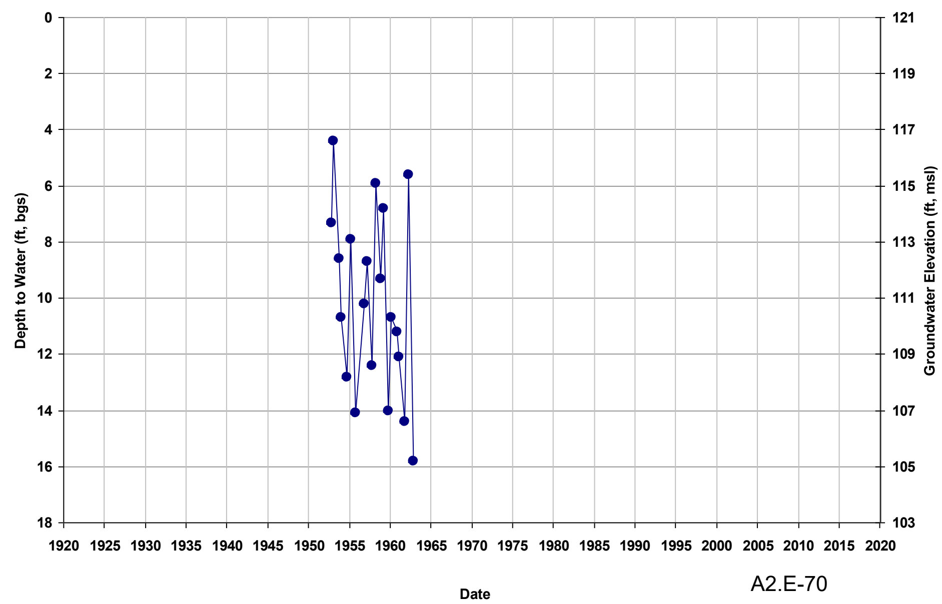
Well ID: 10S13E26J001M
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 125
Total Depth (ft): 175
Perf Top (ft): NA
Perf Bottom (ft): NA



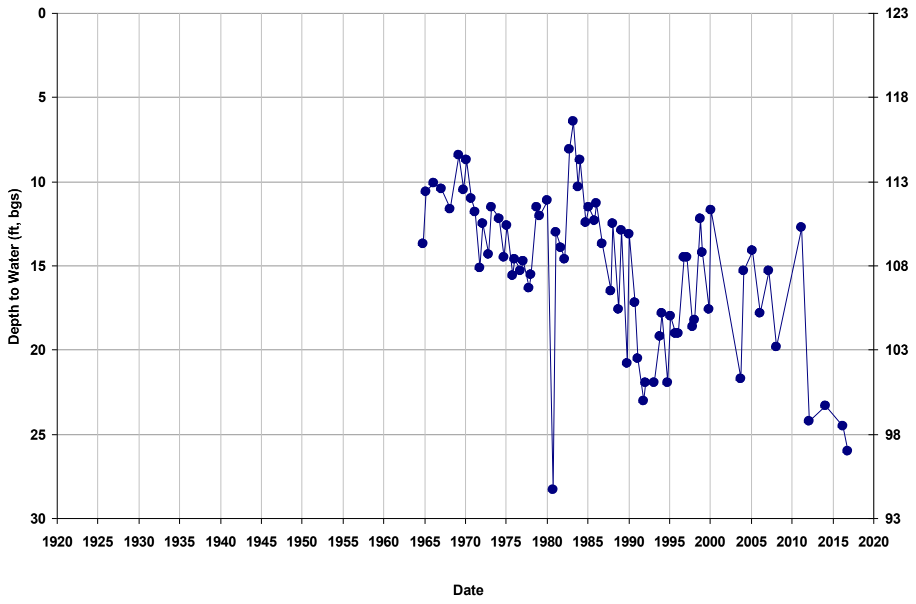
Well ID: 10S13E27R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 121
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



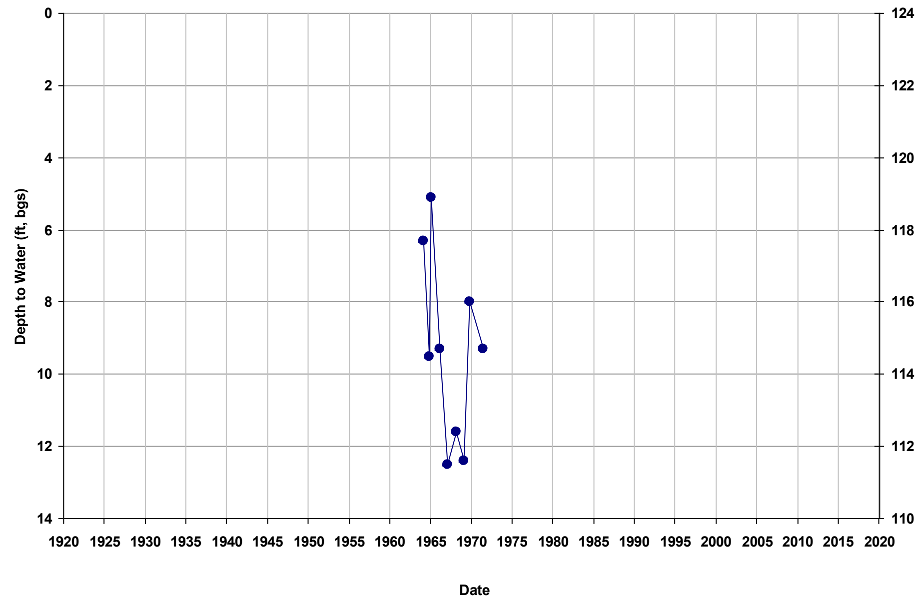
Well ID: 10S13E34G001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 123
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



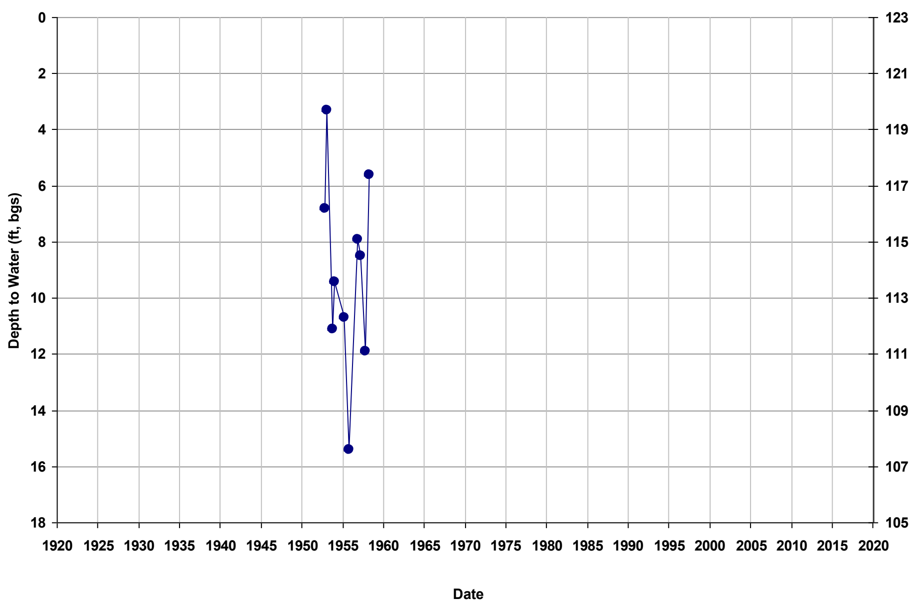
Well ID: 10S13E35G001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 124
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



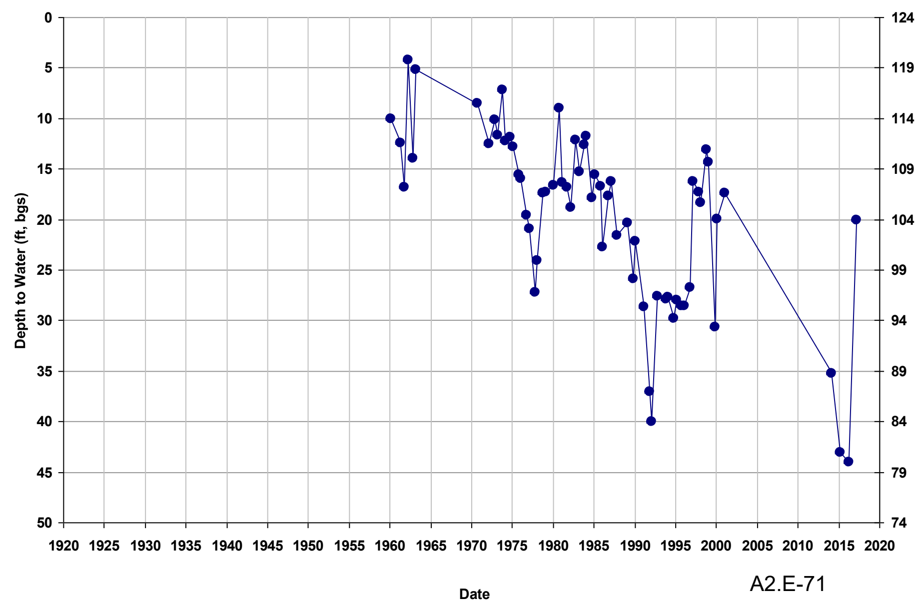
Well ID: 10S13E35H001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 123
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



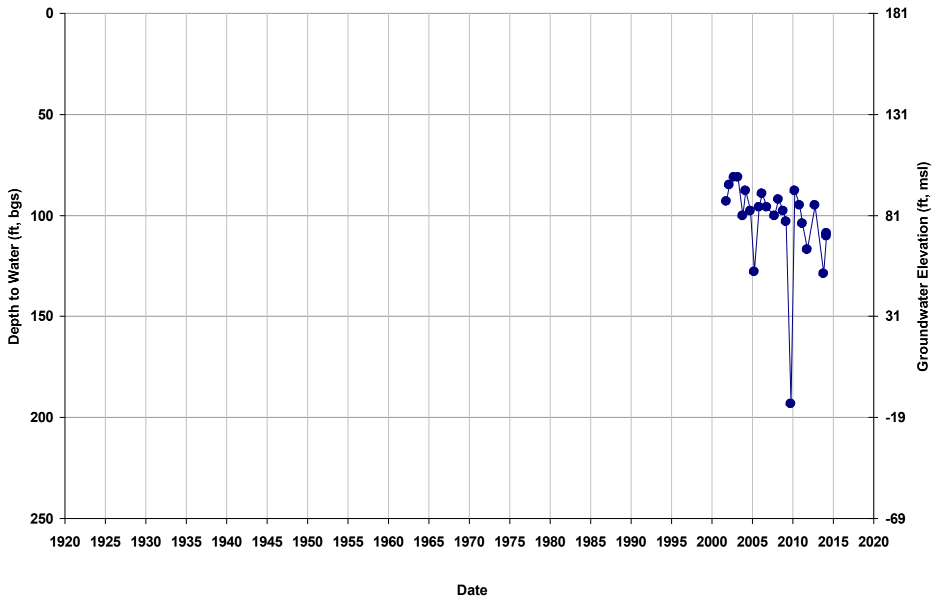
Well ID: 10S13E35K001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 124
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



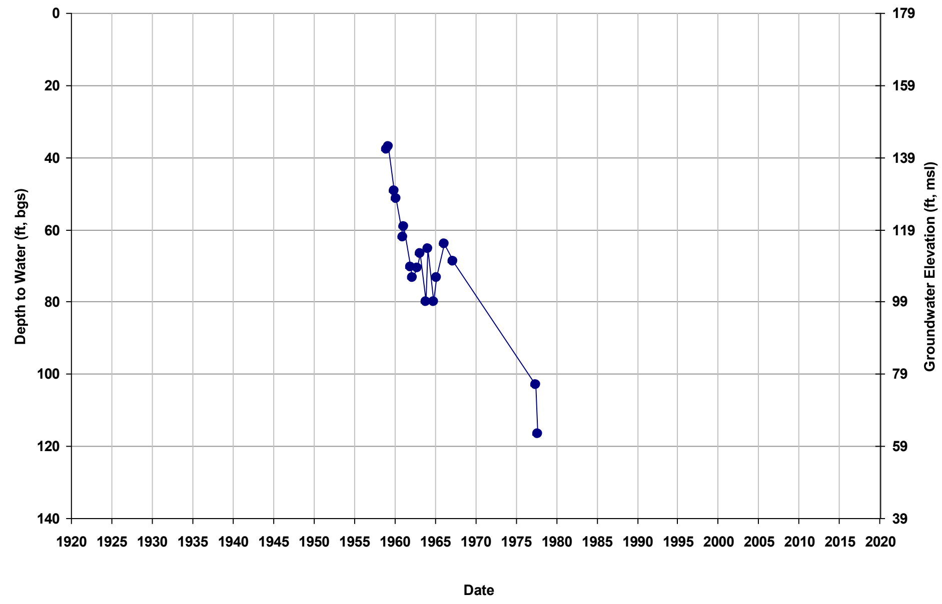
Well ID: 10S14E01A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 181
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



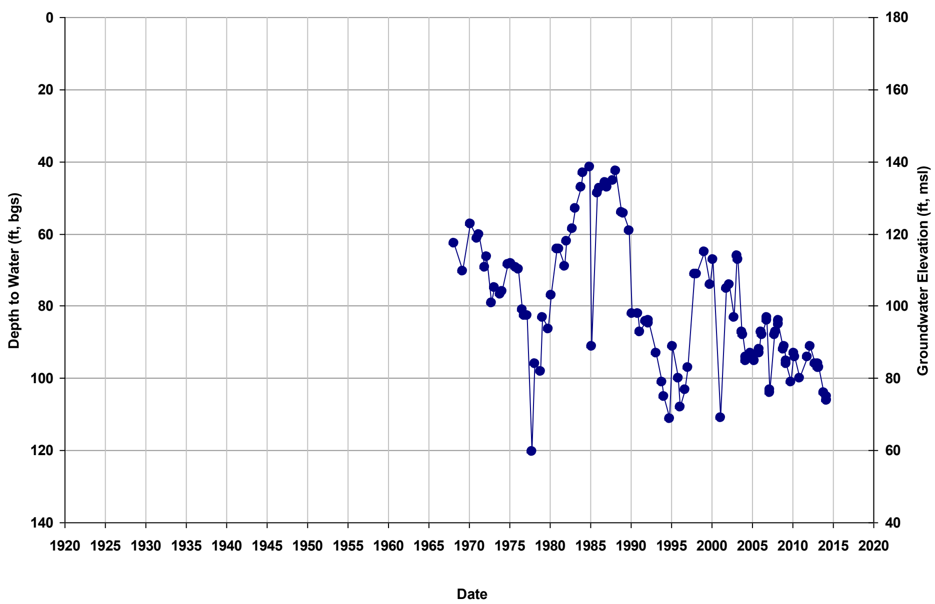
Well ID: 10S14E01R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 179
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



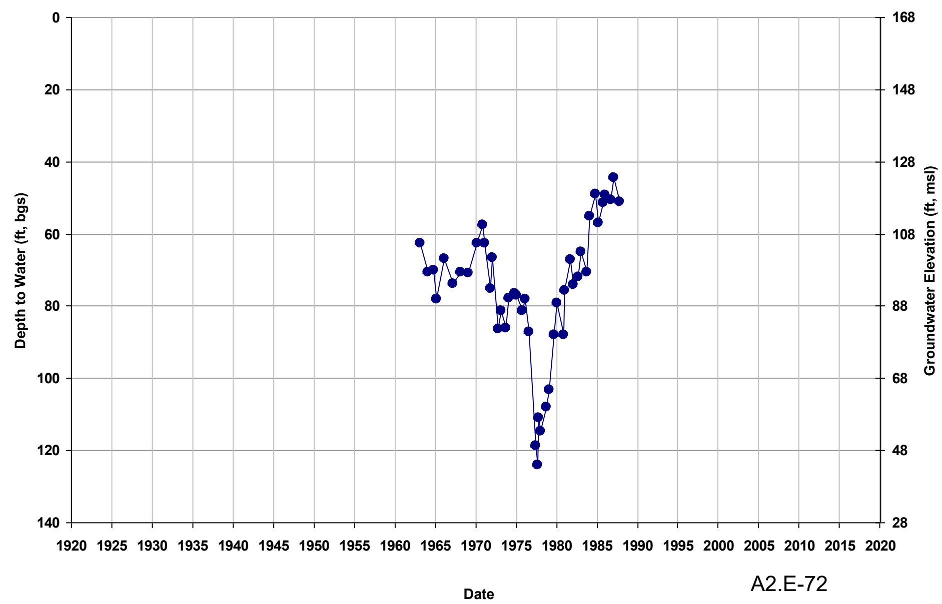
Well ID: 10S14E01R002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 180
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



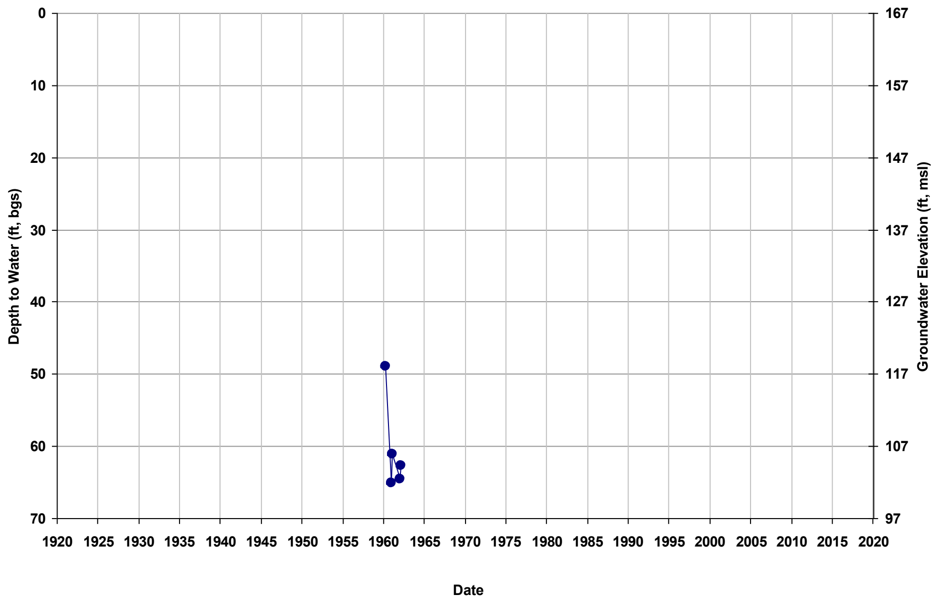
Well ID: 10S14E02L001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 168
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



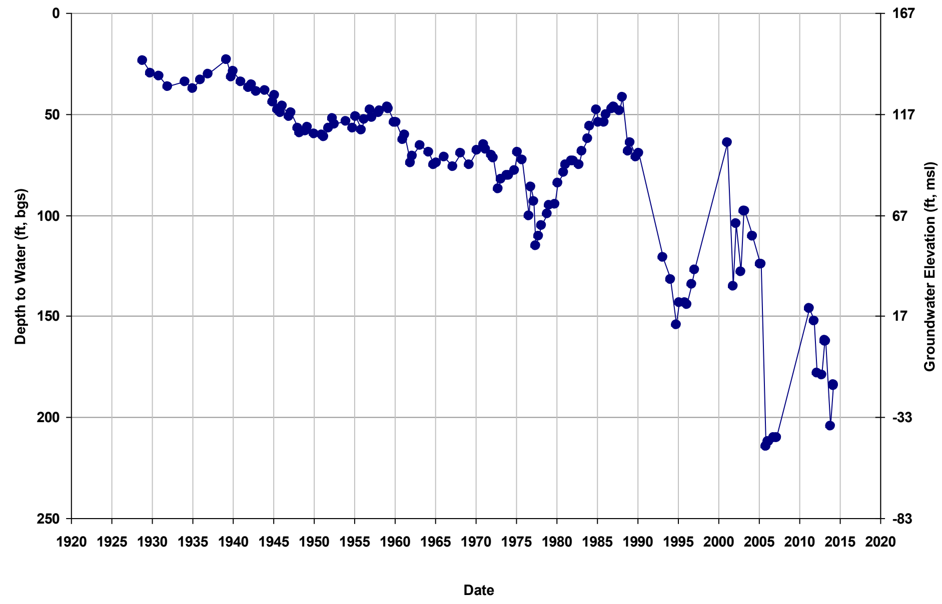
Well ID: 10S14E02Q001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 167
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



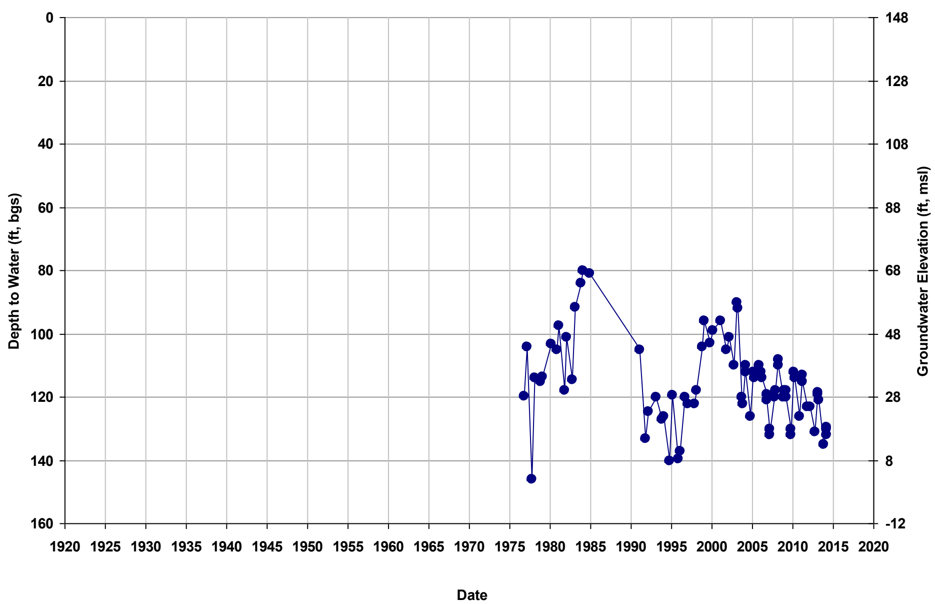
Well ID: 10S14E03A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 167
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



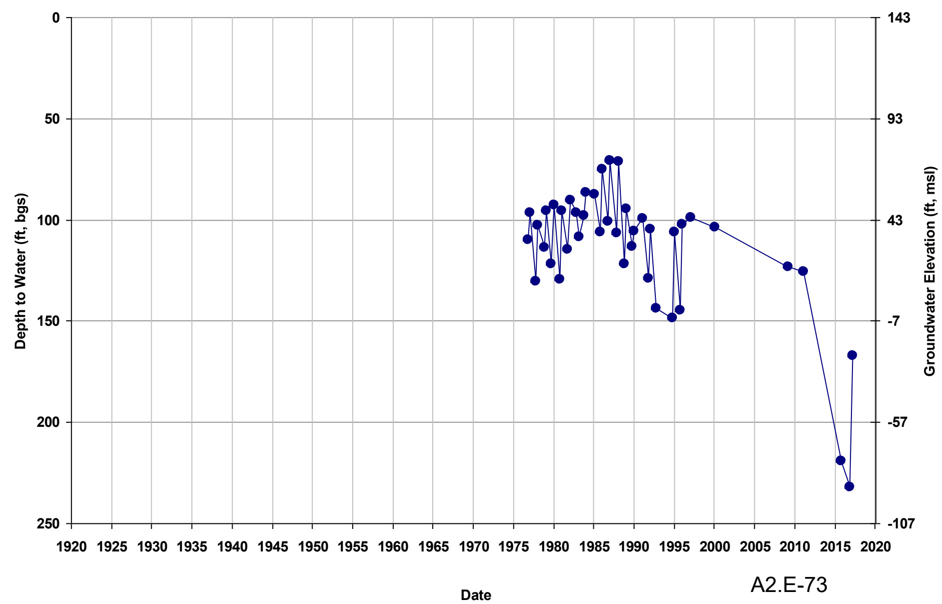
Well ID: 10S14E05C003M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 148
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



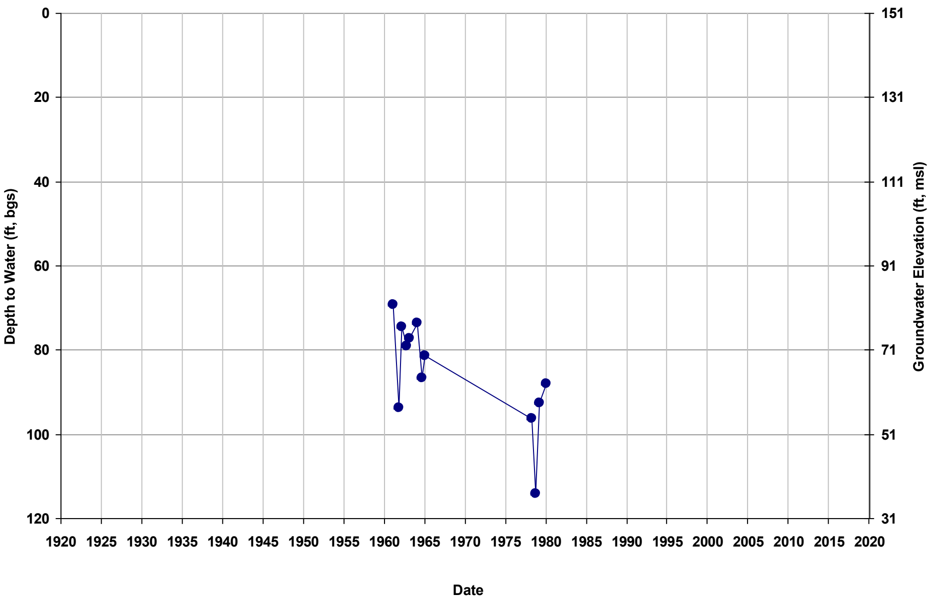
Well ID: 10S14E06R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 143
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



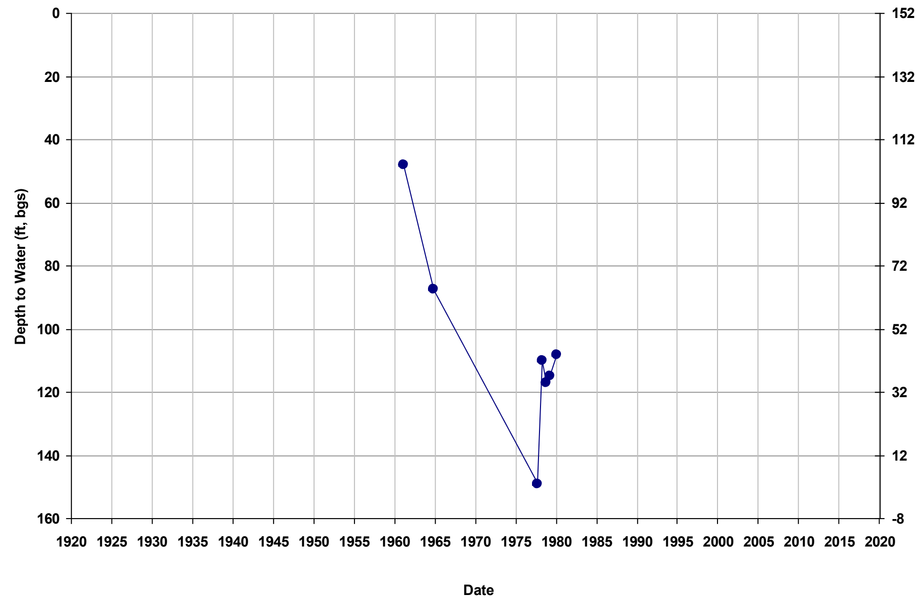
Well ID: 10S14E08B001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 151
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



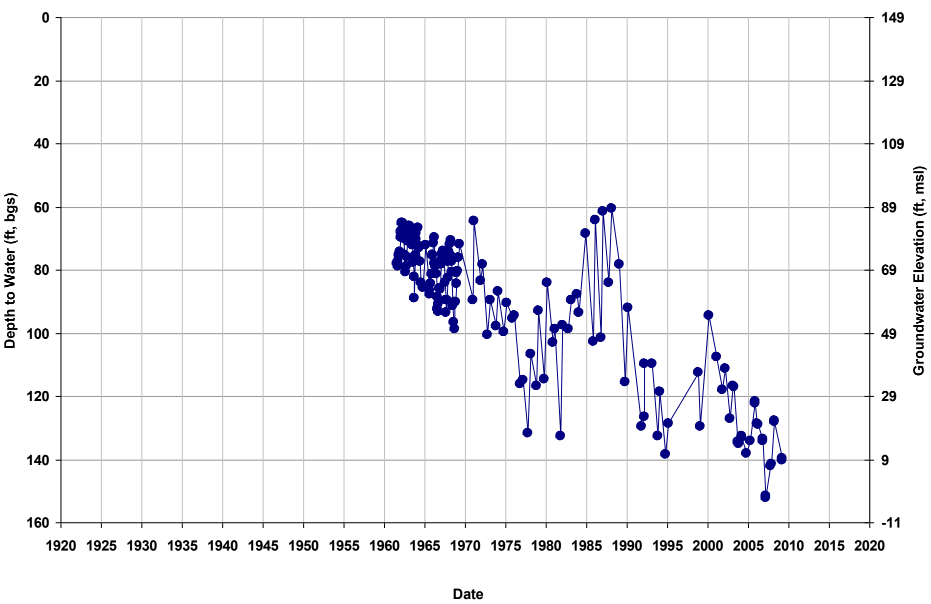
Well ID: 10S14E08B002M
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 152
Total Depth (ft): 137
Perf Top (ft): NA
Perf Bottom (ft): NA



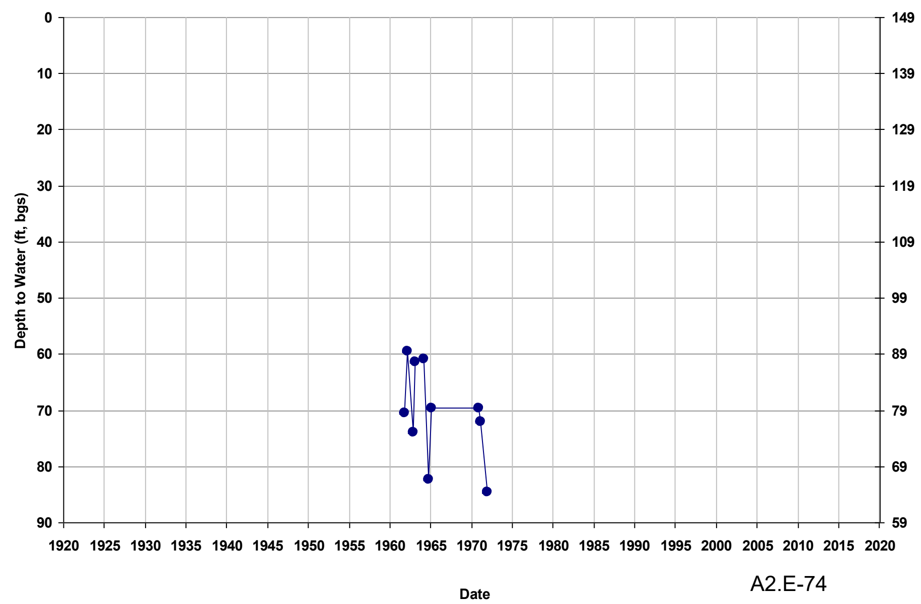
Well ID: 10S14E08B003M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 149
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



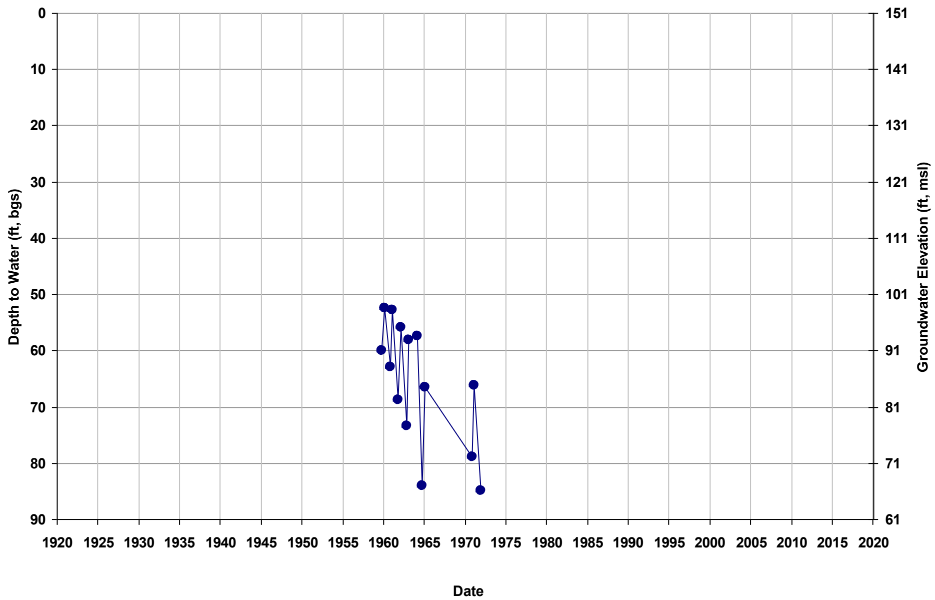
Well ID: 10S14E08B004M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 149
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



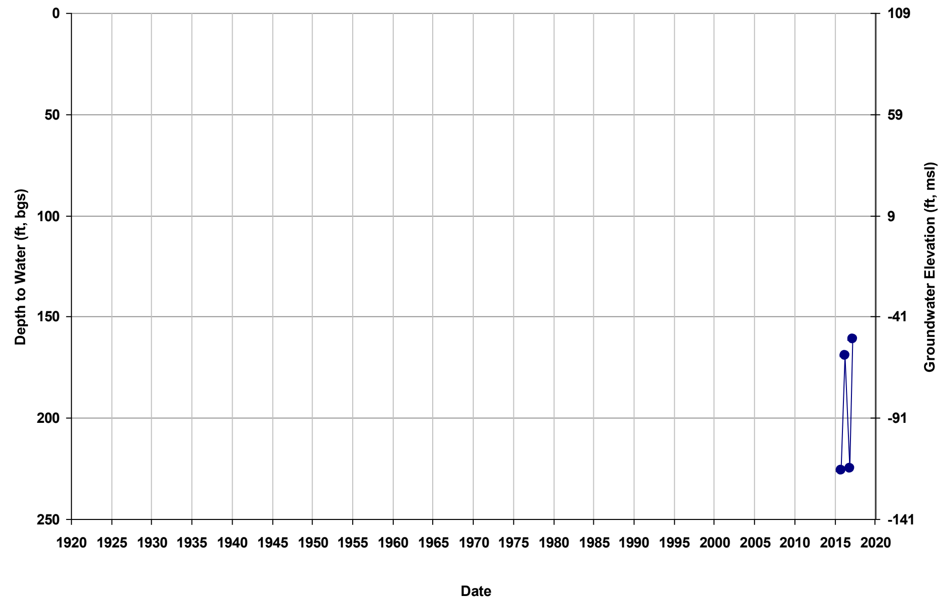
Well ID: 10S14E08B005M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 151
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



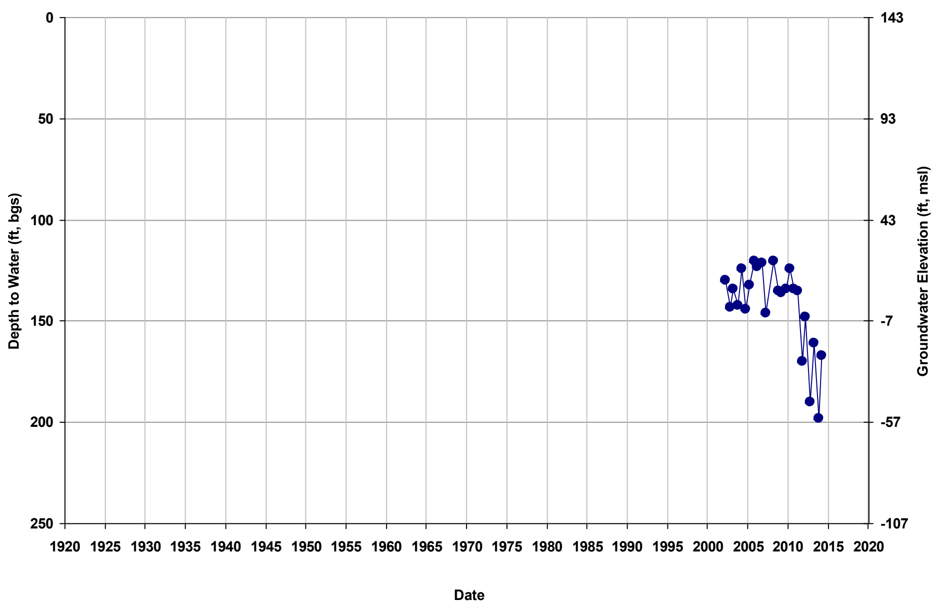
Well ID: 10S14E08D
Depth Zone: Composite; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 109
Total Depth (ft): 410
Perf Top (ft): 230
Perf Bottom (ft): 360



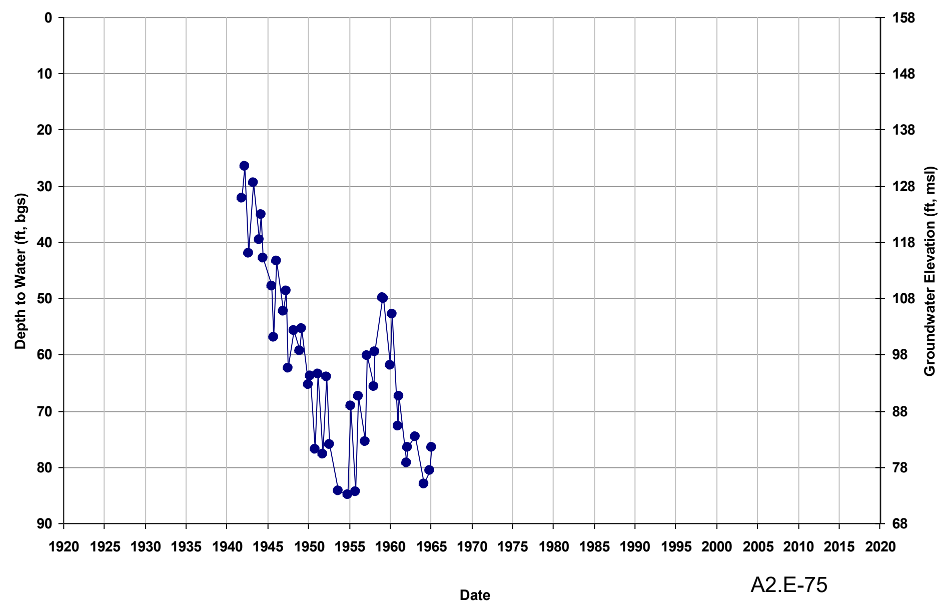
Well ID: 10S14E08N001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 142
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



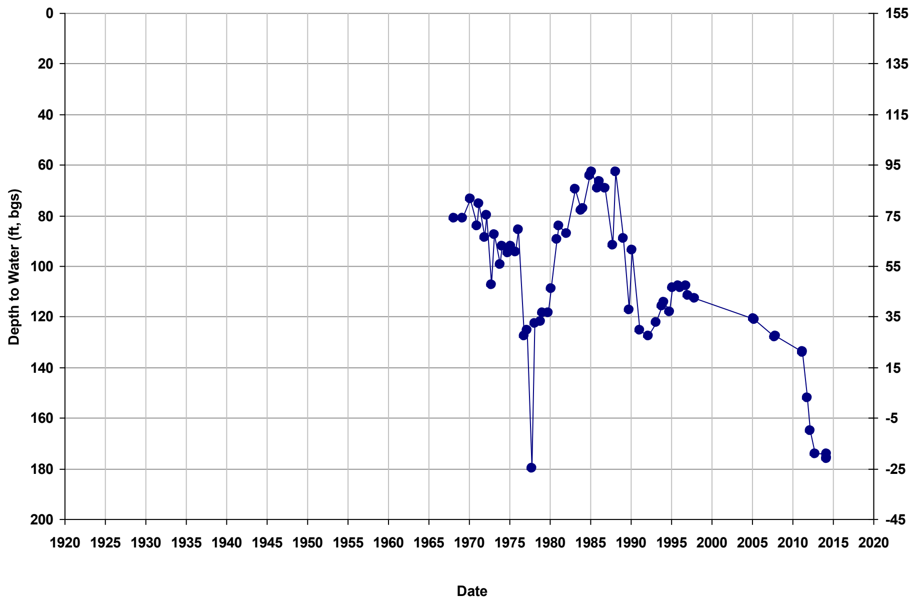
Well ID: 10S14E09A002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 157
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



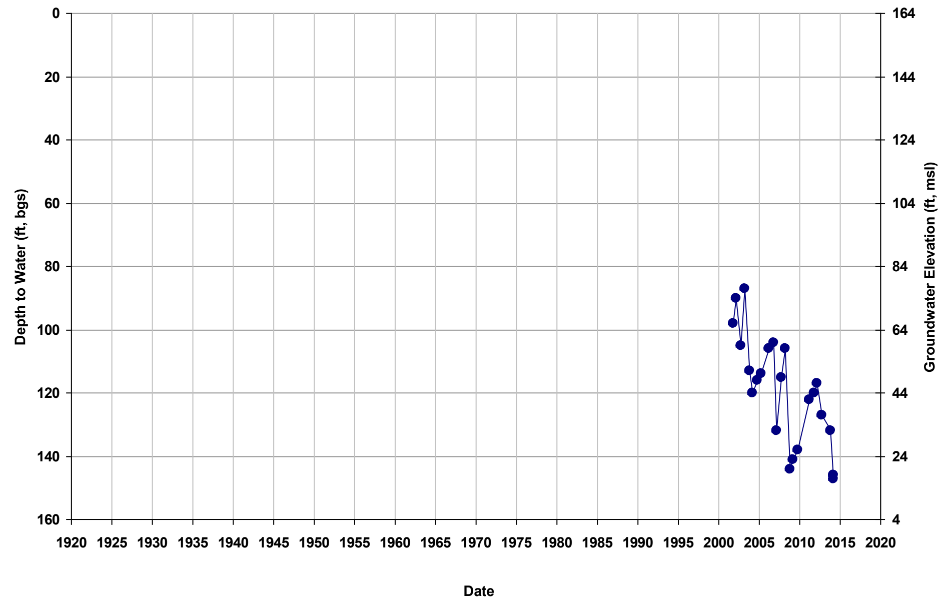
Well ID: 10S14E09A003M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 155
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



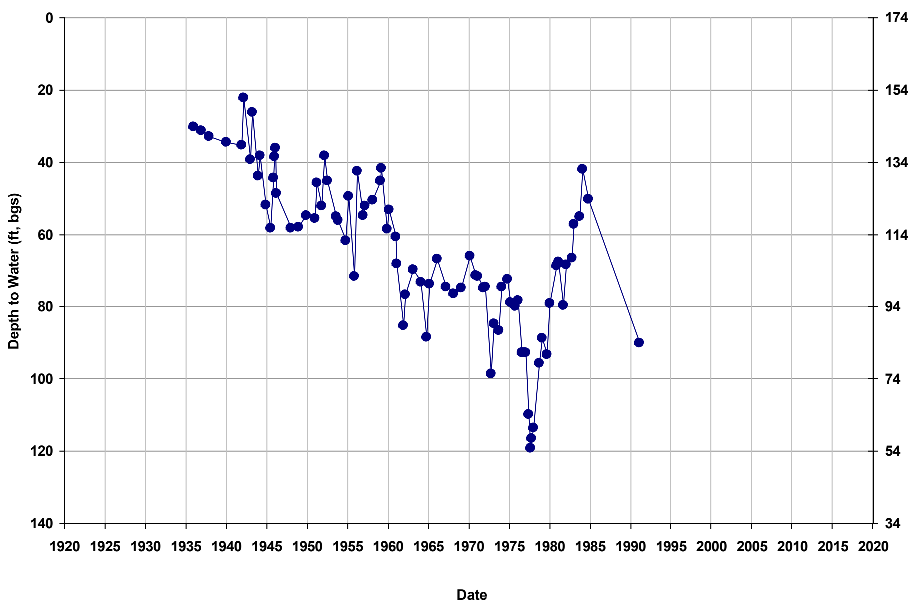
Well ID: 10S14E10H001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 164
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



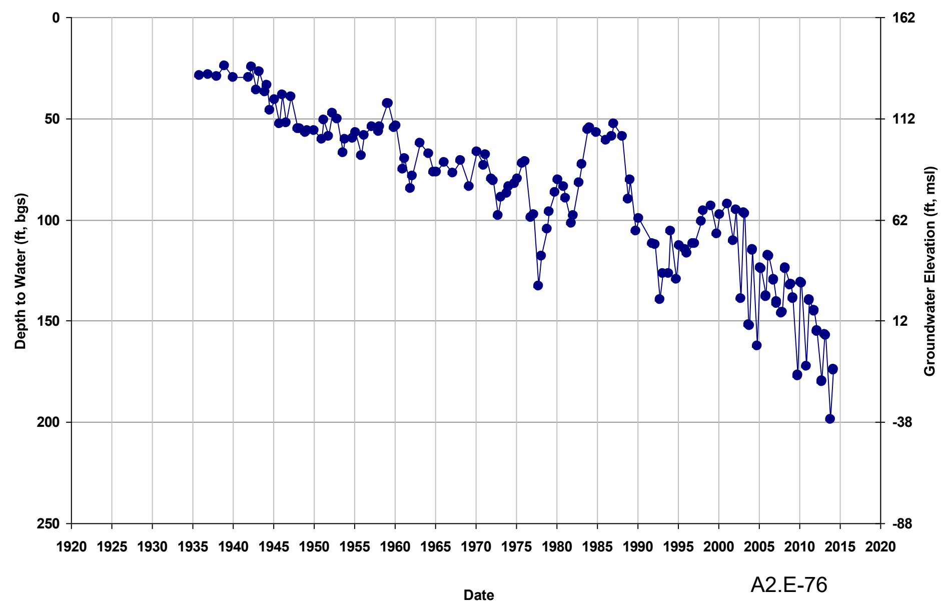
Well ID: 10S14E11R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 173
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



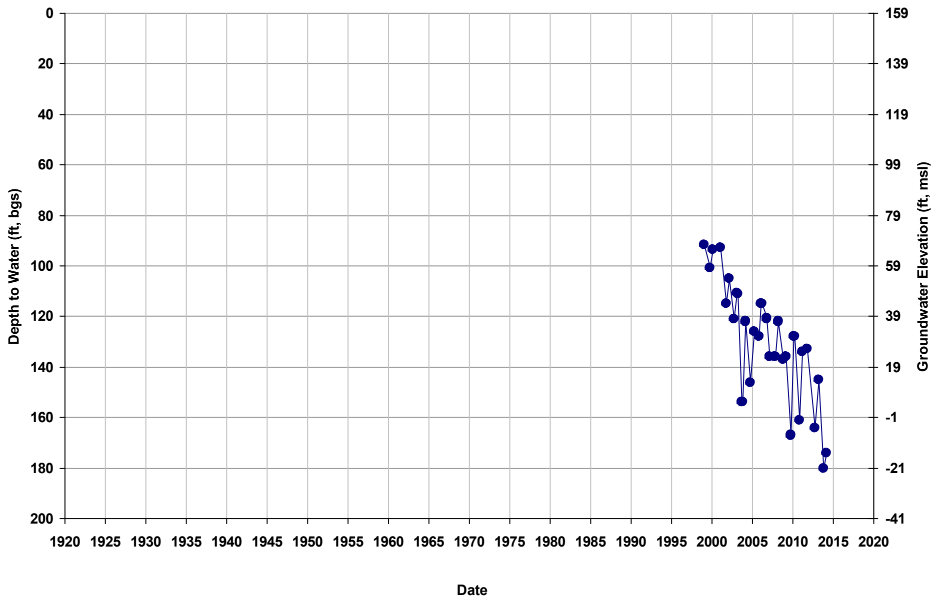
Well ID: 10S14E15H001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 162
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



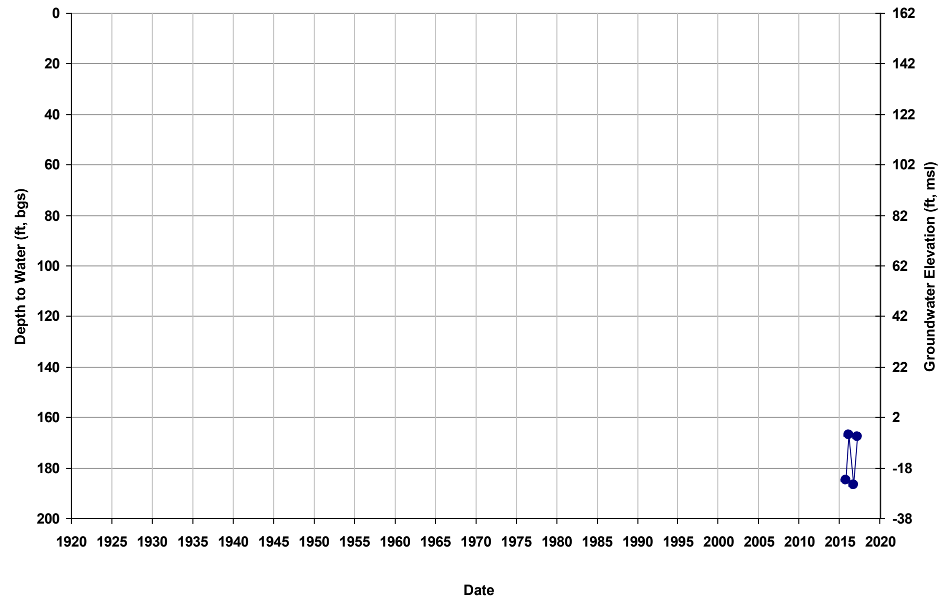
Well ID: 10S14E15J001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 159
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



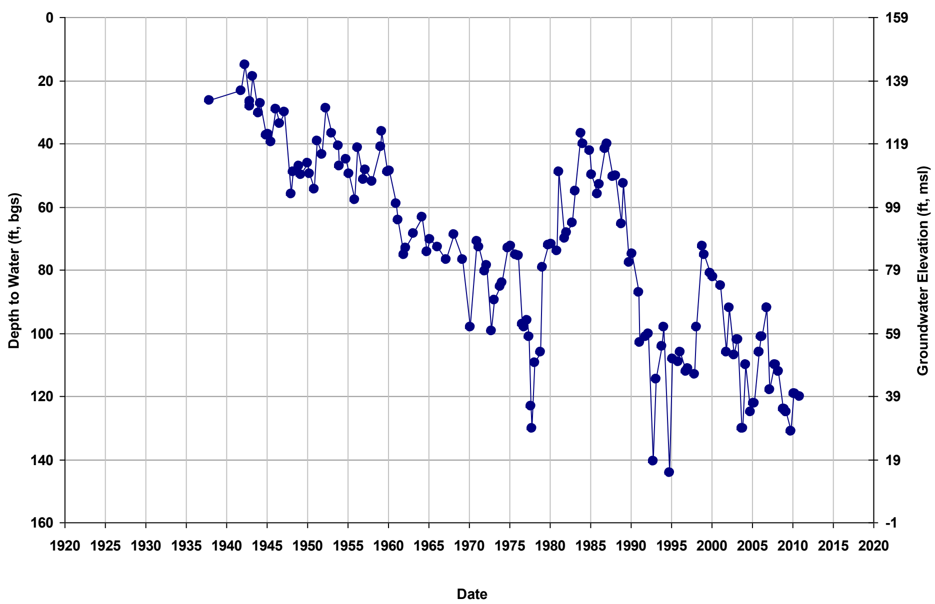
Well ID: 10S14E15J1
Depth Zone: Composite; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 162
Total Depth (ft): 330
Perf Top (ft): 135
Perf Bottom (ft): 288



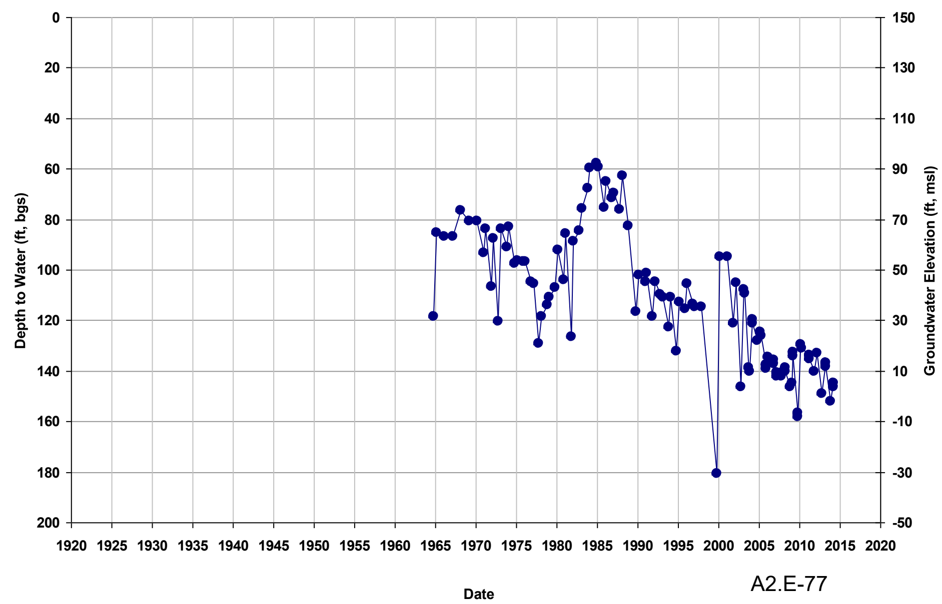
Well ID: 10S14E15R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 159
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



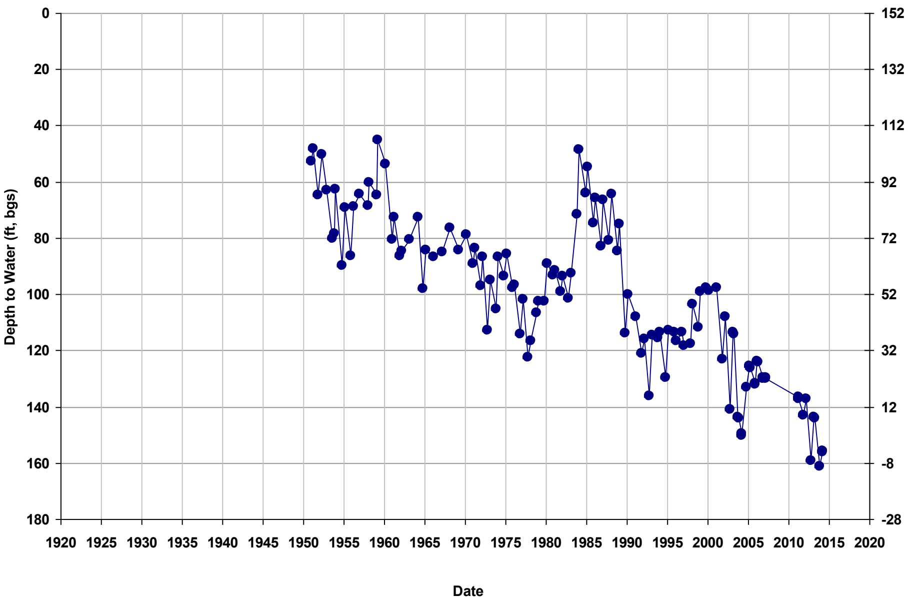
Well ID: 10S14E16F002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 150
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



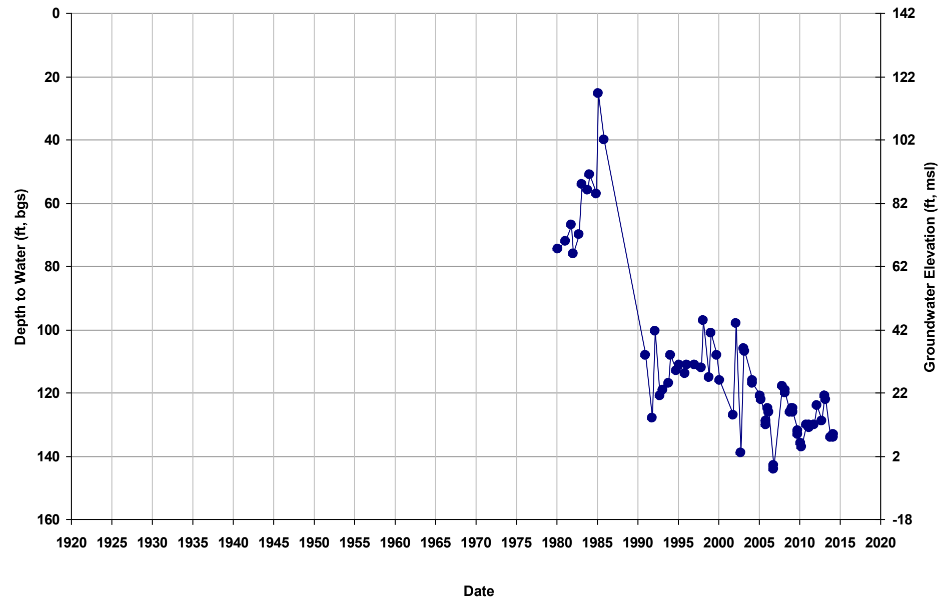
Well ID: 10S14E16H001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 152
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



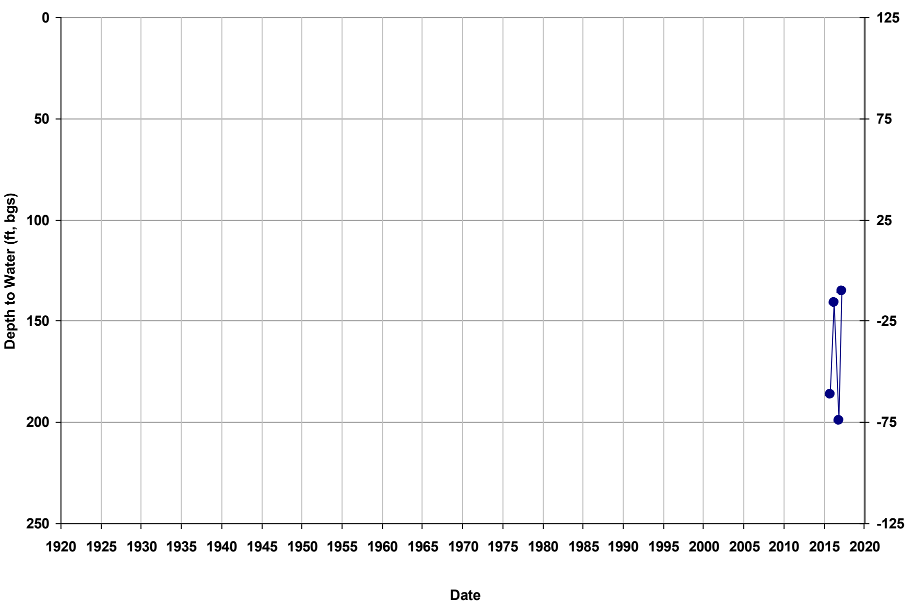
Well ID: 10S14E17J001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 142
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



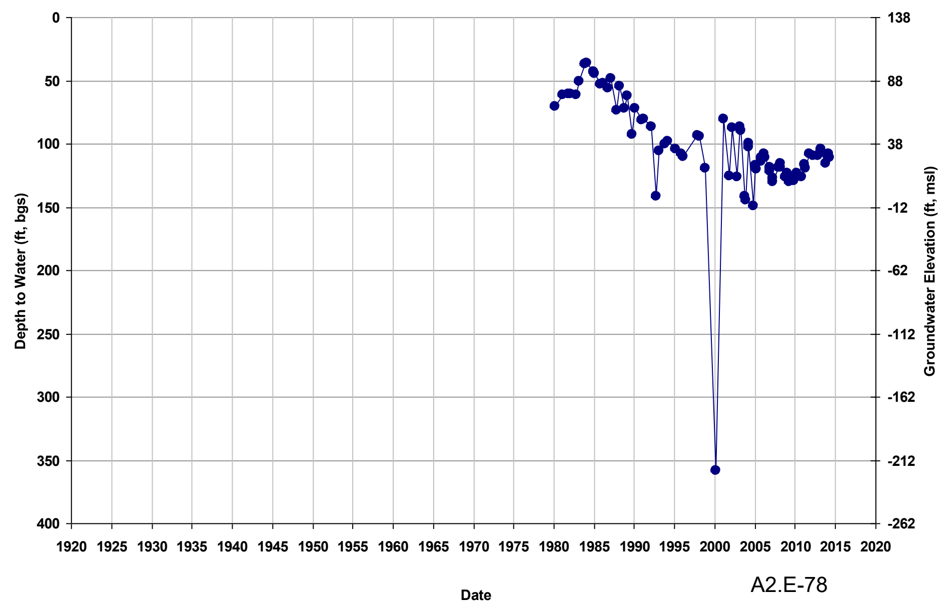
Well ID: 10S14E18D
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 125
Total Depth (ft): 516
Perf Top (ft): 265
Perf Bottom (ft): 506



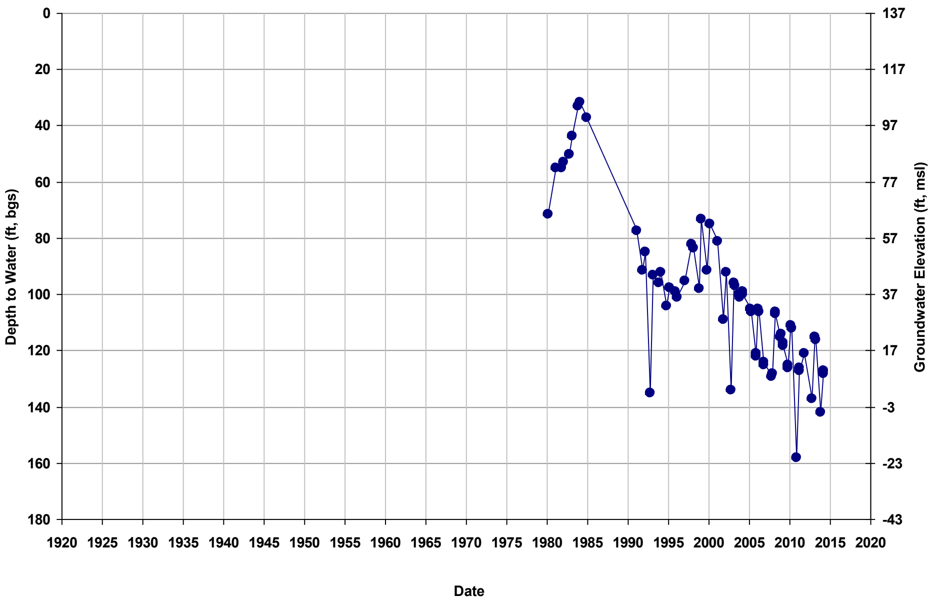
Well ID: 10S14E18K001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 138
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



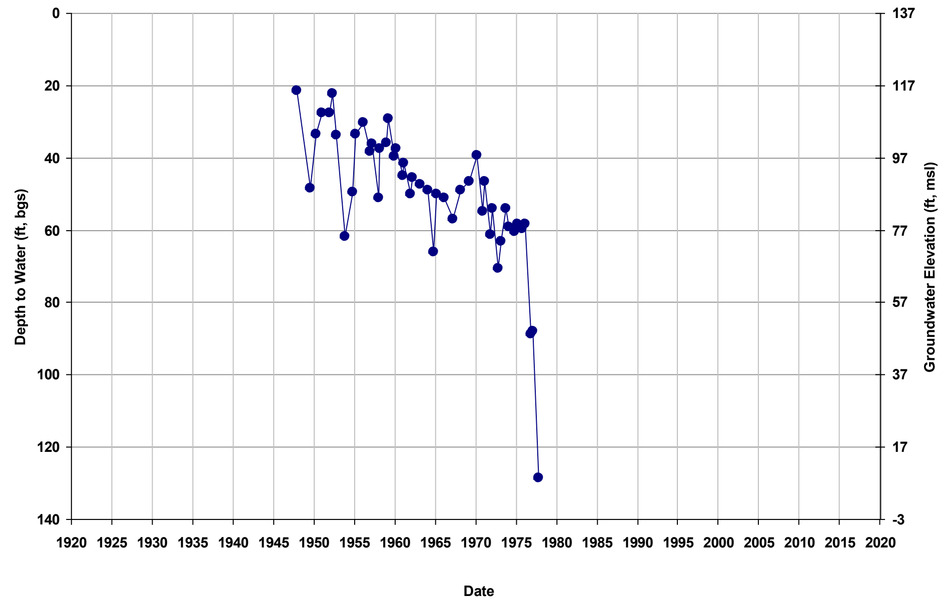
Well ID: 10S14E19A002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 137
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



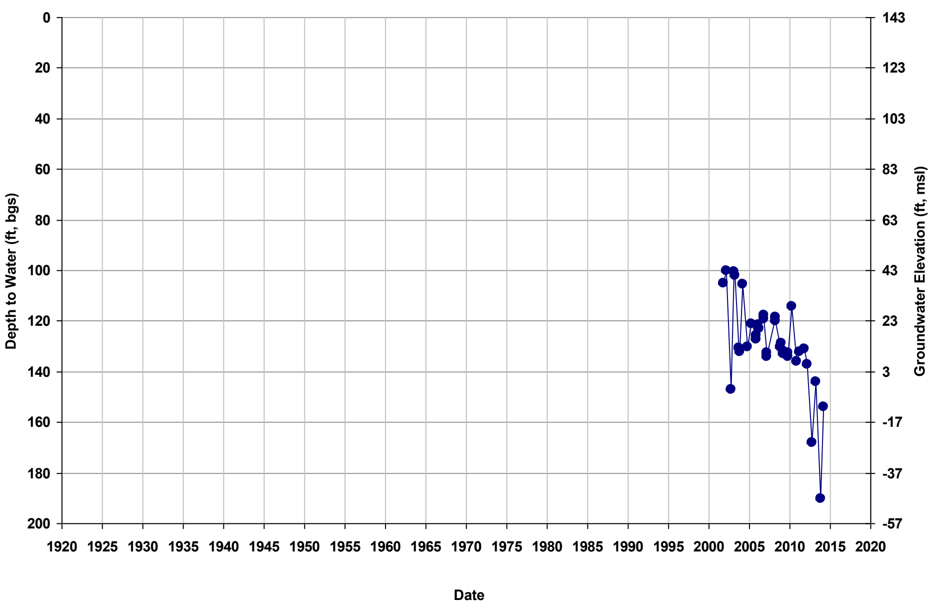
Well ID: 10S14E19R003M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 136
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



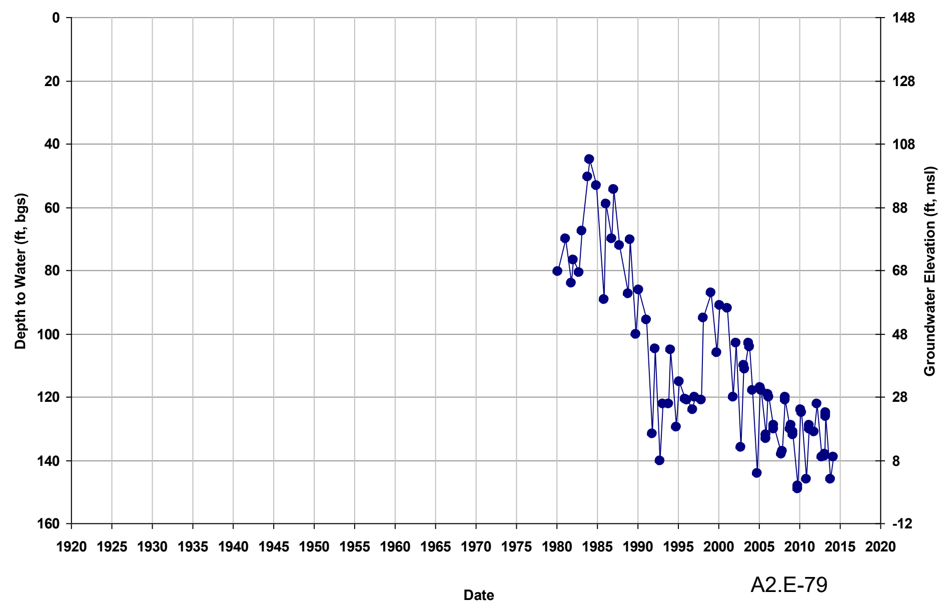
Well ID: 10S14E20H002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 143
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



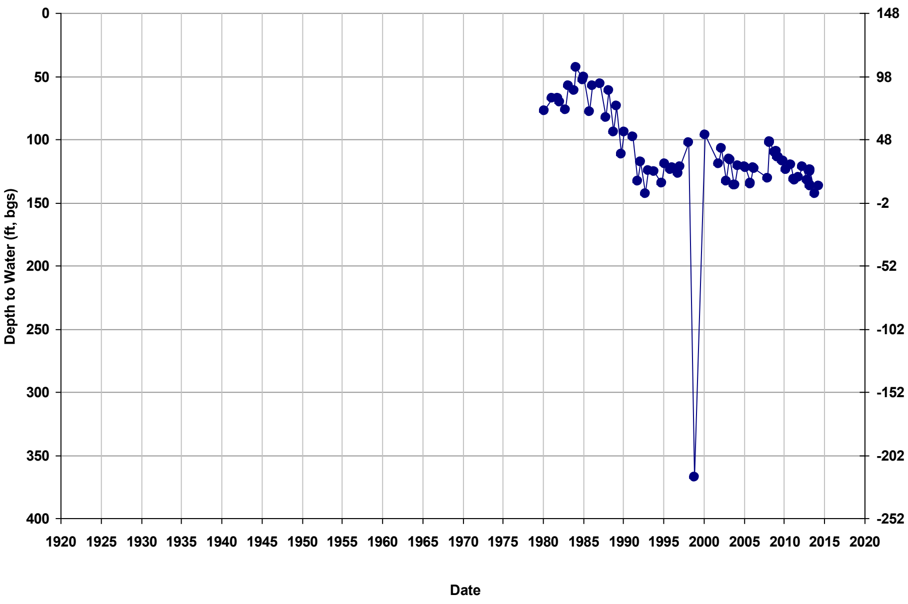
Well ID: 10S14E21C003M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 147
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



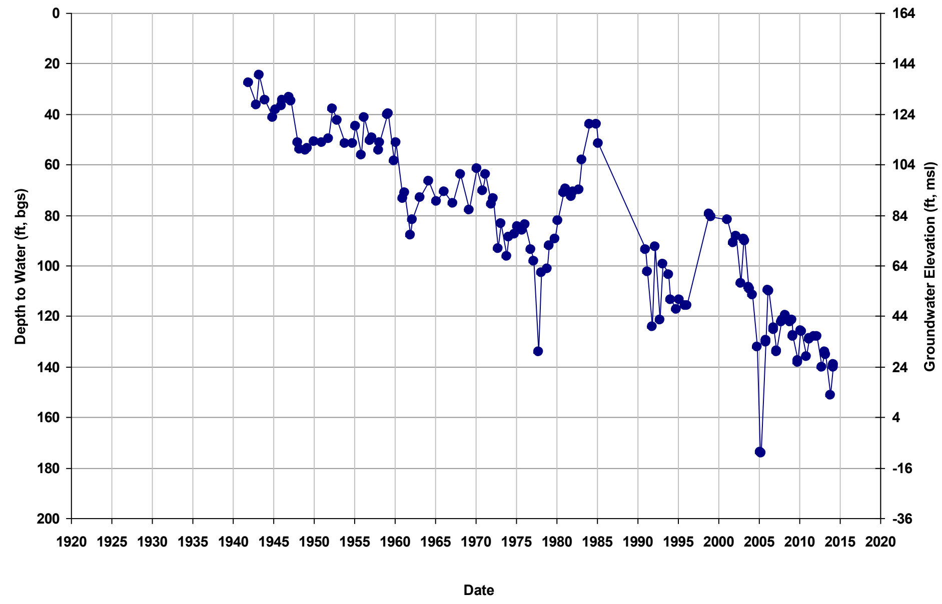
Well ID: 10S14E21G001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 148
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



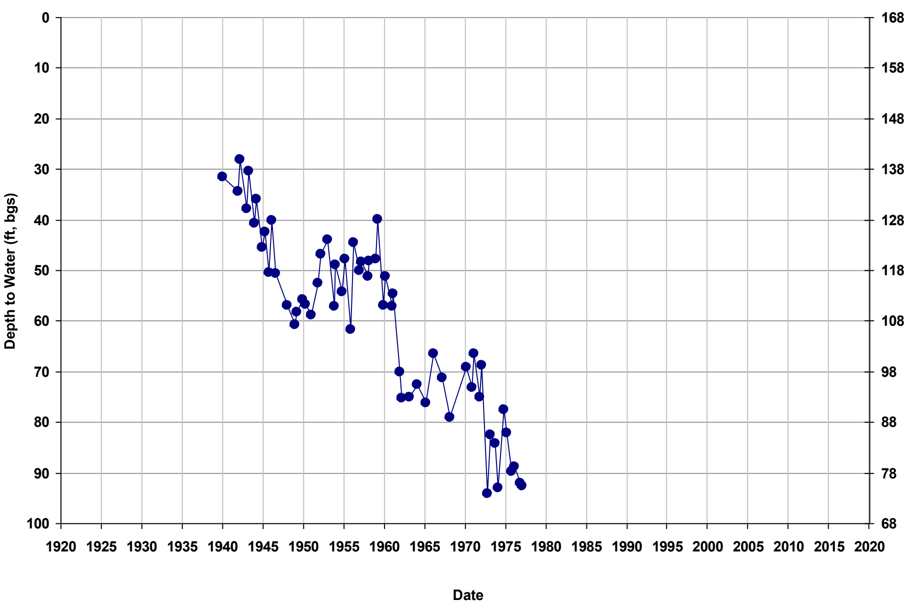
Well ID: 10S14E23A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 164
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



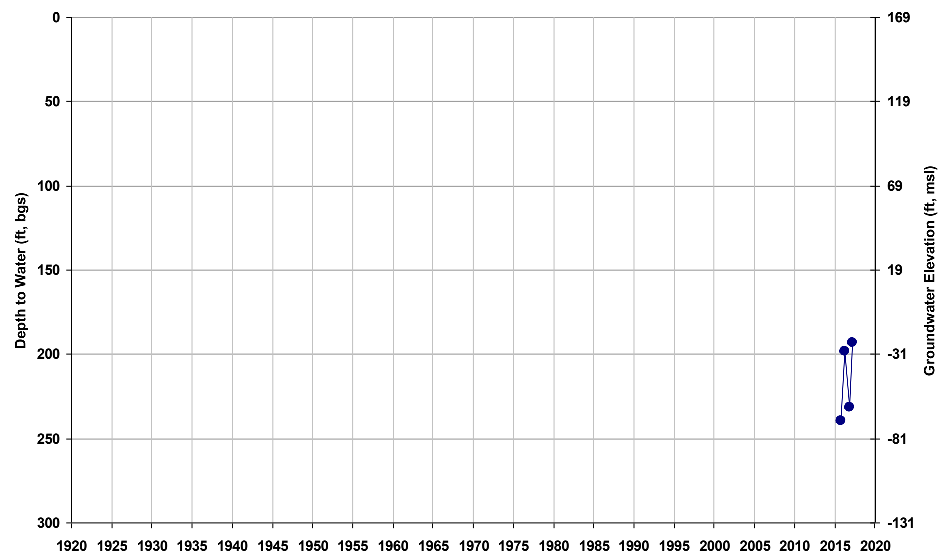
Well ID: 10S14E24C001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

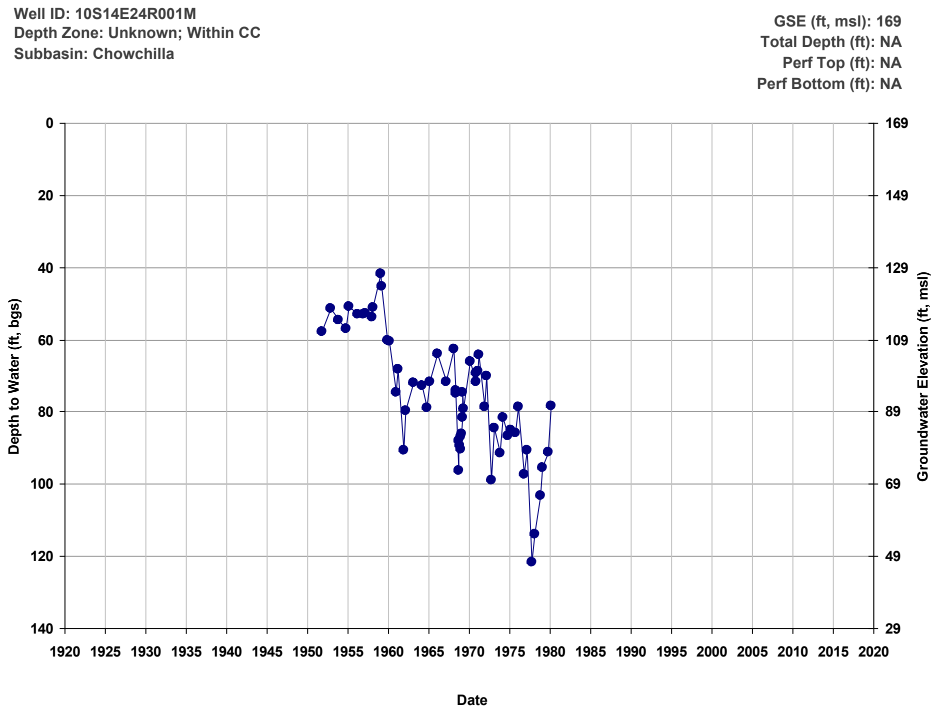
GSE (ft, msl): 168
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA

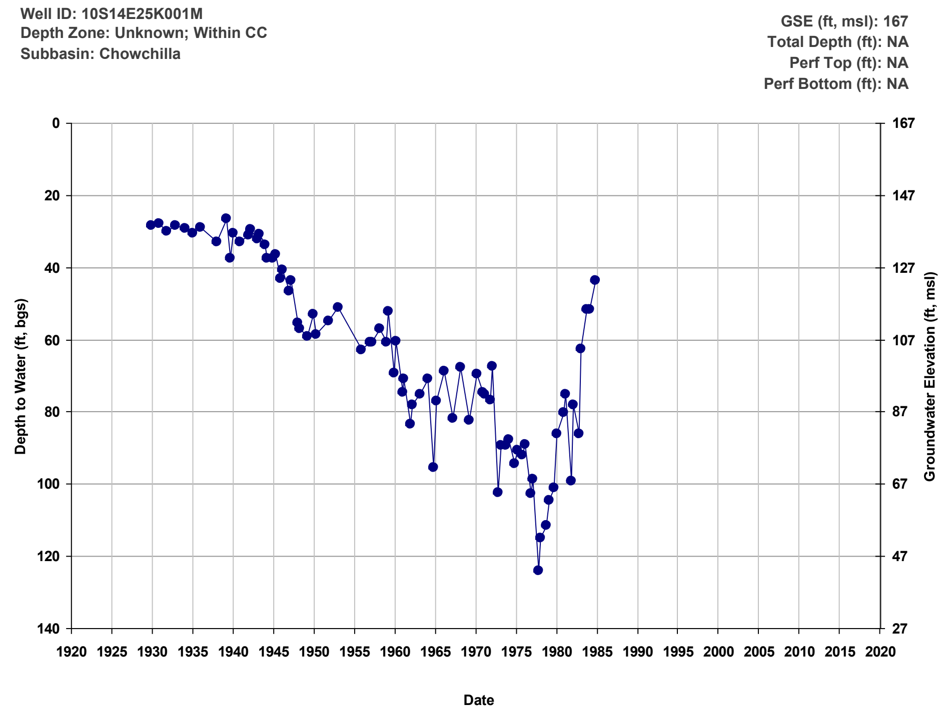


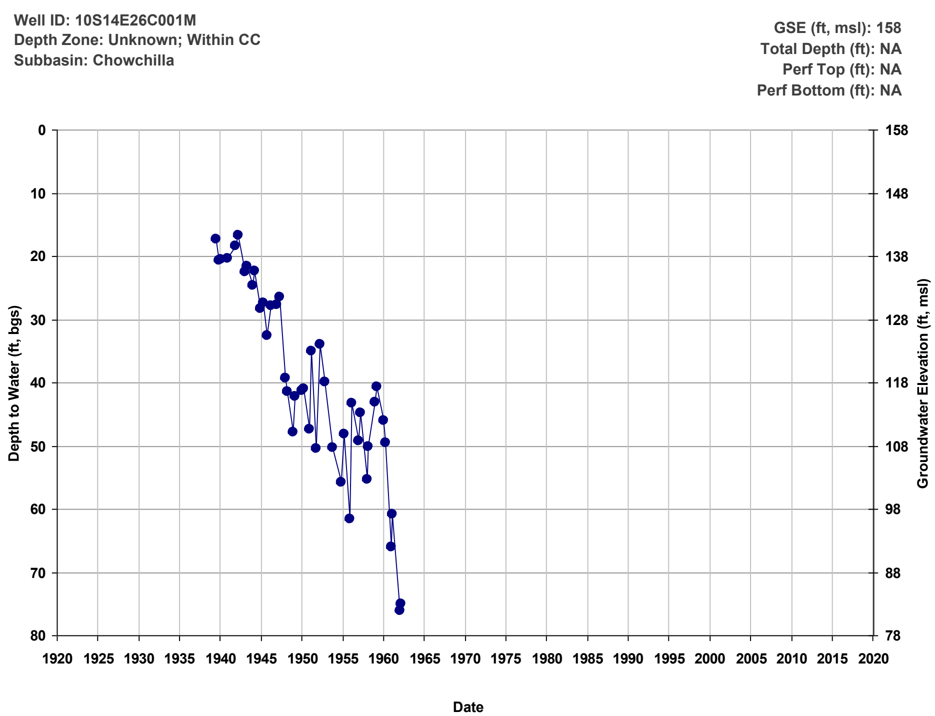
Well ID: 10S14E24M
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

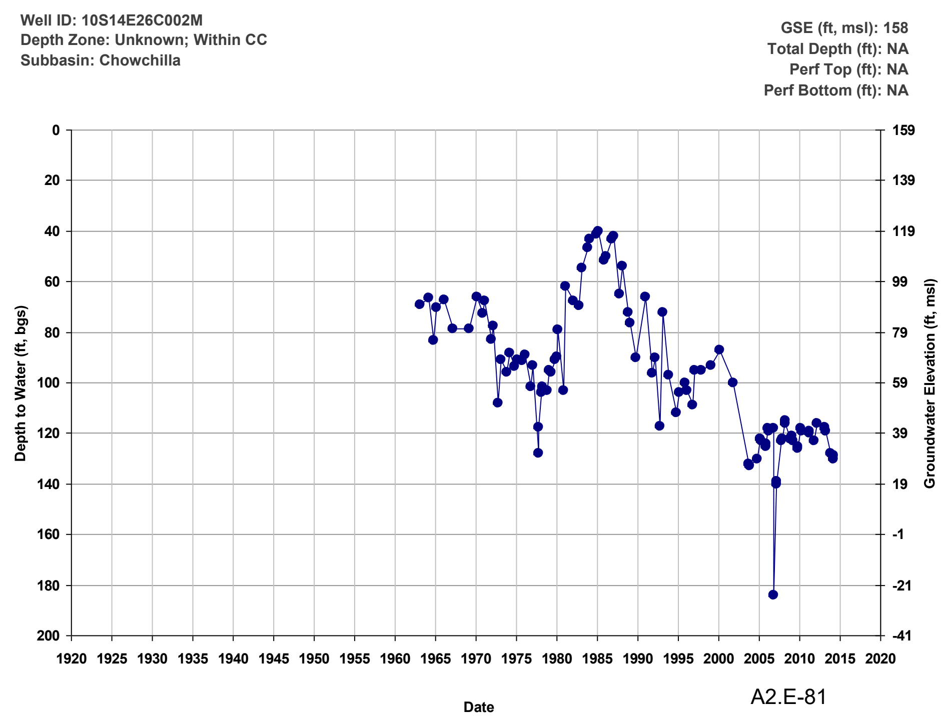
GSE (ft, msl): 169
Total Depth (ft): 696
Perf Top (ft): 255
Perf Bottom (ft): 636




Well ID: 10S14E24R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 169
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

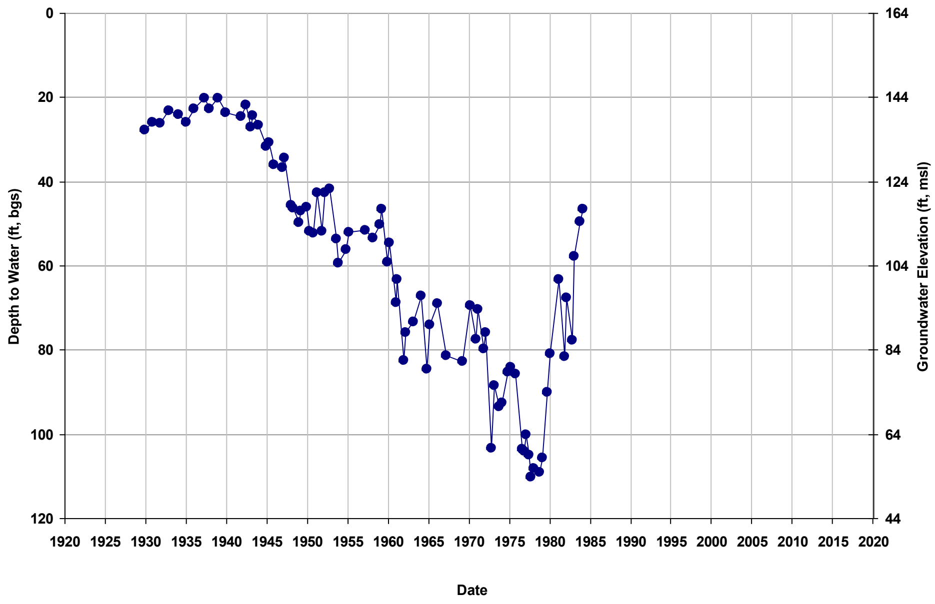

Well ID: 10S14E25K001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 167
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 10S14E26C001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 158
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 10S14E26C002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 158
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

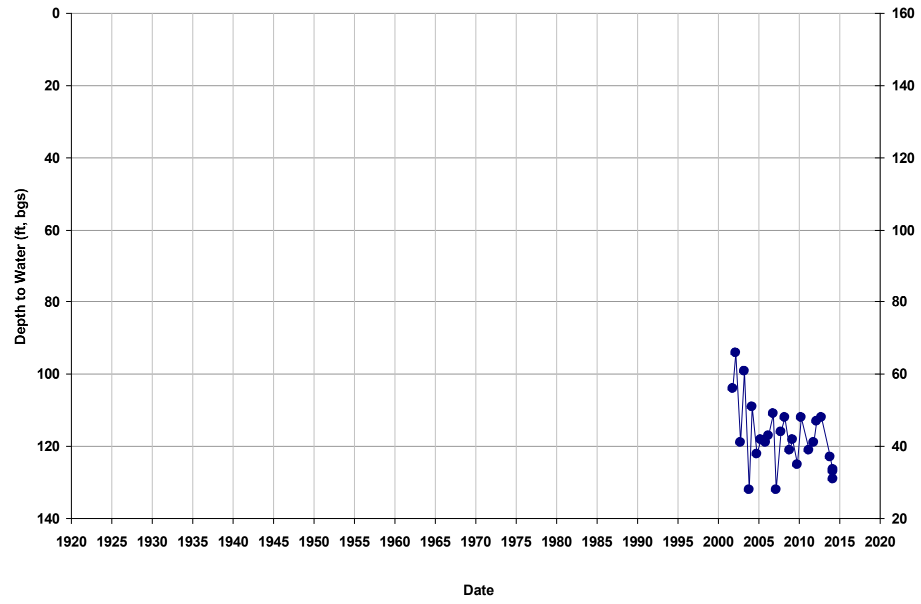
Well ID: 10S14E26H001M
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 163
Total Depth (ft): 145
Perf Top (ft): NA
Perf Bottom (ft): NA



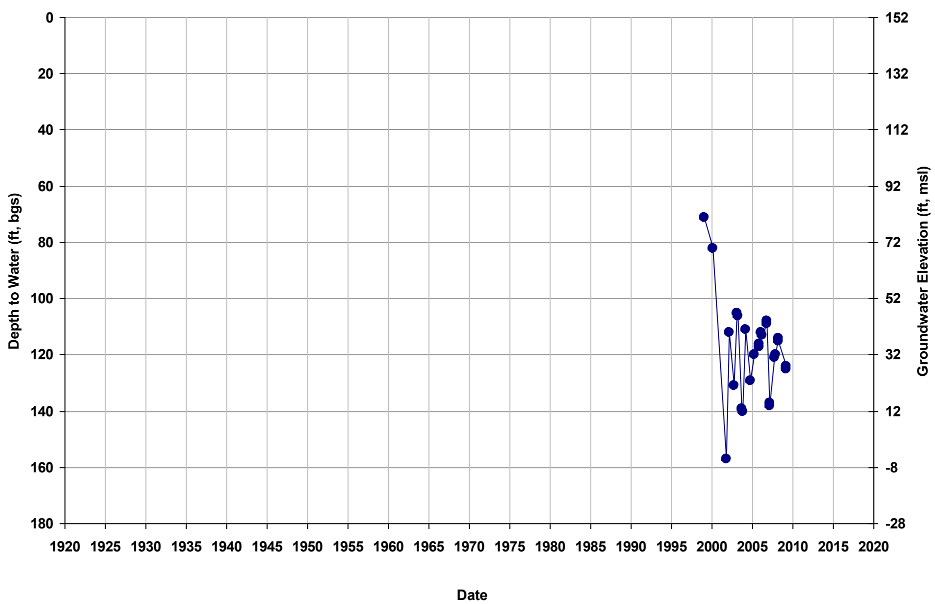
Well ID: 10S14E26R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 160
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



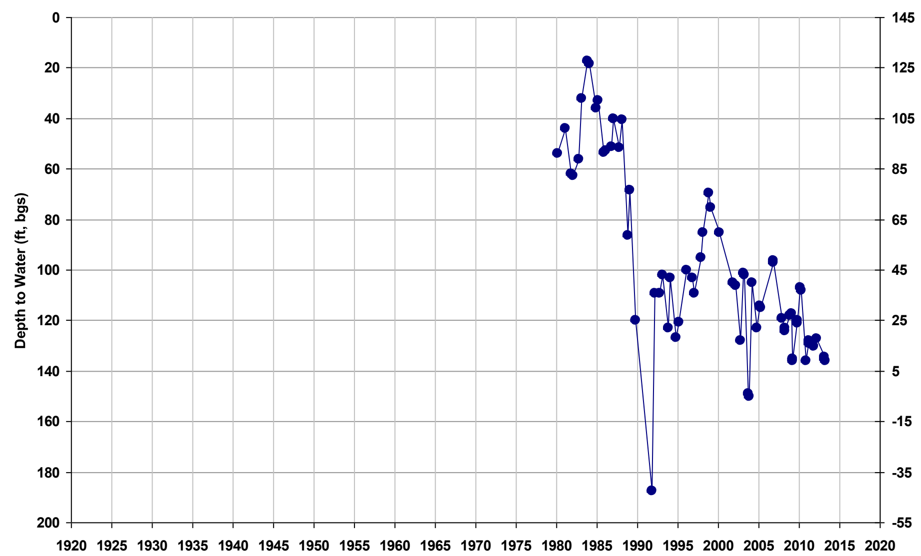
Well ID: 10S14E27H001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 152
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



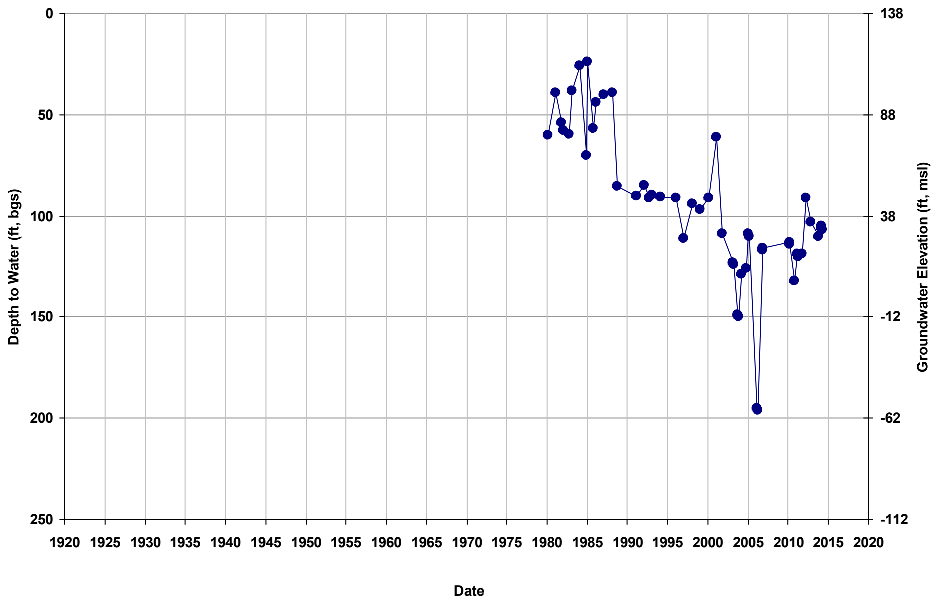
Well ID: 10S14E28B001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 145
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



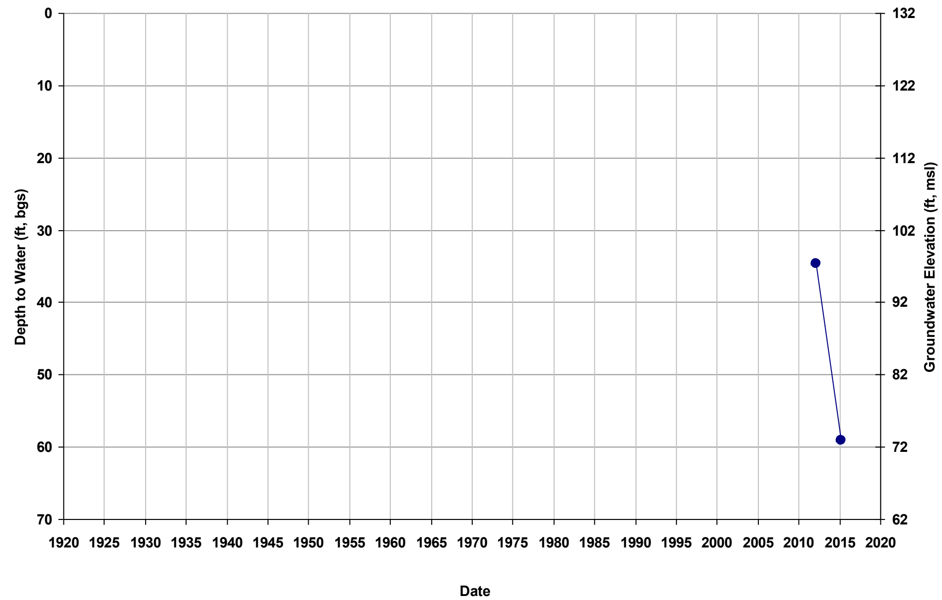
Well ID: 10S14E29C002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 138
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



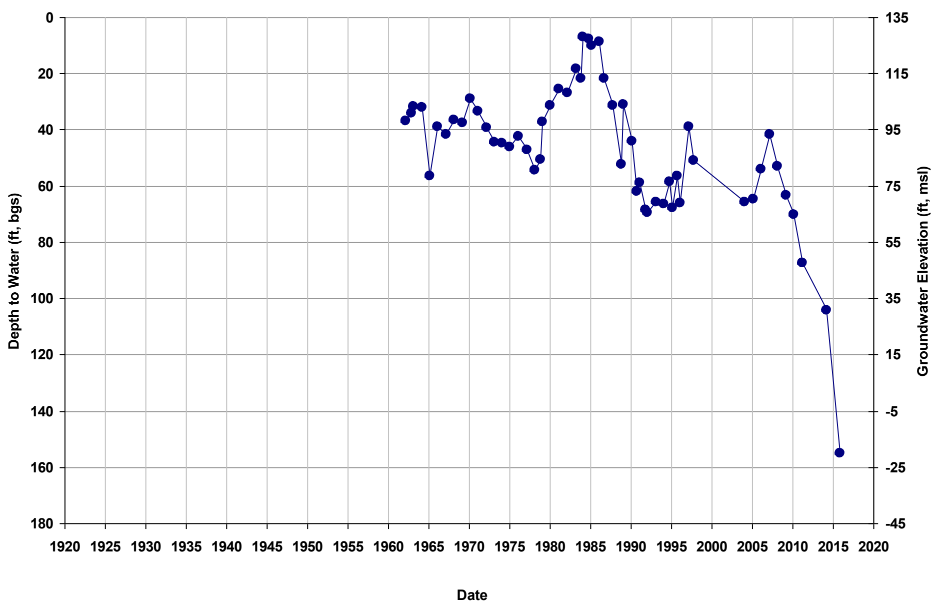
Well ID: 10S14E31H001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 132
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



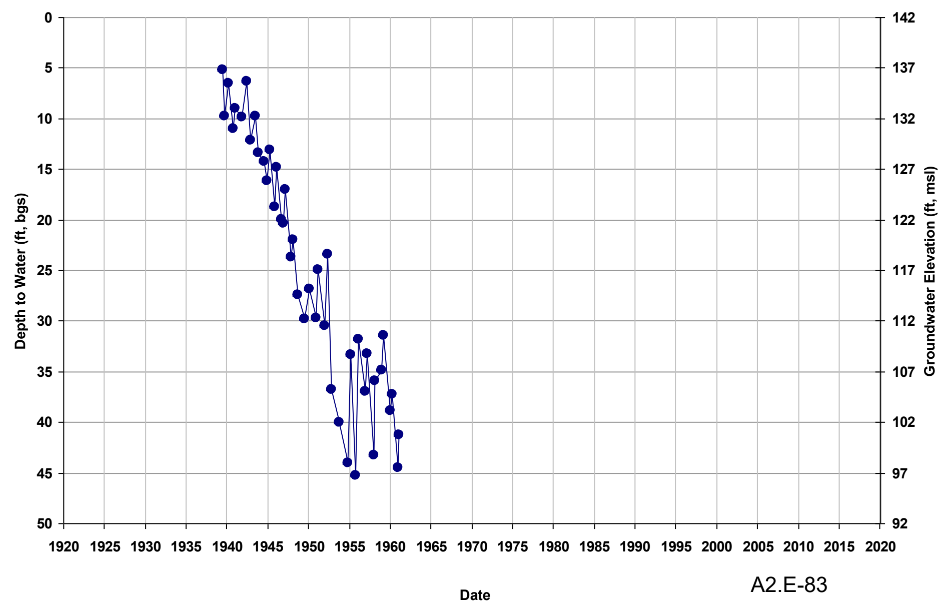
Well ID: 10S14E32Q001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 134
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



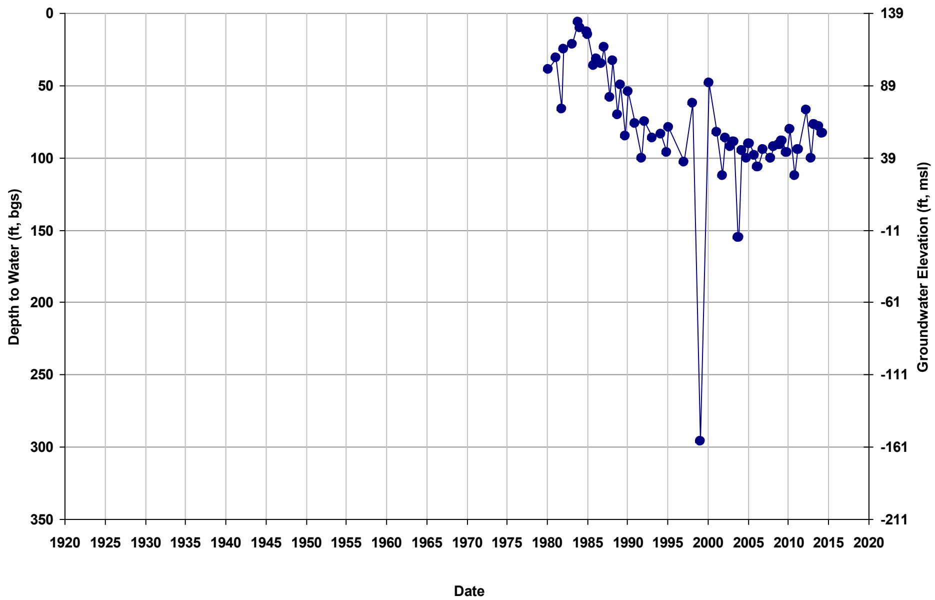
Well ID: 10S14E33J001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 142
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



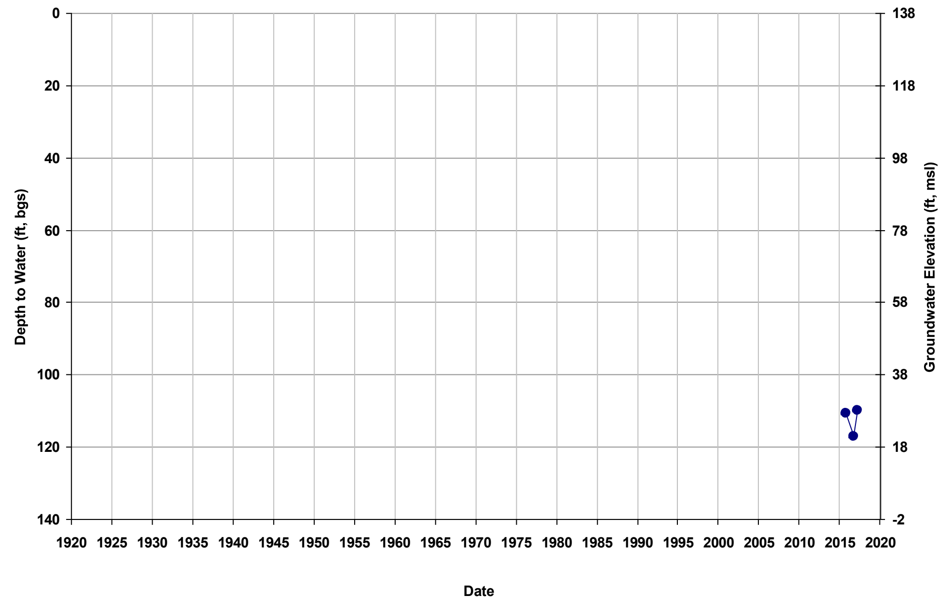
Well ID: 10S14E33L002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 139
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



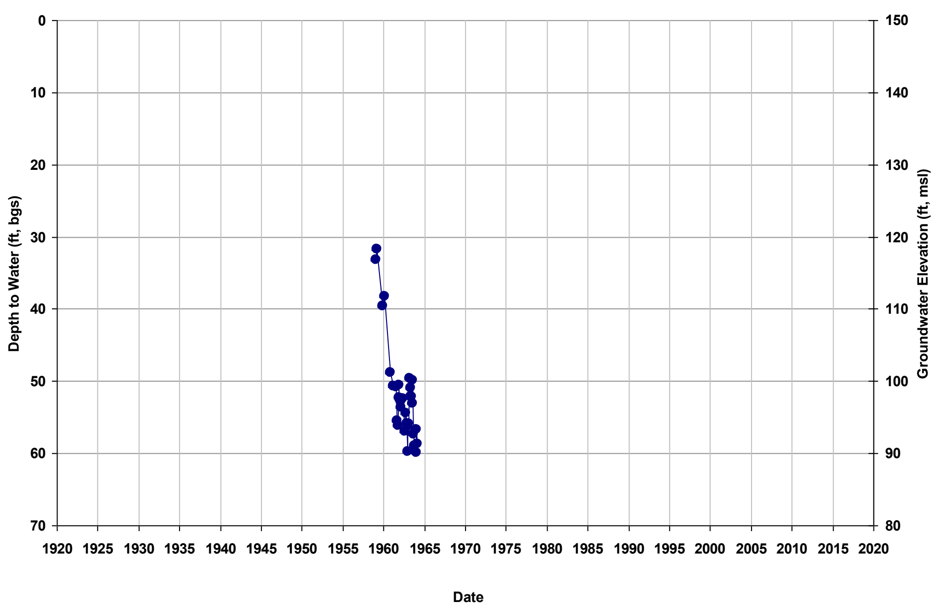
Well ID: 10S14E33M001M
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 138
Total Depth (ft): 800
Perf Top (ft): 290
Perf Bottom (ft): 400



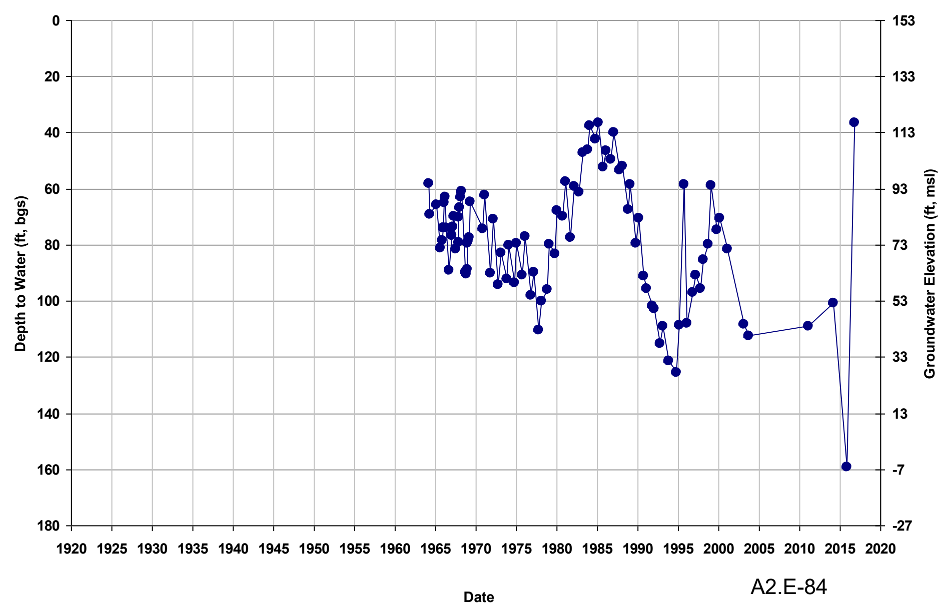
Well ID: 10S14E34H001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

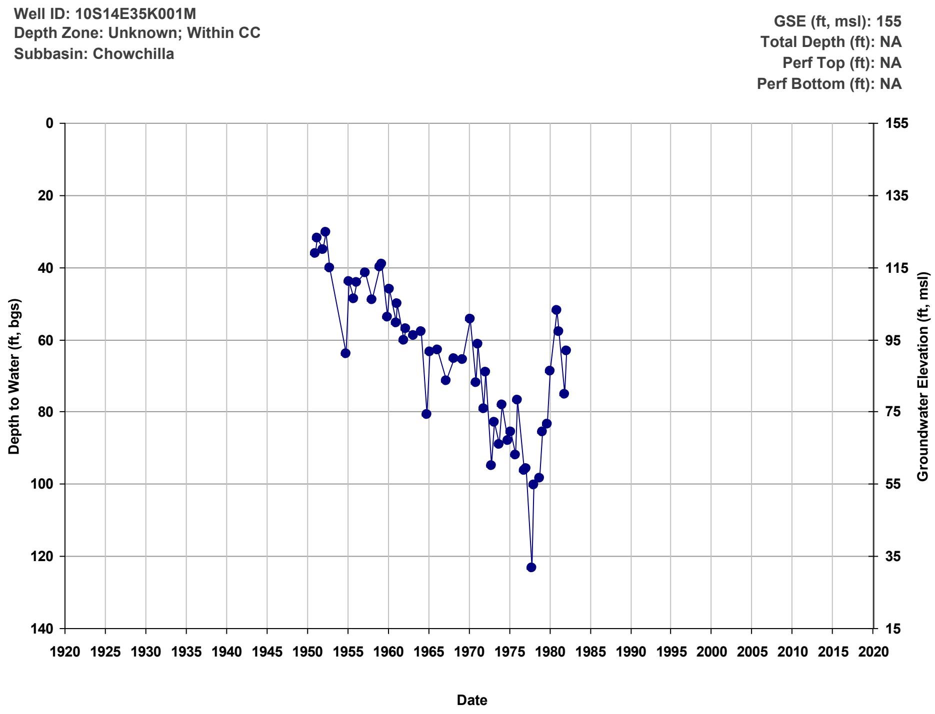
GSE (ft, msl): 150
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA

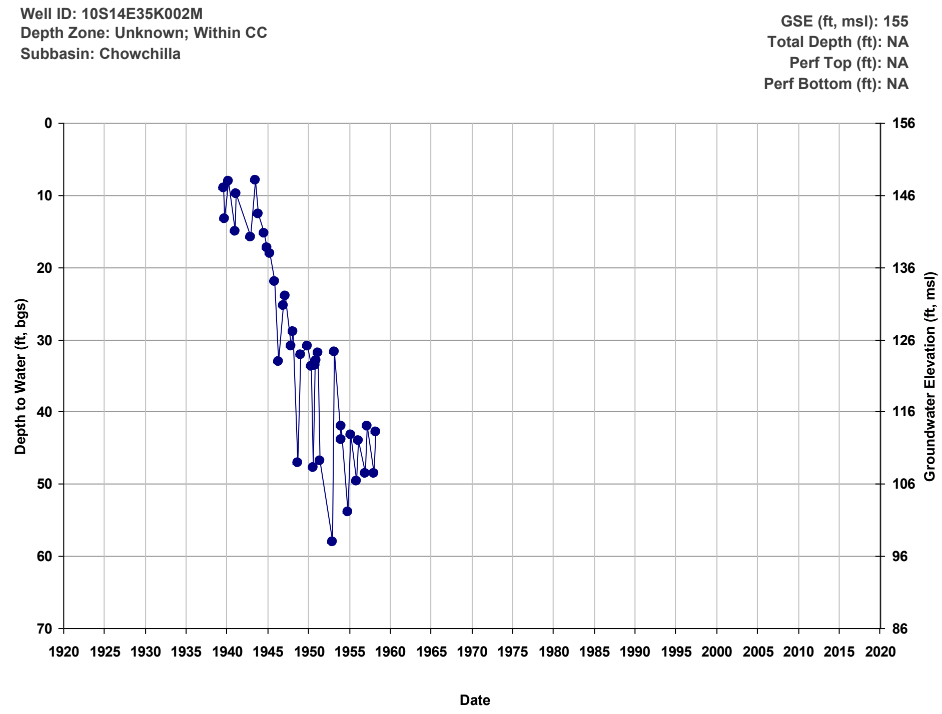


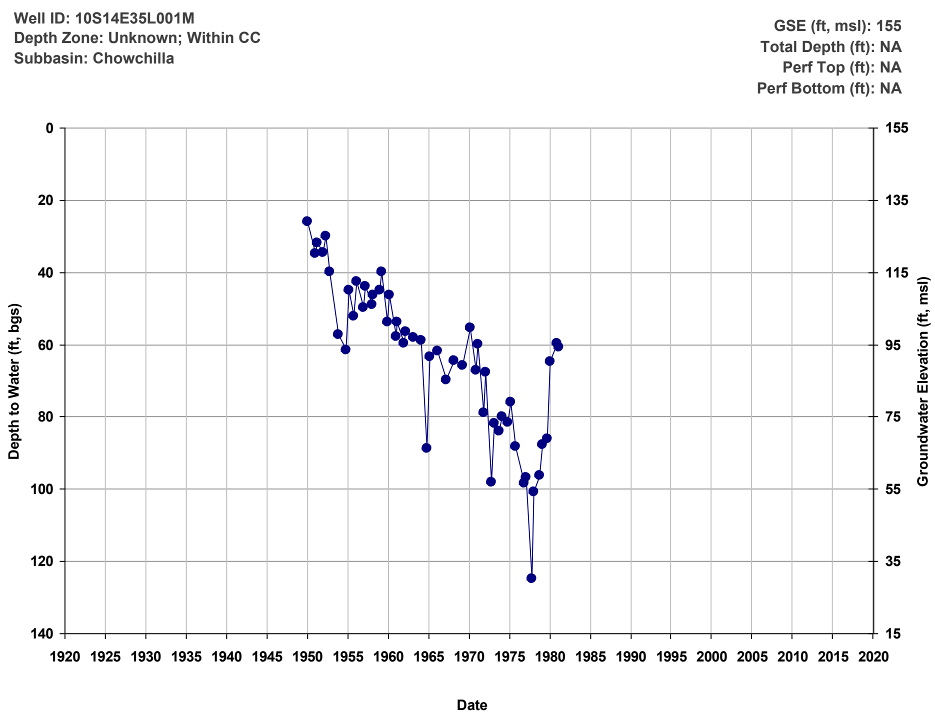
Well ID: 10S14E35F001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

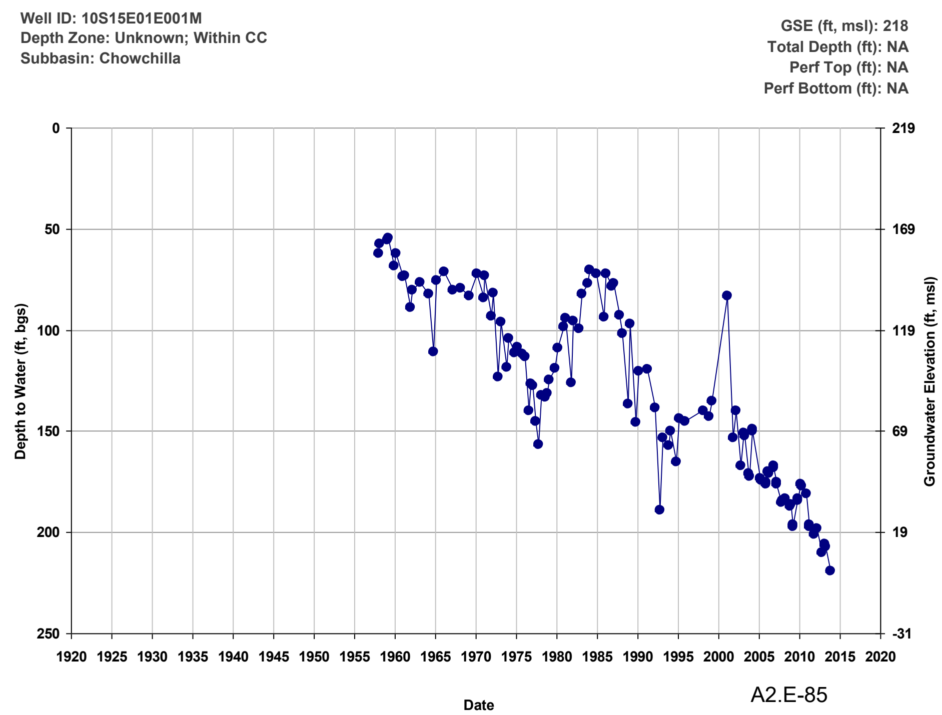
GSE (ft, msl): 153
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA




Well ID: 10S14E35K001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 155
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

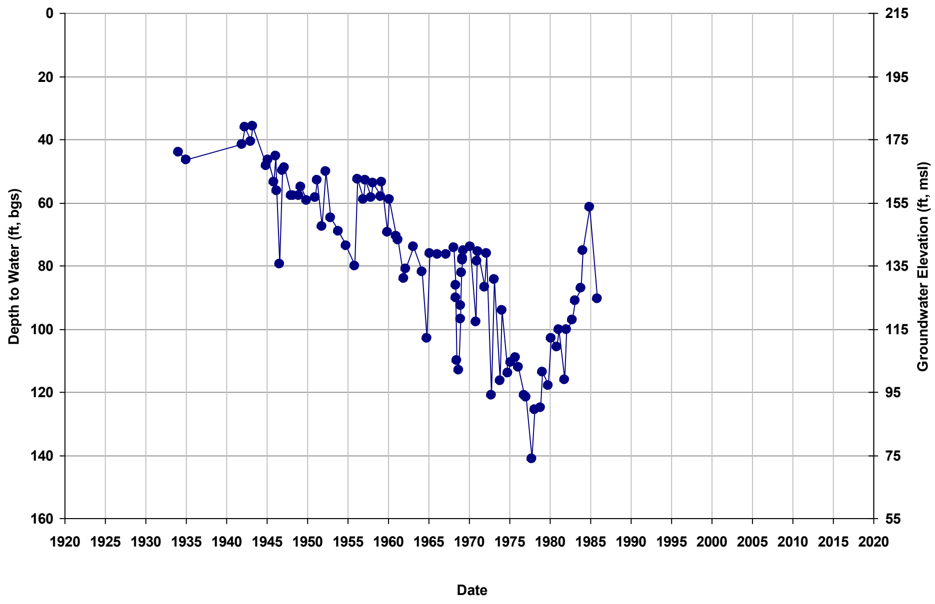

Well ID: 10S14E35K002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 155
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 10S14E35L001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 155
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 10S15E01E001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 218
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

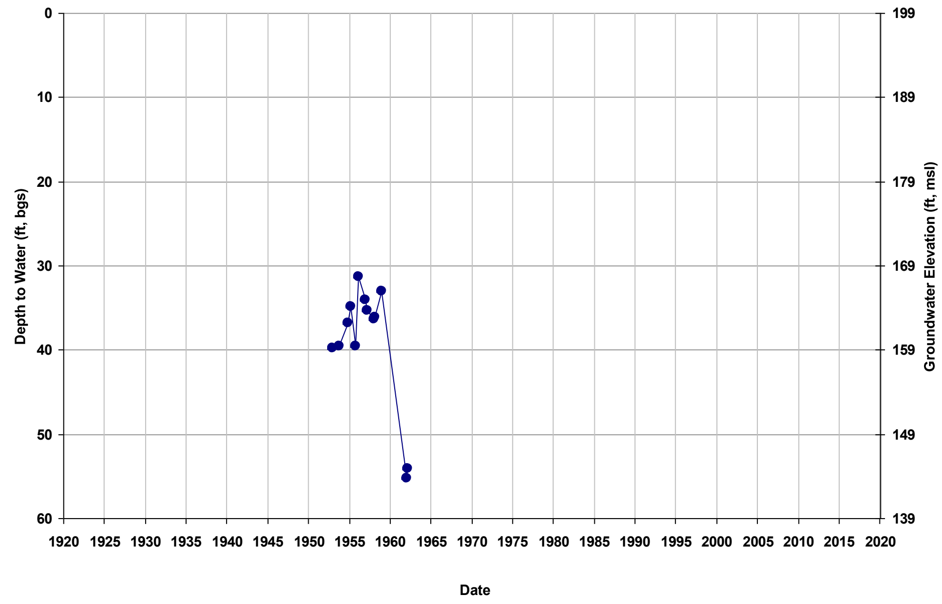
Well ID: 10S15E02Q001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 214
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



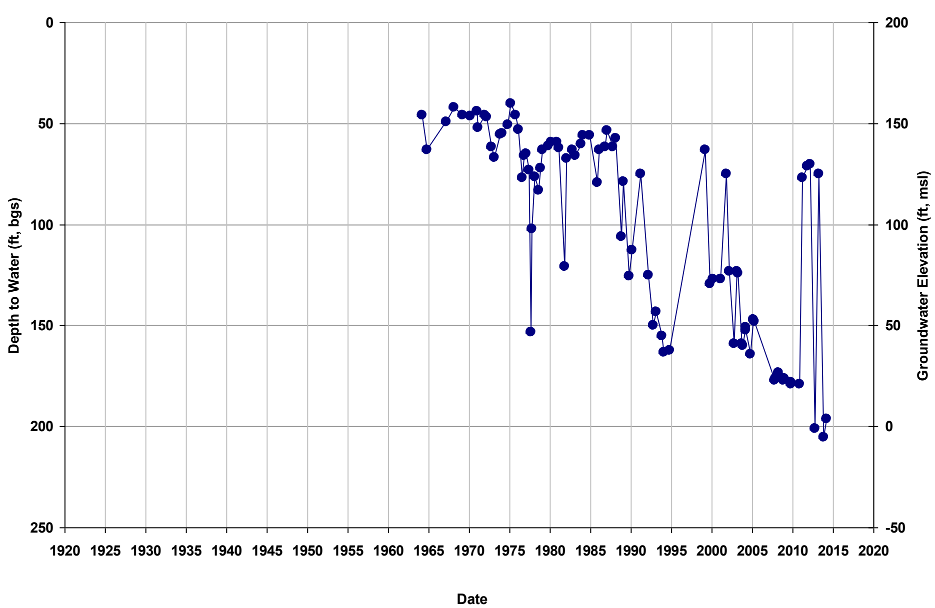
Well ID: 10S15E03E001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 199
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



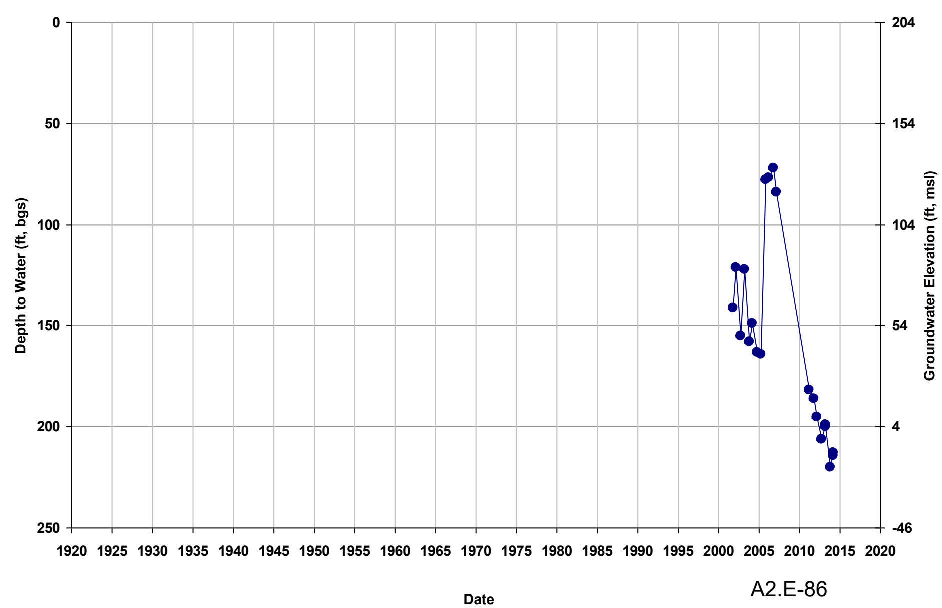
Well ID: 10S15E03E002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 200
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



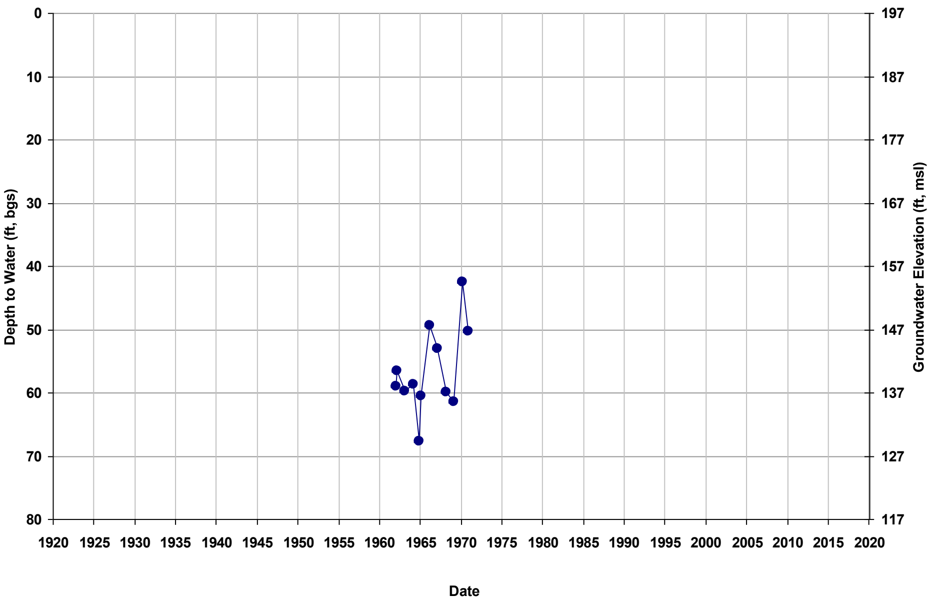
Well ID: 10S15E03L001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 204
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



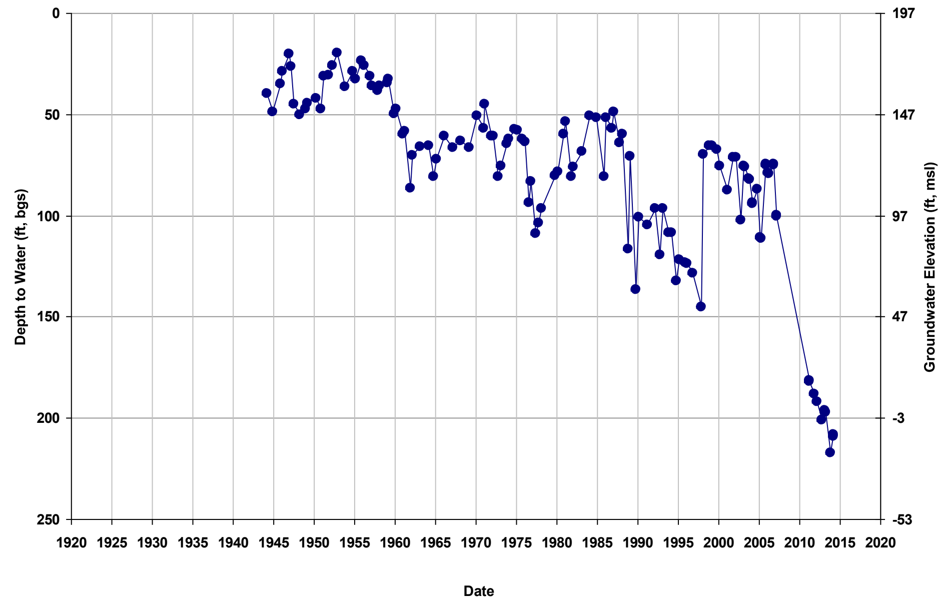
Well ID: 10S15E04K001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 197
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



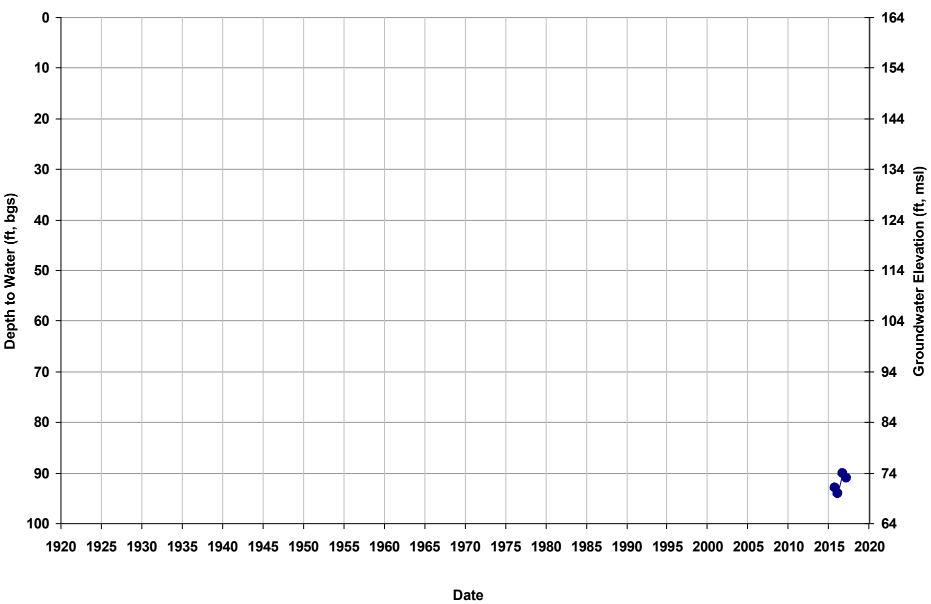
Well ID: 10S15E05B001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 197
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



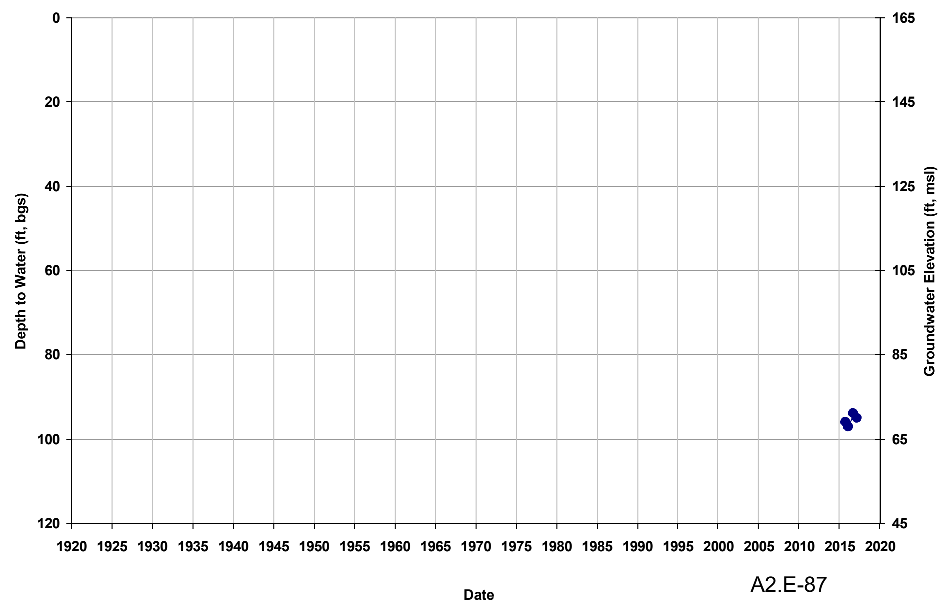
Well ID: 10S15E05J-1
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

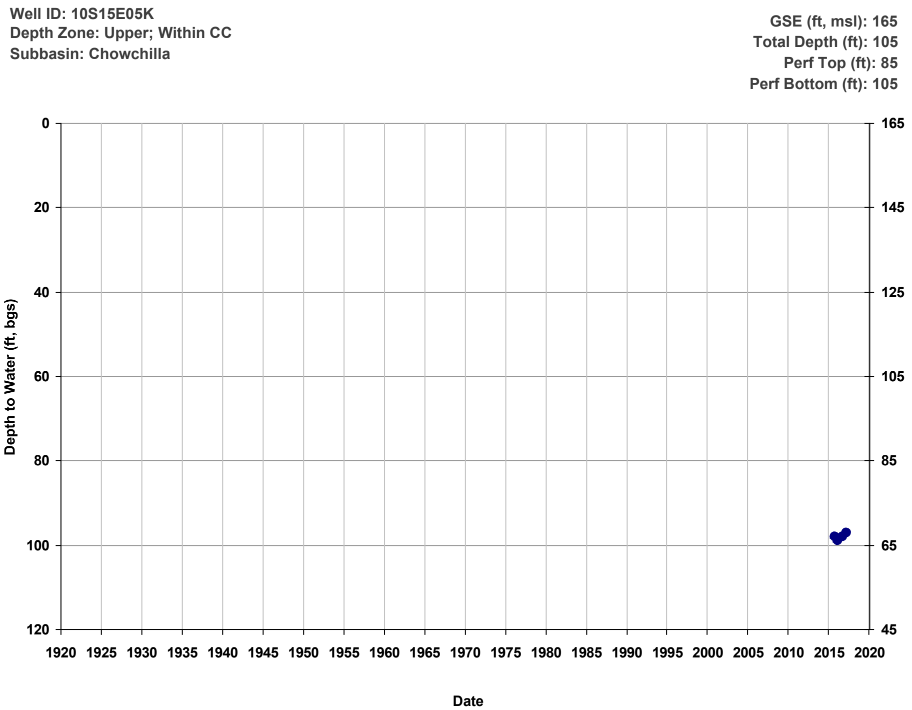
GSE (ft, msl): 164
Total Depth (ft): 97
Perf Top (ft): 82
Perf Bottom (ft): 97

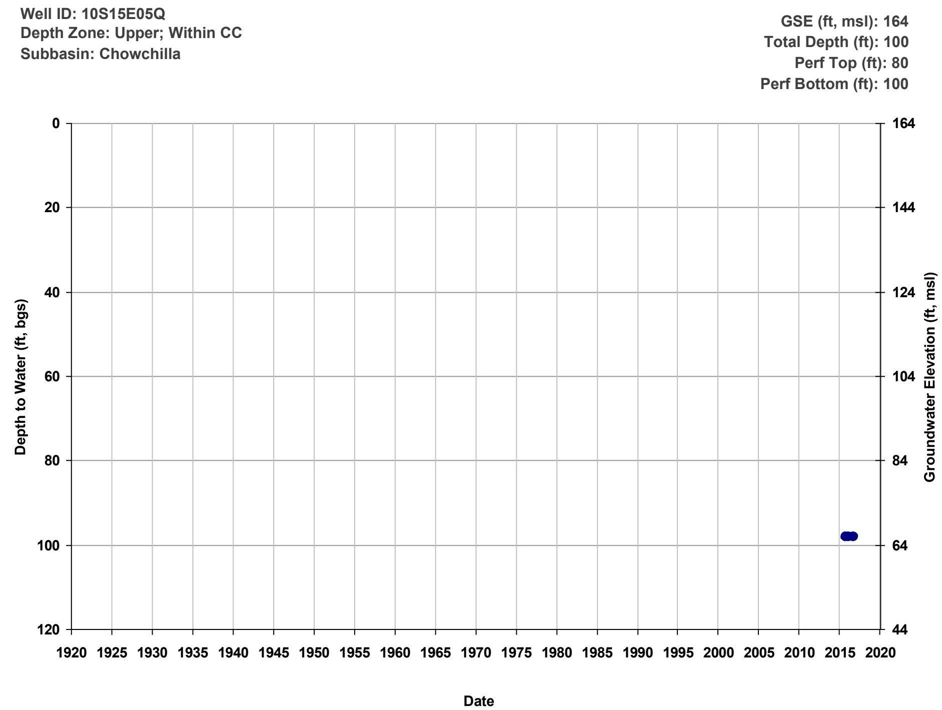


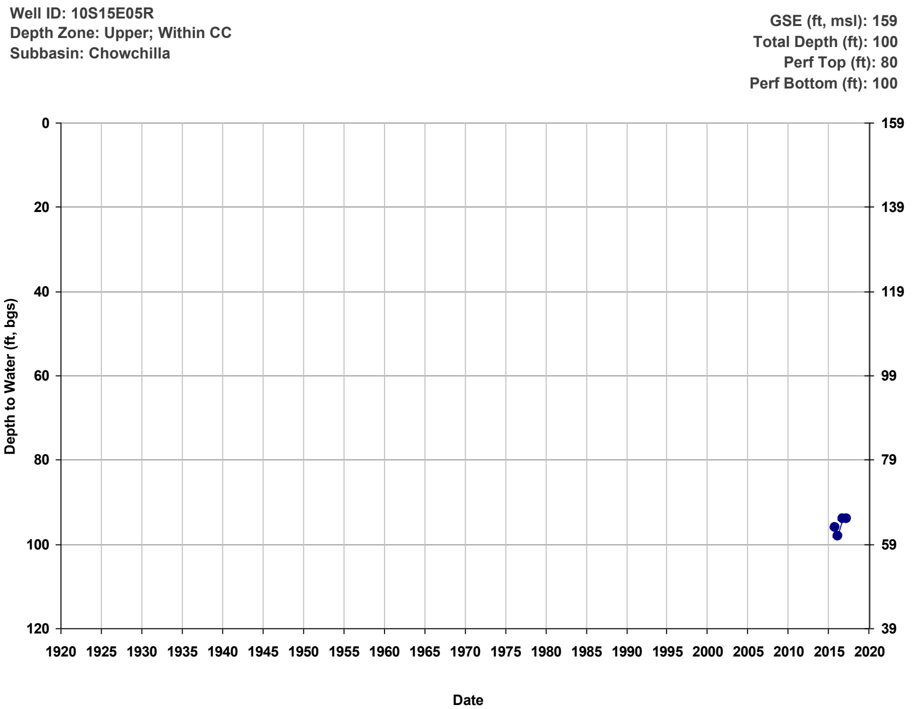
Well ID: 10S15E05J-2
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

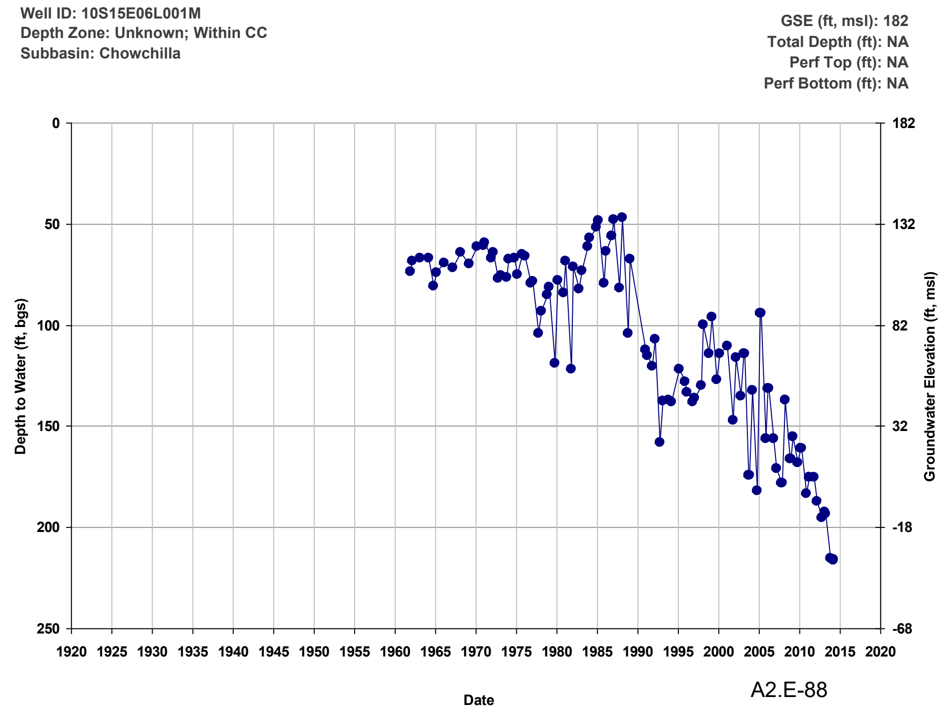
GSE (ft, msl): 165
Total Depth (ft): 104
Perf Top (ft): 84
Perf Bottom (ft): 104




Well ID: 10S15E05K
Depth Zone: Upper; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 165
Total Depth (ft): 105
Perf Top (ft): 85
Perf Bottom (ft): 105
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

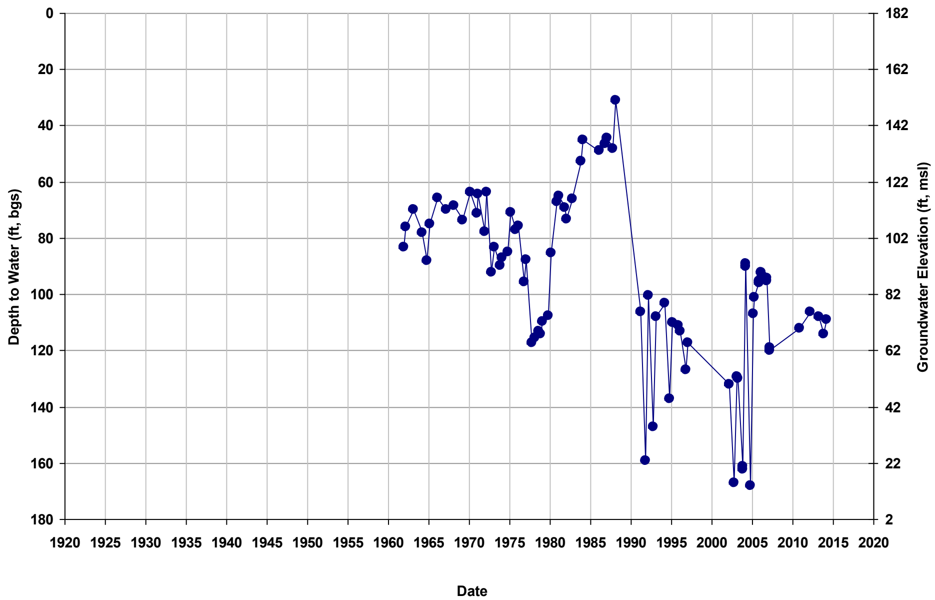

Well ID: 10S15E05Q
Depth Zone: Upper; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 164
Total Depth (ft): 100
Perf Top (ft): 80
Perf Bottom (ft): 100
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 10S15E05R
Depth Zone: Upper; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 159
Total Depth (ft): 100
Perf Top (ft): 80
Perf Bottom (ft): 100
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 10S15E06L001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 182
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

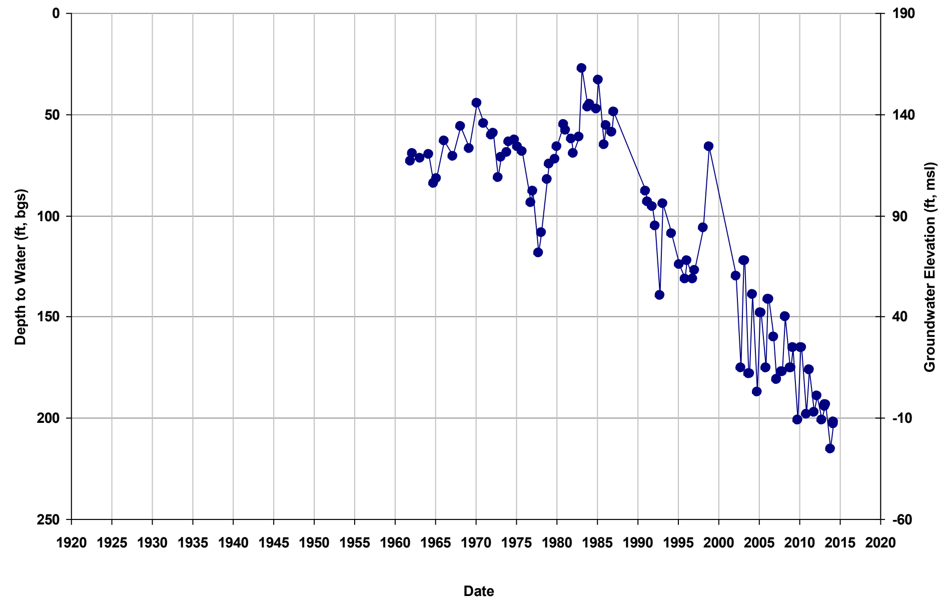
Well ID: 10S15E07Q001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 182
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



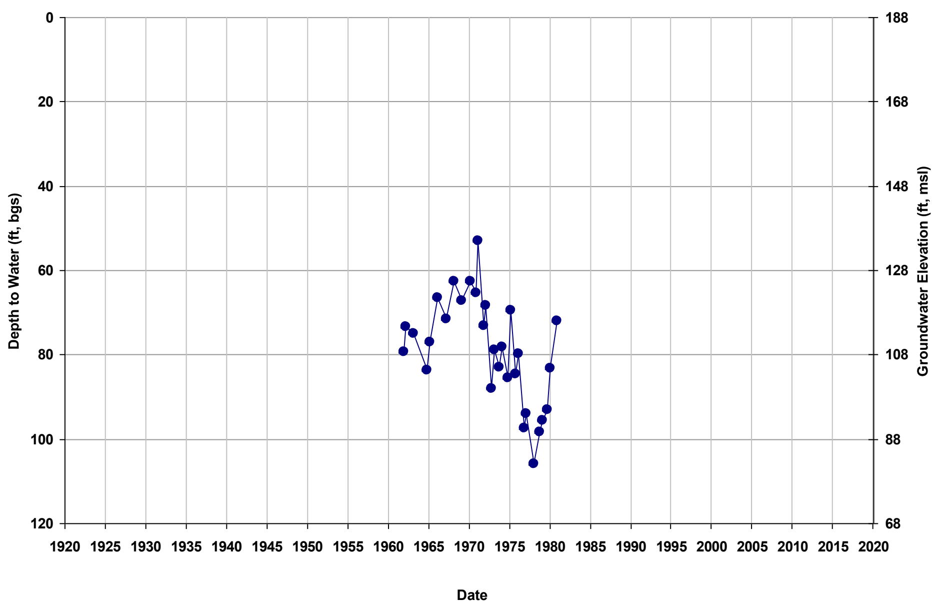
Well ID: 10S15E08C001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 190
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



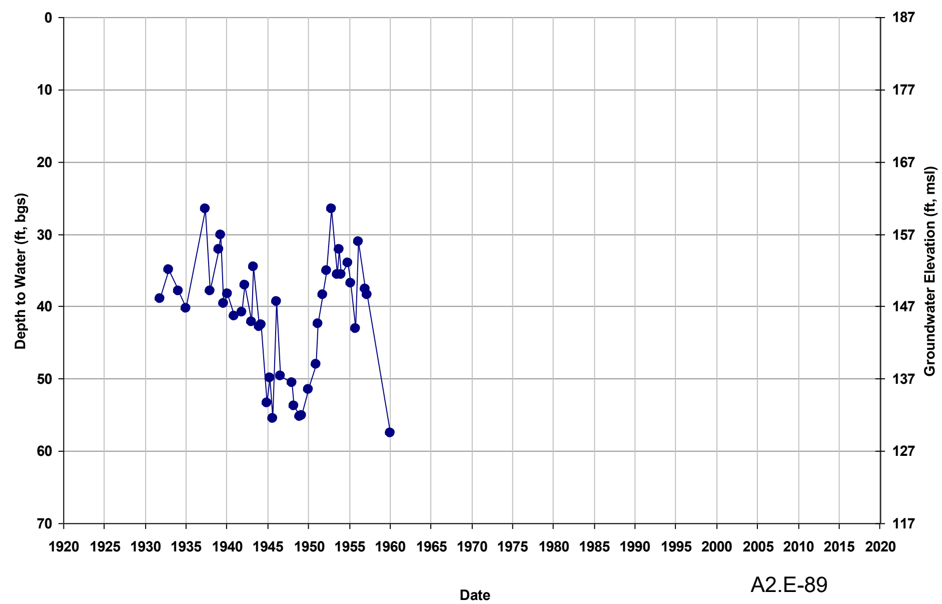
Well ID: 10S15E08K002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

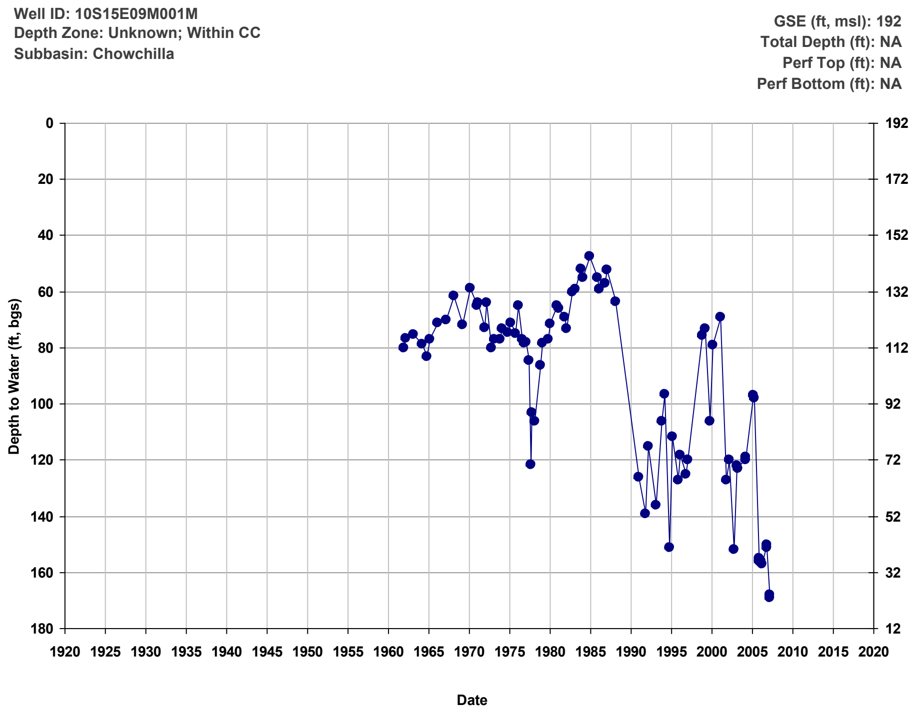
GSE (ft, msl): 188
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA

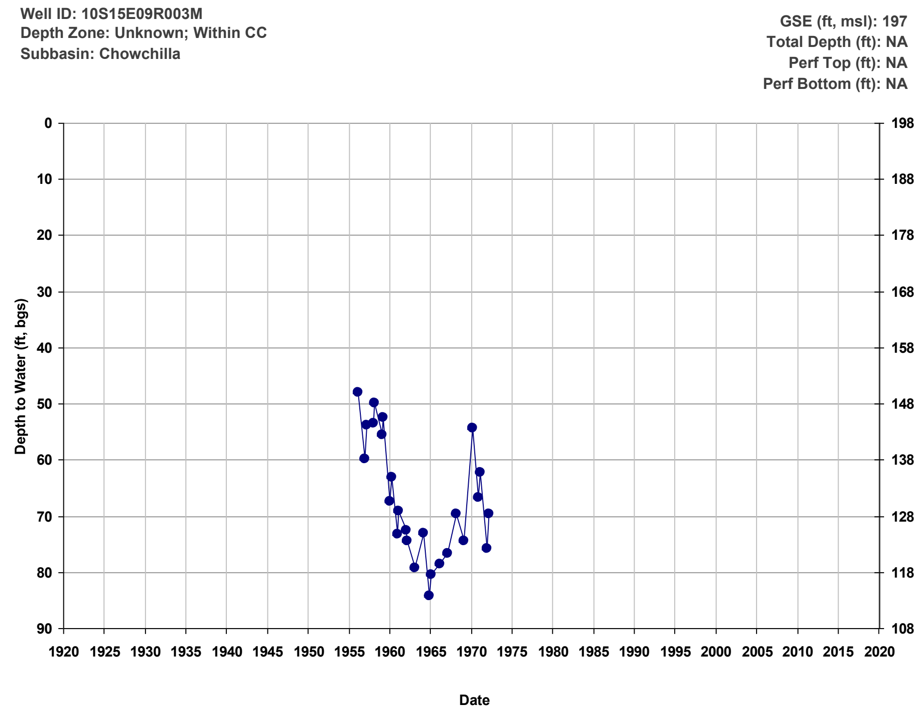


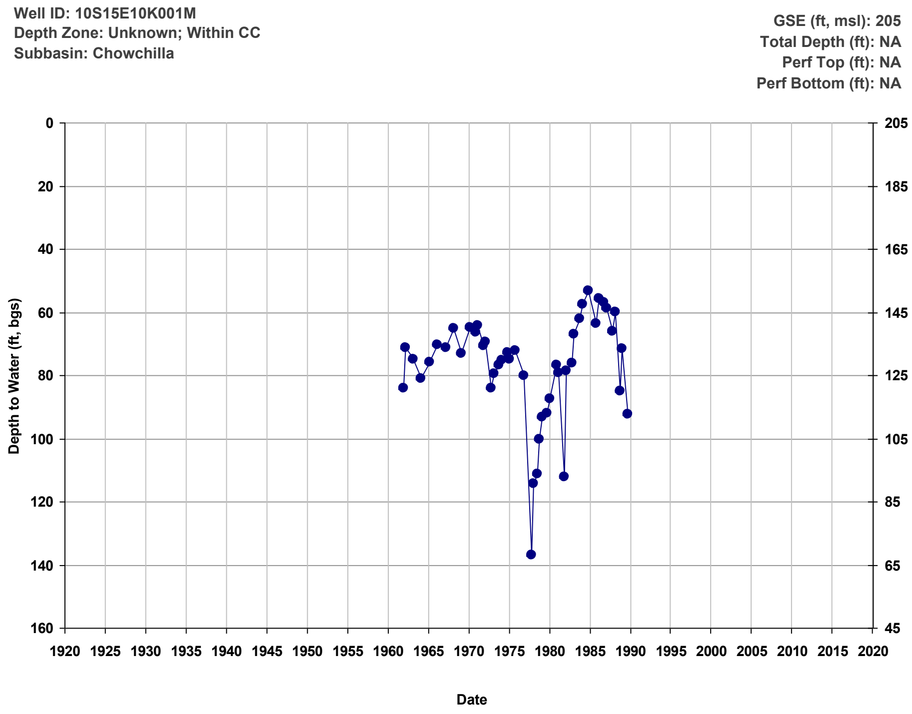
Well ID: 10S15E08L001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

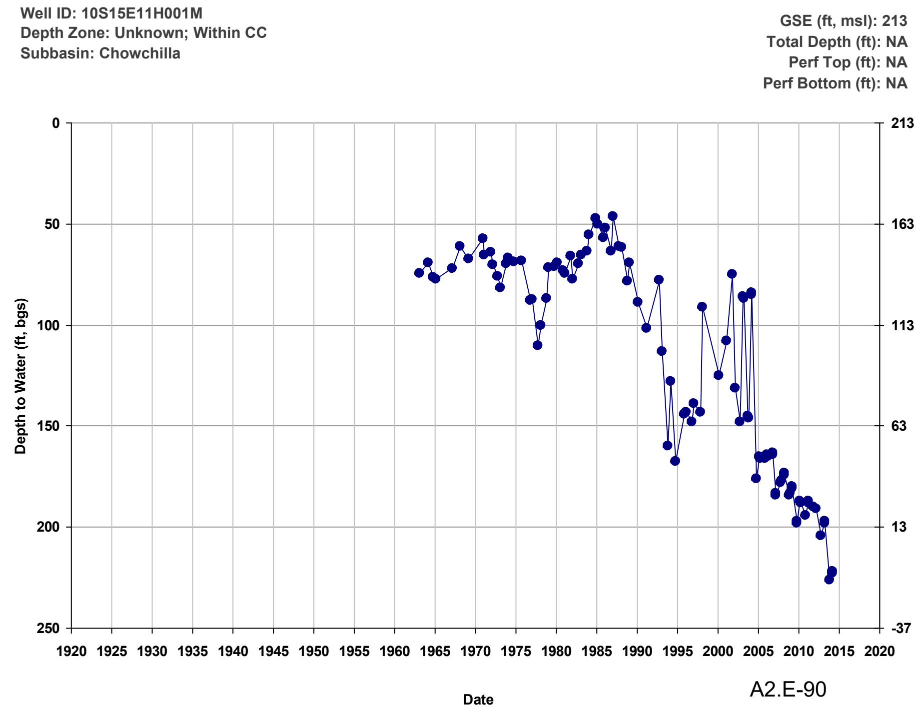
GSE (ft, msl): 186
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA




Well ID: 10S15E09M001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 192
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

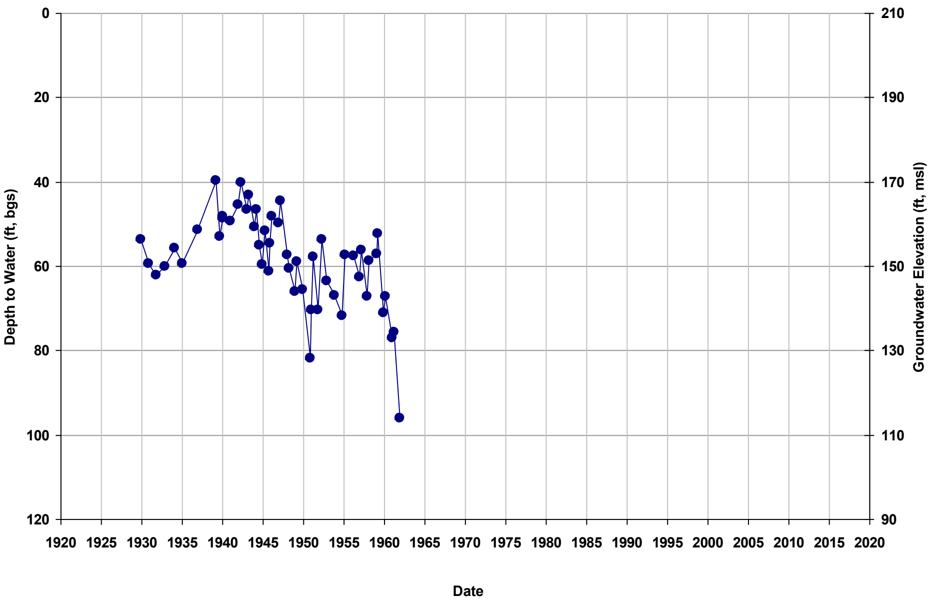

Well ID: 10S15E09R003M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 197
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 10S15E10K001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 205
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 10S15E11H001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 213
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

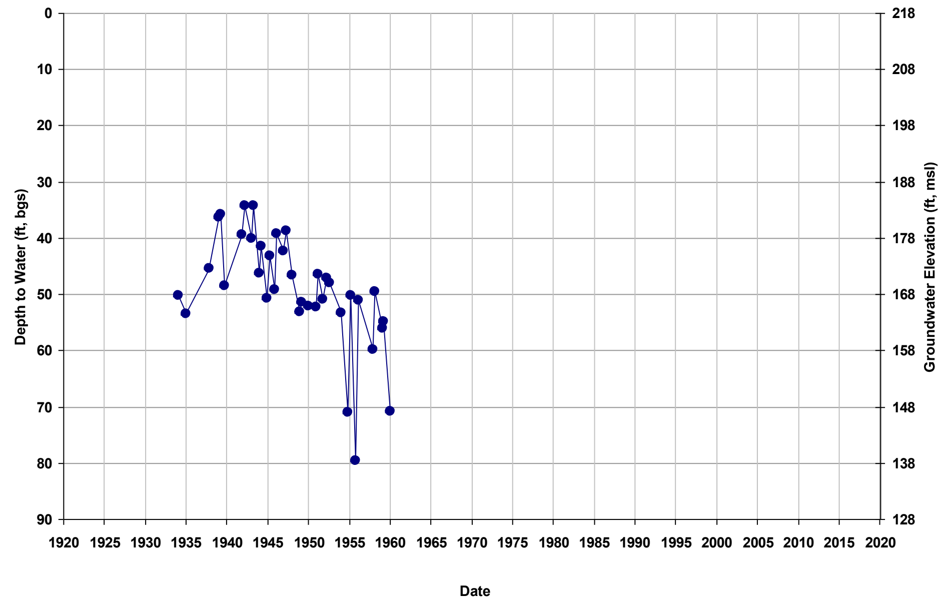
Well ID: 10S15E11R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 209
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



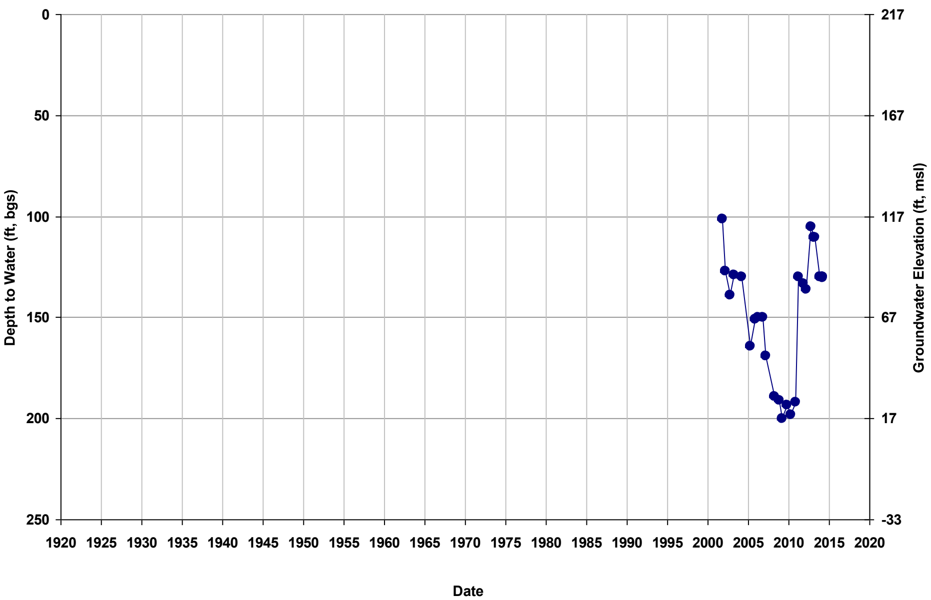
Well ID: 10S15E12C001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 218
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



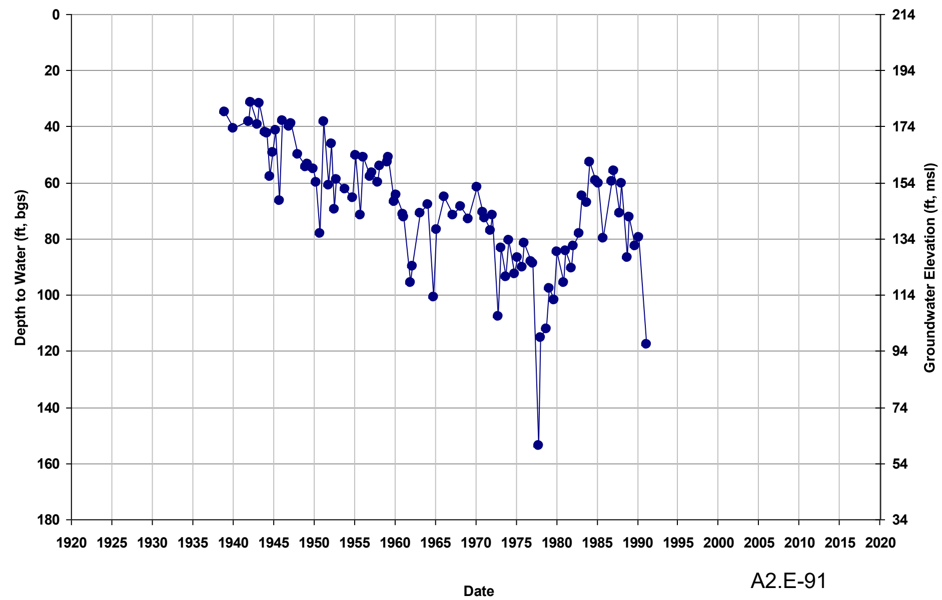
Well ID: 10S15E12C002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 217
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



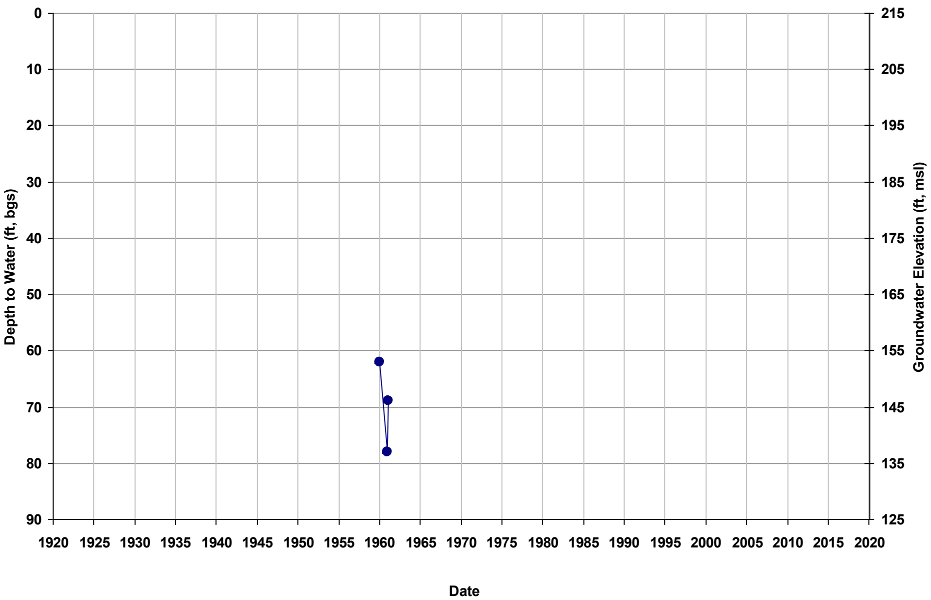
Well ID: 10S15E12P001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 213
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



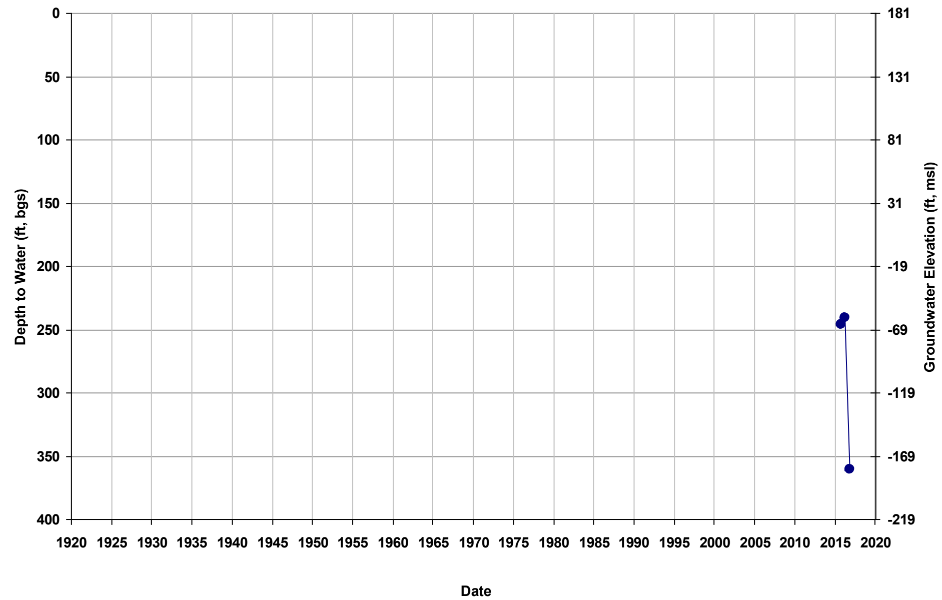
Well ID: 10S15E13A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 215
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



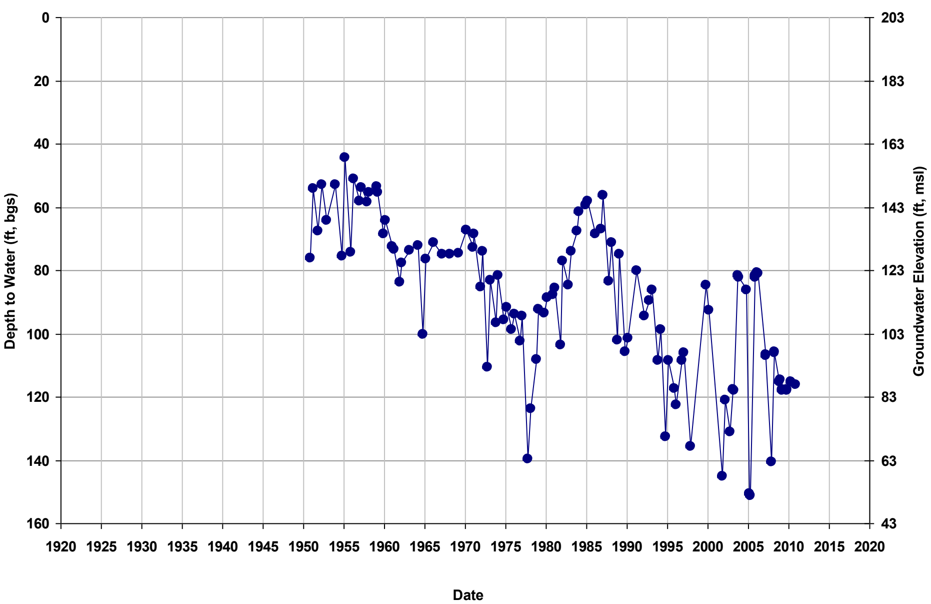
Well ID: 10S15E13F
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 180
Total Depth (ft): 390
Perf Top (ft): 150
Perf Bottom (ft): 390



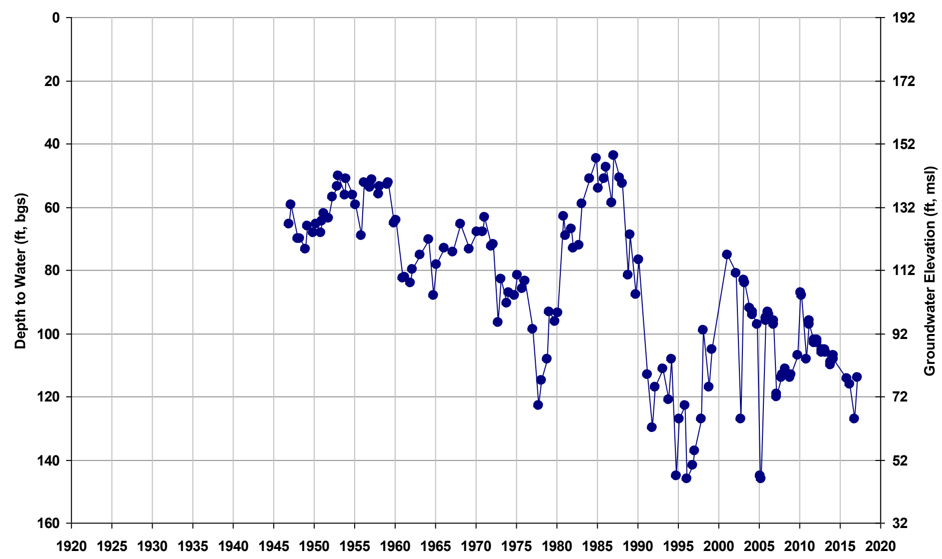
Well ID: 10S15E14D001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

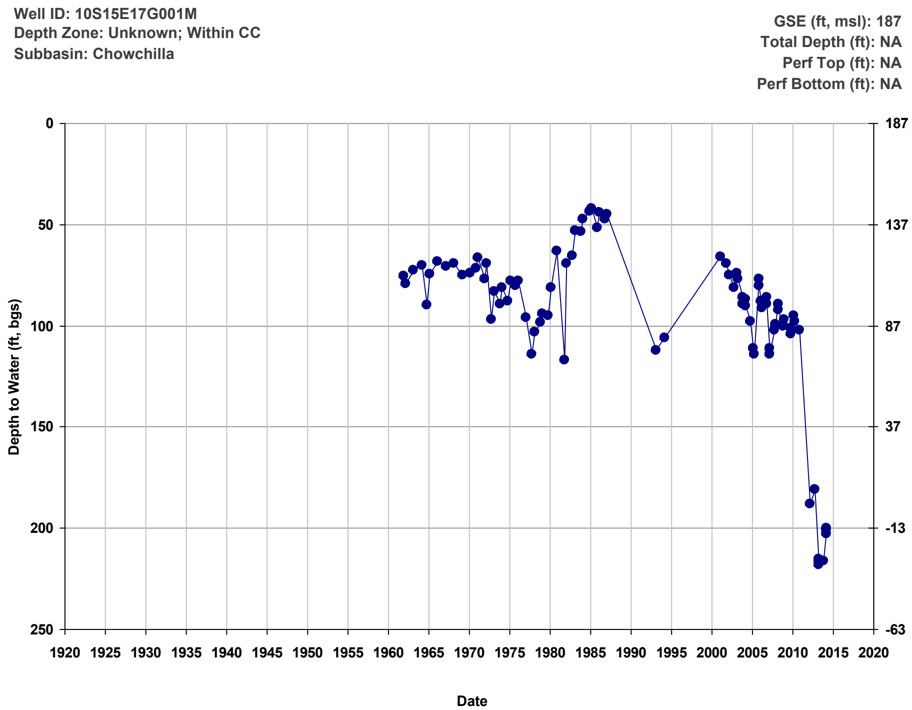
GSE (ft, msl): 203
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA

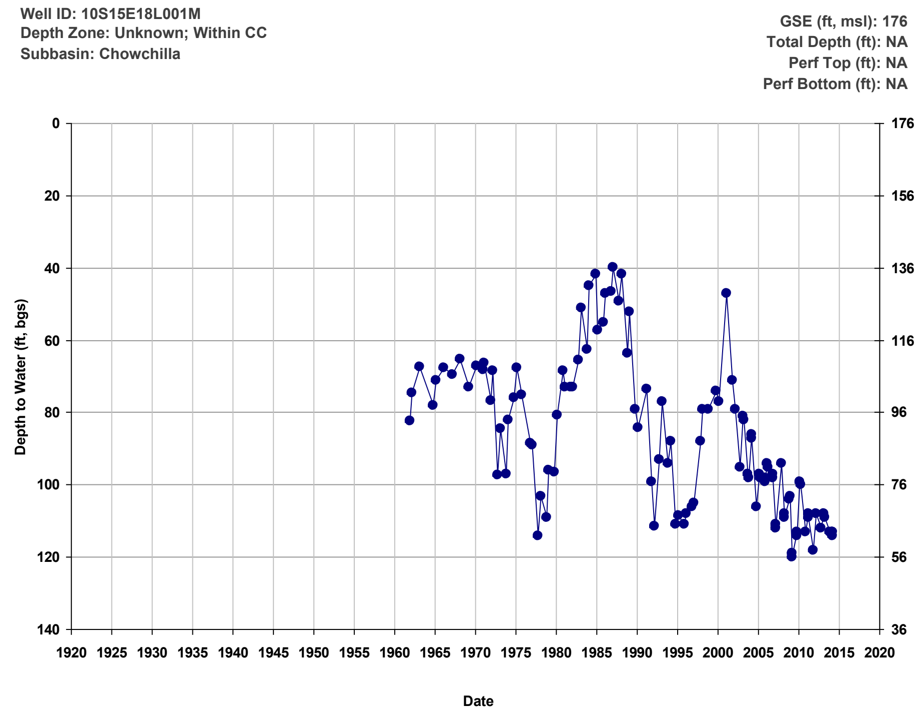


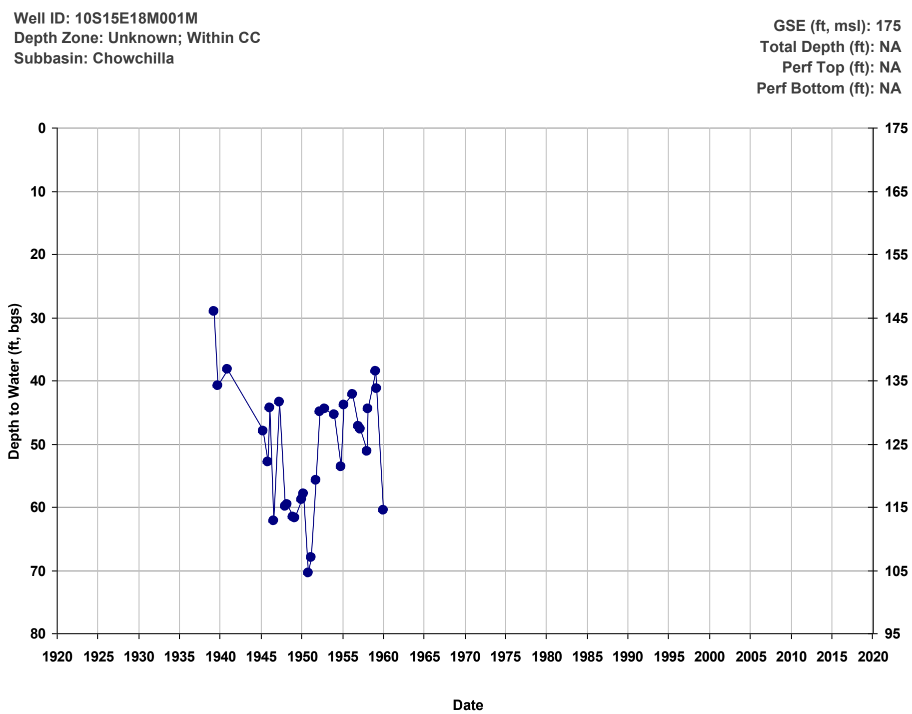
Well ID: 10S15E16R002M
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

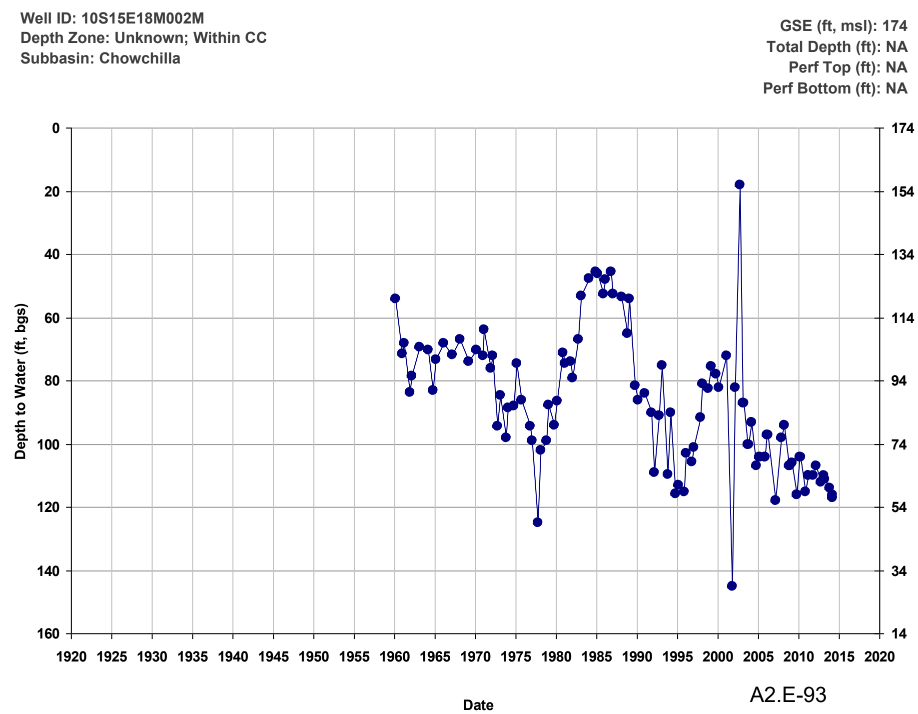
GSE (ft, msl): 192
Total Depth (ft): 529
Perf Top (ft): 187
Perf Bottom (ft): 529




Well ID: 10S15E17G001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 187
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

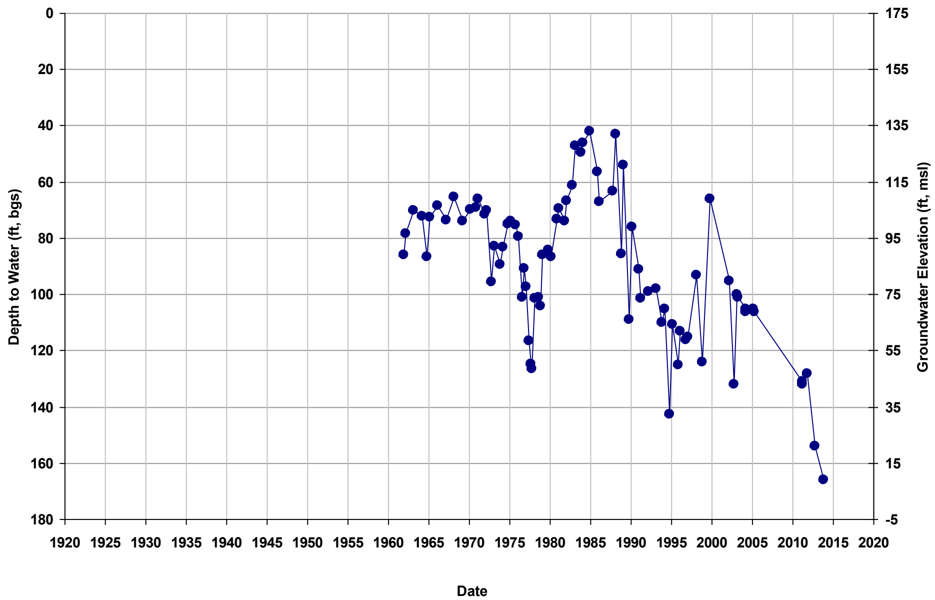

Well ID: 10S15E18L001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 176
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 10S15E18M001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 175
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 10S15E18M002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 174
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

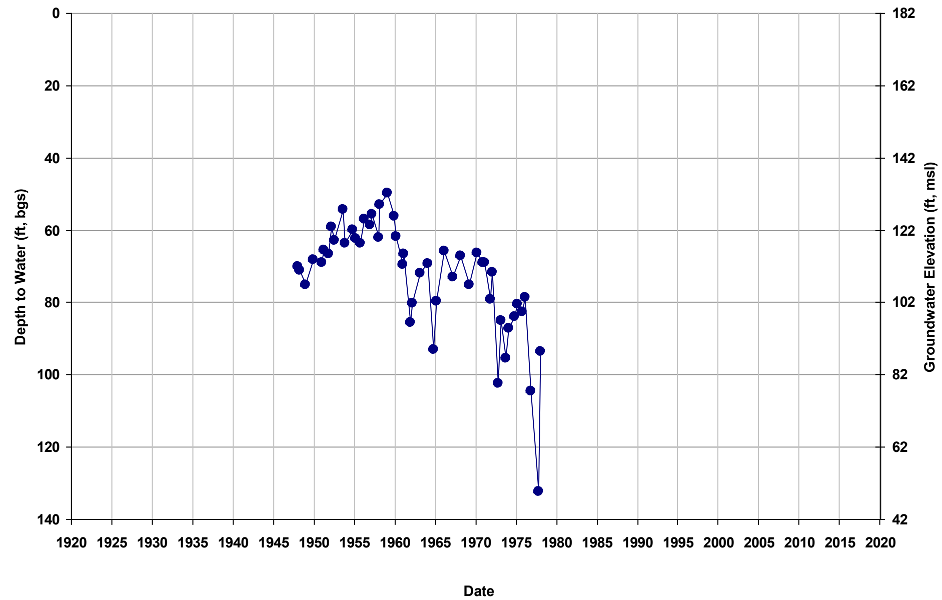
Well ID: 10S15E19F001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 175
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



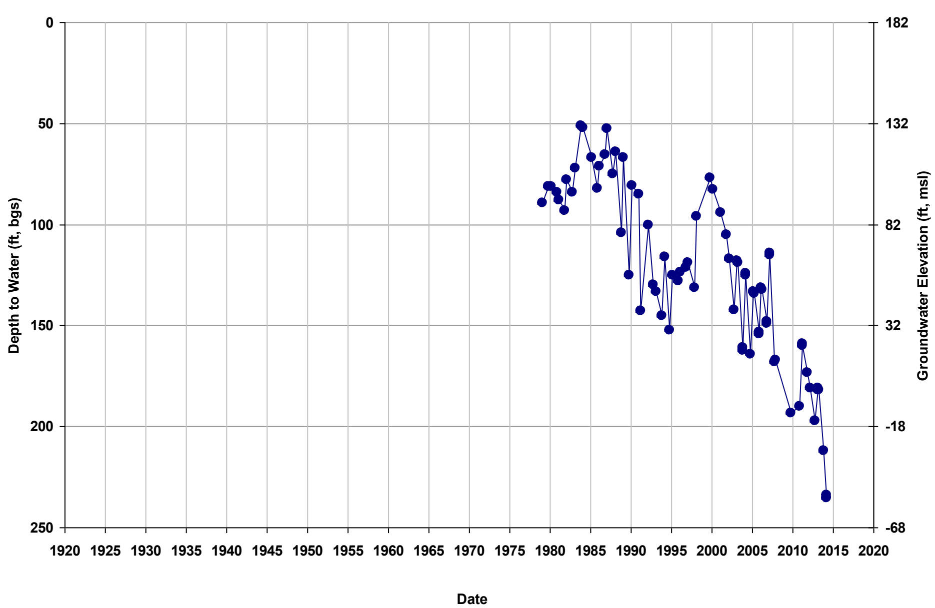
Well ID: 10S15E20C003M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 182
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



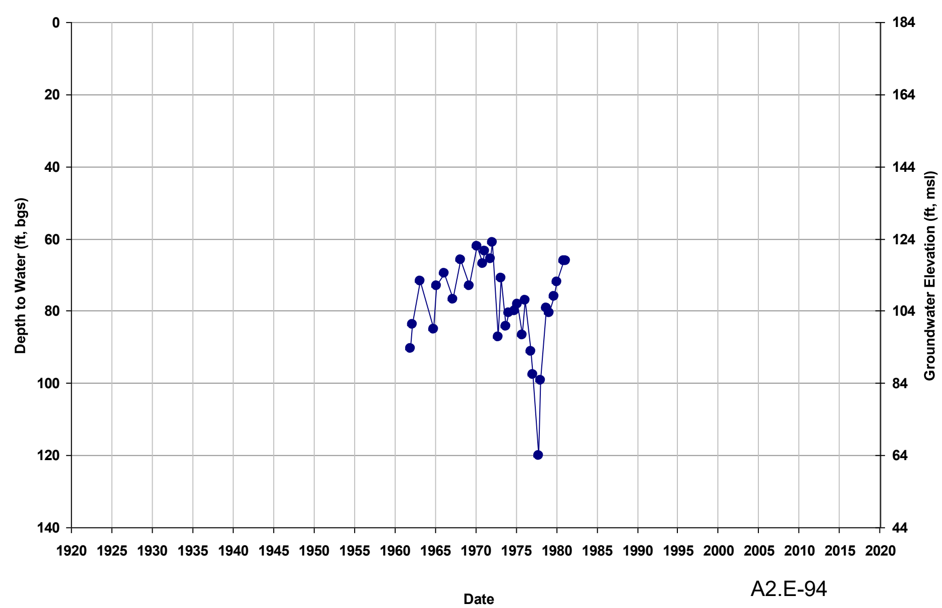
Well ID: 10S15E20C004M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 182
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



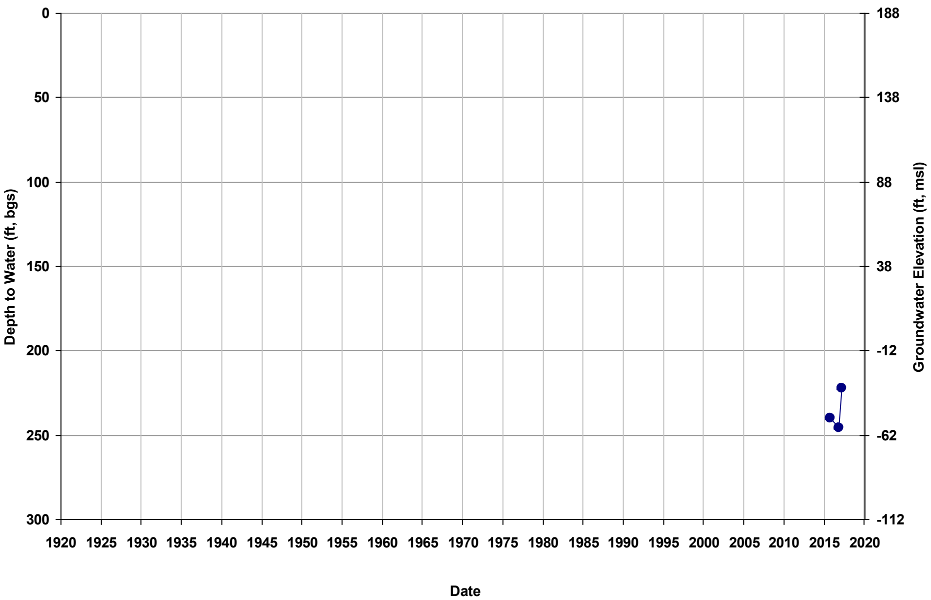
Well ID: 10S15E21F001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 184
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



Well ID: 10S15E21R001M
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 188
Total Depth (ft): 600
Perf Top (ft): 280
Perf Bottom (ft): 600

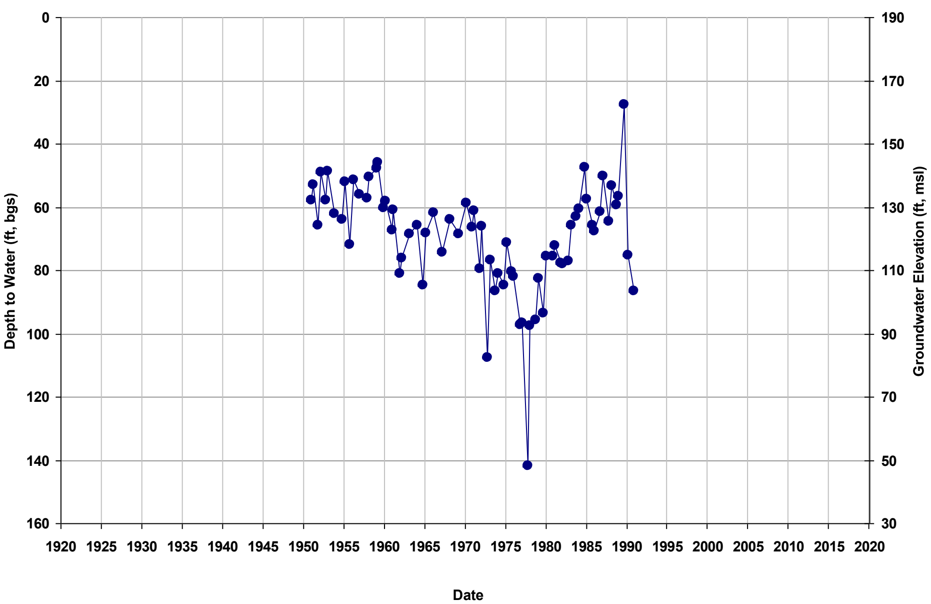


Well ID: 10S15E22D
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 198
Total Depth (ft): 800
Perf Top (ft): 360
Perf Bottom (ft): 800

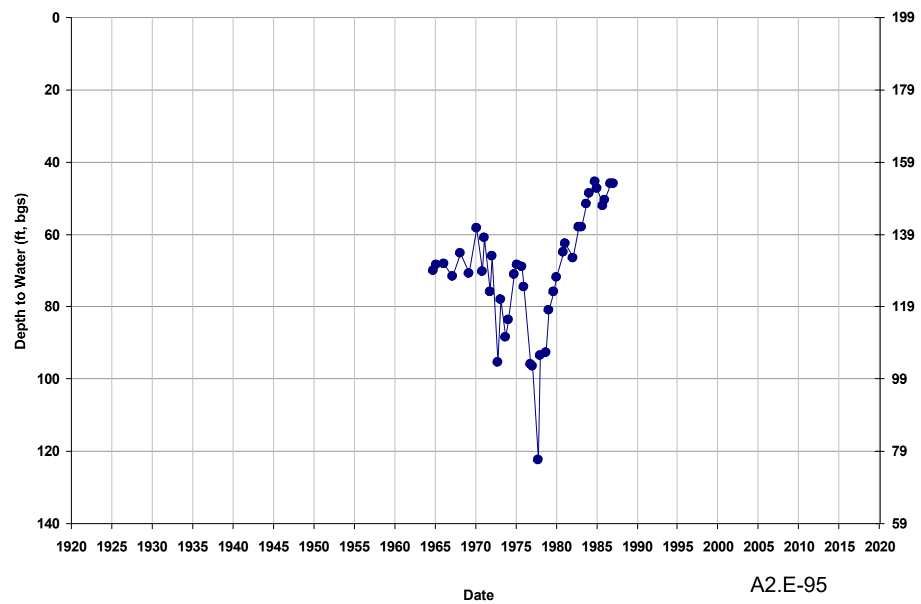
Well ID: 10S15E22K001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 190
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



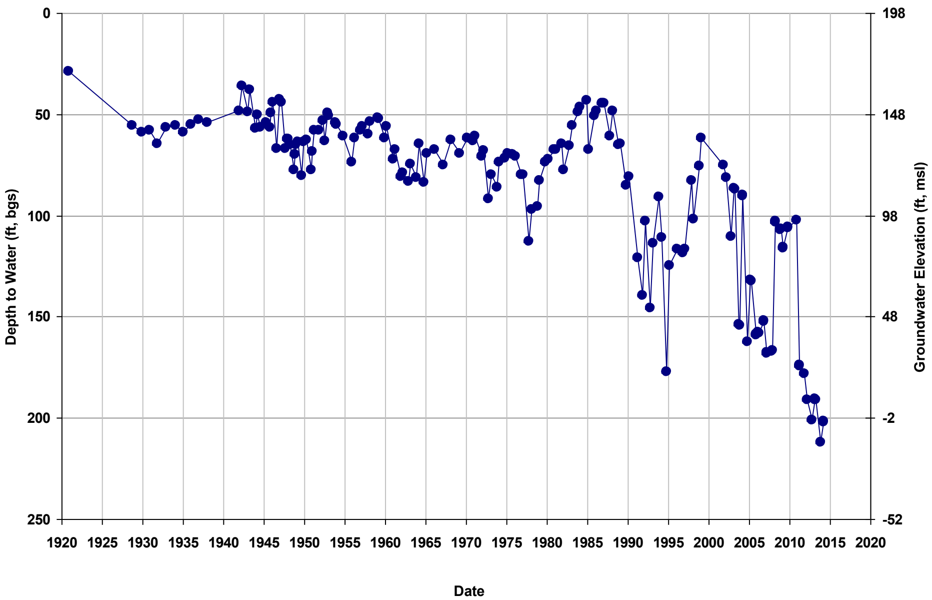
Well ID: 10S15E23C001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 199
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



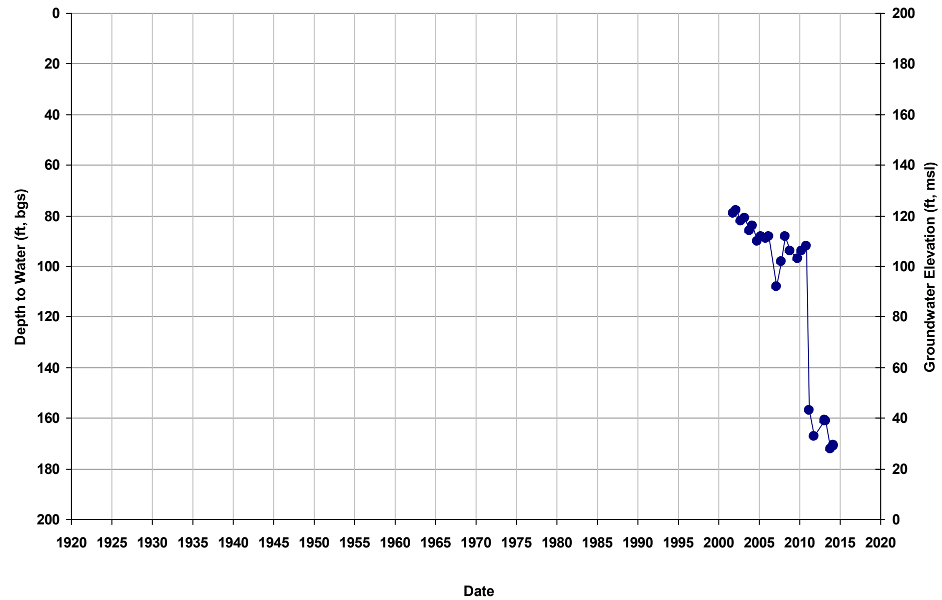
Well ID: 10S15E23K001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 197
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



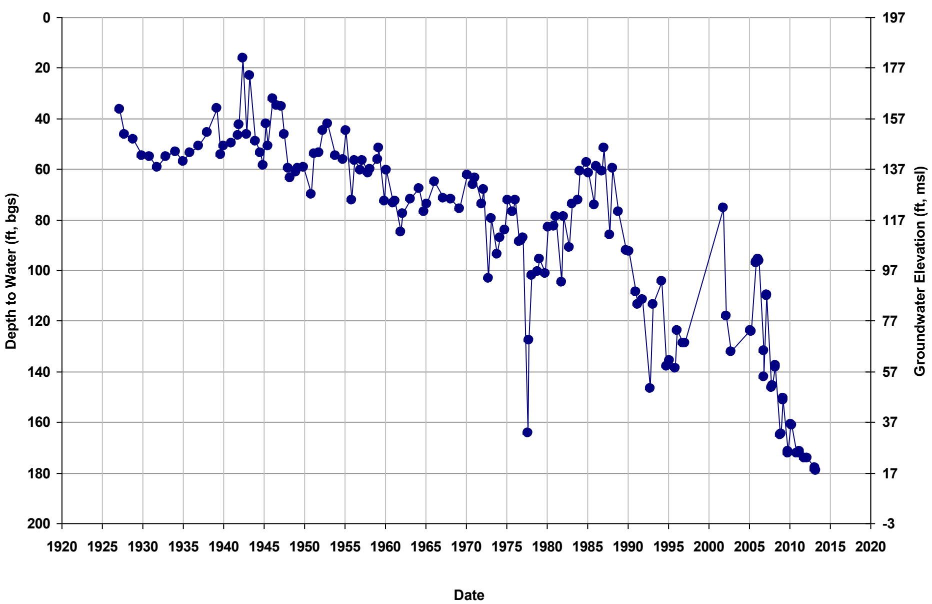
Well ID: 10S15E25A001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 200
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



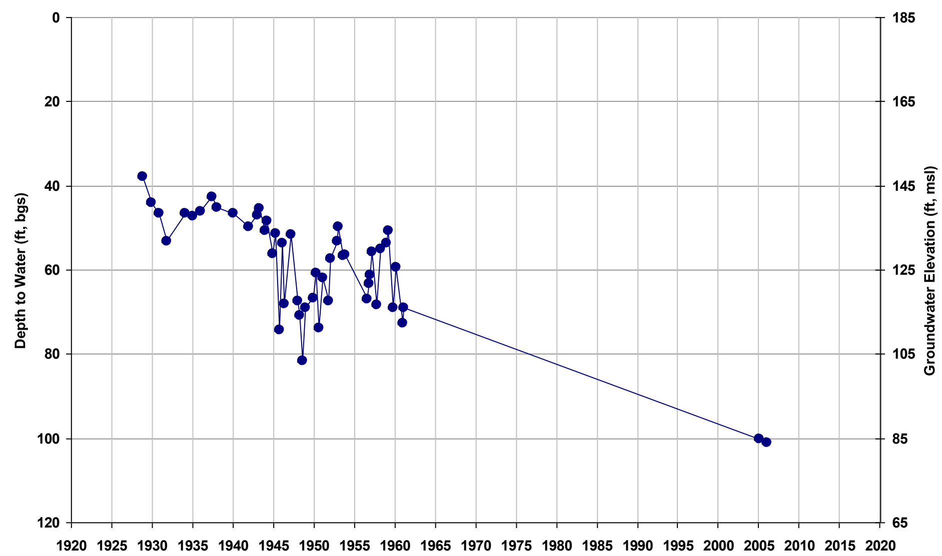
Well ID: 10S15E26A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 197
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



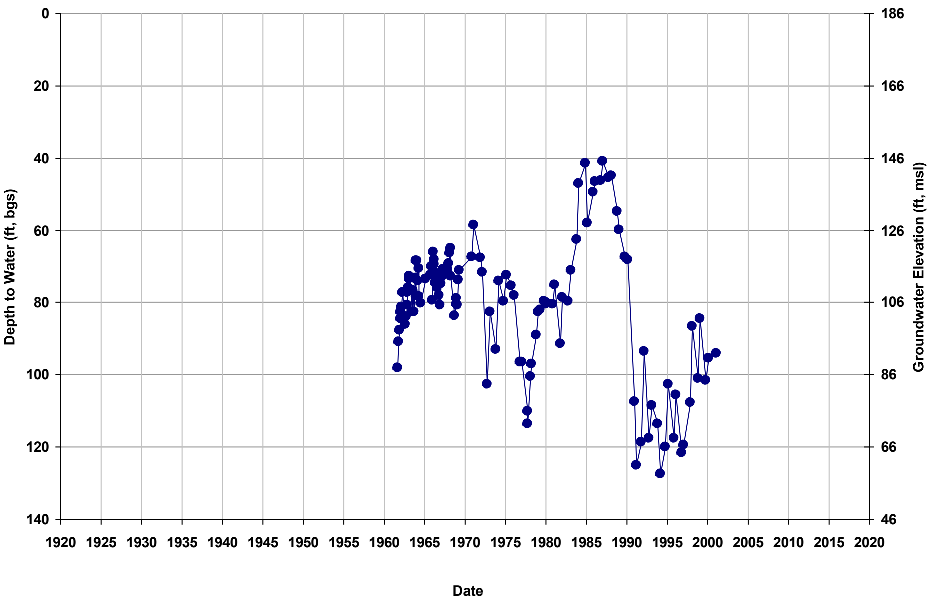
Well ID: 10S15E27D001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 185
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



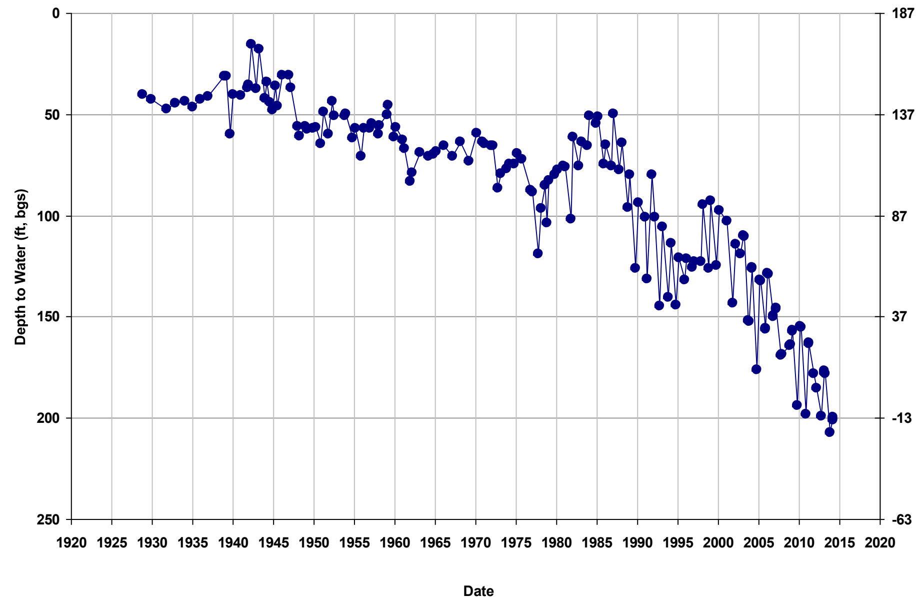
Well ID: 10S15E27D003M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 186
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



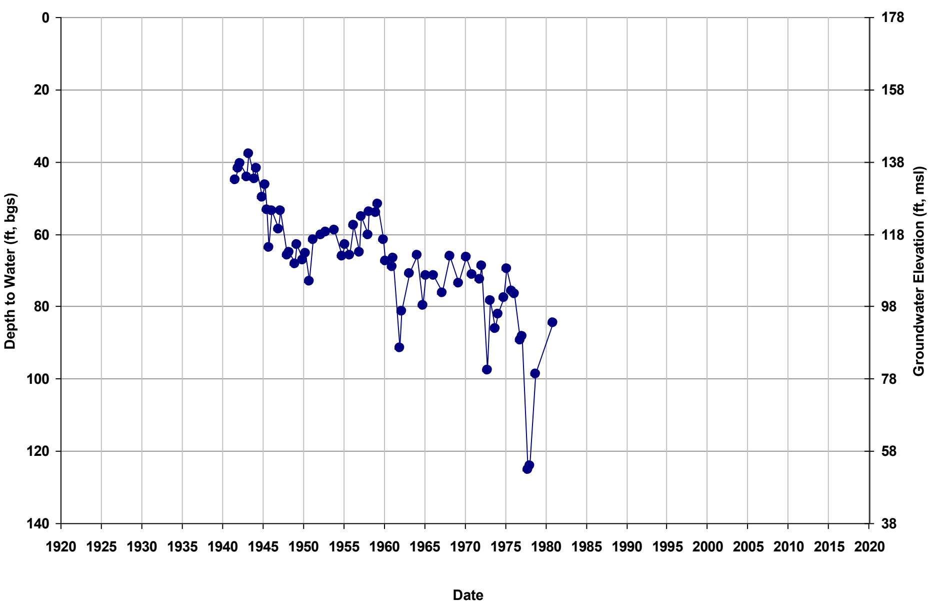
Well ID: 10S15E27R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 187
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



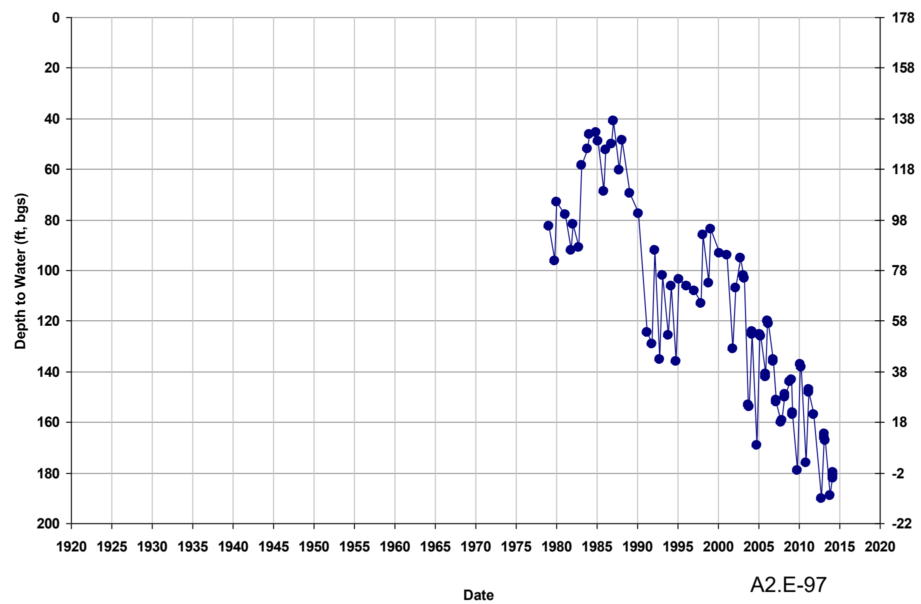
Well ID: 10S15E29A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 178
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



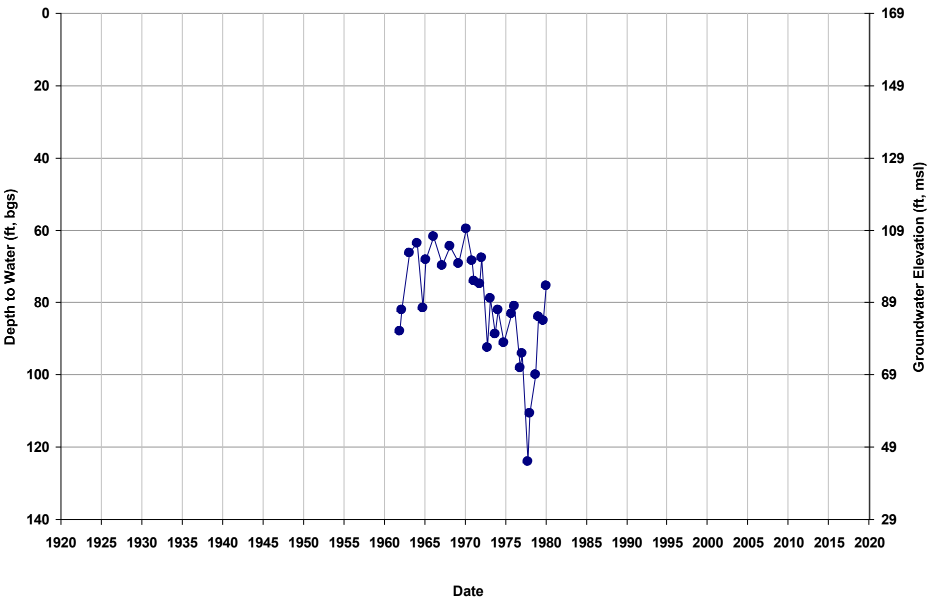
Well ID: 10S15E29A002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 178
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



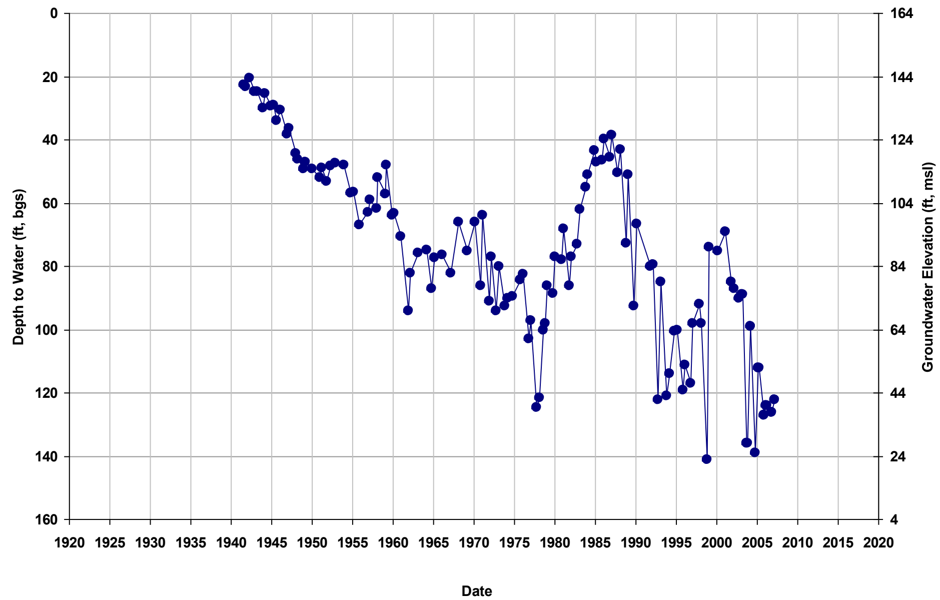
Well ID: 10S15E30J001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 169
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



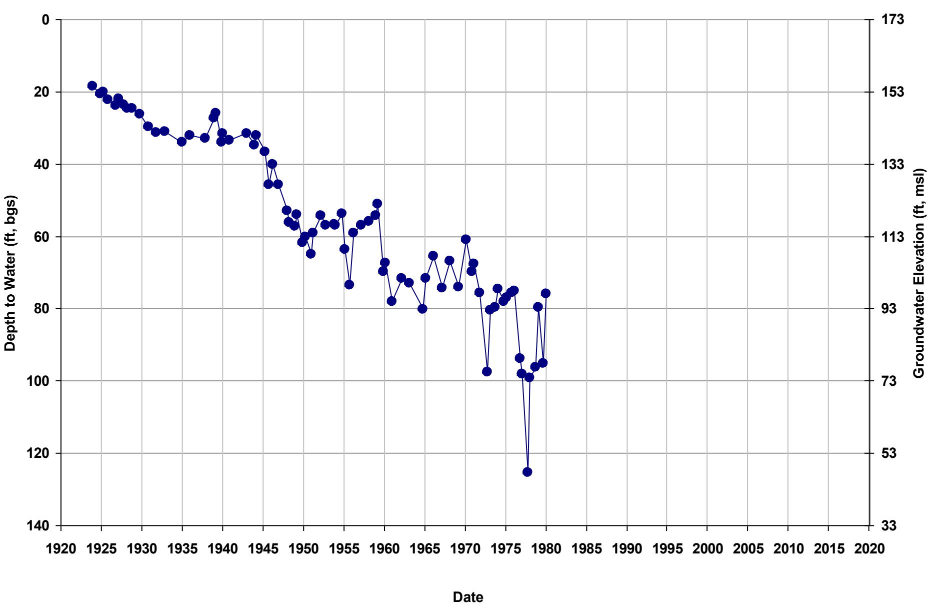
Well ID: 10S15E31C001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 164
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



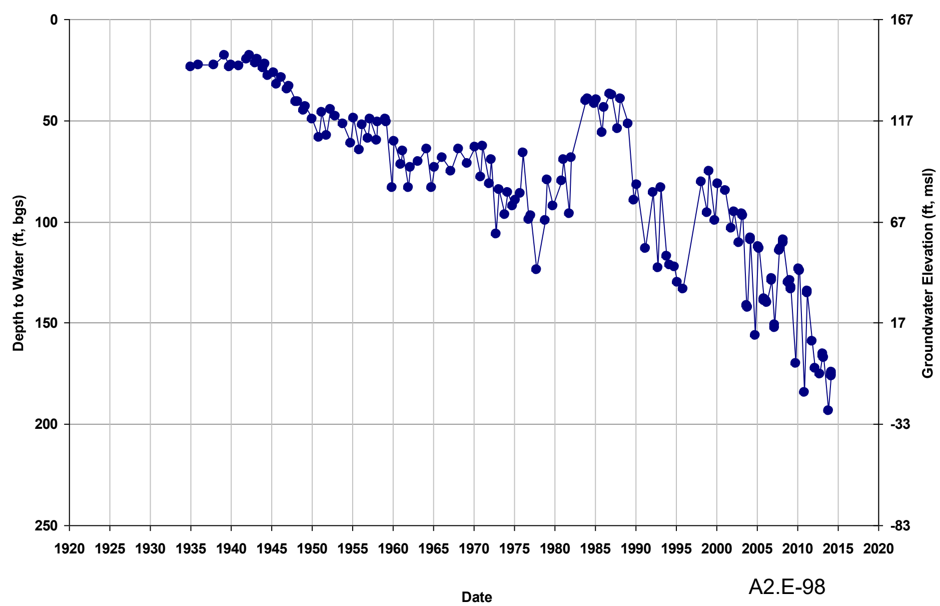
Well ID: 10S15E32A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 172
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



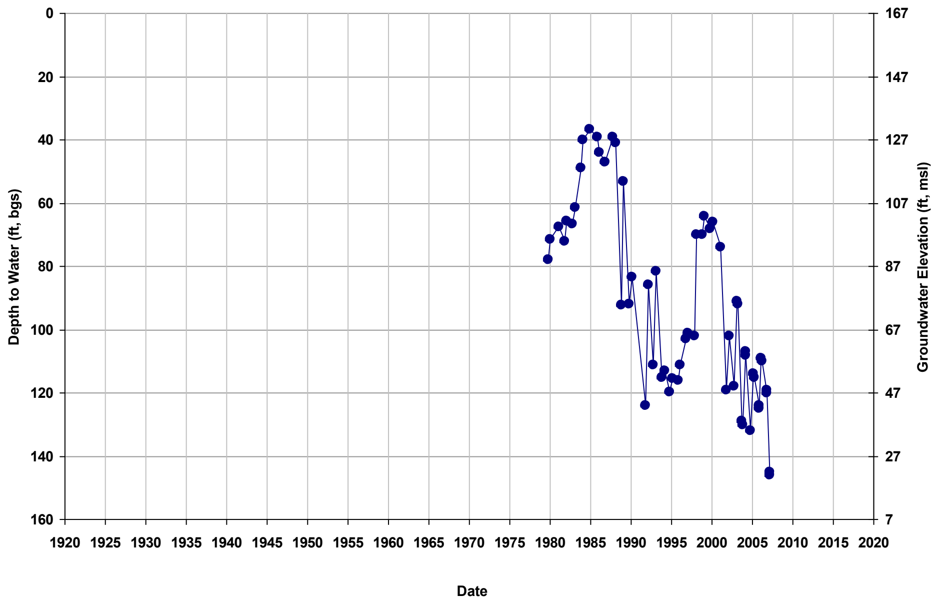
Well ID: 10S15E32L001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 166
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



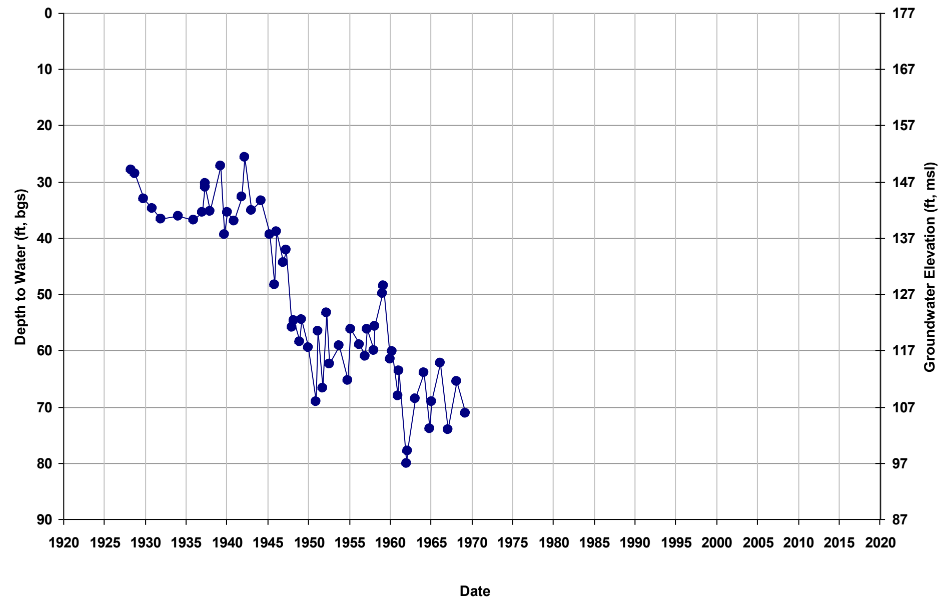
Well ID: 10S15E32L002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 167
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



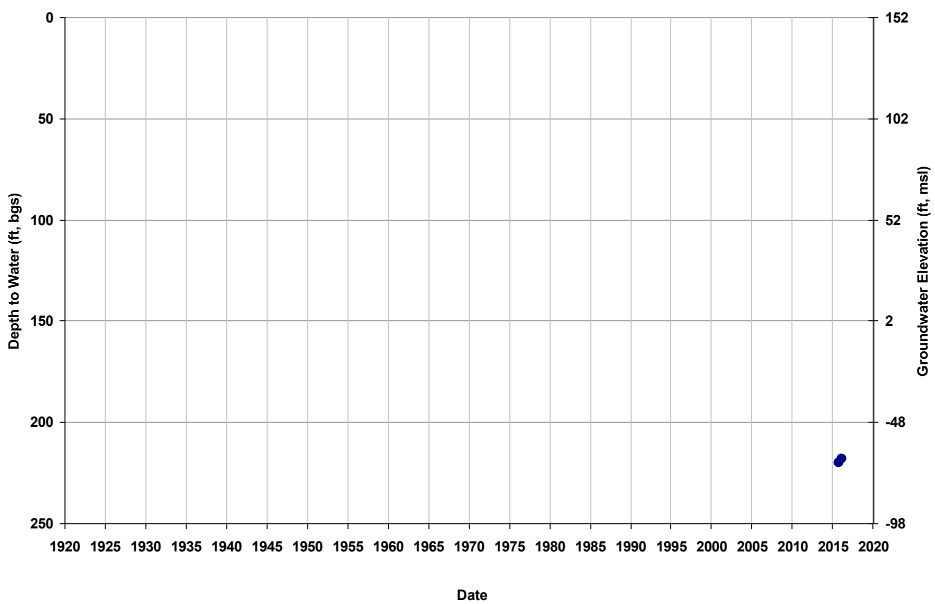
Well ID: 10S15E33B001M
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 176
Total Depth (ft): 150
Perf Top (ft): NA
Perf Bottom (ft): NA



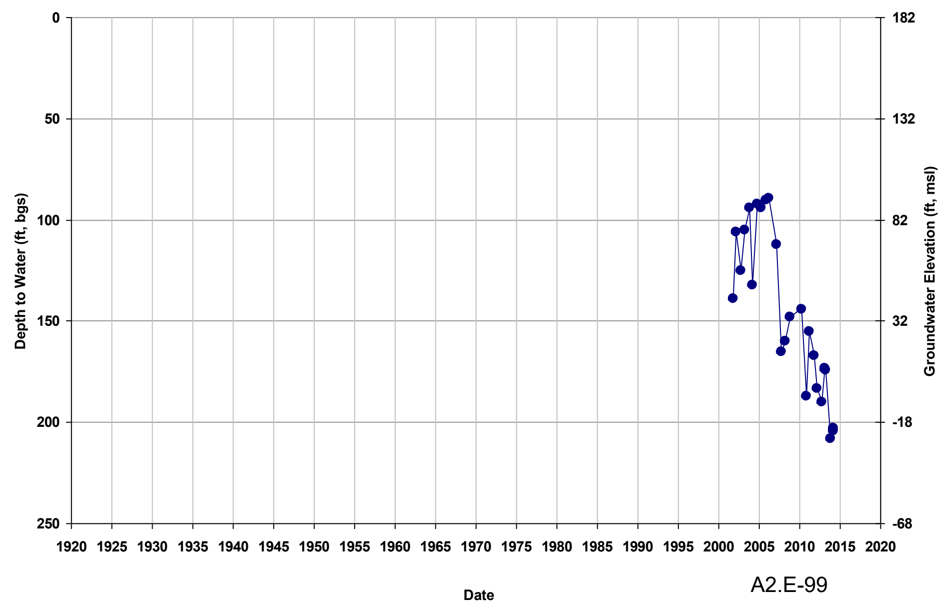
Well ID: 10S15E34A
Depth Zone: Composite; Within CC
Subbasin: Chowchilla

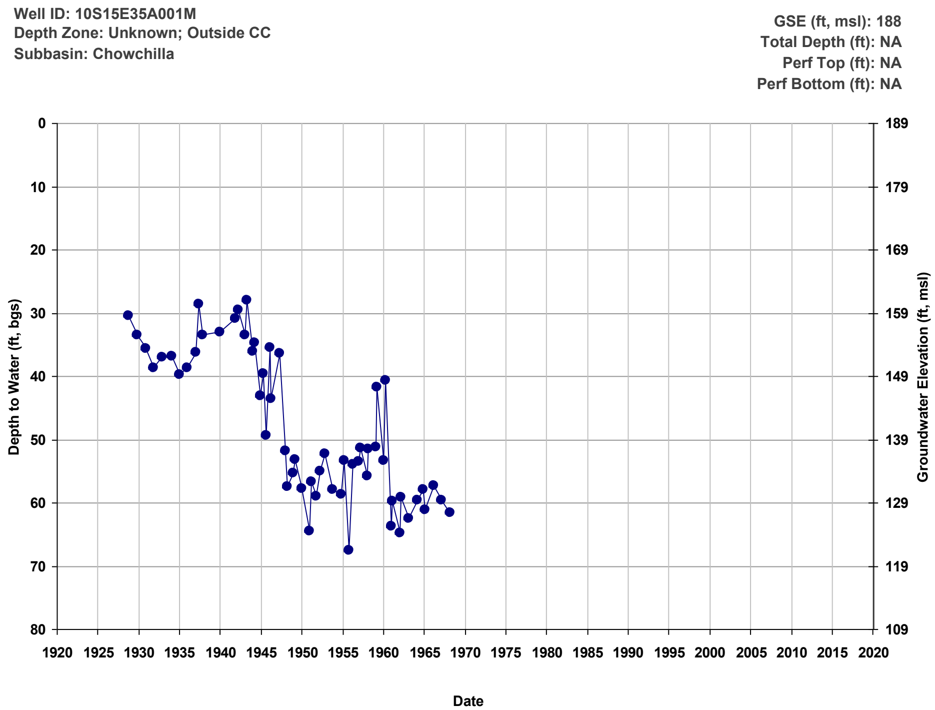
GSE (ft, msl): 152
Total Depth (ft): 455
Perf Top (ft): 185
Perf Bottom (ft): 365

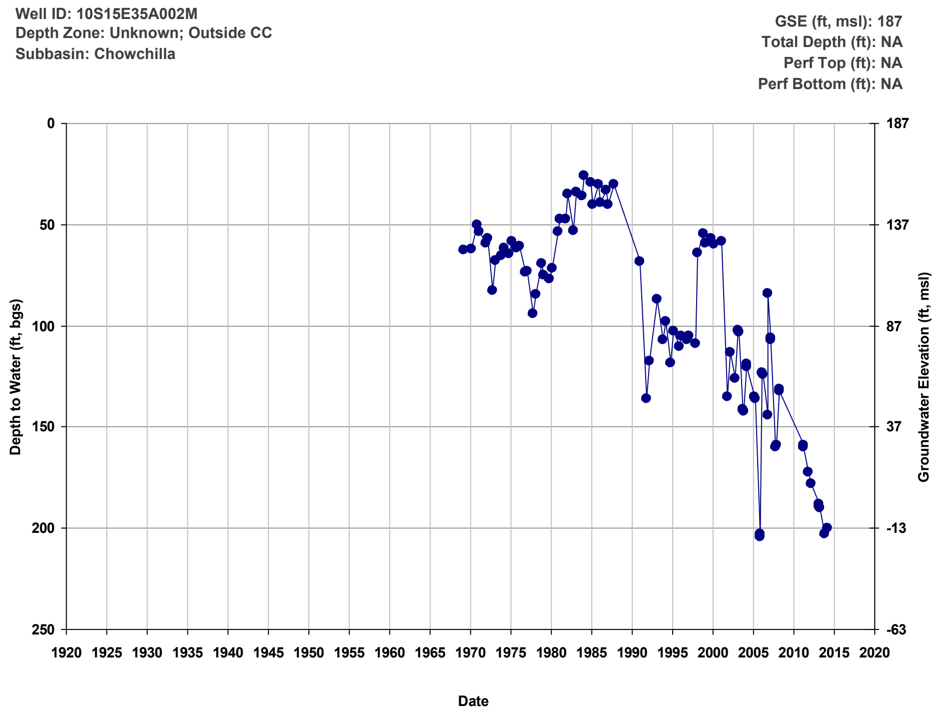


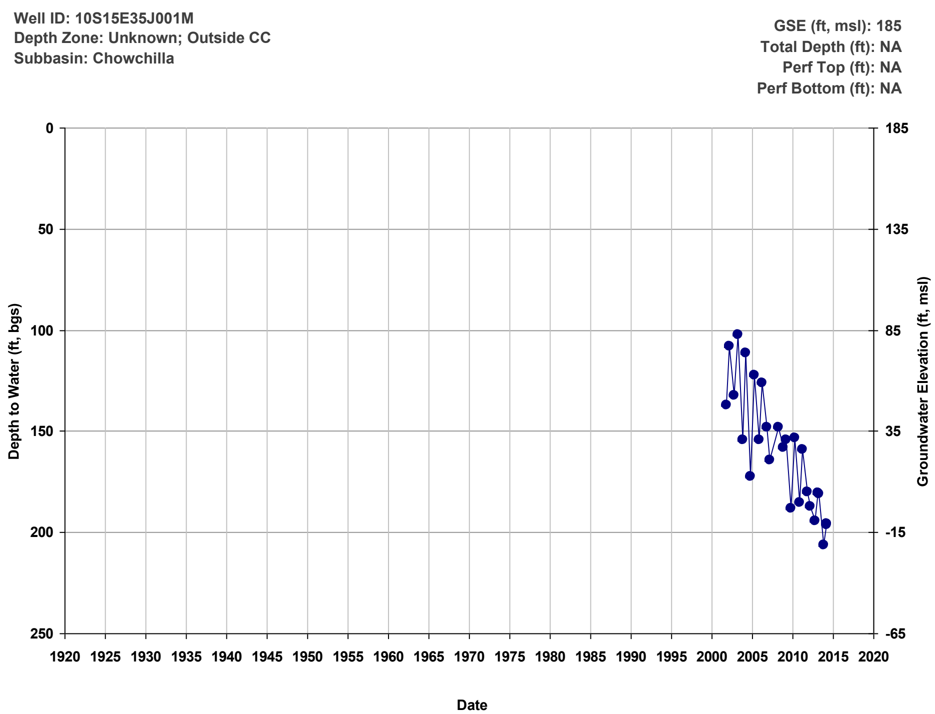
Well ID: 10S15E34L001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

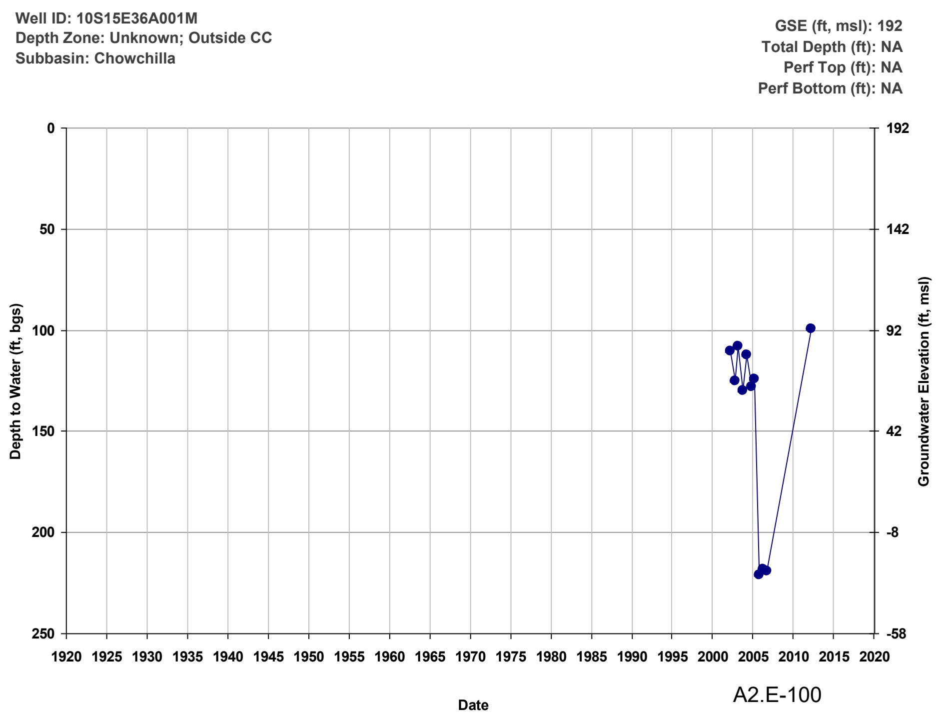
GSE (ft, msl): 182
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA




Well ID: 10S15E35A001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla
GSE (ft, msl): 188
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

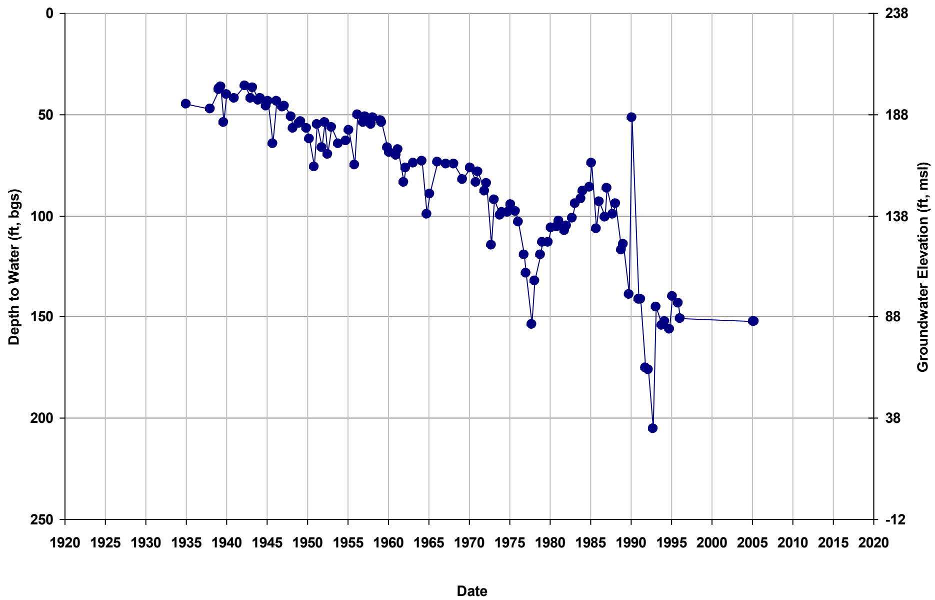

Well ID: 10S15E35A002M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla
GSE (ft, msl): 187
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 10S15E35J001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla
GSE (ft, msl): 185
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: 10S15E36A001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla
GSE (ft, msl): 192
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

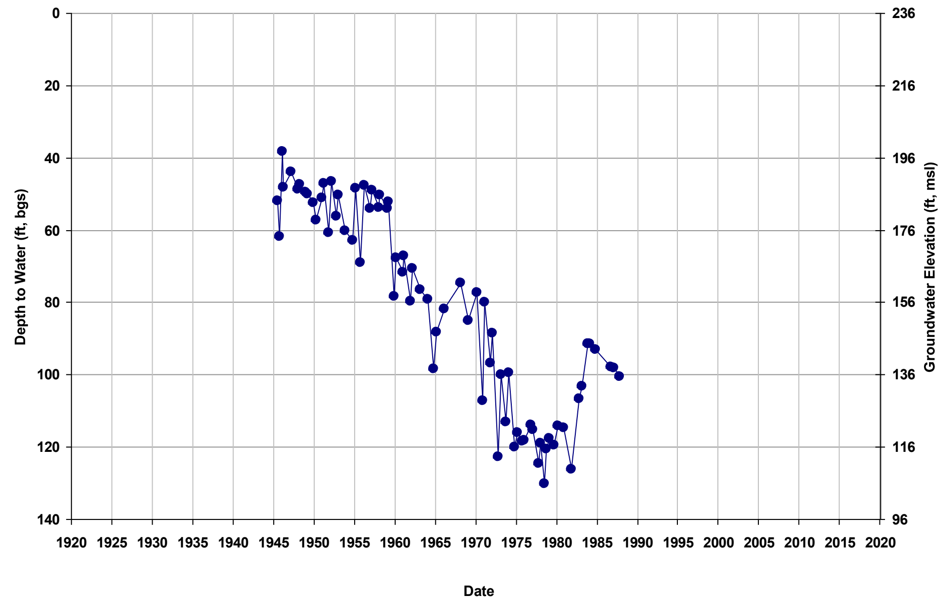
Well ID: 10S16E04N001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 238
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



Well ID: 10S16E05C001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 236
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA

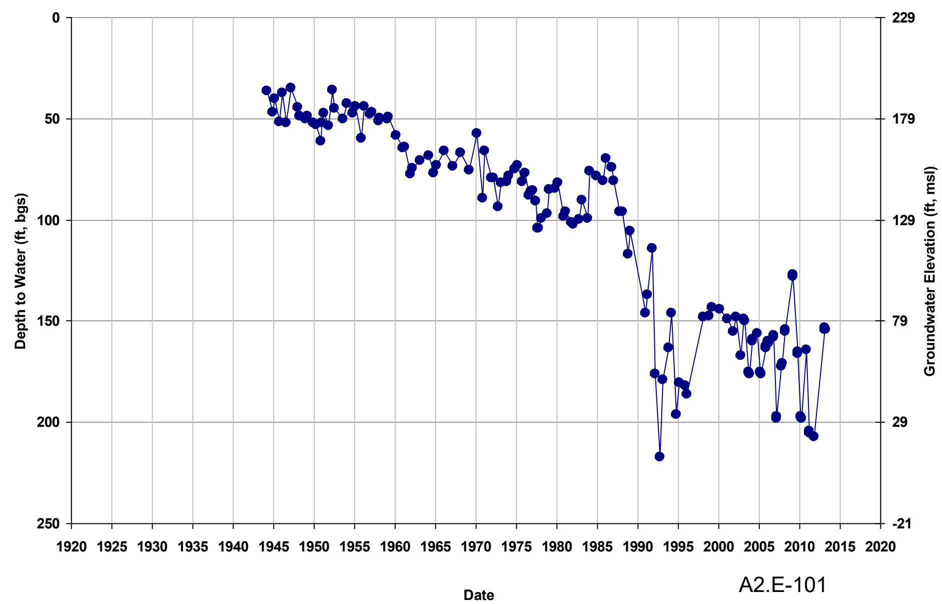


Well ID: 10S16E05M
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 239
Total Depth (ft): 440
Perf Top (ft): 240
Perf Bottom (ft): 440

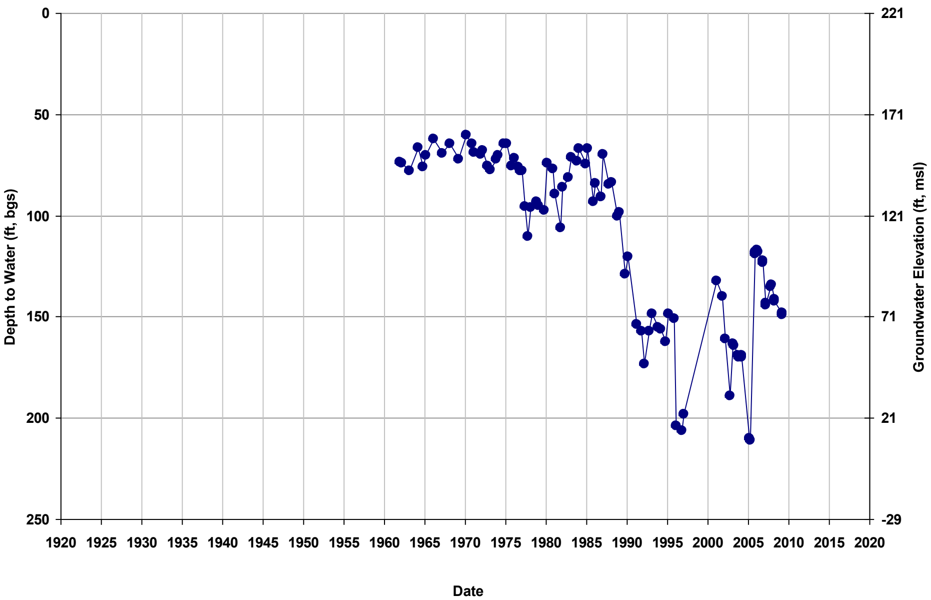
Well ID: 10S16E06R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 229
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



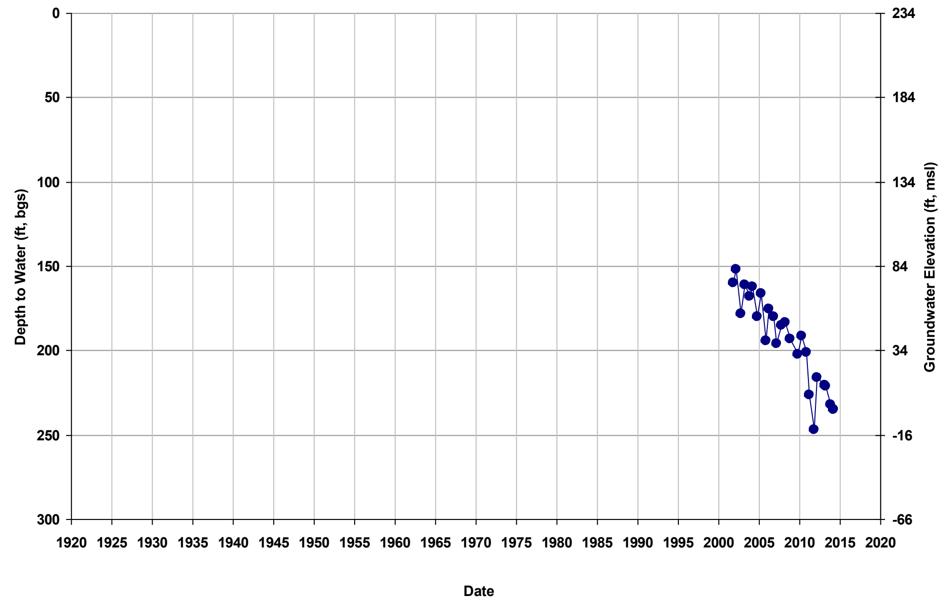
Well ID: 10S16E07K001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 221
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



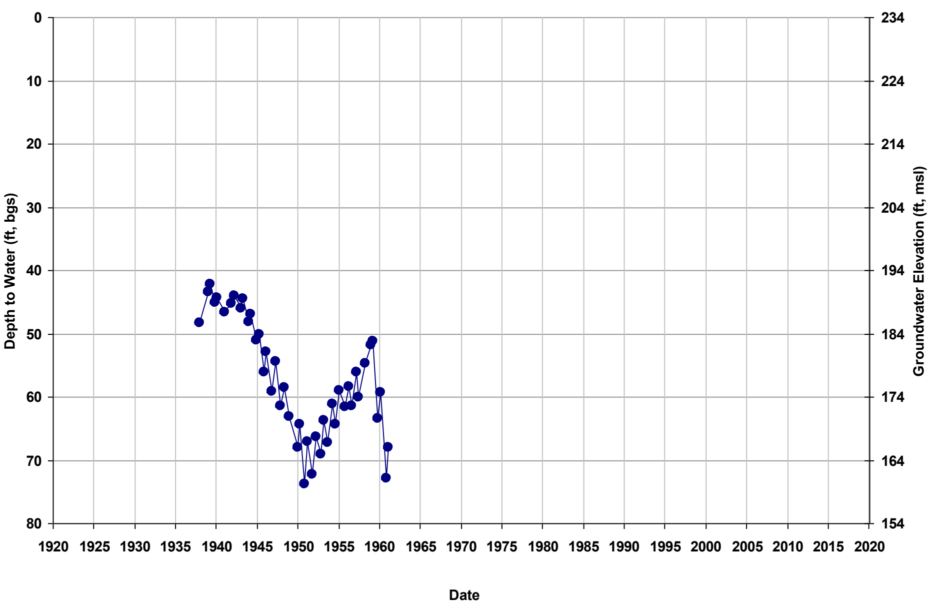
Well ID: 10S16E09E001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 234
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



Well ID: 10S16E09E002M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 233
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA

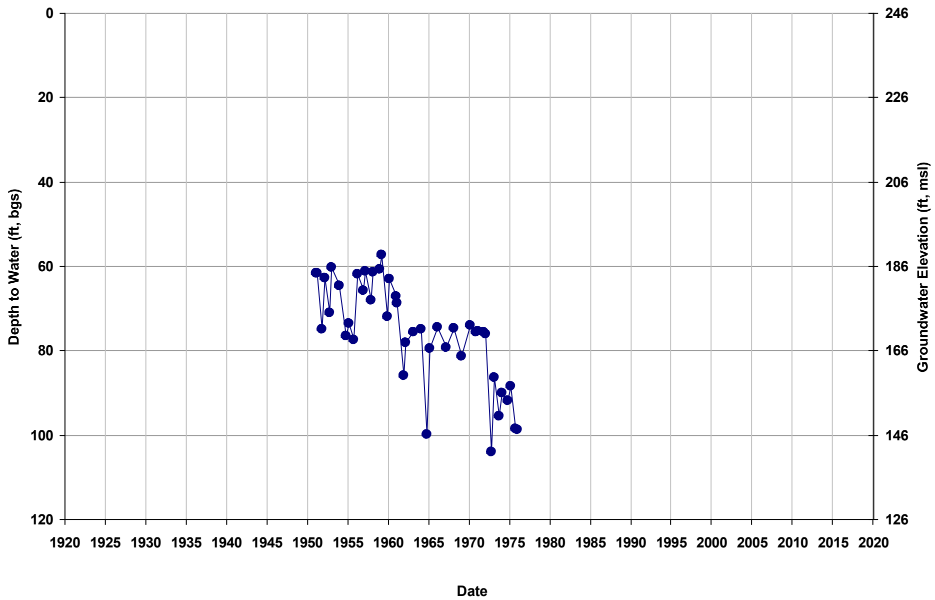


Well ID: 10S16E09M
Depth Zone: Lower; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 213
Total Depth (ft): 955
Perf Top (ft): 290
Perf Bottom (ft): 935

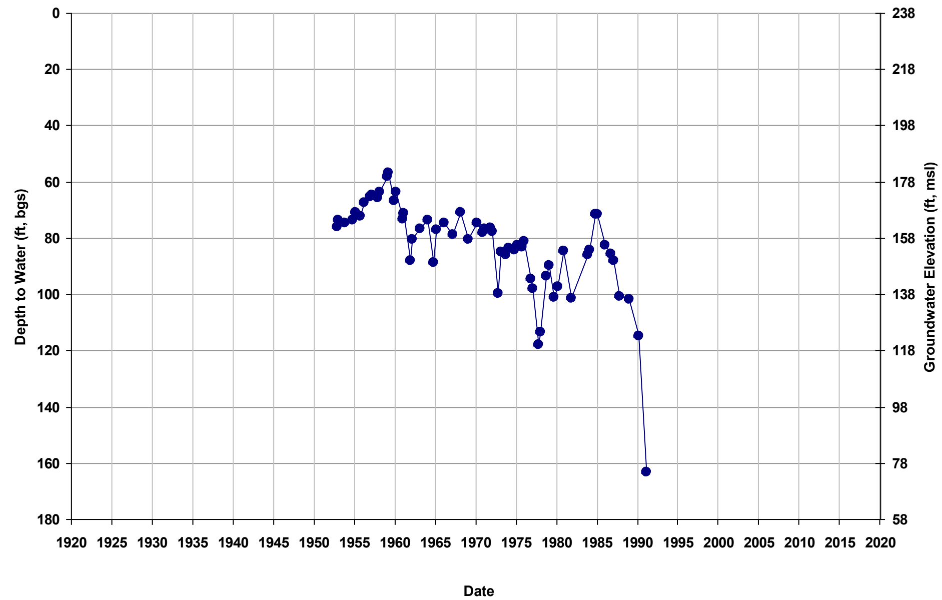
Well ID: 10S16E10C001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 246
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



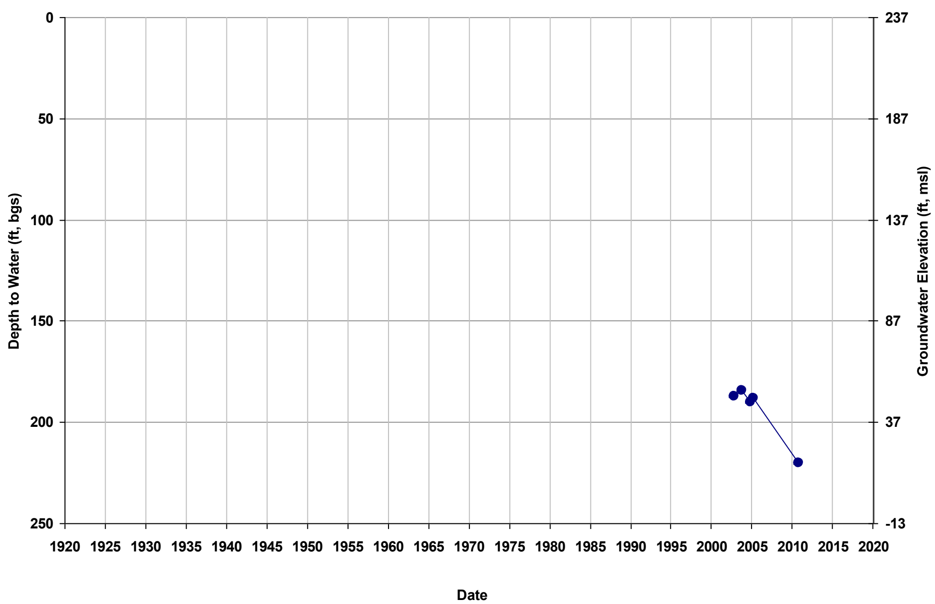
Well ID: 10S16E10N001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 238
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



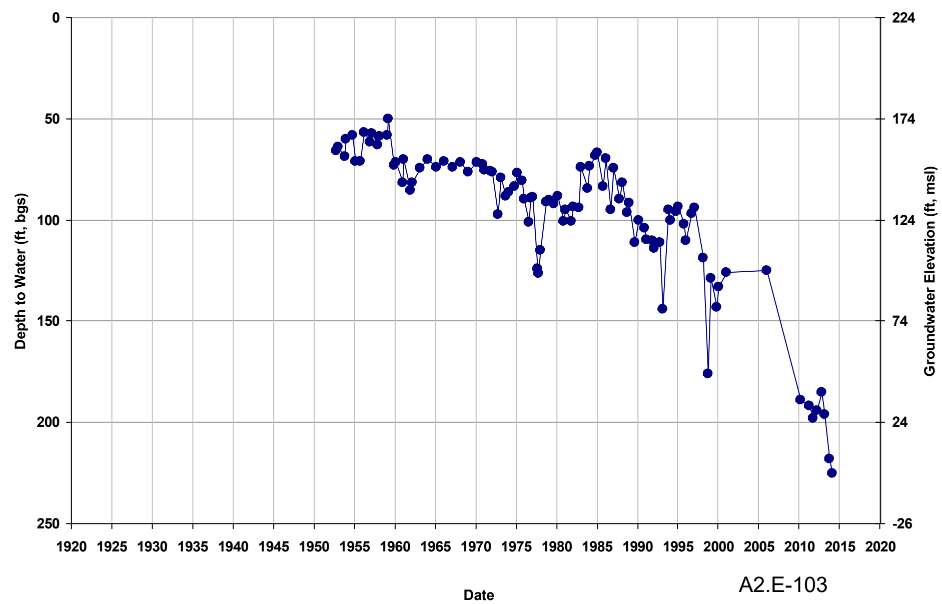
Well ID: 10S16E15F001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 237
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



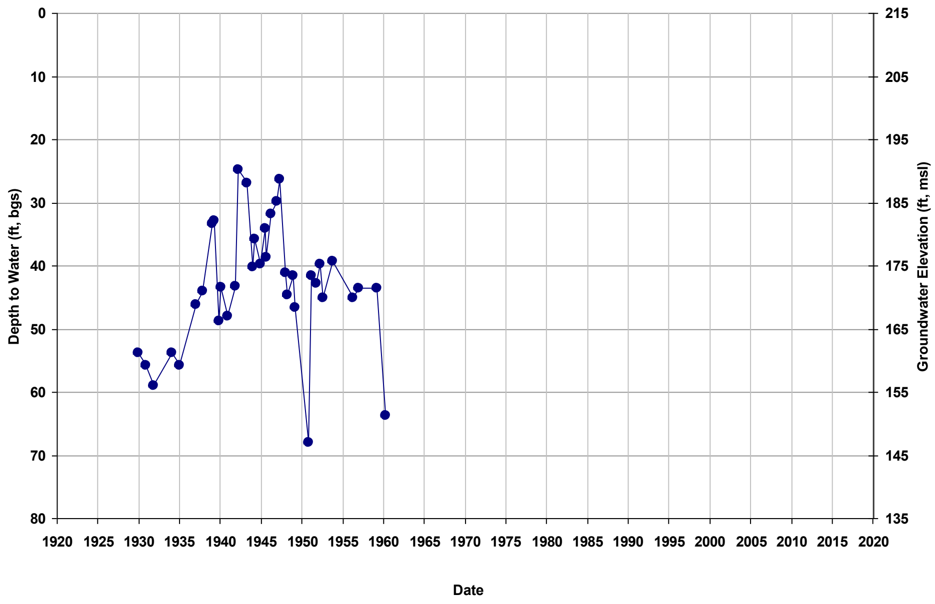
Well ID: 10S16E17C001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 224
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



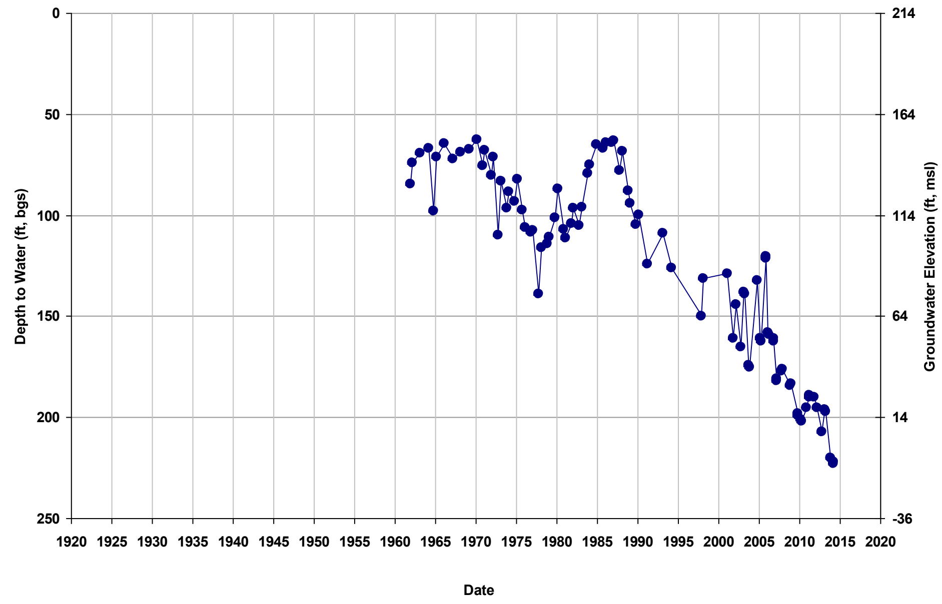
Well ID: 10S16E18D001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 214
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



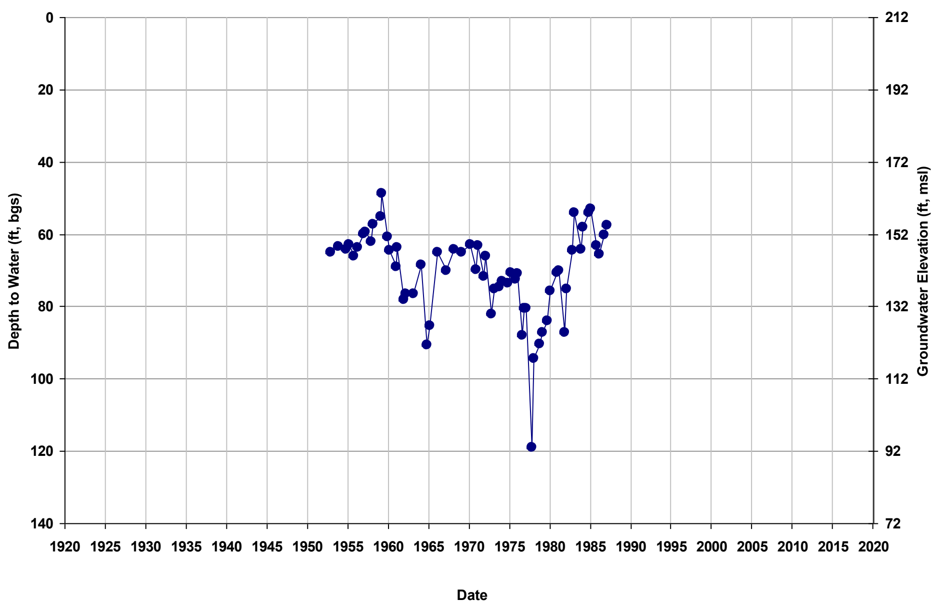
Well ID: 10S16E18D002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 214
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



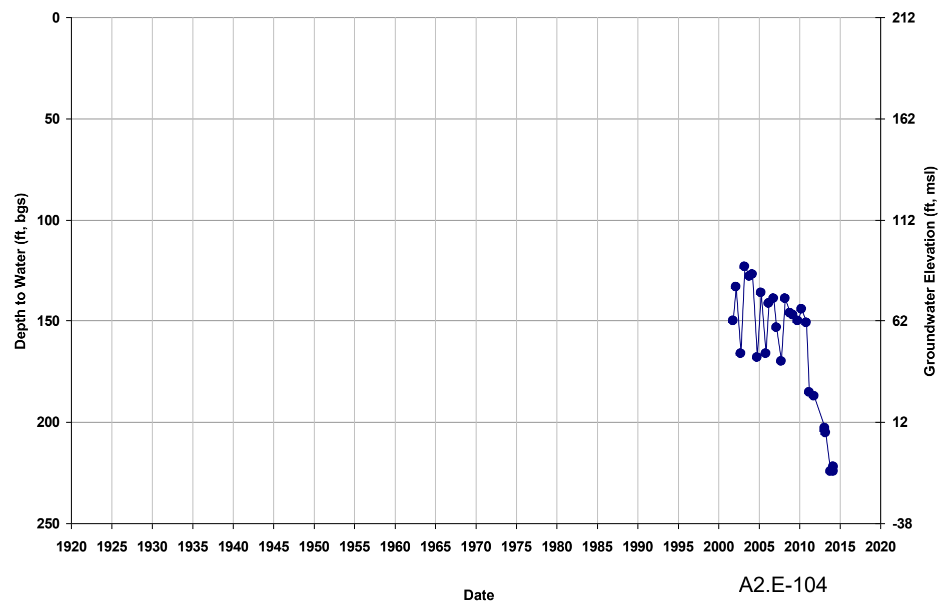
Well ID: 10S16E19A001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 212
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



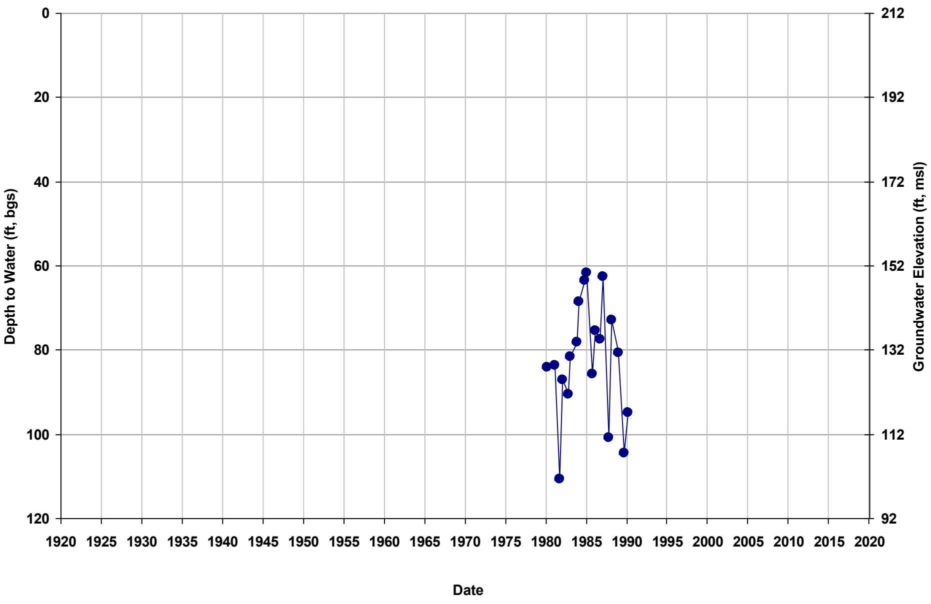
Well ID: 10S16E19A002M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 212
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



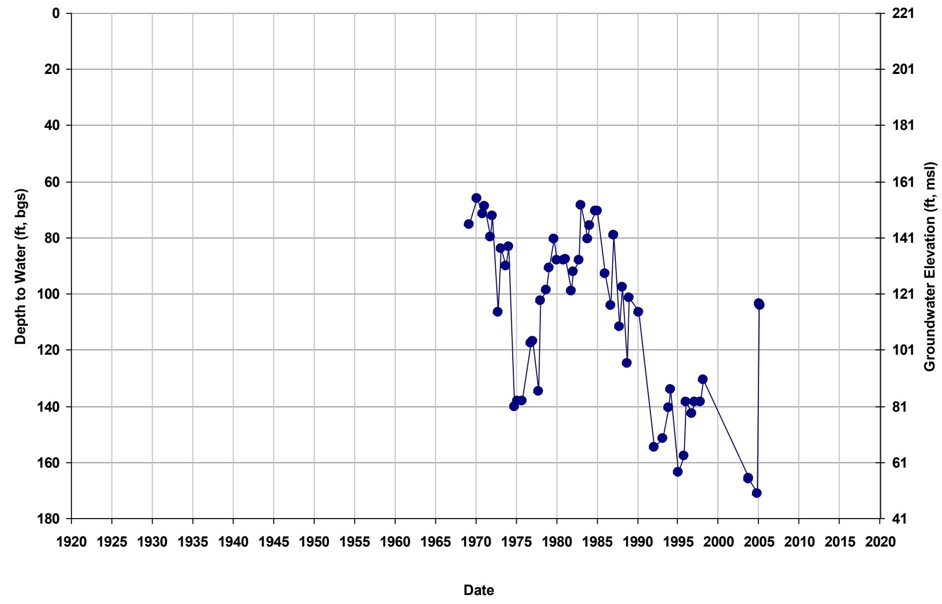
Well ID: 10S16E19J001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 211
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



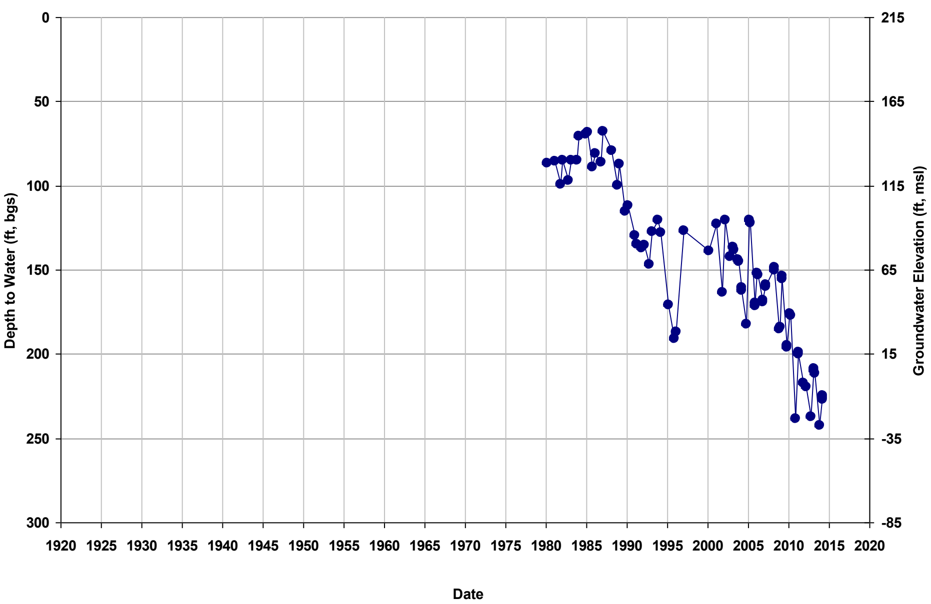
Well ID: 10S16E20A001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 221
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



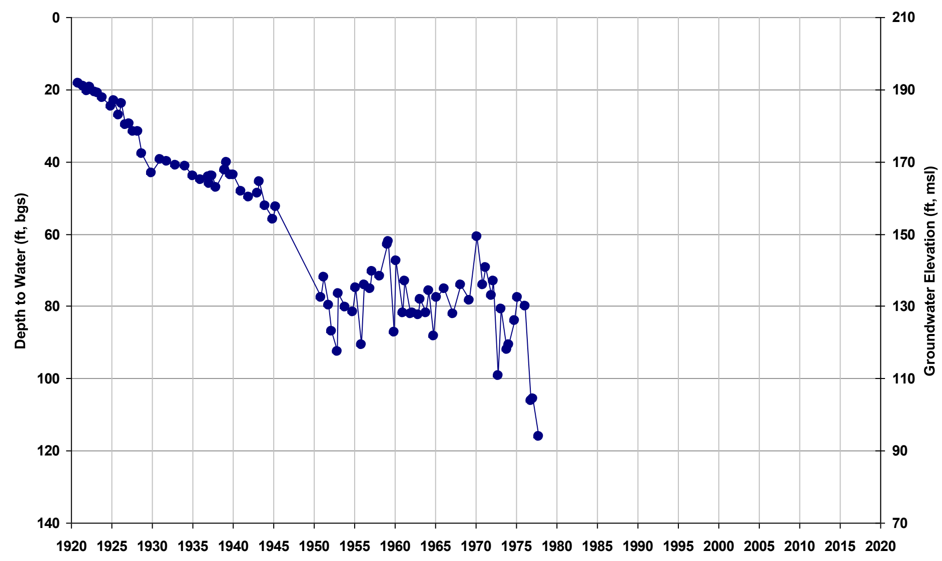
Well ID: 10S16E29A001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 215
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



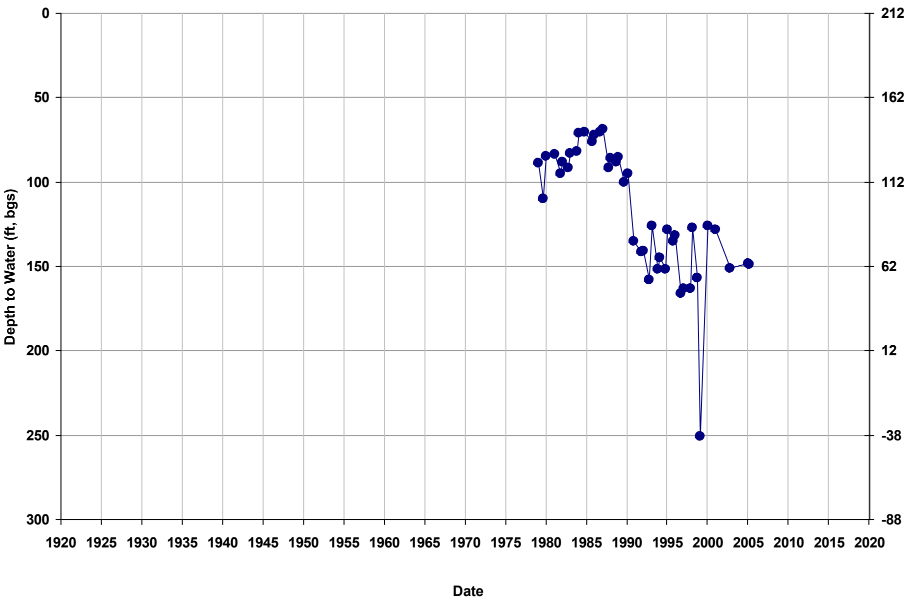
Well ID: 10S16E29R001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 210
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



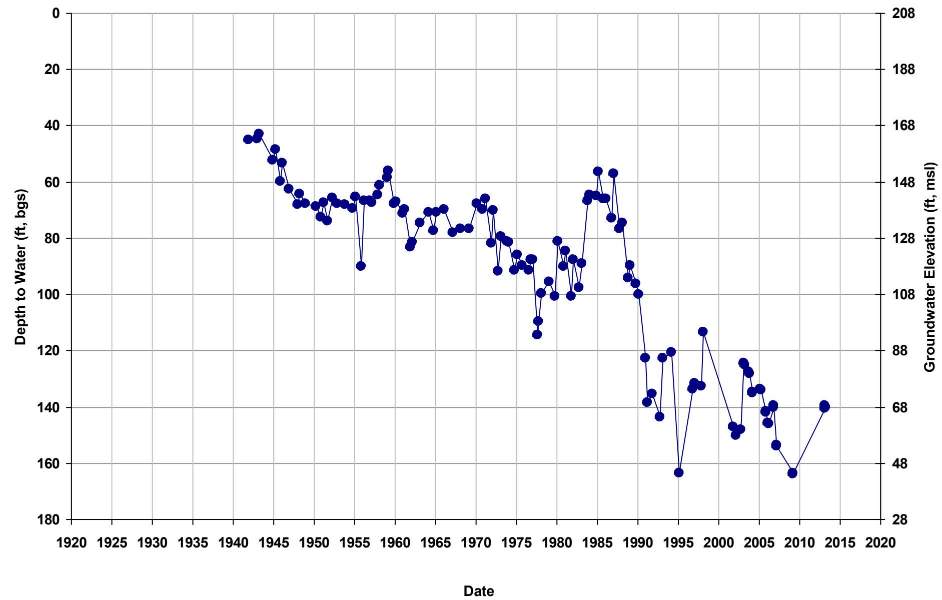
Well ID: 10S16E29R002M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 211
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



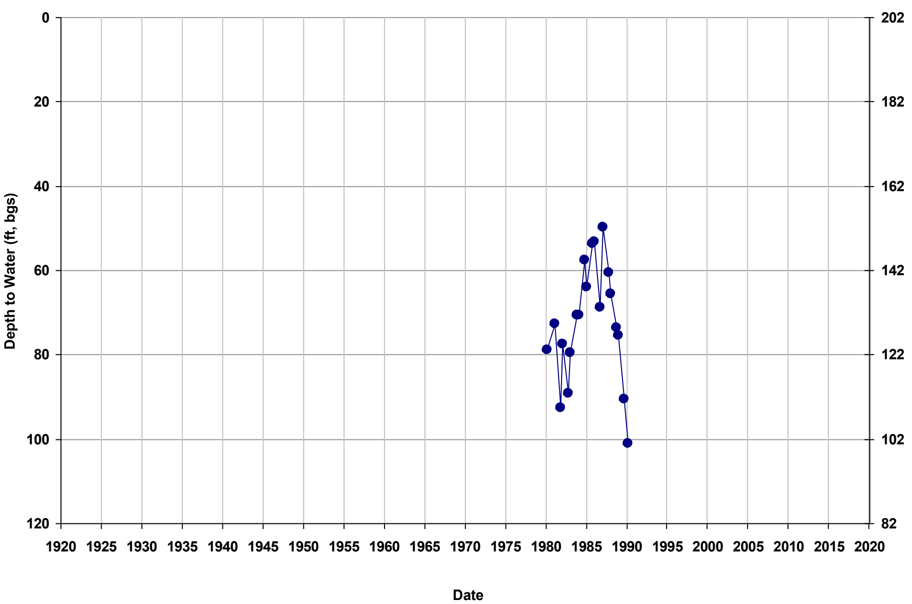
Well ID: 10S16E30A001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 208
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



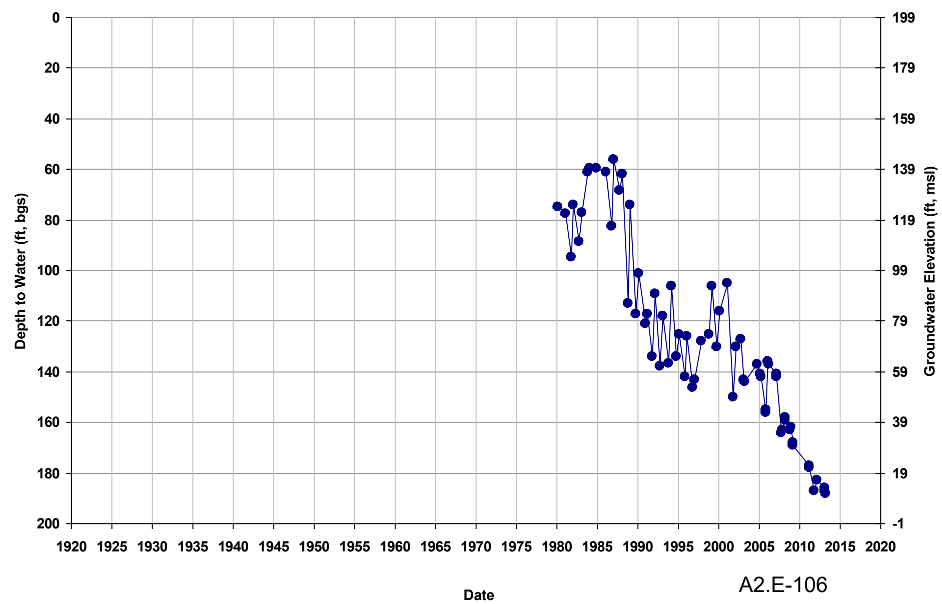
Well ID: 10S16E30D001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 202
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



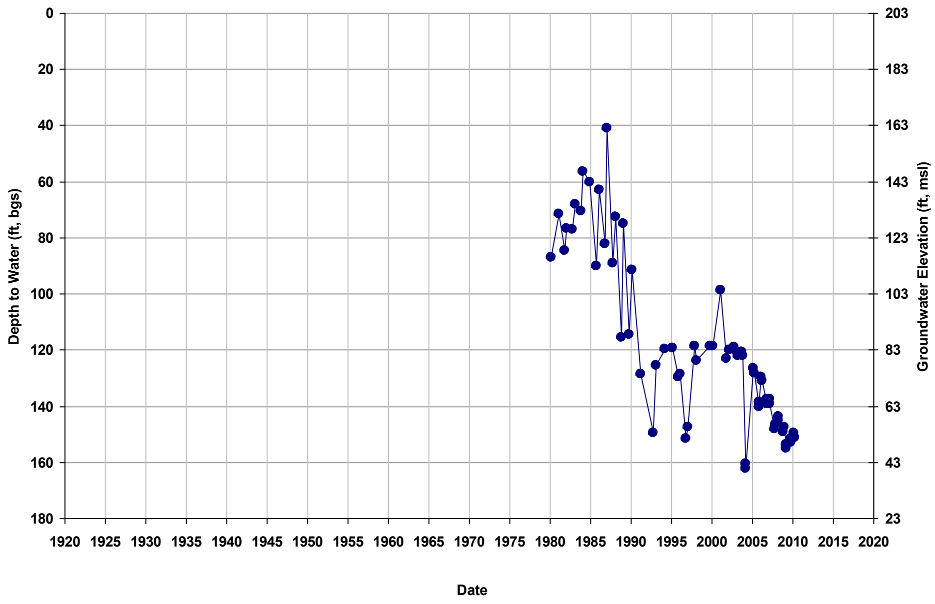
Well ID: 10S16E31J001M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 198
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



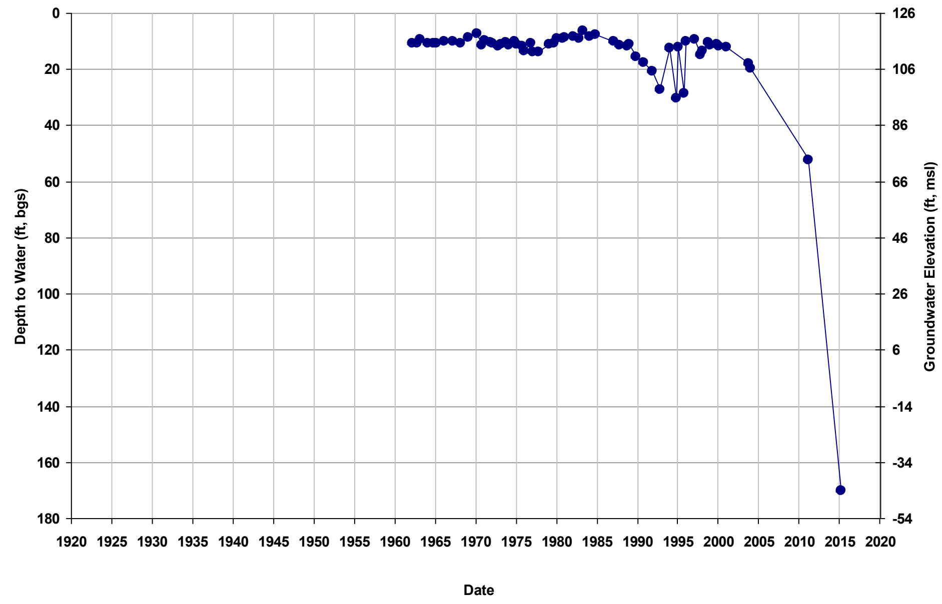
Well ID: 10S16E32D002M
Depth Zone: Unknown; Outside CC
Subbasin: Chowchilla

GSE (ft, msl): 203
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



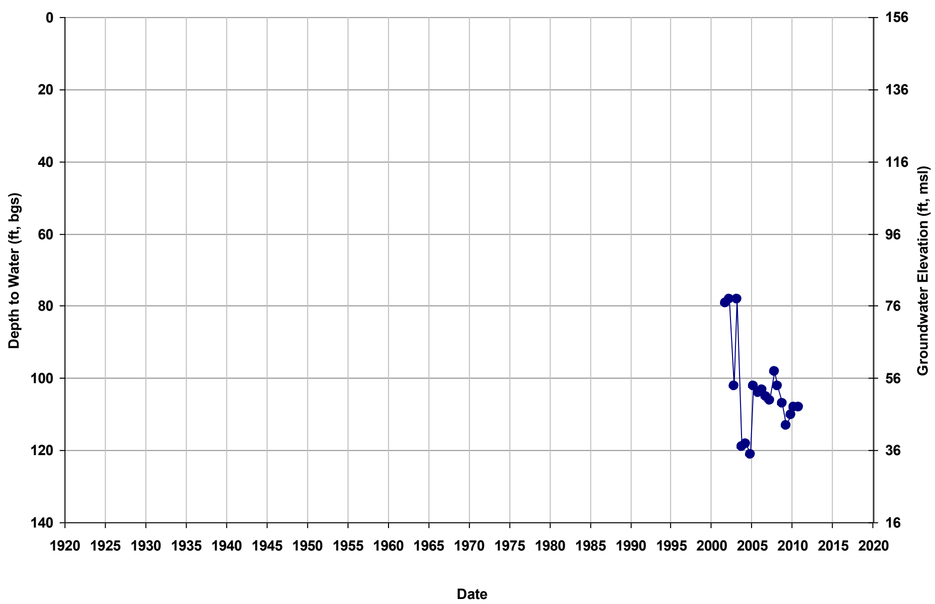
Well ID: 11S13E01Q001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 126
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



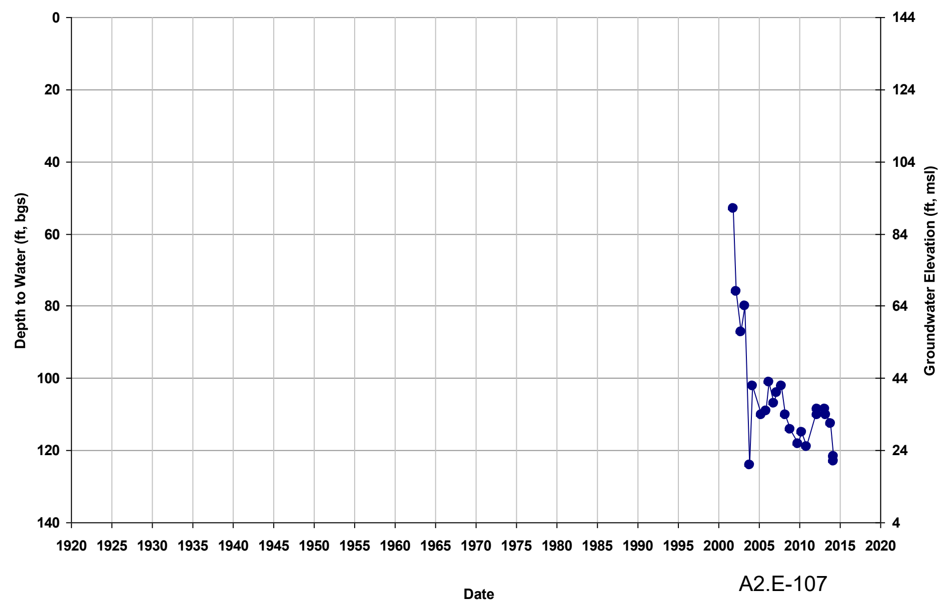
Well ID: 11S14E01R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 156
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



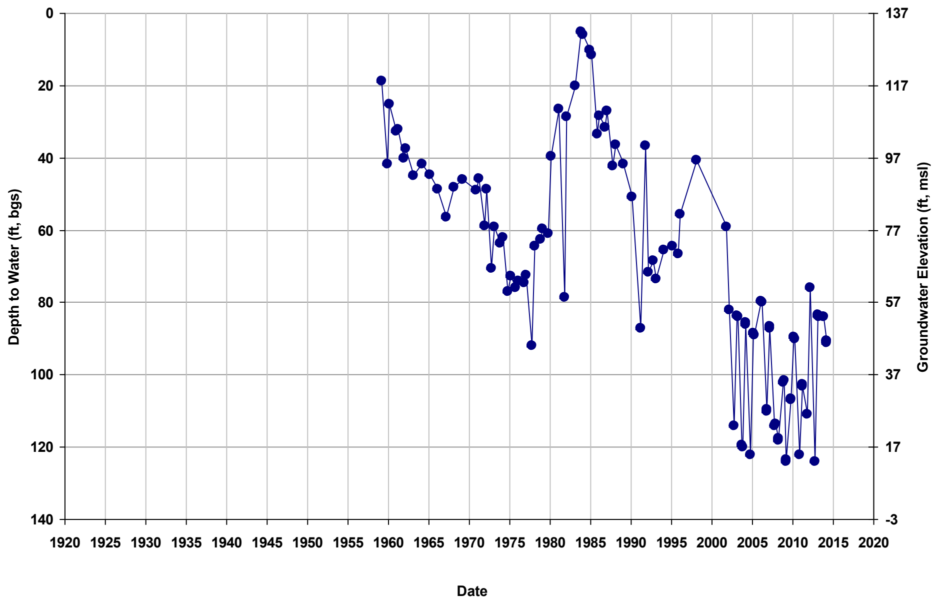
Well ID: 11S14E03G001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 144
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



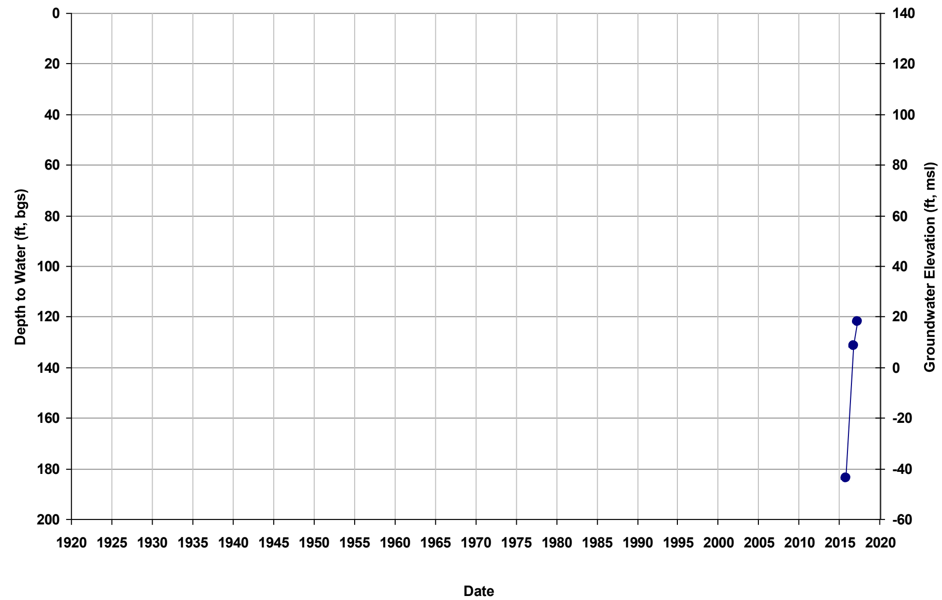
Well ID: 11S14E04C001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 137
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



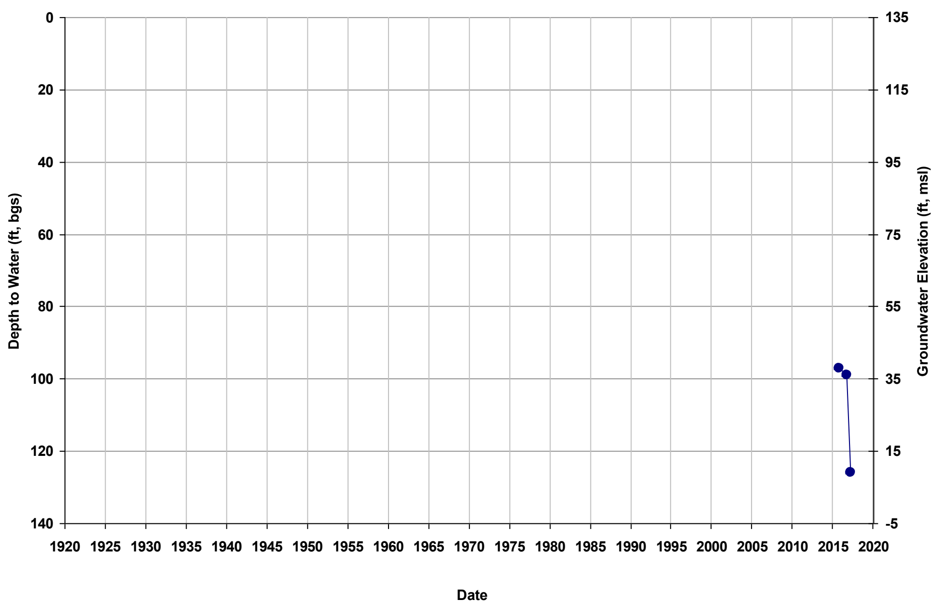
Well ID: 11S14E04J001M
Depth Zone: Composite or Lower; Wi
Subbasin: Chowchilla

GSE (ft, msl): 140
Total Depth (ft): 900
Perf Top (ft): NA
Perf Bottom (ft): NA



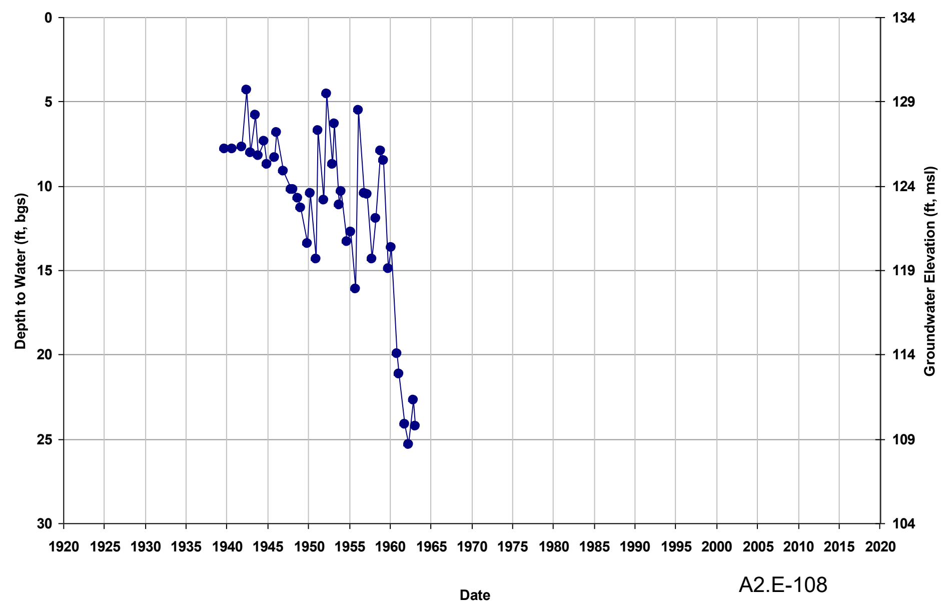
Well ID: 11S14E05J001M
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 135
Total Depth (ft): 500
Perf Top (ft): 300
Perf Bottom (ft): 500



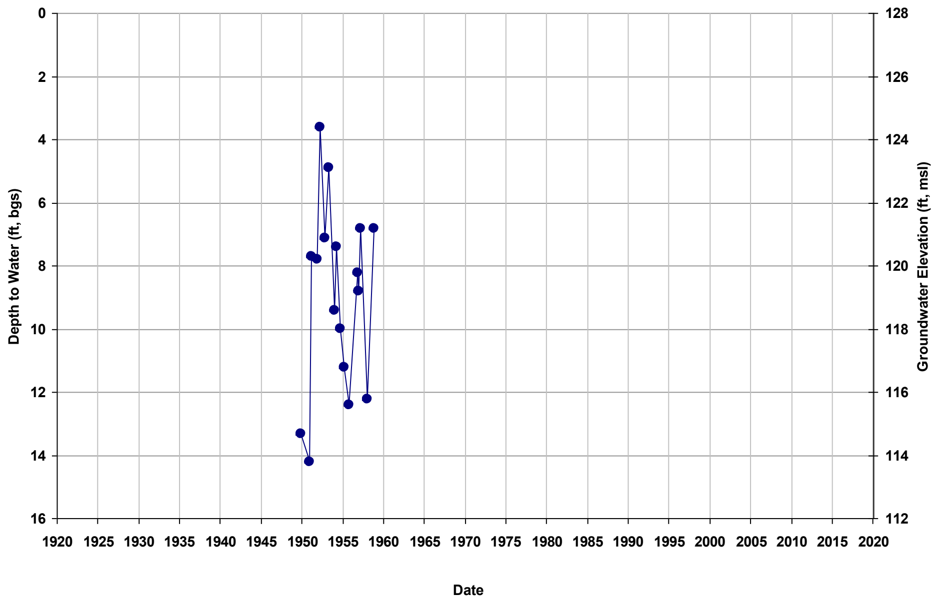
Well ID: 11S14E05P001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 134
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



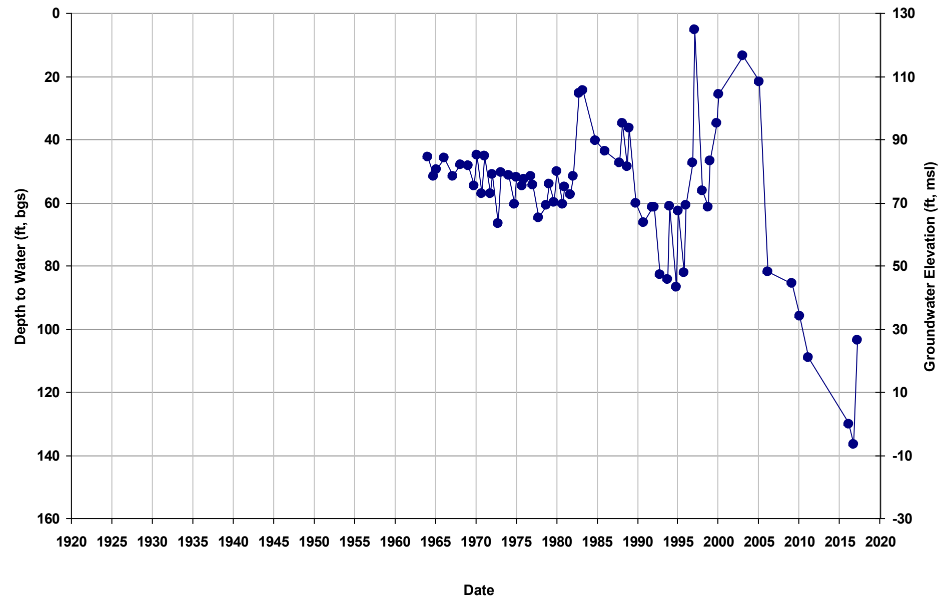
Well ID: 11S14E06M001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 128
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



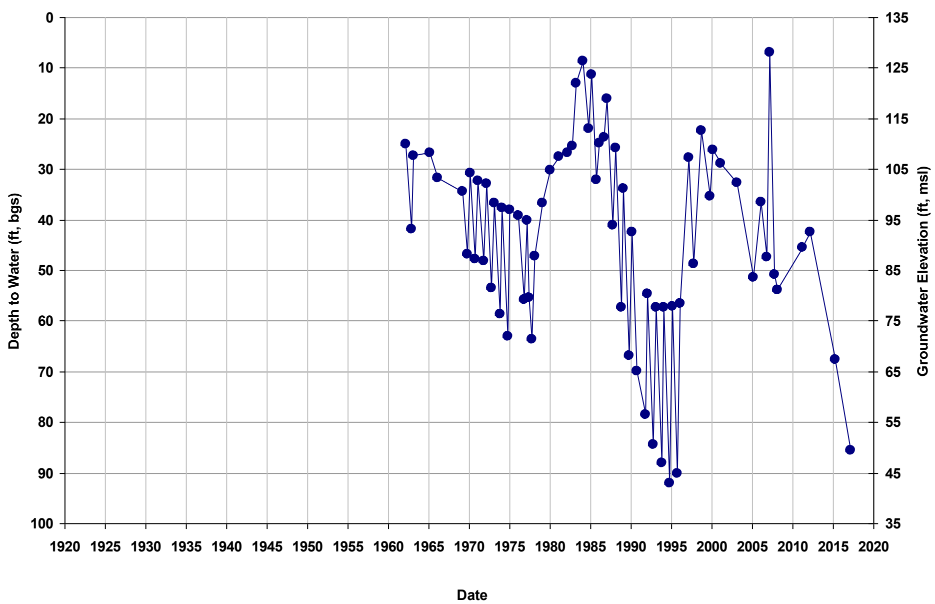
Well ID: 11S14E07N001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 129
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



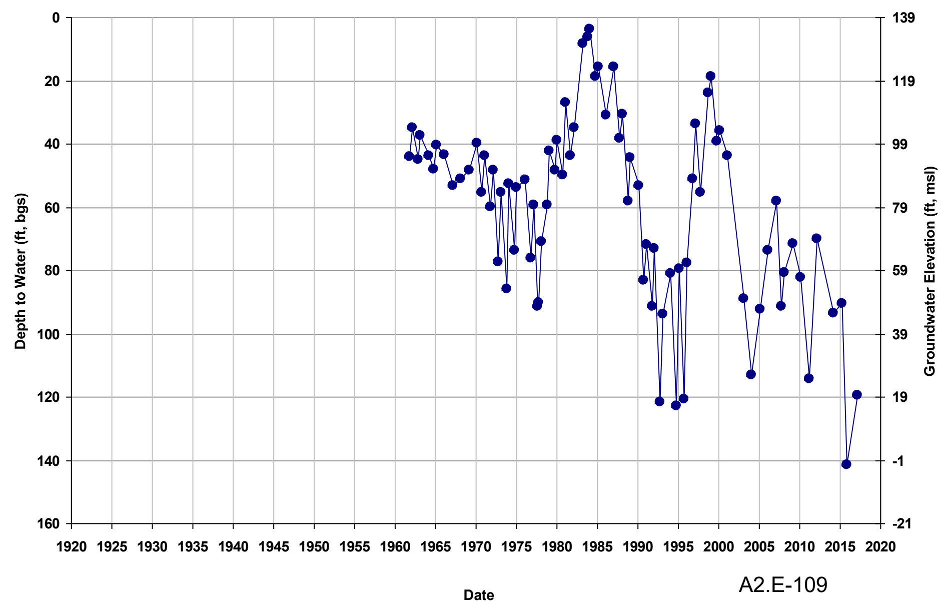
Well ID: 11S14E08R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 134
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



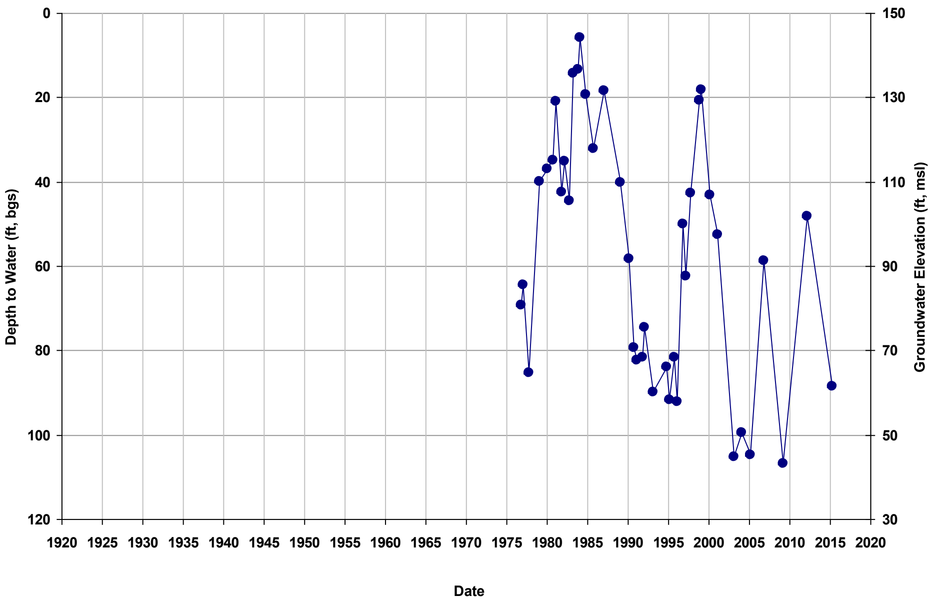
Well ID: 11S14E09A003M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 138
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



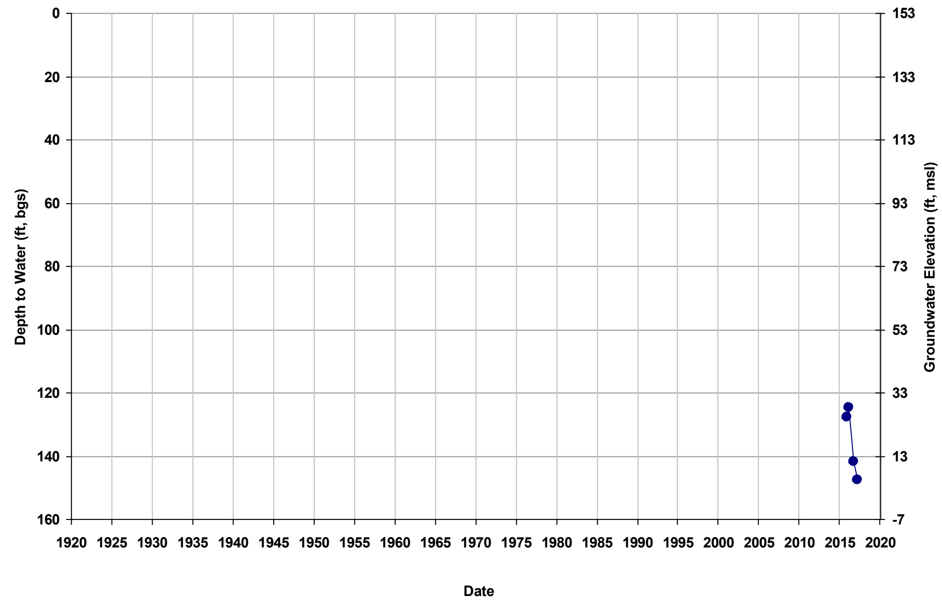
Well ID: 11S14E12E001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 150
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



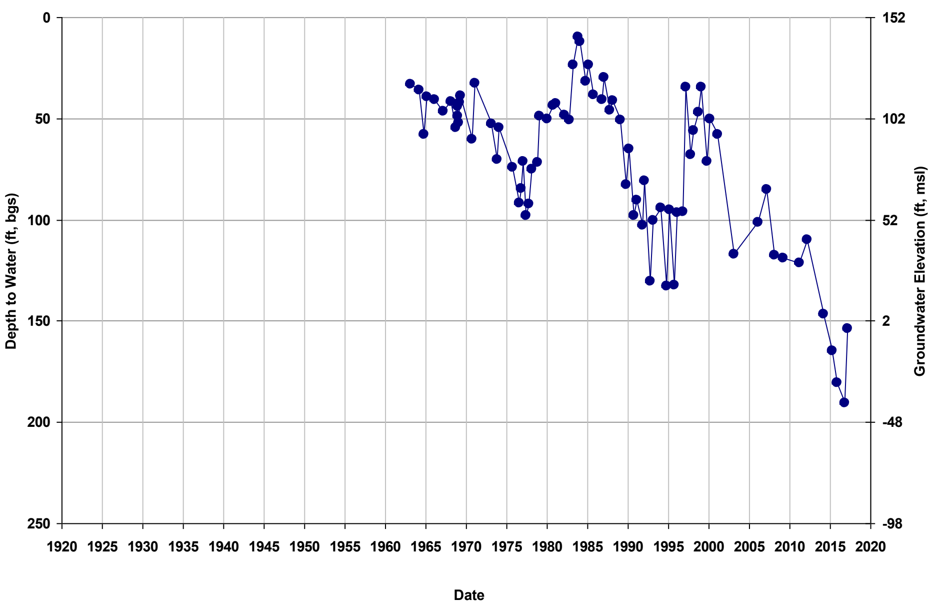
Well ID: 11S14E12H1
Depth Zone: Composite or Lower; Wi
Subbasin: Chowchilla

GSE (ft, msl): 153
Total Depth (ft): 420
Perf Top (ft): NA
Perf Bottom (ft): NA



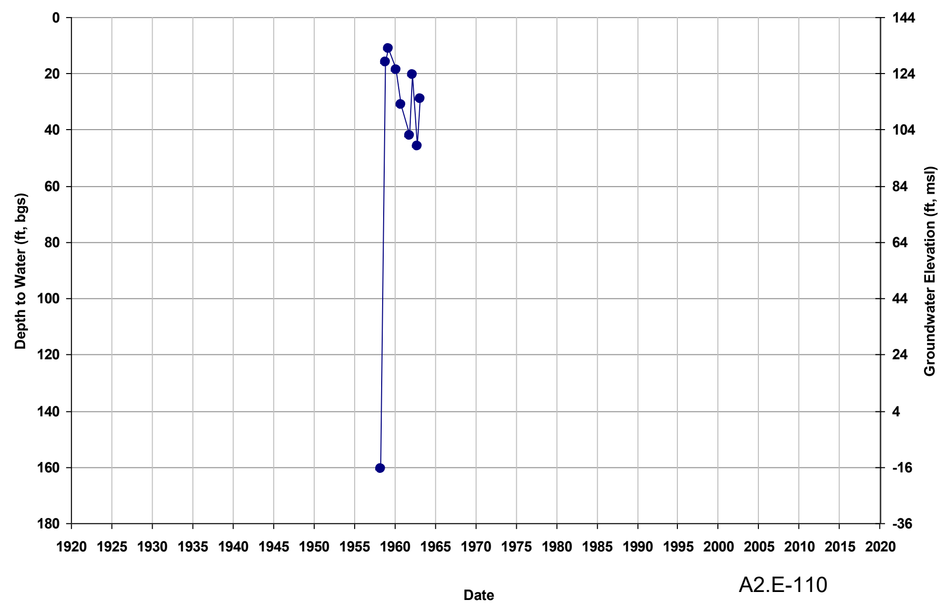
Well ID: 11S14E13R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 152
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



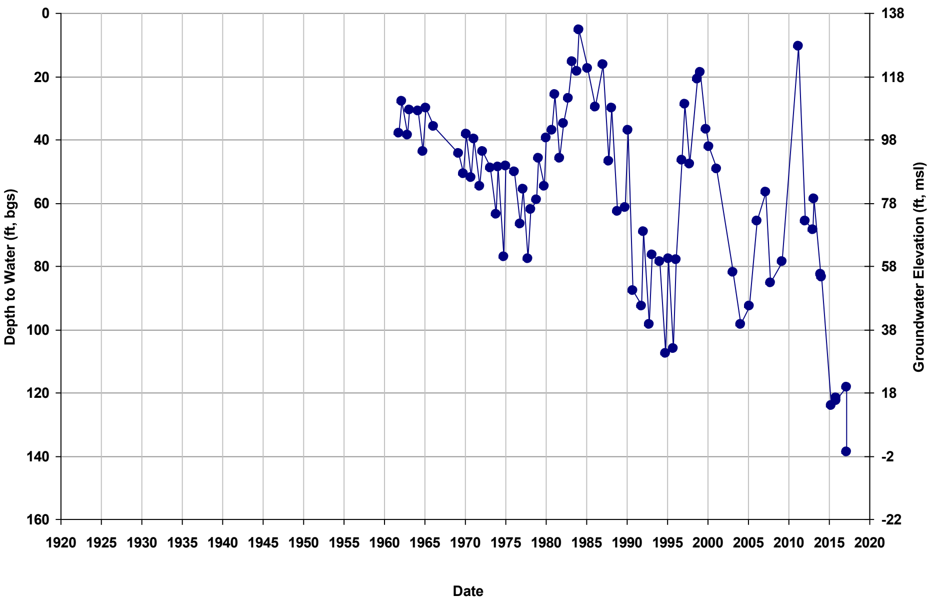
Well ID: 11S14E14Q001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 144
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



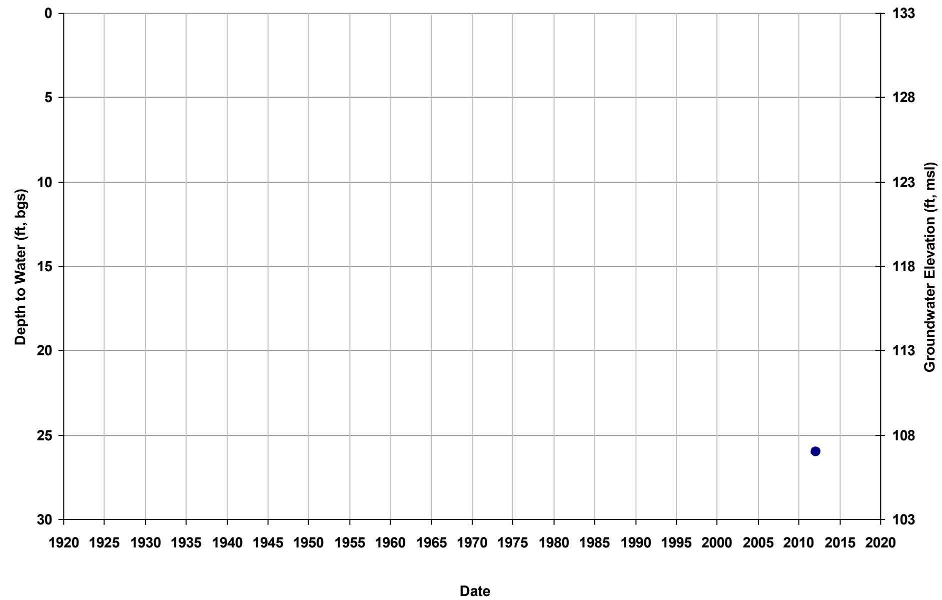
Well ID: 11S14E16A001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 138
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



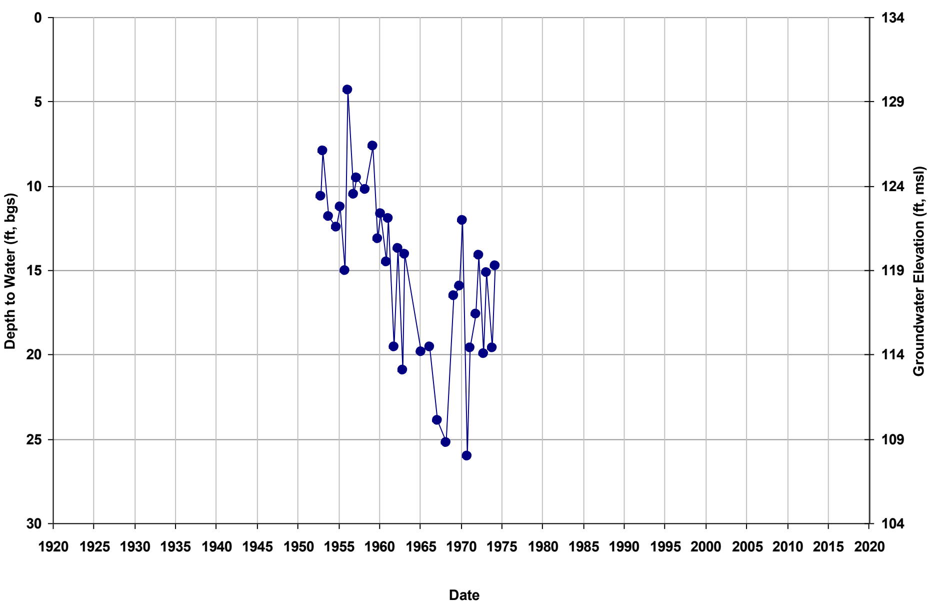
Well ID: 11S14E17J001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 132
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



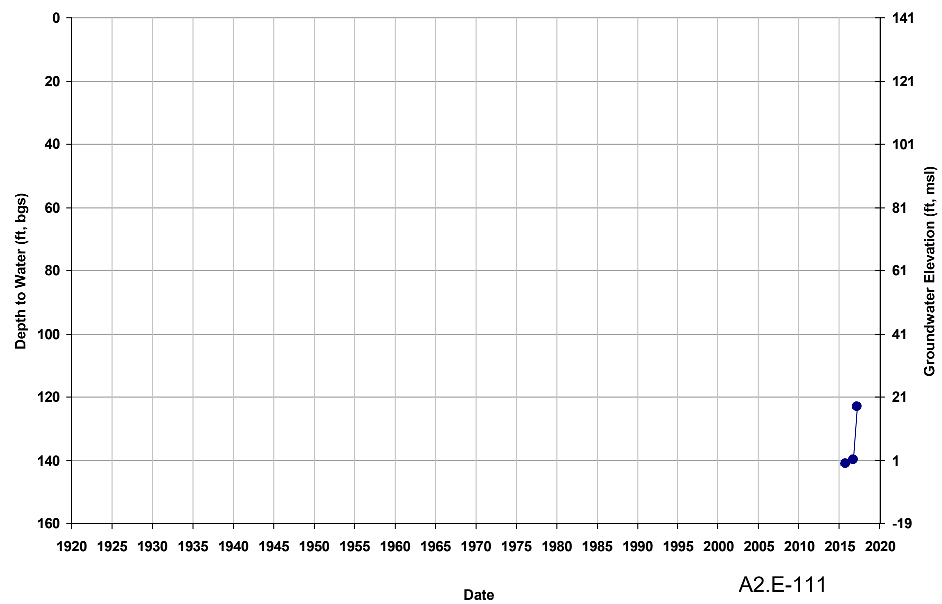
Well ID: 11S14E21N001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 134
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



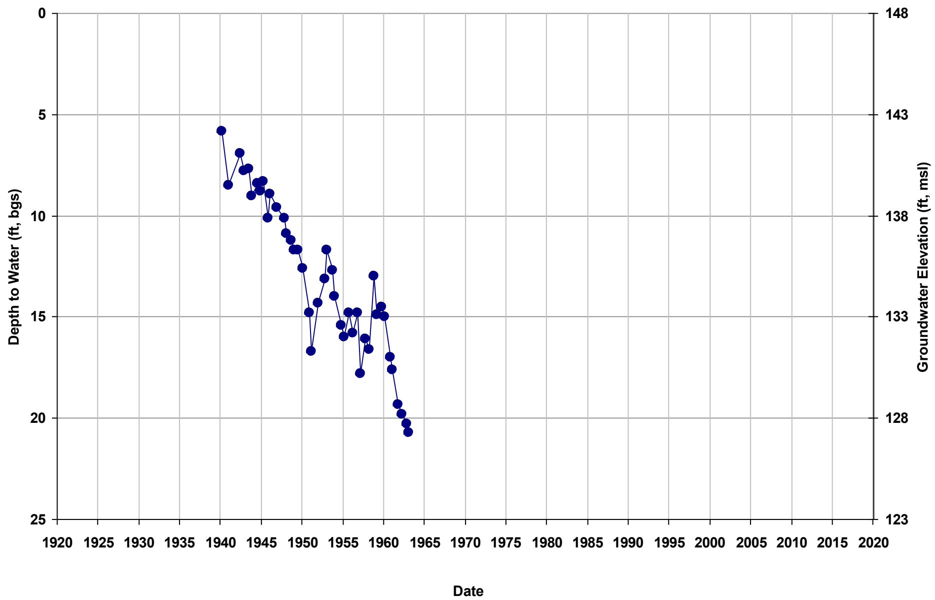
Well ID: 11S14E22F001M
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 141
Total Depth (ft): 840
Perf Top (ft): 190
Perf Bottom (ft): 260



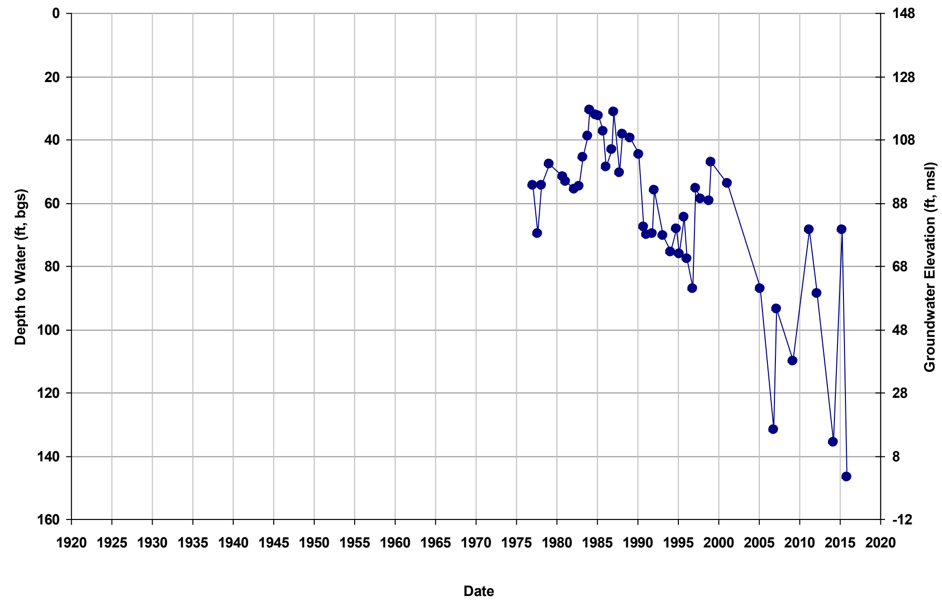
Well ID: 11S14E25L001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 147
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



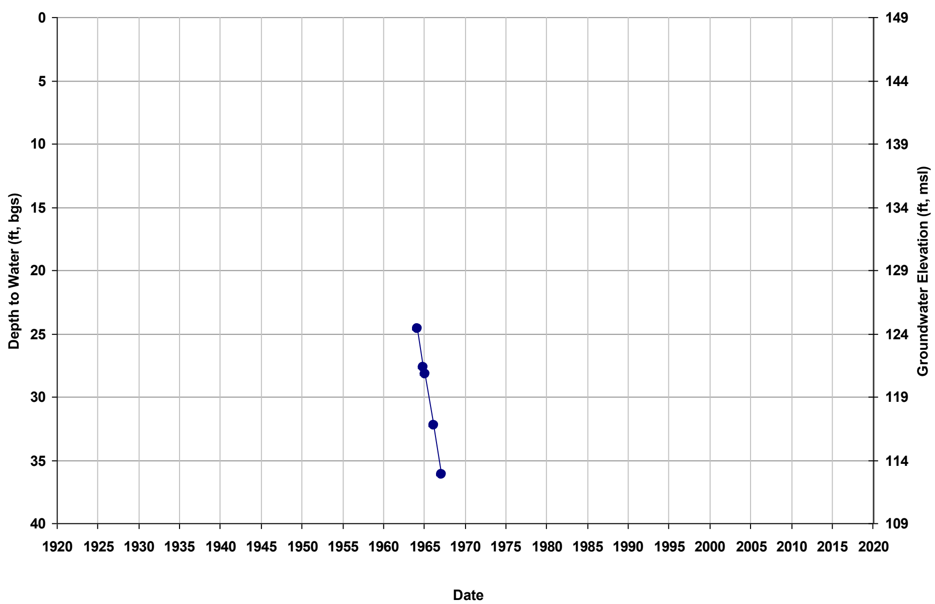
Well ID: 11S14E25L002M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 148
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



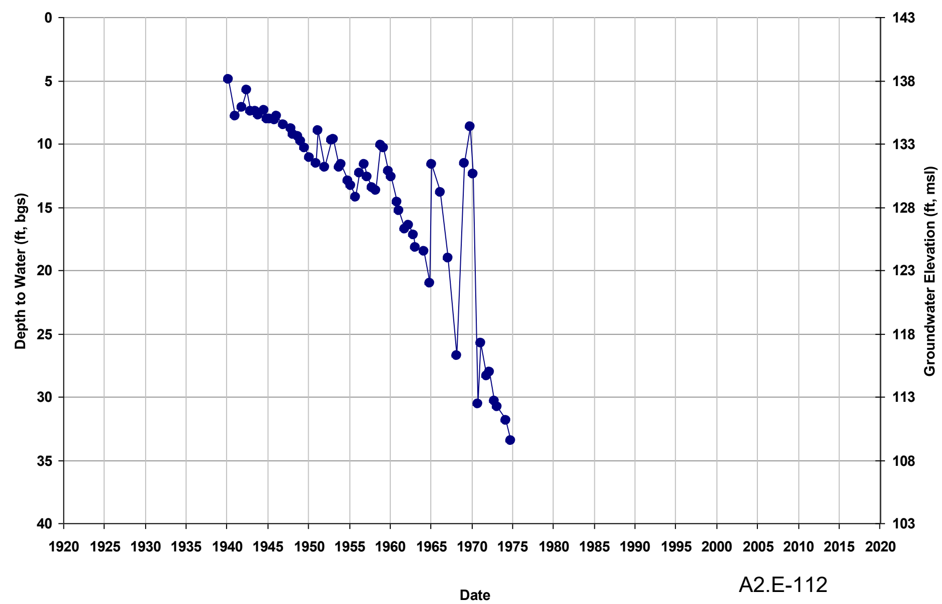
Well ID: 11S14E25R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 149
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



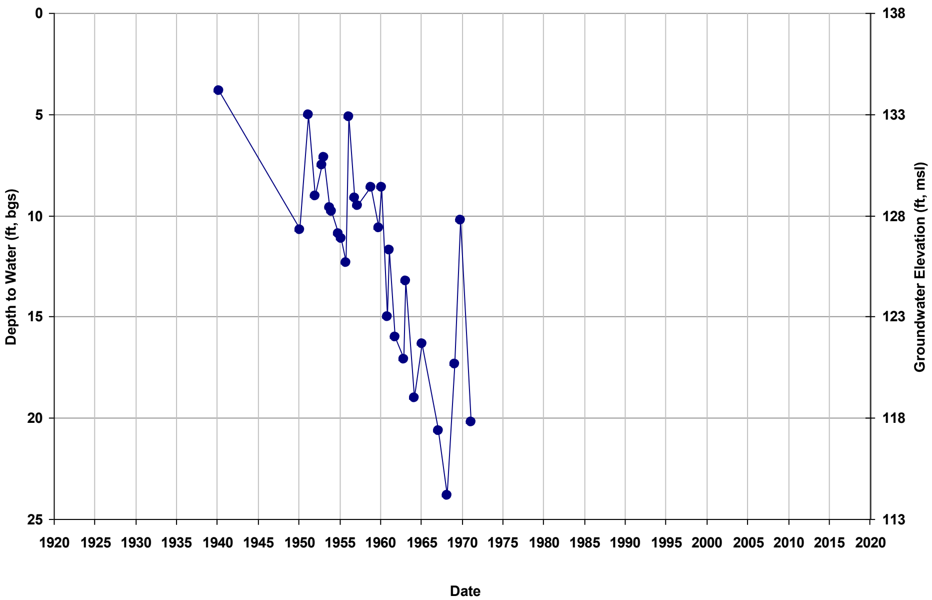
Well ID: 11S14E26L001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 143
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



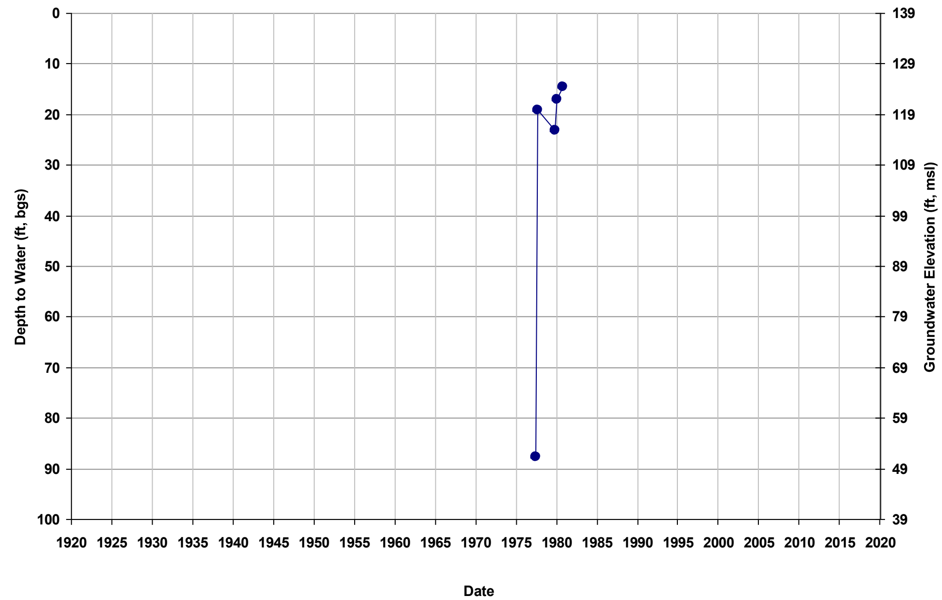
Well ID: 11S14E27F001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 138
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



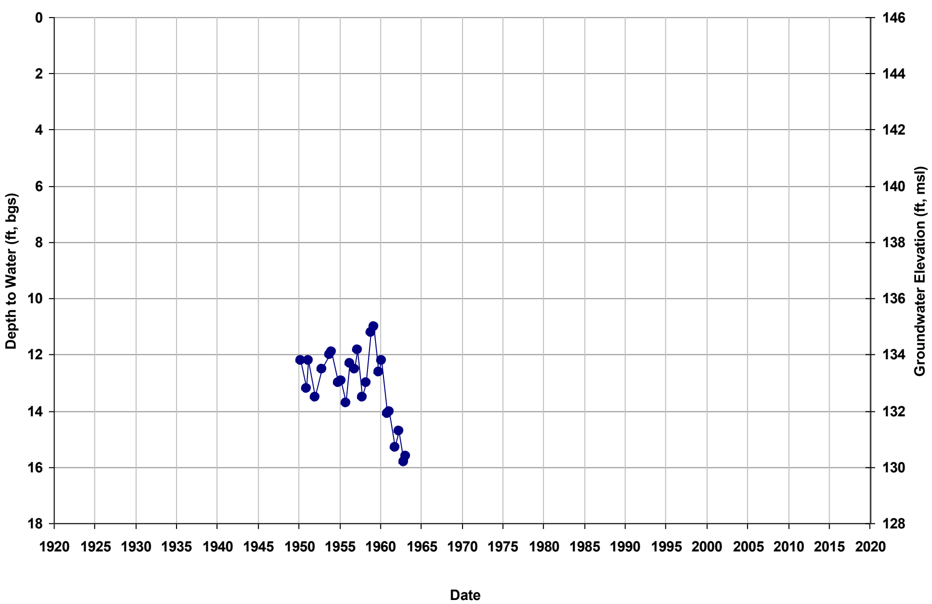
Well ID: 11S14E33P001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 139
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



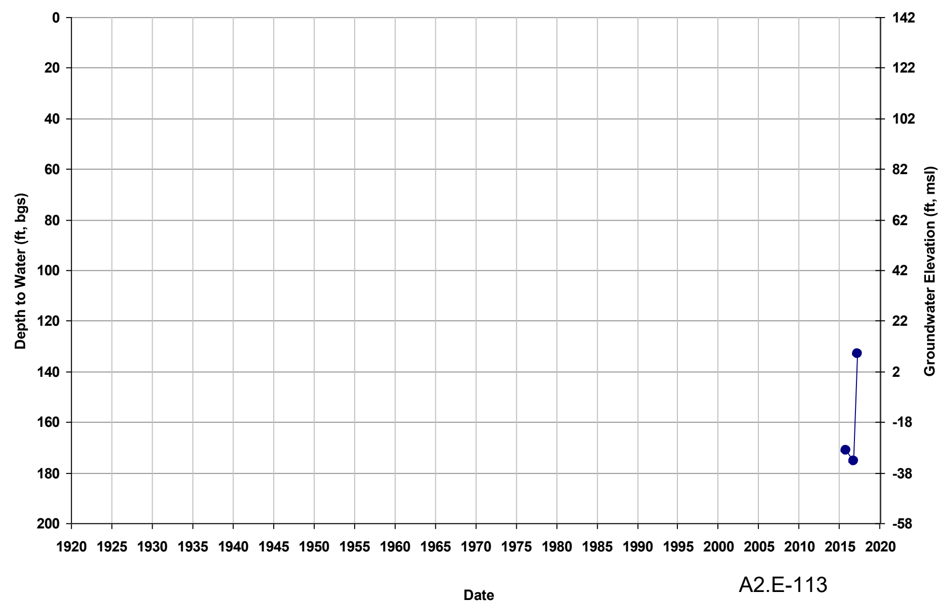
Well ID: 11S14E35Q001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 146
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



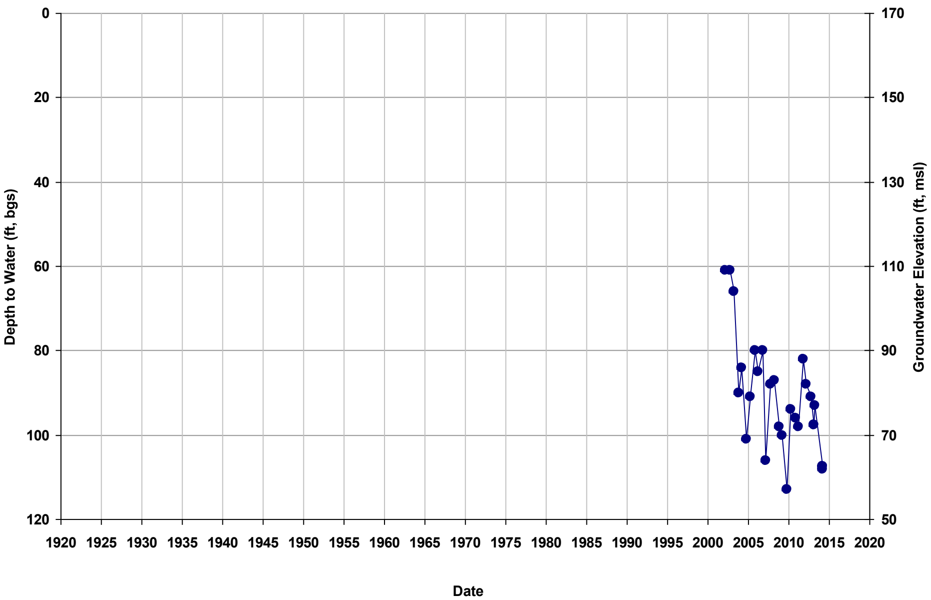
Well ID: 11S15E01F
Depth Zone: Composite; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 142
Total Depth (ft): 480
Perf Top (ft): 160
Perf Bottom (ft): 475



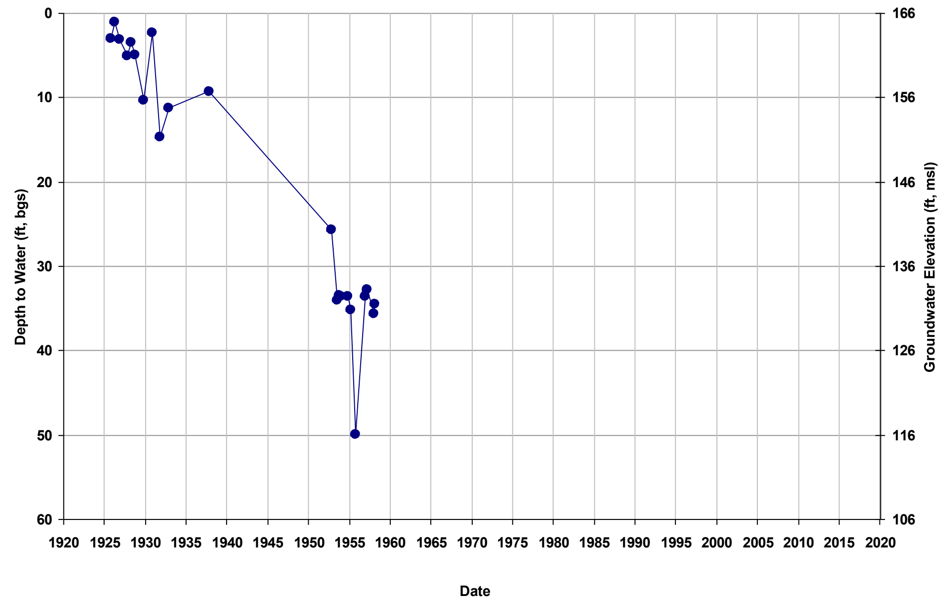
Well ID: 11S15E04H001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 170
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



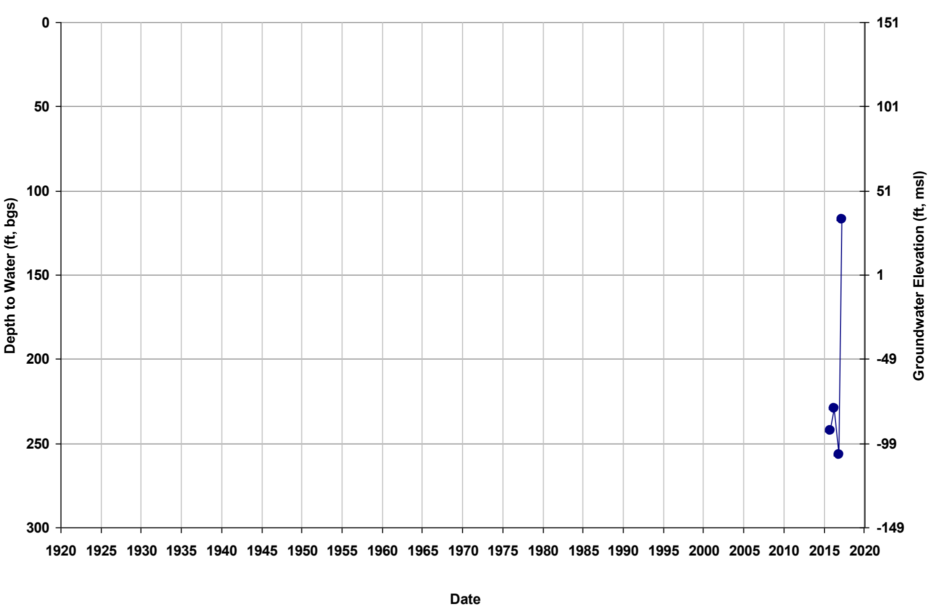
Well ID: 11S15E04P001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 165
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



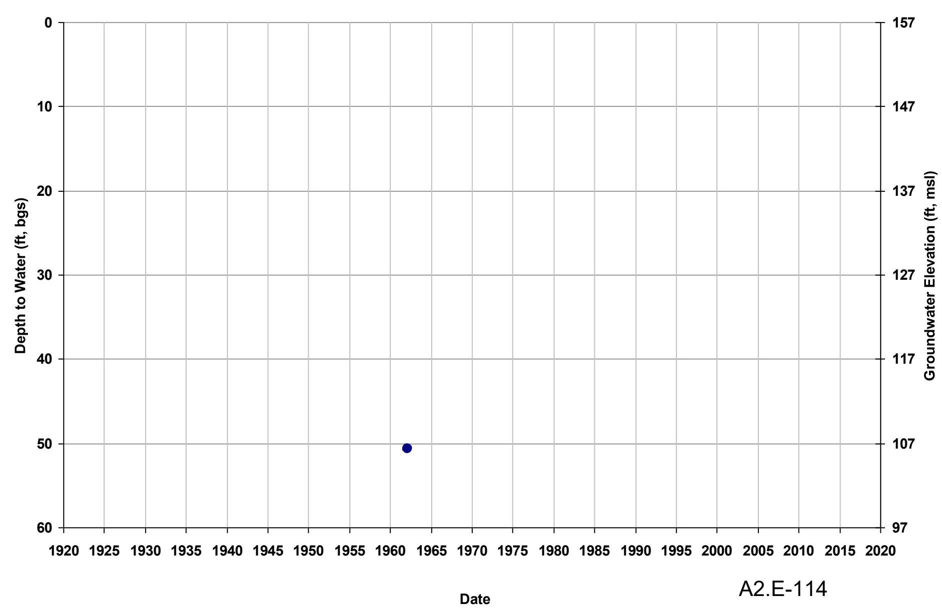
Well ID: 11S15E06L
Depth Zone: Composite; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 151
Total Depth (ft): 390
Perf Top (ft): 120
Perf Bottom (ft): 390



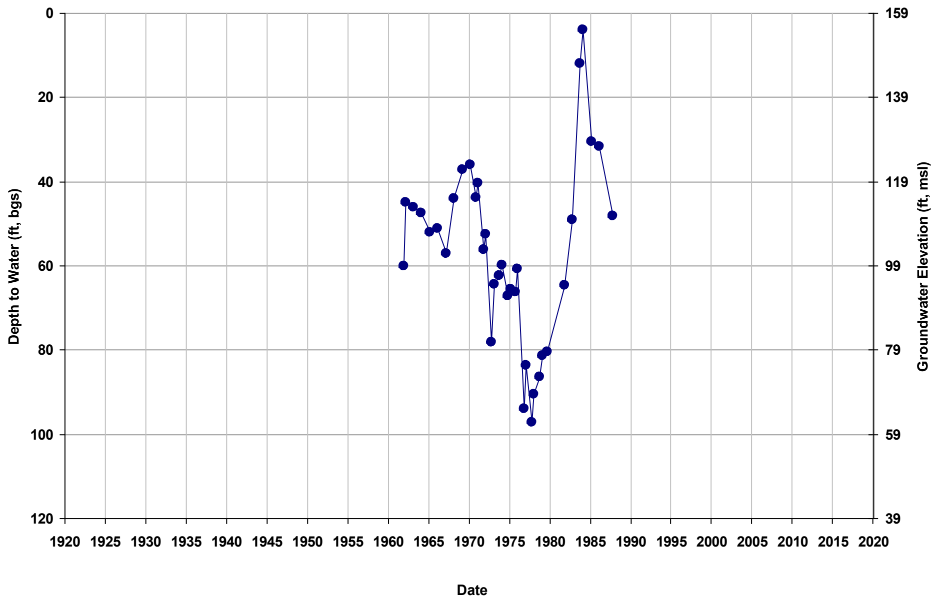
Well ID: 11S15E07K001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 156
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



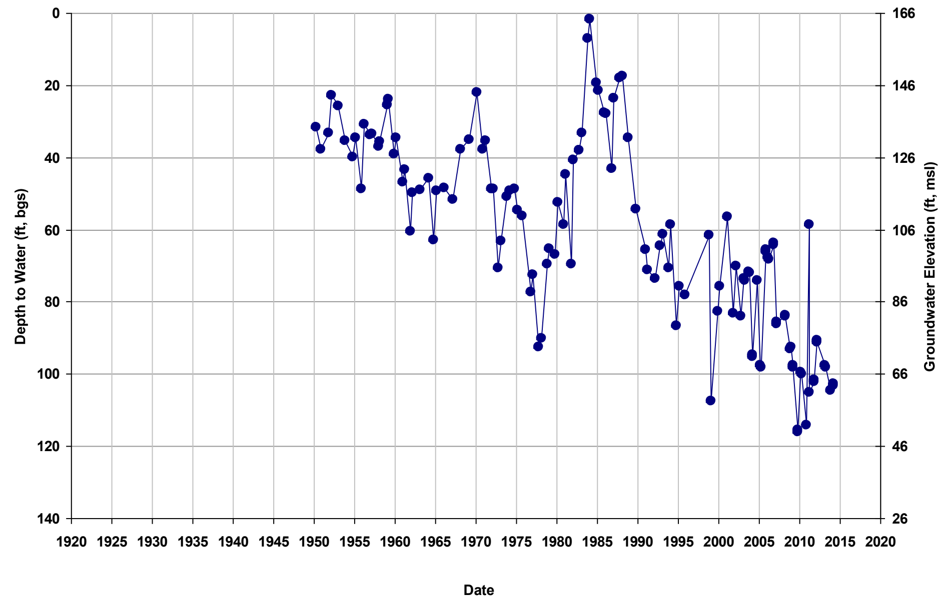
Well ID: 11S15E07R001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 159
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



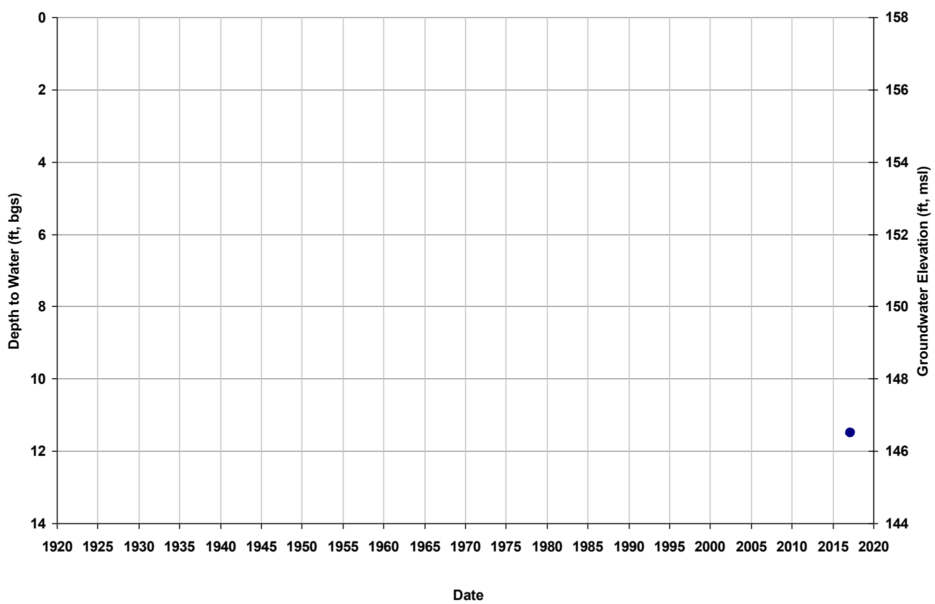
Well ID: 11S15E09C001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 166
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



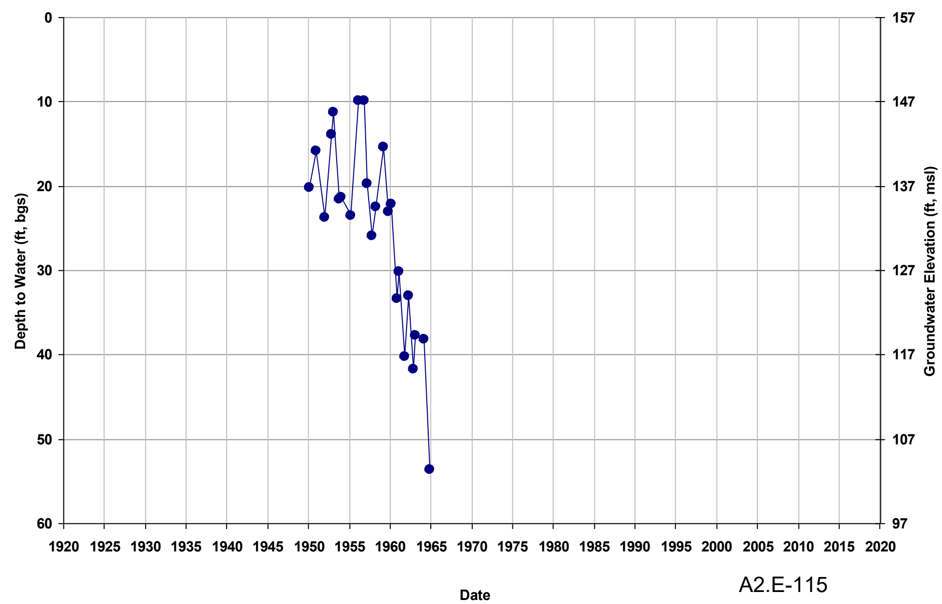
Well ID: 11S15E17P001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 158
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



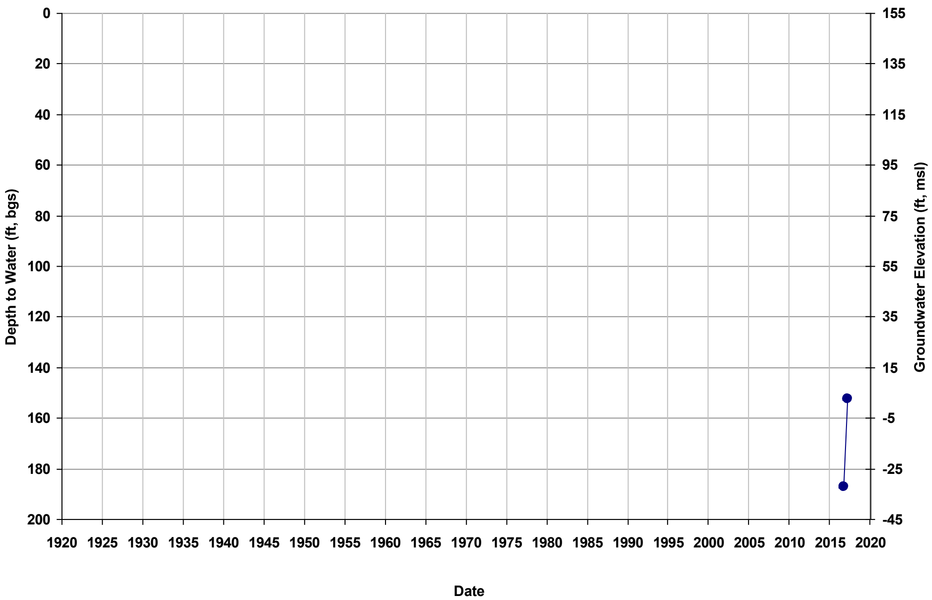
Well ID: 11S15E18H001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 157
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



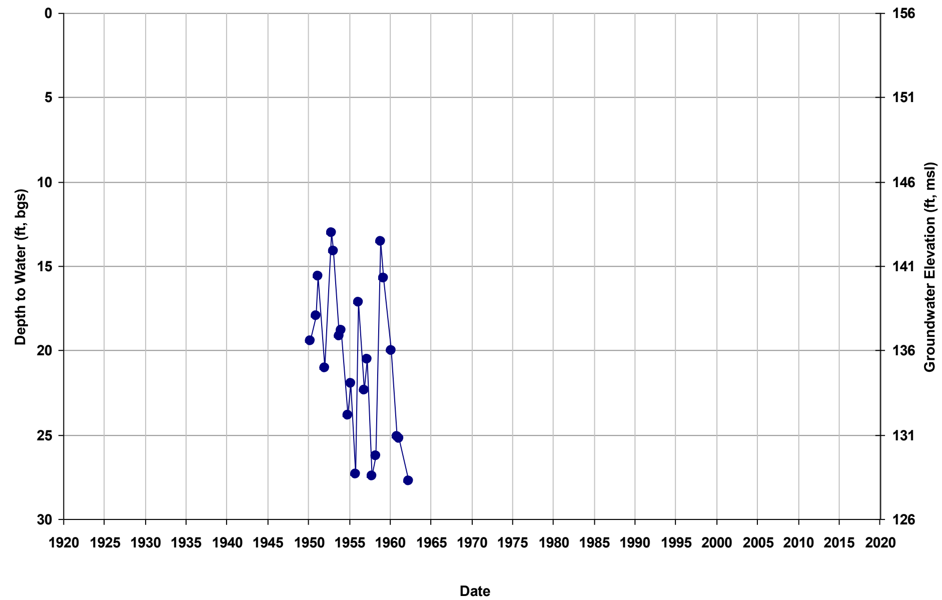
Well ID: 11S15E18P001M
Depth Zone: Composite; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 155
Total Depth (ft): 700
Perf Top (ft): 265
Perf Bottom (ft): 696



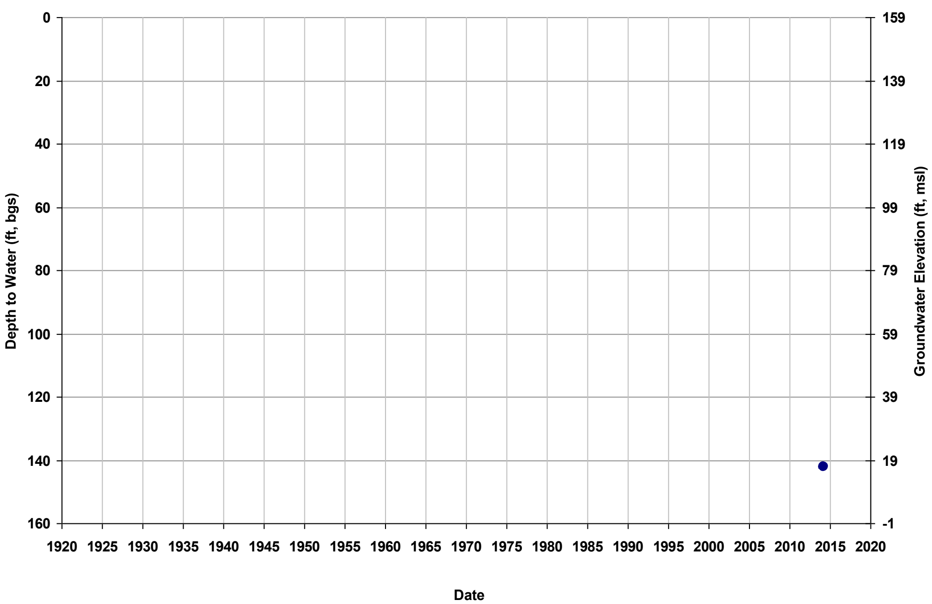
Well ID: 11S15E19H001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 156
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



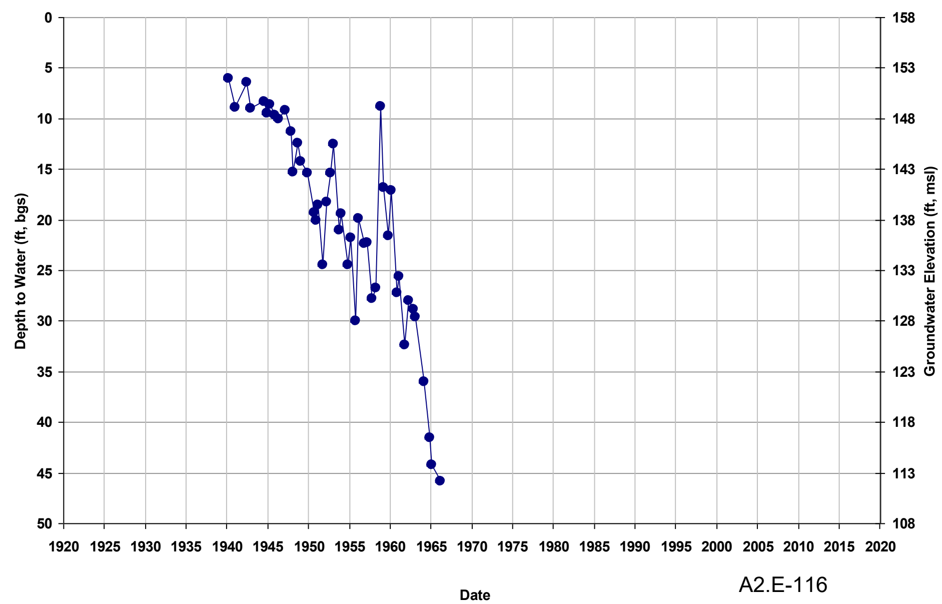
Well ID: 11S15E20Q001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 159
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



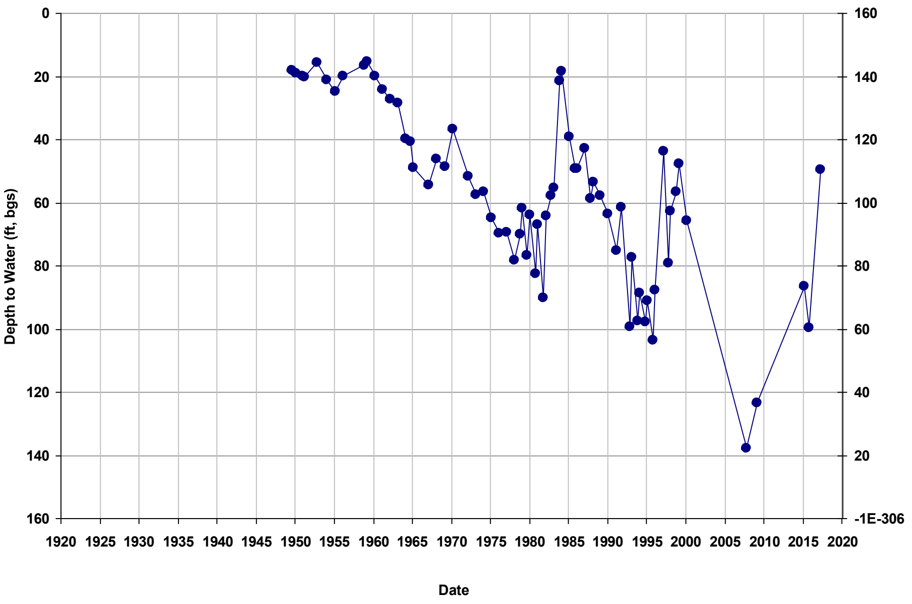
Well ID: 11S15E29G001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 158
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



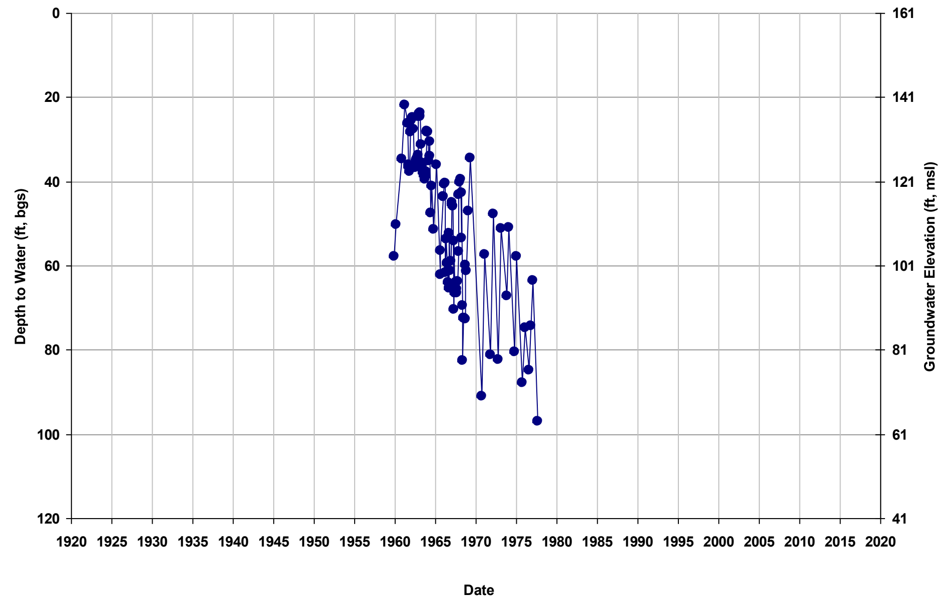
Well ID: 11S15E29H001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 159
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



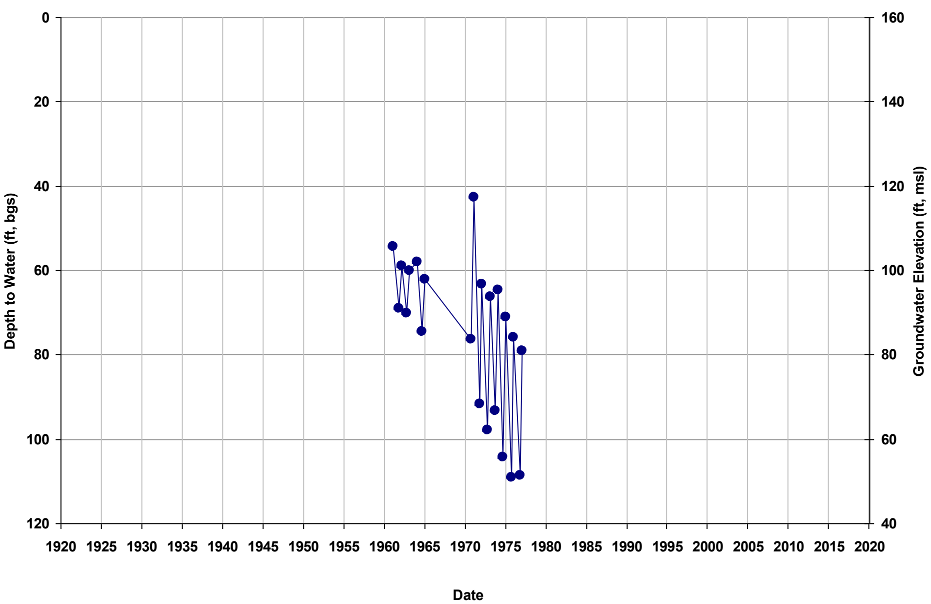
Well ID: 11S15E33P001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 161
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



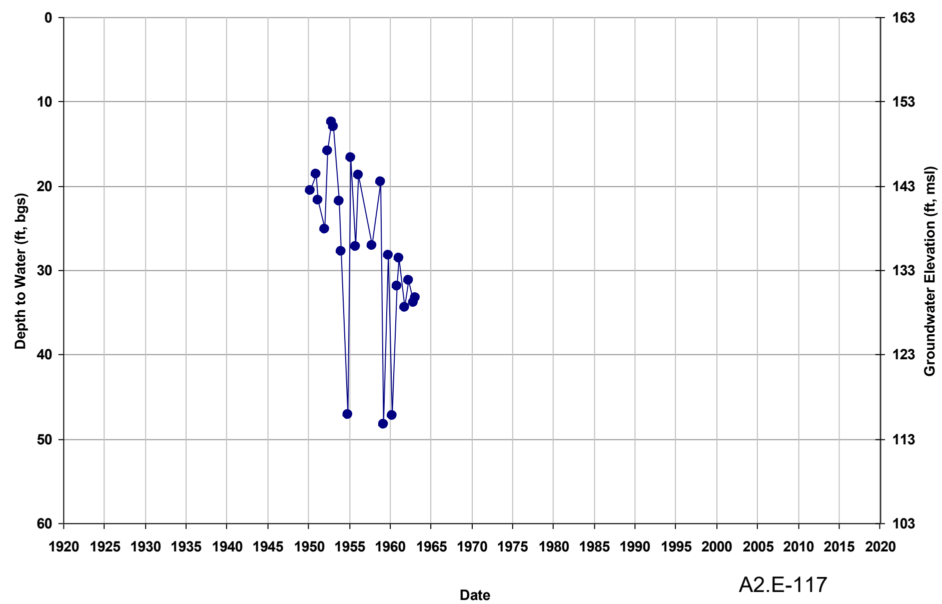
Well ID: 11S15E33P004M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 160
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



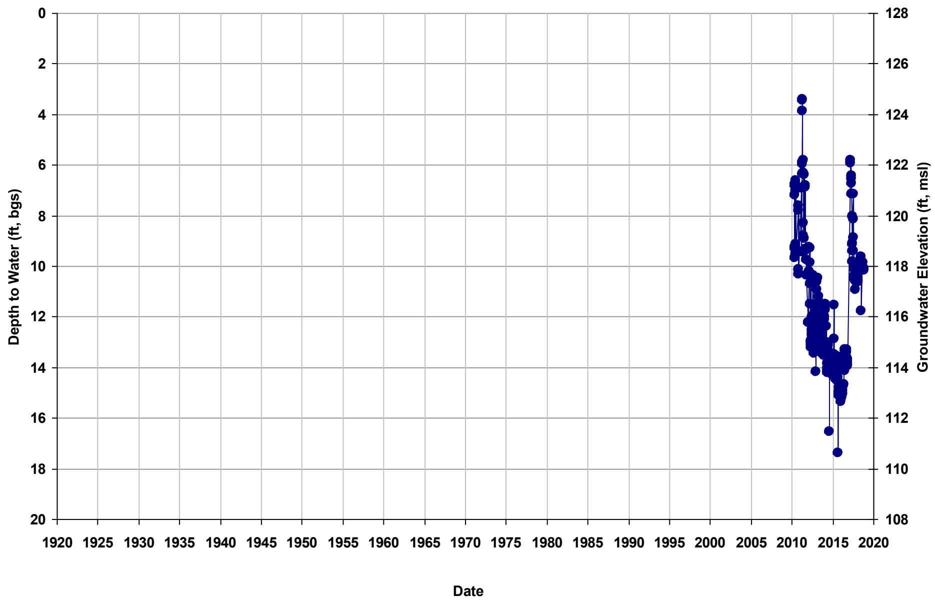
Well ID: 11S15E33Q001M
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 163
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



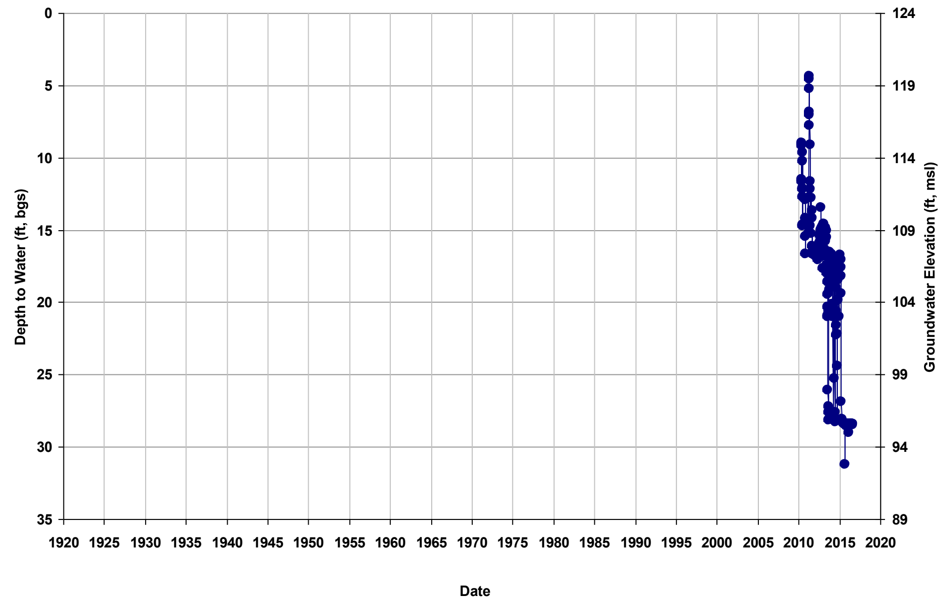
Well ID: SJRRP_MW-10-78
Depth Zone: Upper, Shallow GW; Wit
Subbasin: Chowchilla

GSE (ft, msl): 127
Total Depth (ft): 28
Perf Top (ft): 10
Perf Bottom (ft): 25



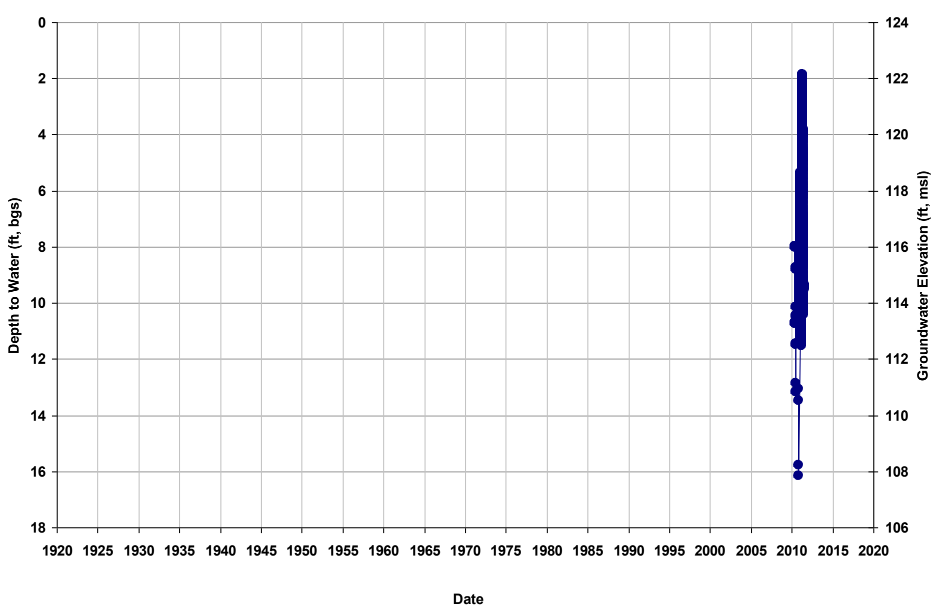
Well ID: SJRRP_MW-10-80
Depth Zone: Upper, Shallow GW; Wit
Subbasin: Chowchilla

GSE (ft, msl): 123
Total Depth (ft): 27.9
Perf Top (ft): 10
Perf Bottom (ft): 25



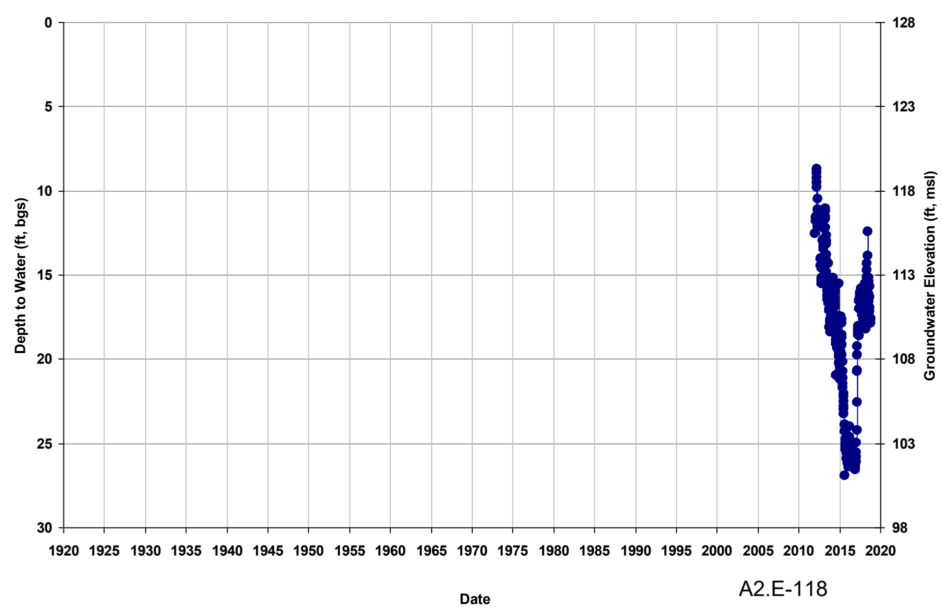
Well ID: SJRRP_MW-10-89
Depth Zone: Upper, Shallow GW; Wit
Subbasin: Chowchilla

GSE (ft, msl): 123
Total Depth (ft): 26.4
Perf Top (ft): 10
Perf Bottom (ft): 25



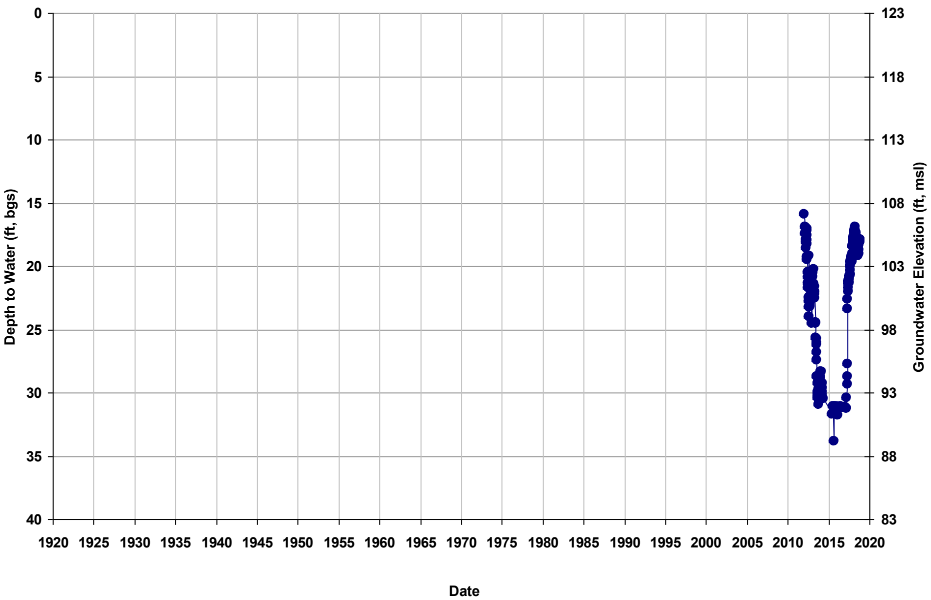
Well ID: SJRRP_MW-11-161
Depth Zone: Upper, Shallow GW; Wit
Subbasin: Chowchilla

GSE (ft, msl): 127
Total Depth (ft): 30
Perf Top (ft): NA
Perf Bottom (ft): NA



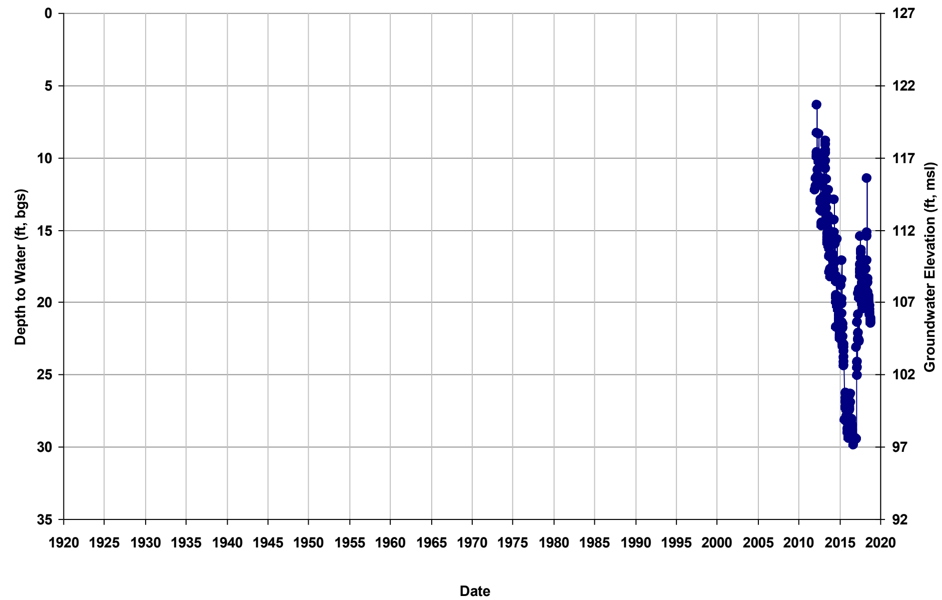
Well ID: SJRRP_MW-11-162
Depth Zone: Upper, Shallow GW; Wit
Subbasin: Chowchilla

GSE (ft, msl): 123
Total Depth (ft): 30
Perf Top (ft): NA
Perf Bottom (ft): NA



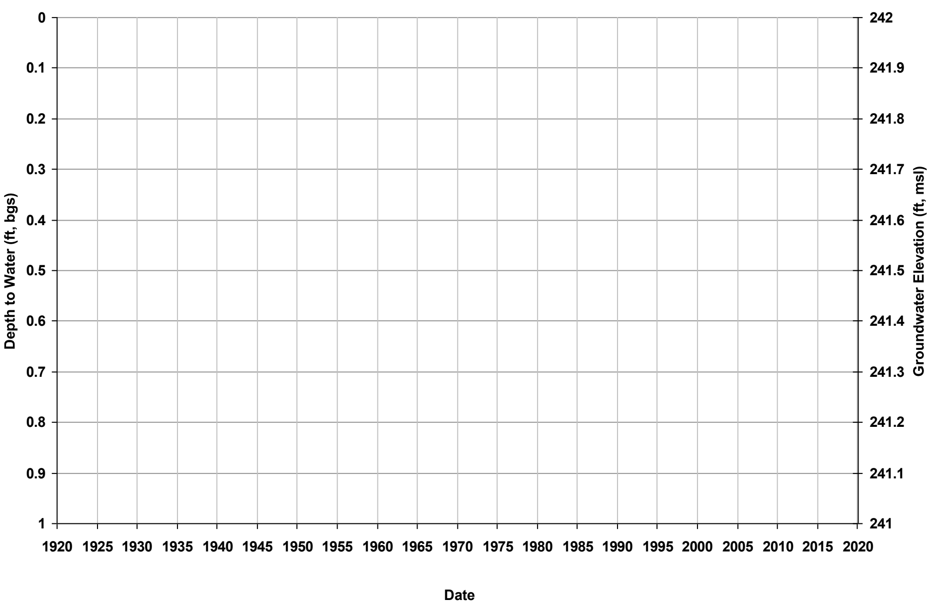
Well ID: SJRRP_MW-11-163
Depth Zone: Upper, Shallow GW; Wit
Subbasin: Chowchilla

GSE (ft, msl): 127
Total Depth (ft): 29
Perf Top (ft): NA
Perf Bottom (ft): NA



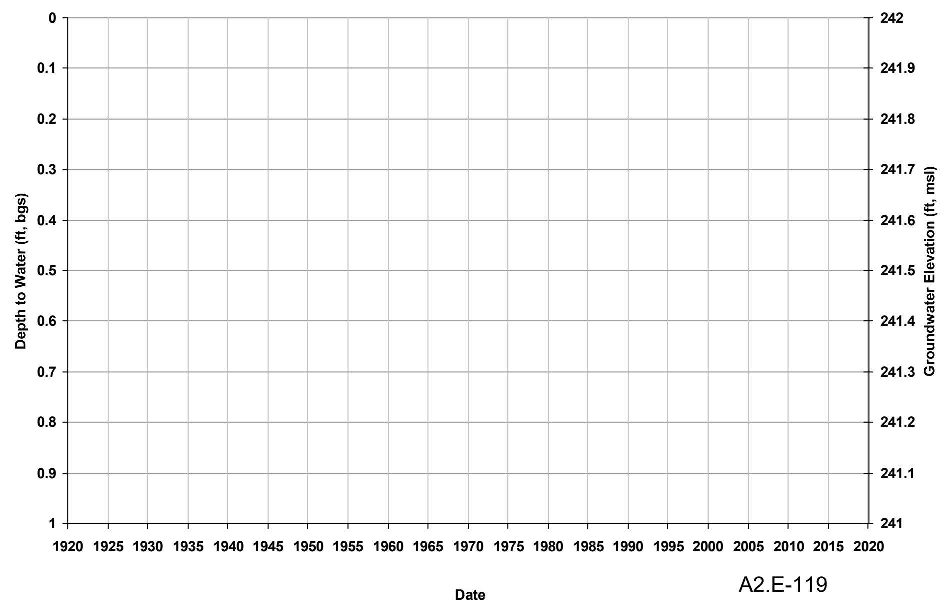
Well ID: SL0603935695 - MW-24
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 242
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



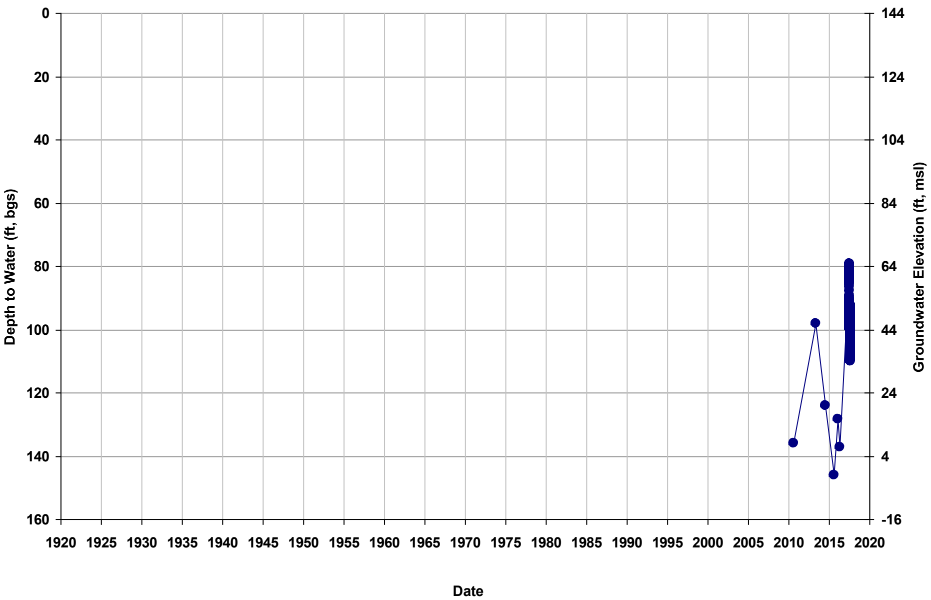
Well ID: SL0603935695 - VEW-11
Depth Zone: Unknown; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 242
Total Depth (ft): NA
Perf Top (ft): NA
Perf Bottom (ft): NA



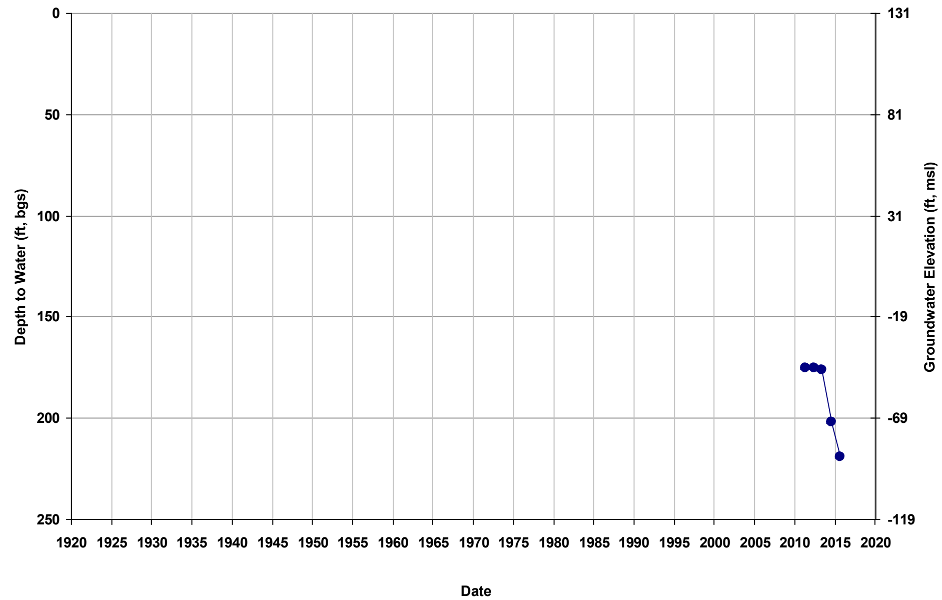
Well ID: TTR-10
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 144
Total Depth (ft): 222
Perf Top (ft): 158
Perf Bottom (ft): 222



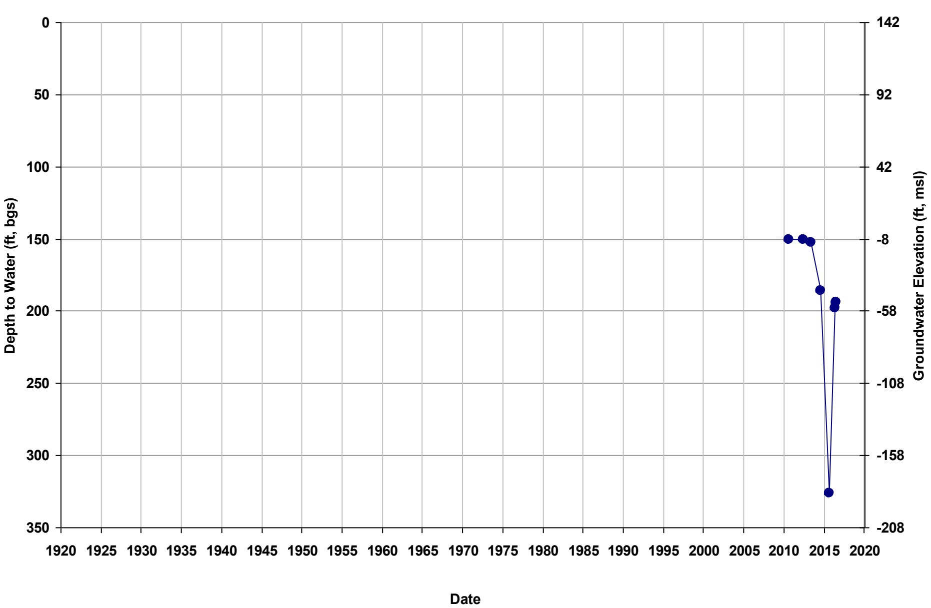
Well ID: TTR-11
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 131
Total Depth (ft): 800
Perf Top (ft): 290
Perf Bottom (ft): 780



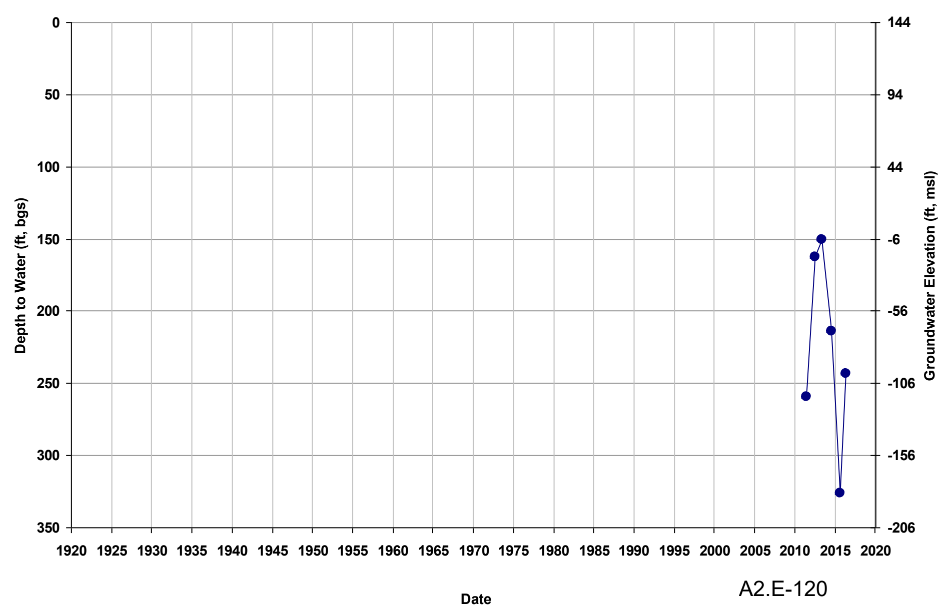
Well ID: TTR-12
Depth Zone: Composite; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 142
Total Depth (ft): 467
Perf Top (ft): 160
Perf Bottom (ft): 440



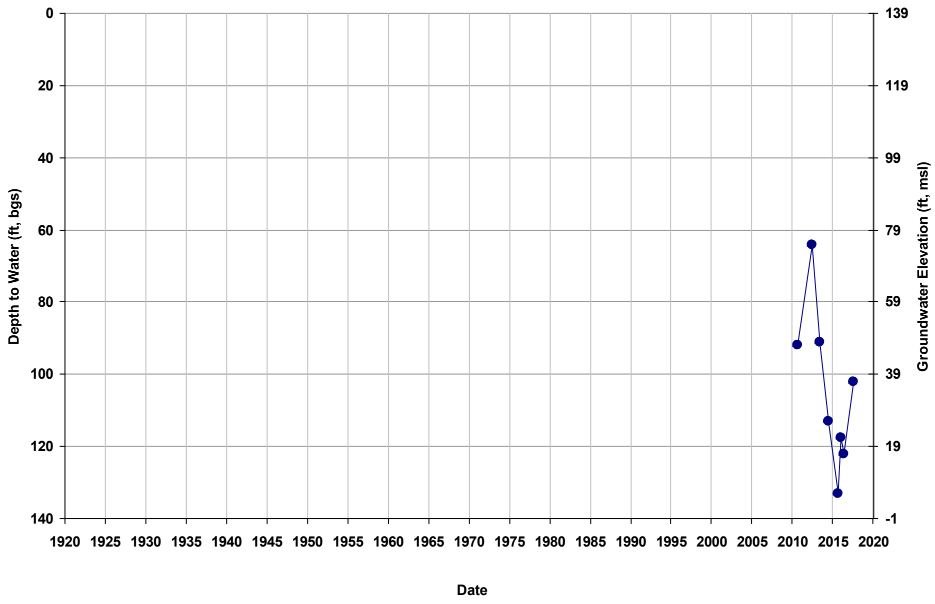
Well ID: TTR-13
Depth Zone: Composite; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 144
Total Depth (ft): 413
Perf Top (ft): 133
Perf Bottom (ft): 413



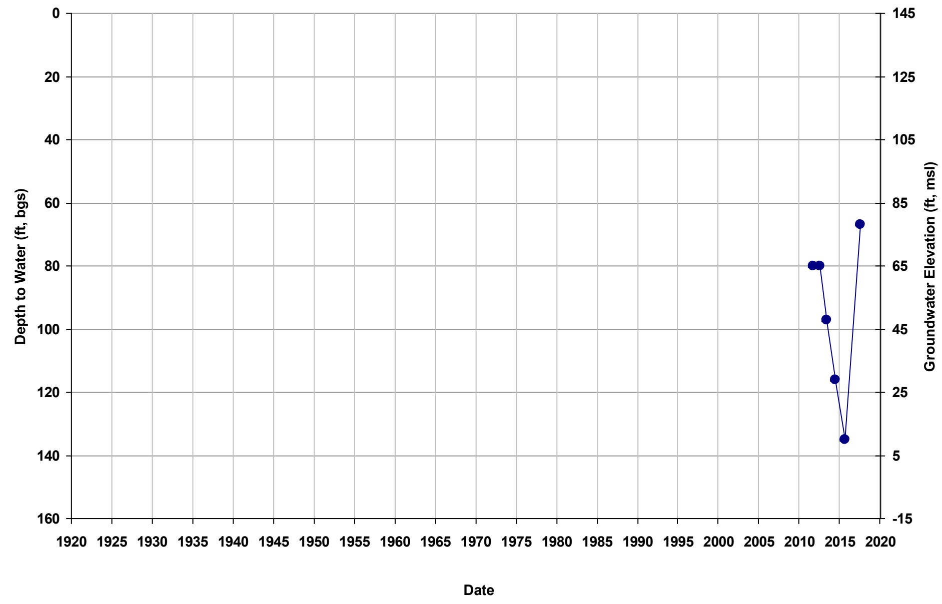
Well ID: TTR-14
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 139
Total Depth (ft): 219
Perf Top (ft): 137
Perf Bottom (ft): 219



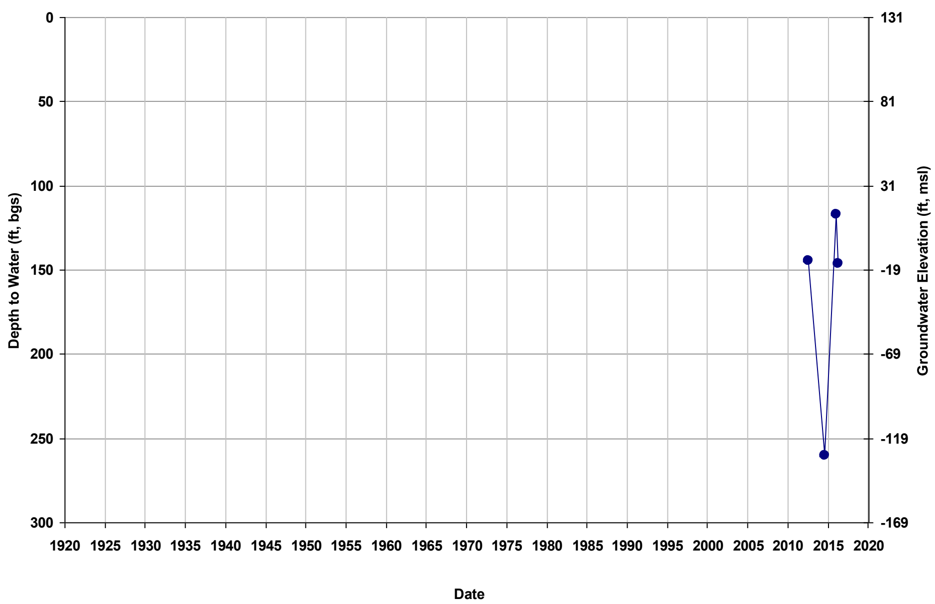
Well ID: TTR-15
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 145
Total Depth (ft): 194
Perf Top (ft): 148
Perf Bottom (ft): 194



Well ID: TTR-16
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 131
Total Depth (ft): 857
Perf Top (ft): 292
Perf Bottom (ft): 854

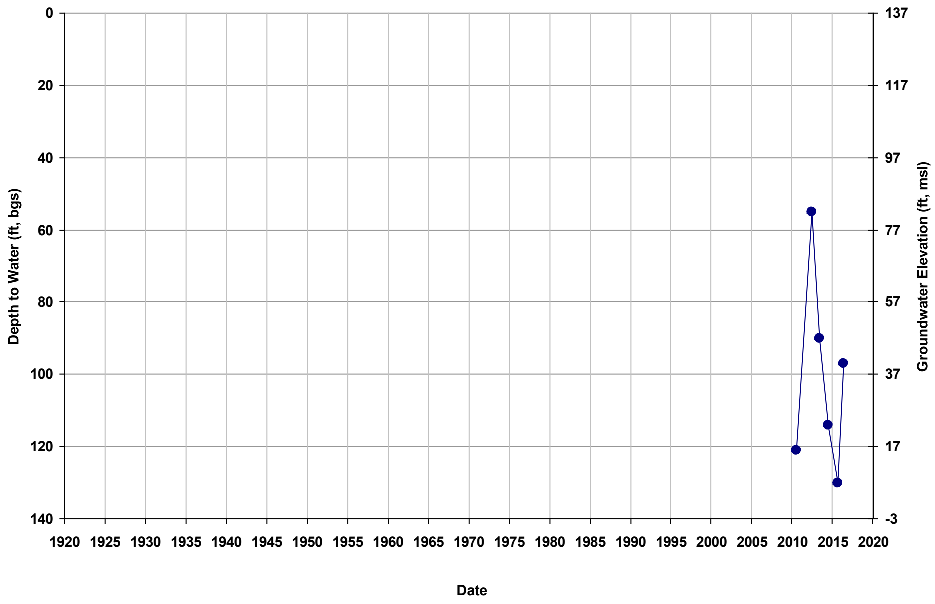


Well ID: TTR-17
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 134
Total Depth (ft): 256
Perf Top (ft): 175
Perf Bottom (ft): 252

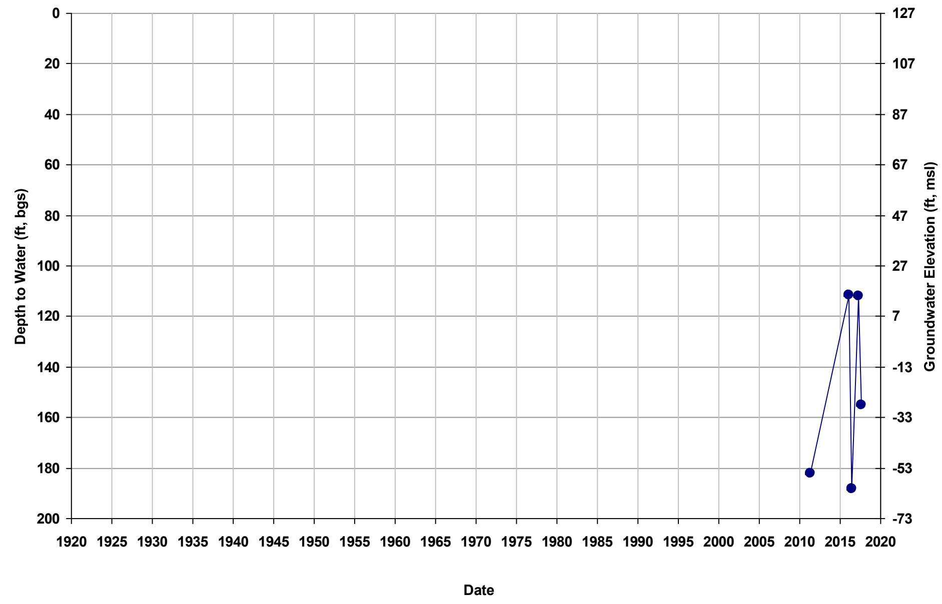
Well ID: TTR-18
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 137
Total Depth (ft): 211
Perf Top (ft): 166
Perf Bottom (ft): 213



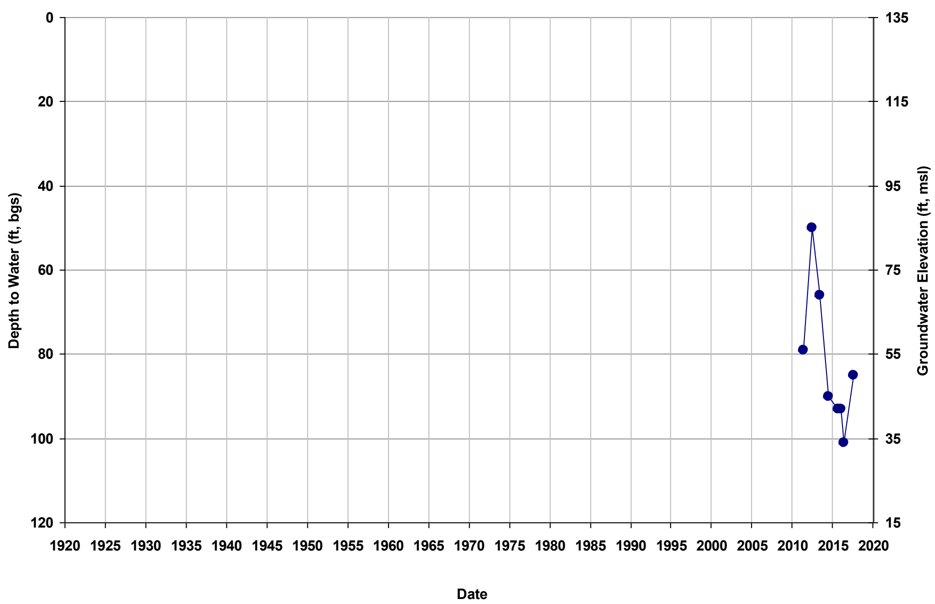
Well ID: TTR-19
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 127
Total Depth (ft): 860
Perf Top (ft): 290
Perf Bottom (ft): 840



Well ID: TTR-2
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 135
Total Depth (ft): 213
Perf Top (ft): 157
Perf Bottom (ft): 209

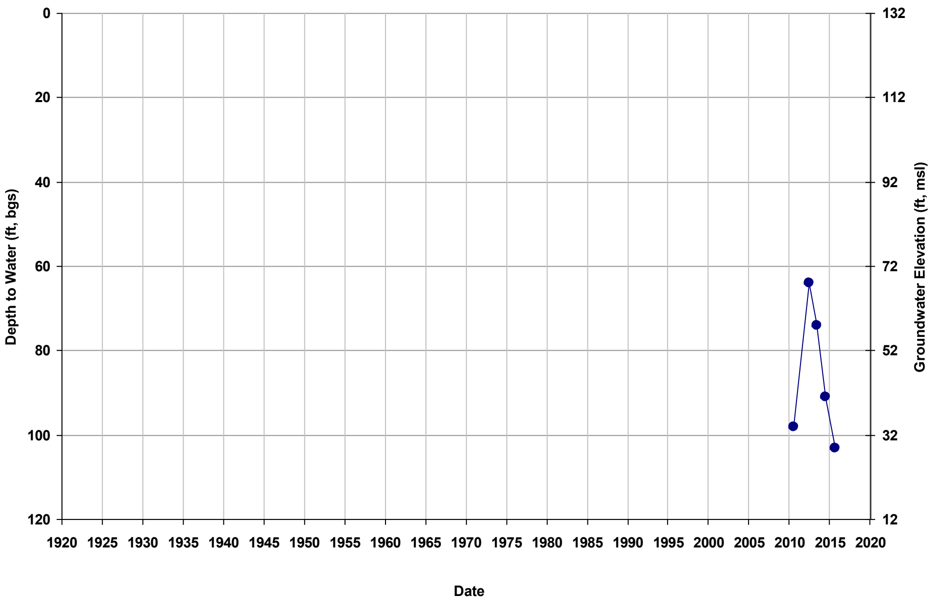


Well ID: TTR-20
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 132
Total Depth (ft): 200
Perf Top (ft): 145
Perf Bottom (ft): 200

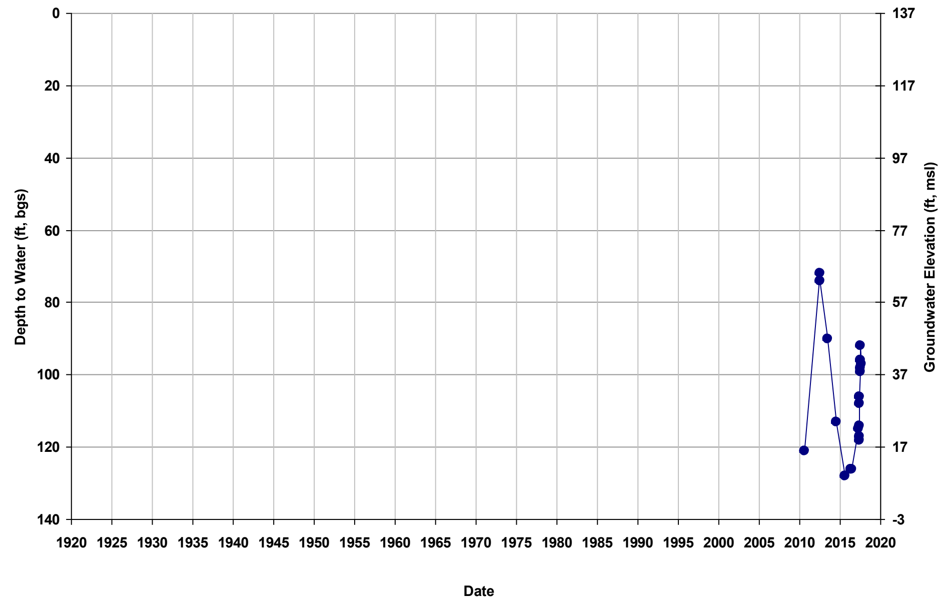
Well ID: TTR-21
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 132
Total Depth (ft): 158
Perf Top (ft): 71
Perf Bottom (ft): 203



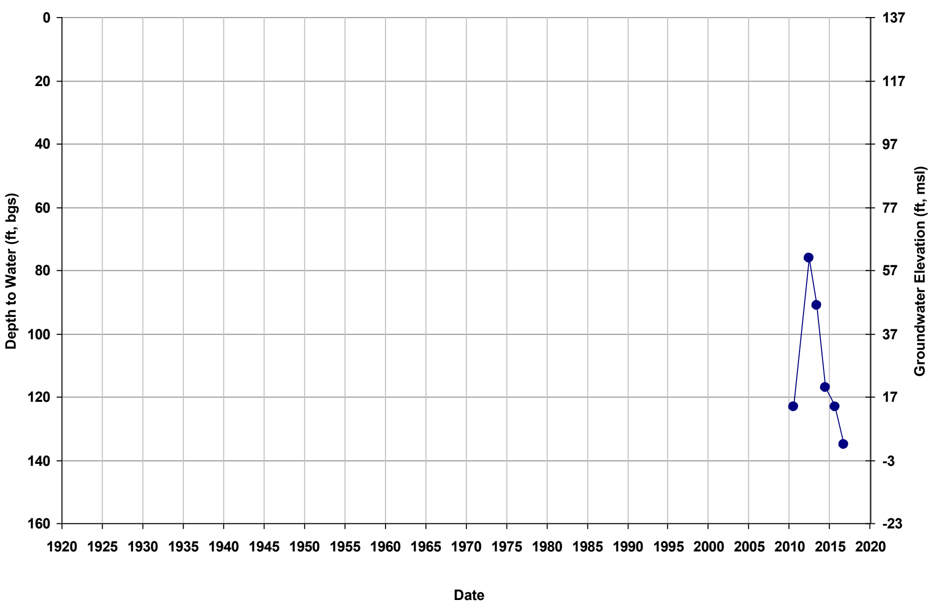
Well ID: TTR-22
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 137
Total Depth (ft): 304
Perf Top (ft): 170
Perf Bottom (ft): 298



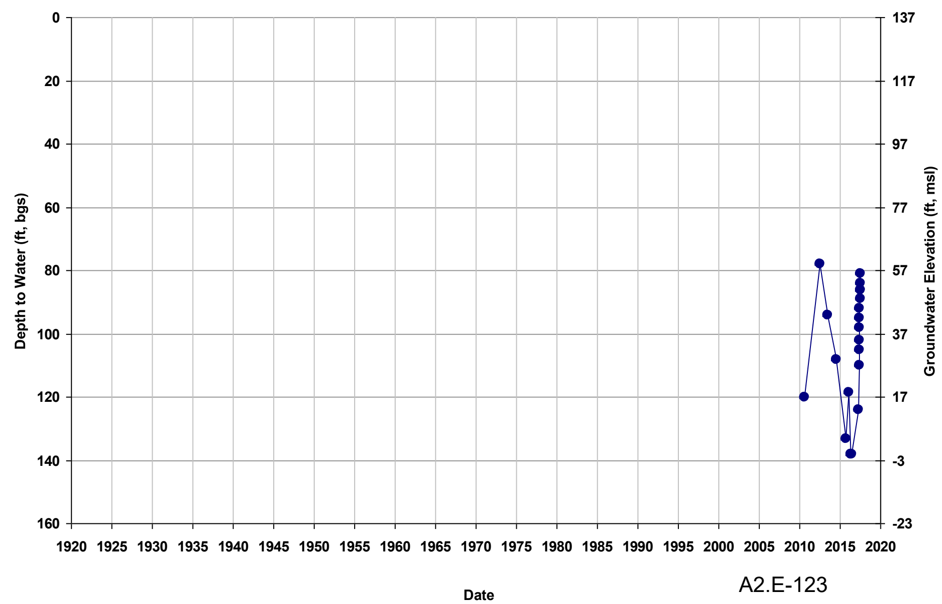
Well ID: TTR-23
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 137
Total Depth (ft): 212
Perf Top (ft): 170
Perf Bottom (ft): 208



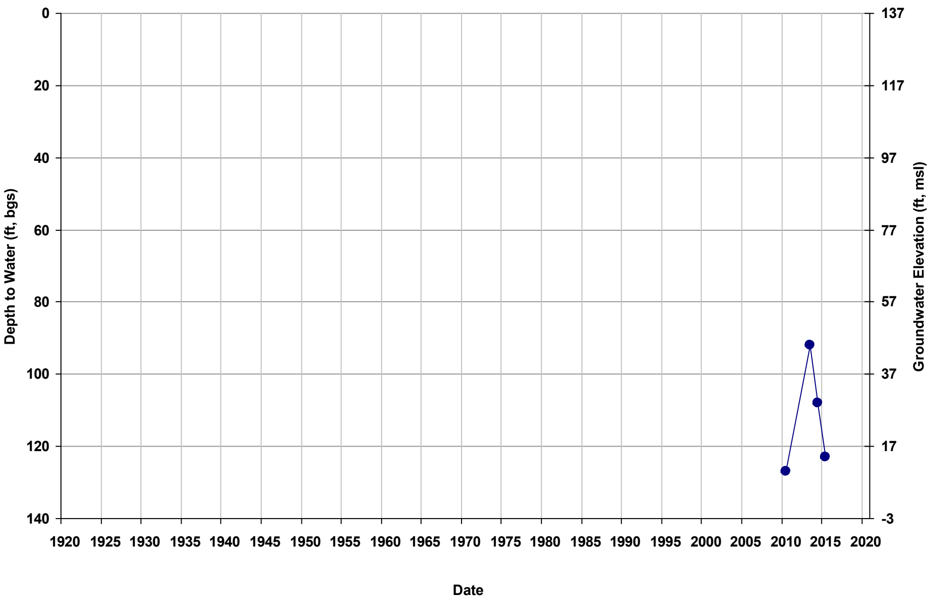
Well ID: TTR-24
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 137
Total Depth (ft): 188
Perf Top (ft): 137
Perf Bottom (ft): 188



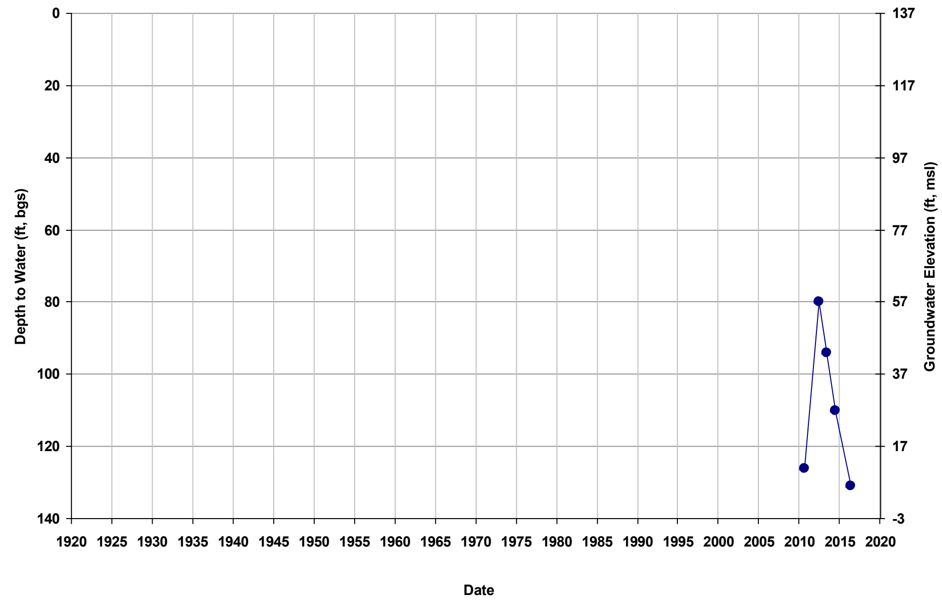
Well ID: TTR-25
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 137
Total Depth (ft): 211
Perf Top (ft): 167
Perf Bottom (ft): 211



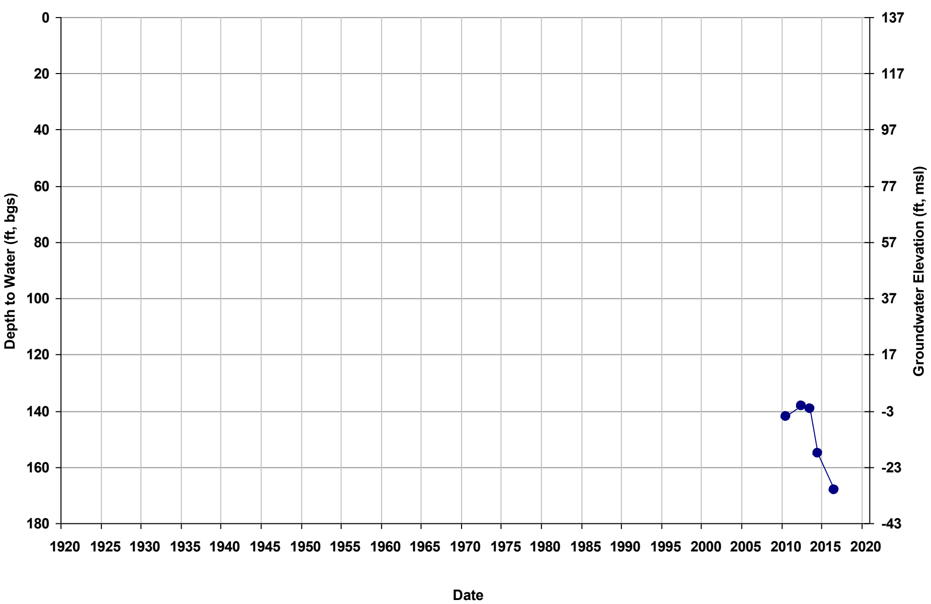
Well ID: TTR-26
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 137
Total Depth (ft): 300
Perf Top (ft): 130
Perf Bottom (ft): 299



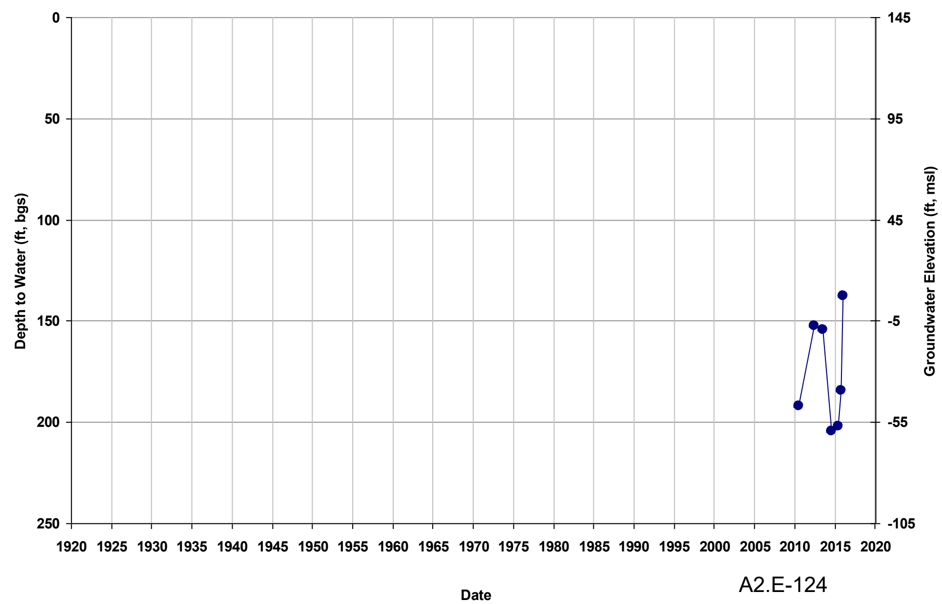
Well ID: TTR-27
Depth Zone: Composite; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 137
Total Depth (ft): 799
Perf Top (ft): 168
Perf Bottom (ft): 790



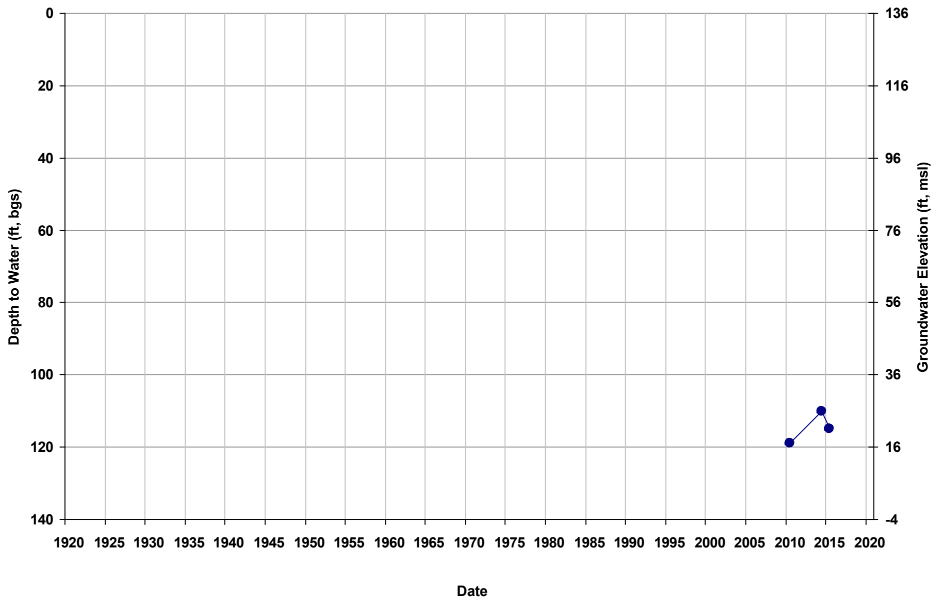
Well ID: TTR-28
Depth Zone: Composite; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 145
Total Depth (ft): 710
Perf Top (ft): 170
Perf Bottom (ft): 690



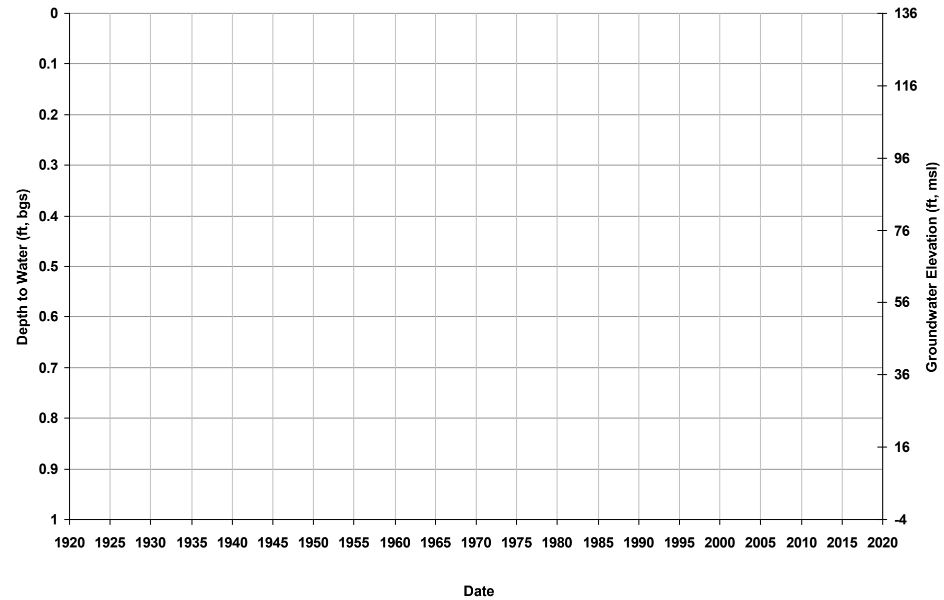
Well ID: TTR-29
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 136
Total Depth (ft): 224
Perf Top (ft): 125
Perf Bottom (ft): 224



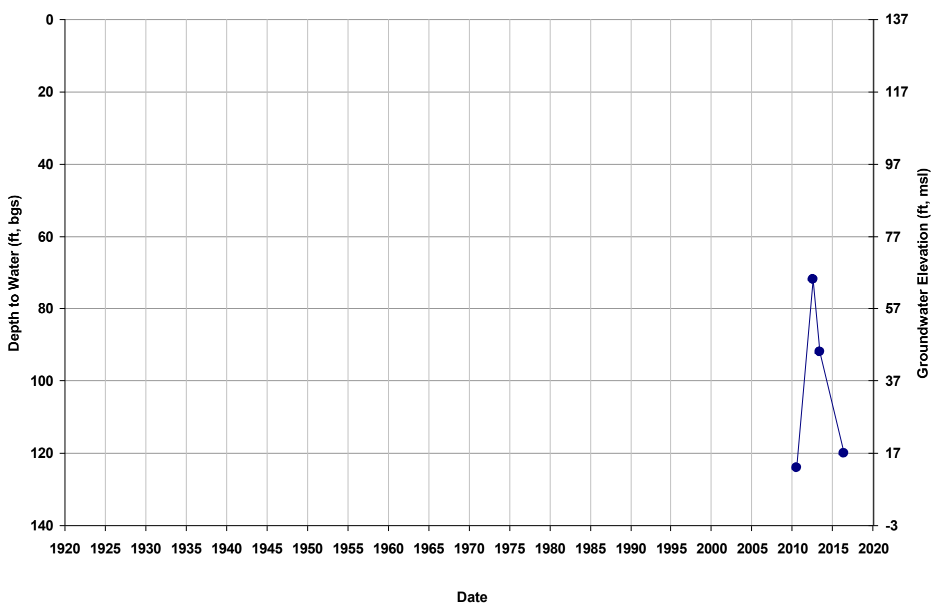
Well ID: TTR-3
Depth Zone: Upper; Outside CC
Subbasin: Chowchilla

GSE (ft, msl):
Total Depth (ft): 219
Perf Top (ft): 143
Perf Bottom (ft): 215



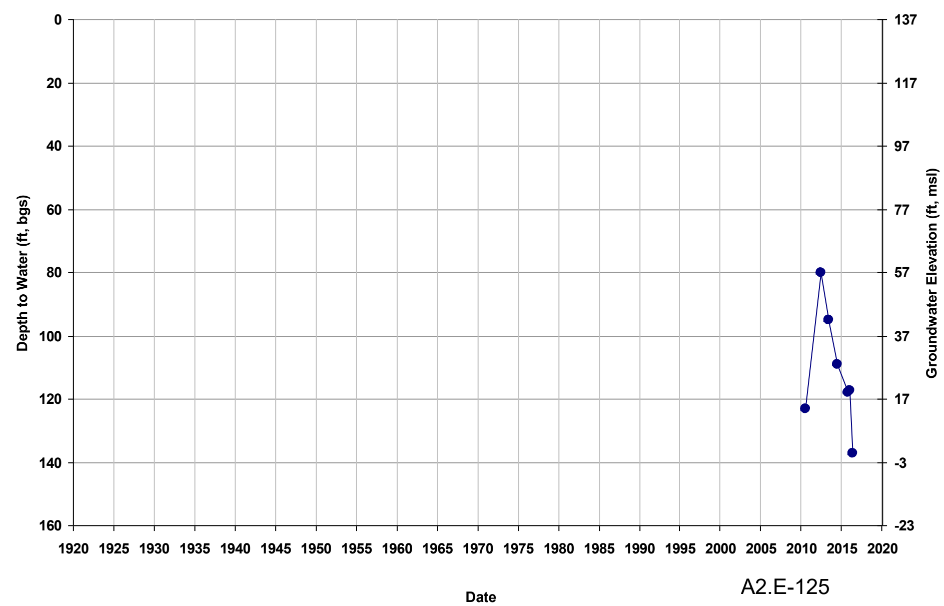
Well ID: TTR-30
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

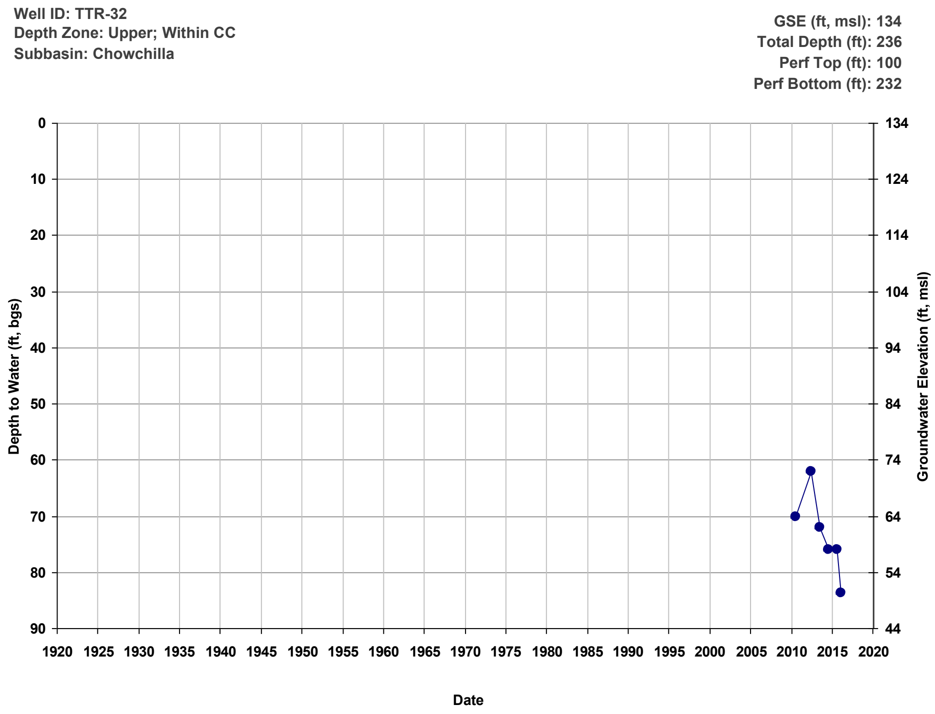
GSE (ft, msl): 137
Total Depth (ft): 185
Perf Top (ft): 150
Perf Bottom (ft): 185

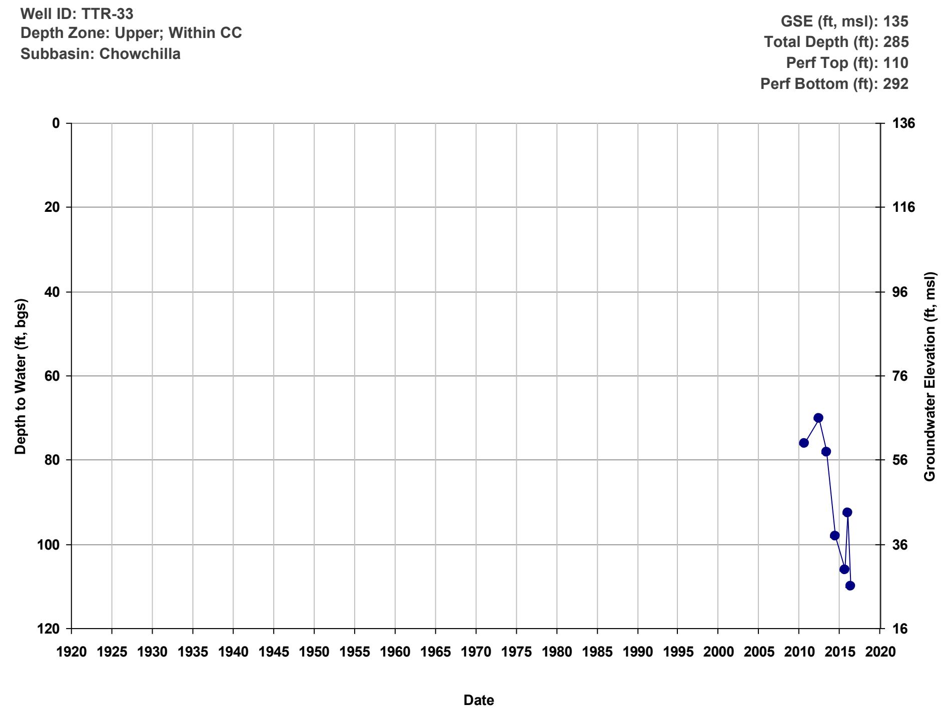


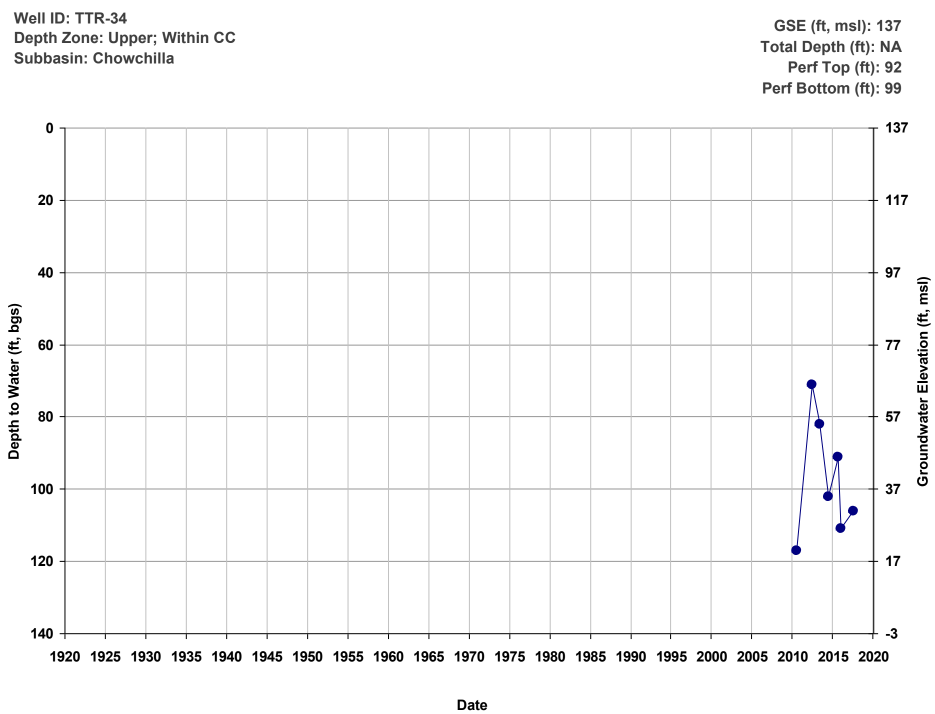
Well ID: TTR-31
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

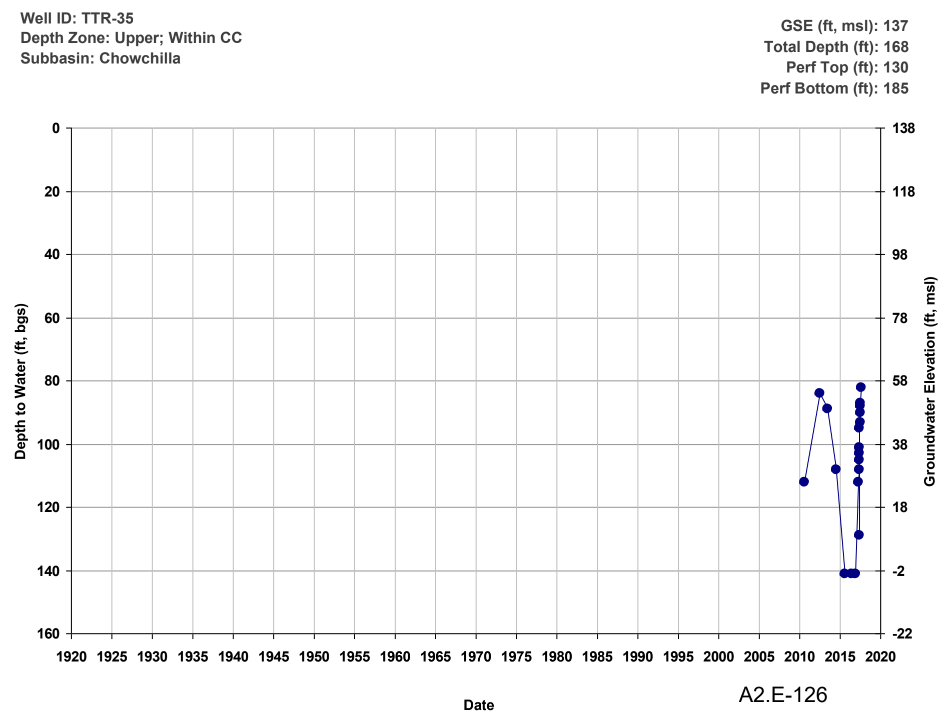
GSE (ft, msl): 137
Total Depth (ft): 197
Perf Top (ft): 158
Perf Bottom (ft): 197




Well ID: TTR-32
Depth Zone: Upper; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 134
Total Depth (ft): 236
Perf Top (ft): 100
Perf Bottom (ft): 232
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

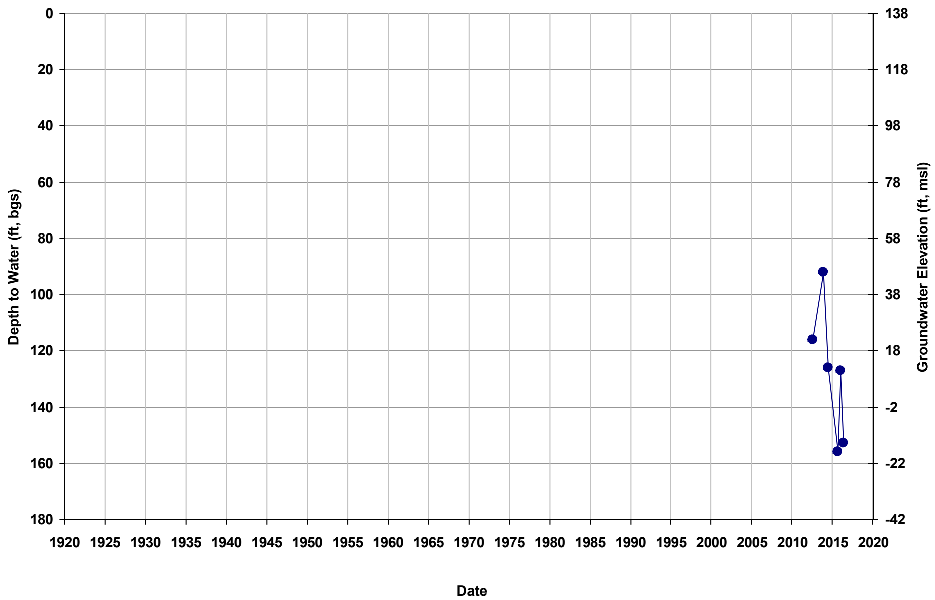

Well ID: TTR-33
Depth Zone: Upper; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 135
Total Depth (ft): 285
Perf Top (ft): 110
Perf Bottom (ft): 292
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: TTR-34
Depth Zone: Upper; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 137
Total Depth (ft): NA
Perf Top (ft): 92
Perf Bottom (ft): 99
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: TTR-35
Depth Zone: Upper; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 137
Total Depth (ft): 168
Perf Top (ft): 130
Perf Bottom (ft): 185
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

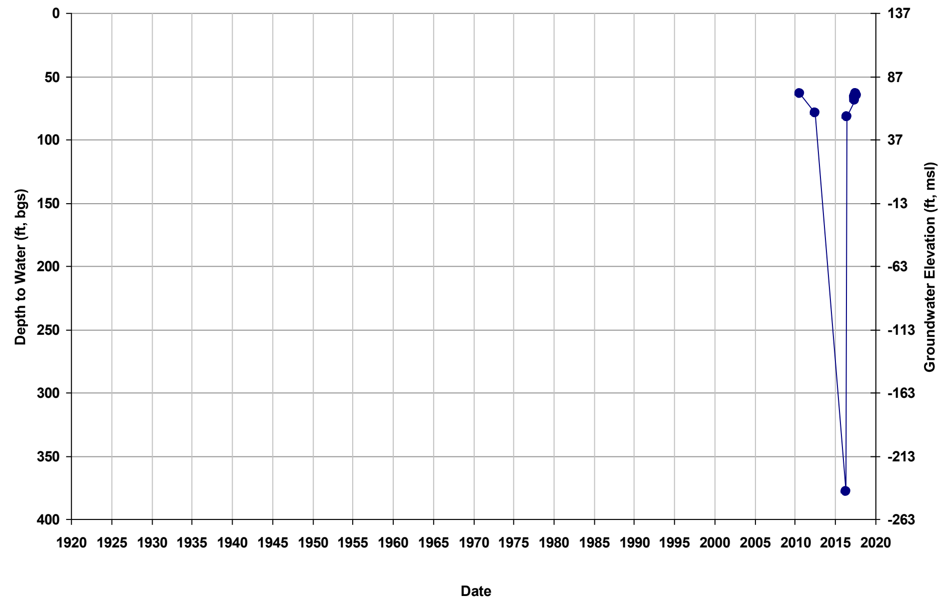
Well ID: TTR-36
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 138
Total Depth (ft): 221
Perf Top (ft): 130
Perf Bottom (ft): 221



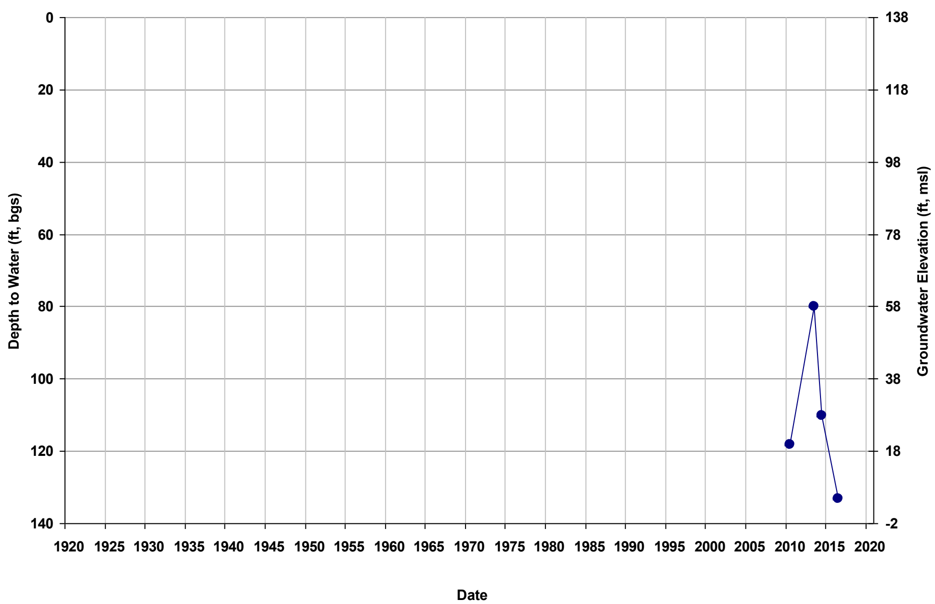
Well ID: TTR-37
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 137
Total Depth (ft): 219
Perf Top (ft): 114
Perf Bottom (ft): 219



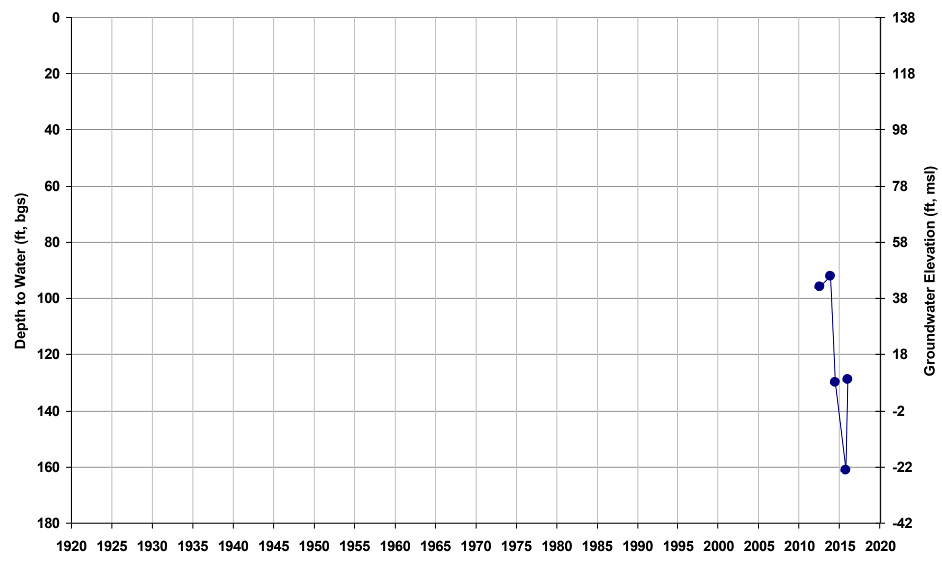
Well ID: TTR-38
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

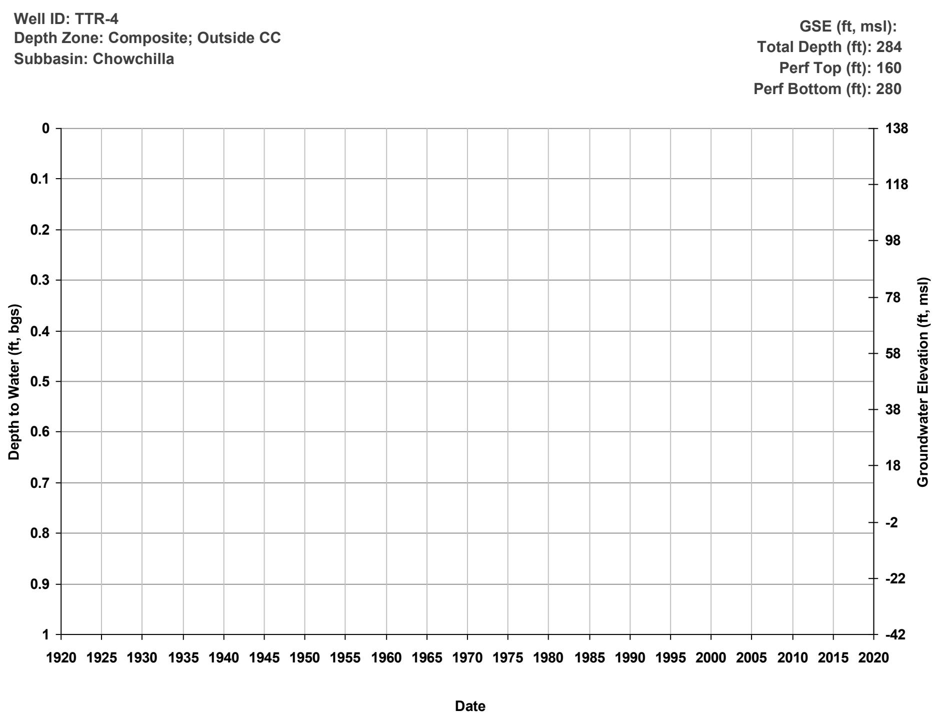
GSE (ft, msl): 137
Total Depth (ft): 206
Perf Top (ft): 125
Perf Bottom (ft): 206

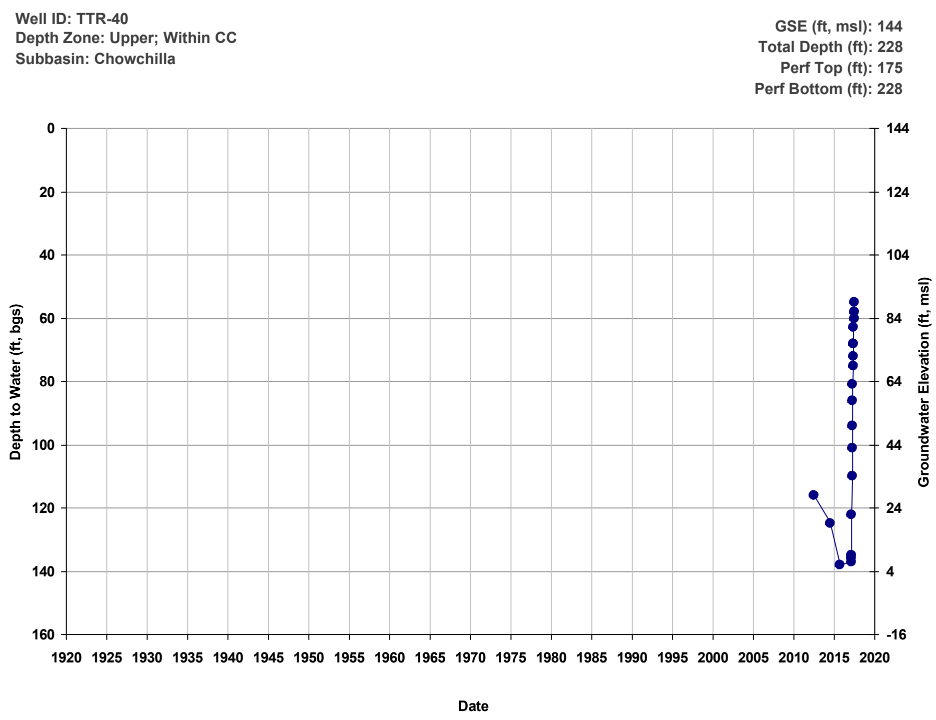


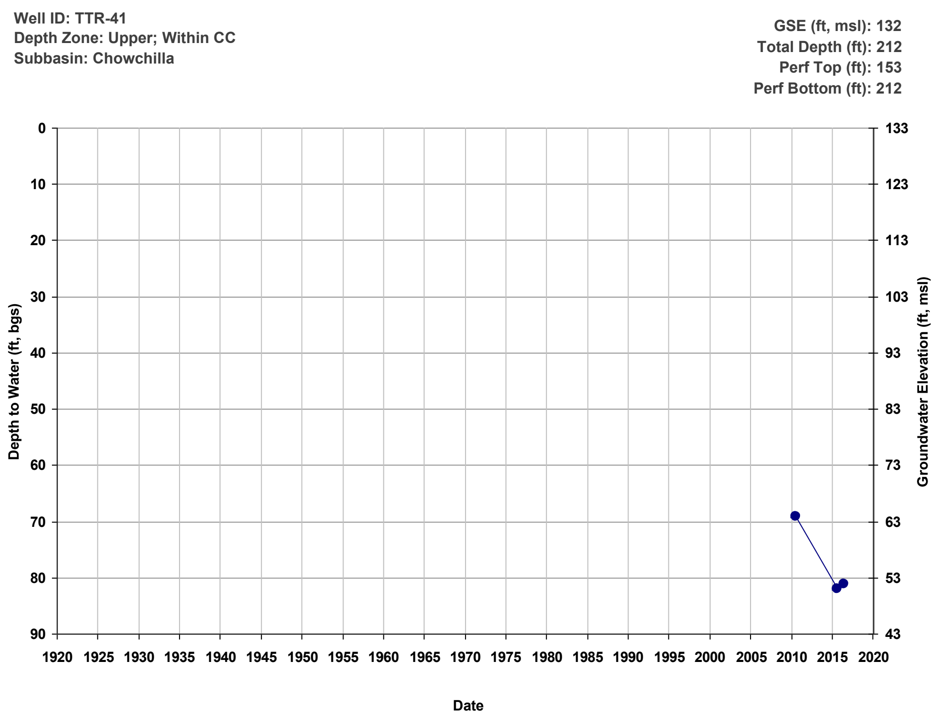
Well ID: TTR-39
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

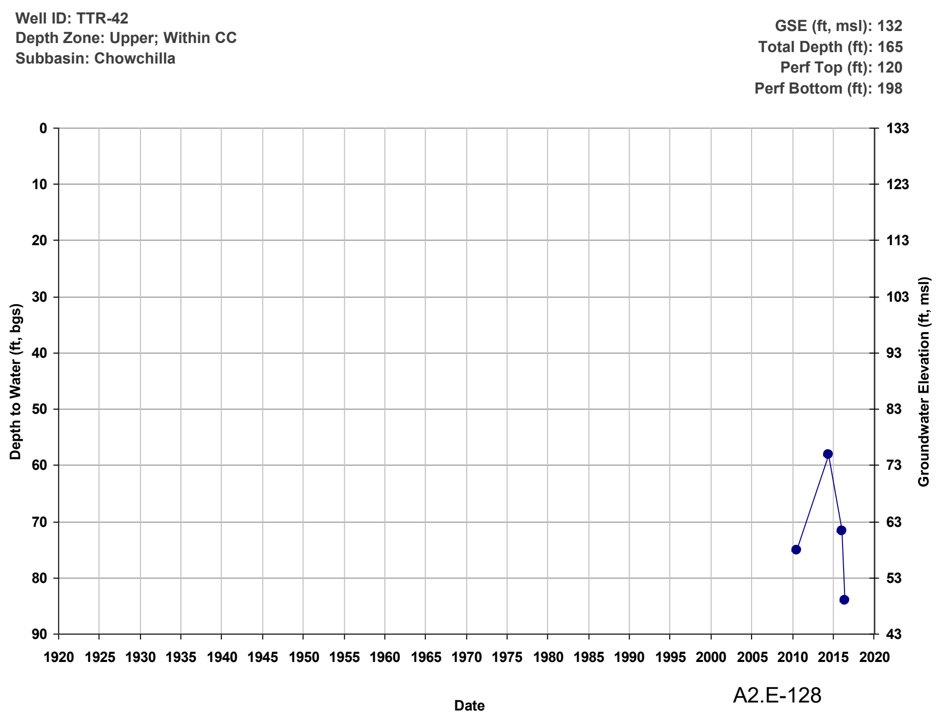
GSE (ft, msl): 138
Total Depth (ft): 211
Perf Top (ft): 132
Perf Bottom (ft): 211




Well ID: TTR-4
Depth Zone: Composite; Outside CC
Subbasin: Chowchilla
GSE (ft, msl):
Total Depth (ft): 284
Perf Top (ft): 160
Perf Bottom (ft): 280
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

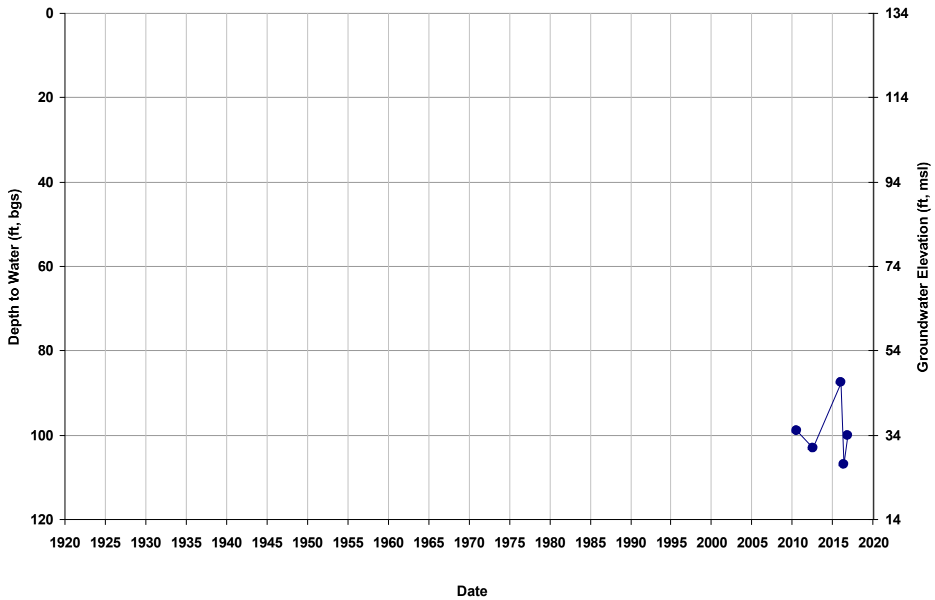

Well ID: TTR-40
Depth Zone: Upper; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 144
Total Depth (ft): 228
Perf Top (ft): 175
Perf Bottom (ft): 228
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: TTR-41
Depth Zone: Upper; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 132
Total Depth (ft): 212
Perf Top (ft): 153
Perf Bottom (ft): 212
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: TTR-42
Depth Zone: Upper; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 132
Total Depth (ft): 165
Perf Top (ft): 120
Perf Bottom (ft): 198
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

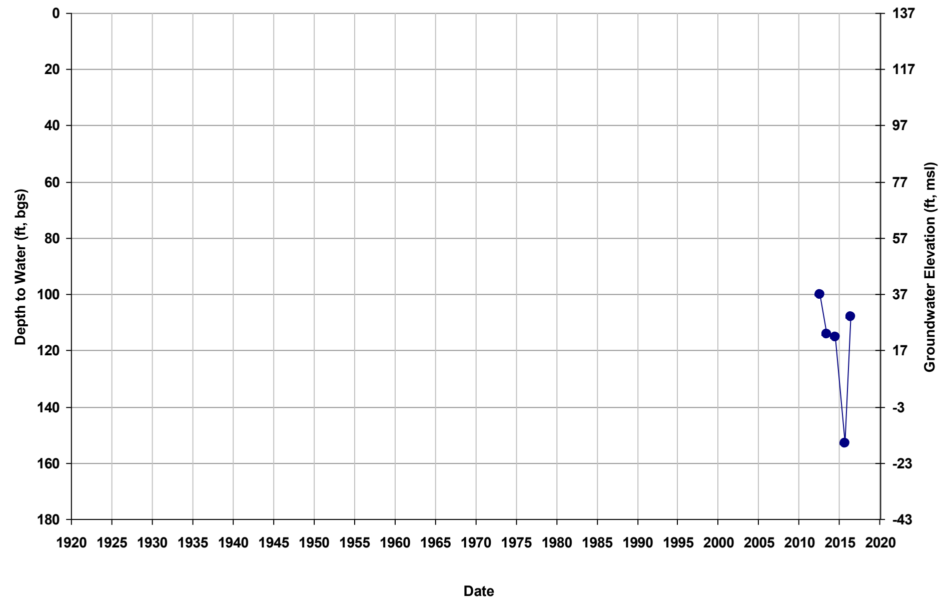
Well ID: TTR-43
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 133
Total Depth (ft): 280
Perf Top (ft): 190
Perf Bottom (ft): 276



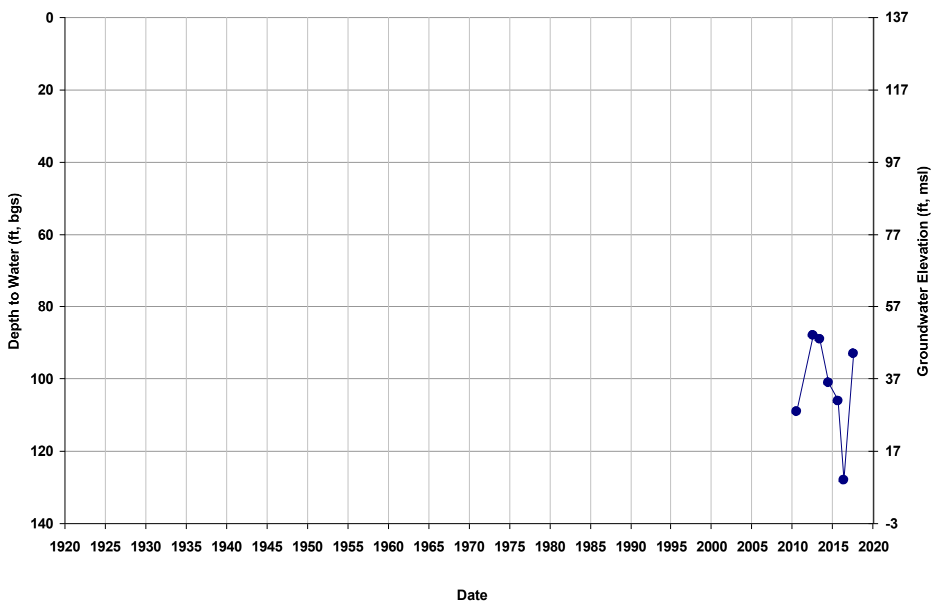
Well ID: TTR-44
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 137
Total Depth (ft): 260
Perf Top (ft): 210
Perf Bottom (ft): 256



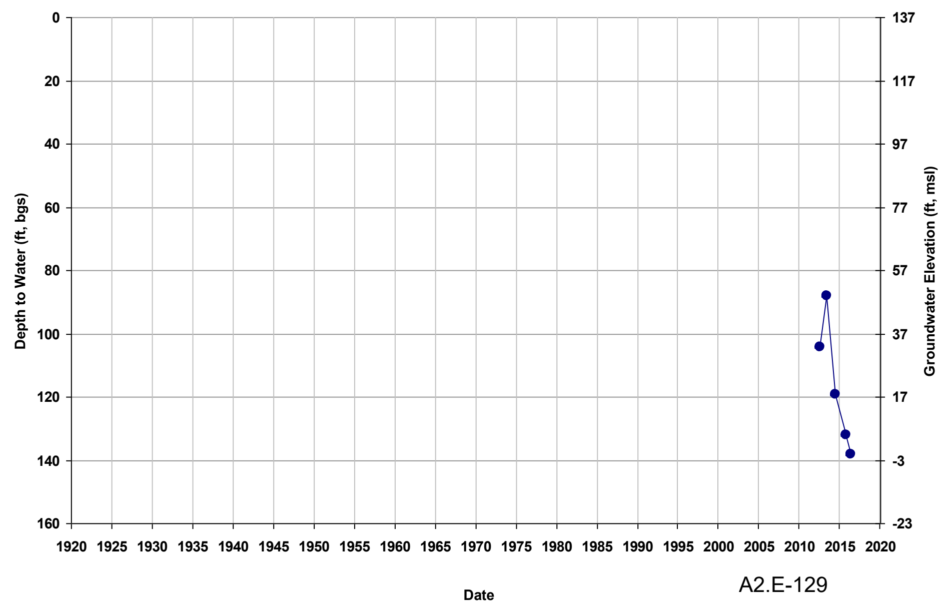
Well ID: TTR-45
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 137
Total Depth (ft): 300
Perf Top (ft): 100
Perf Bottom (ft): 300



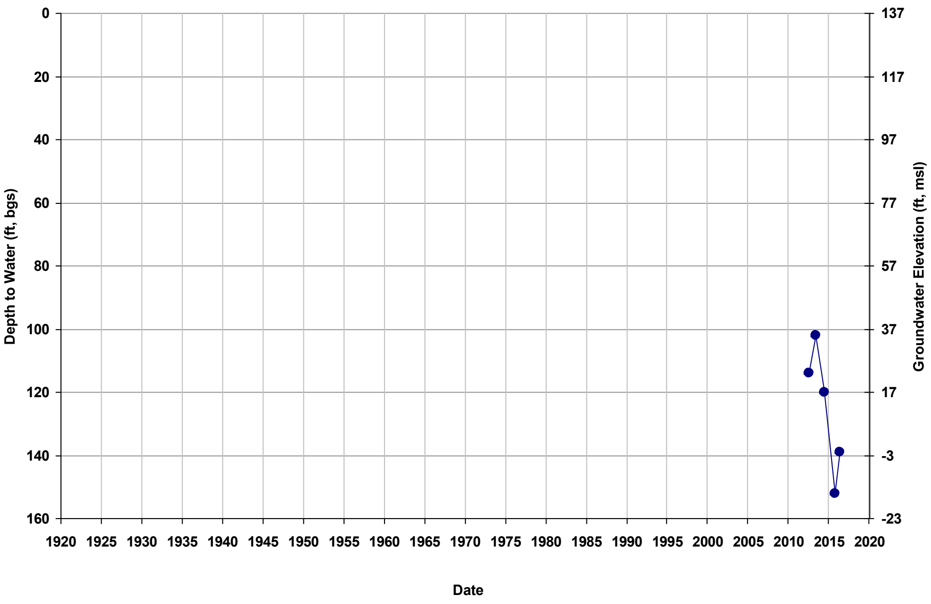
Well ID: TTR-46
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 137
Total Depth (ft): 300
Perf Top (ft): 144
Perf Bottom (ft): 296



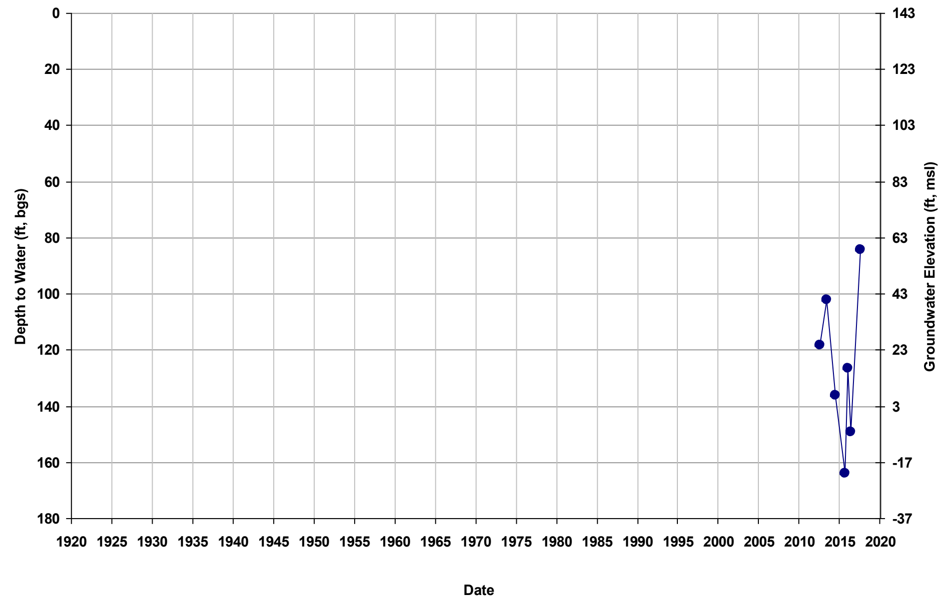
Well ID: TTR-47
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 137
Total Depth (ft): 260
Perf Top (ft): 188
Perf Bottom (ft): 247



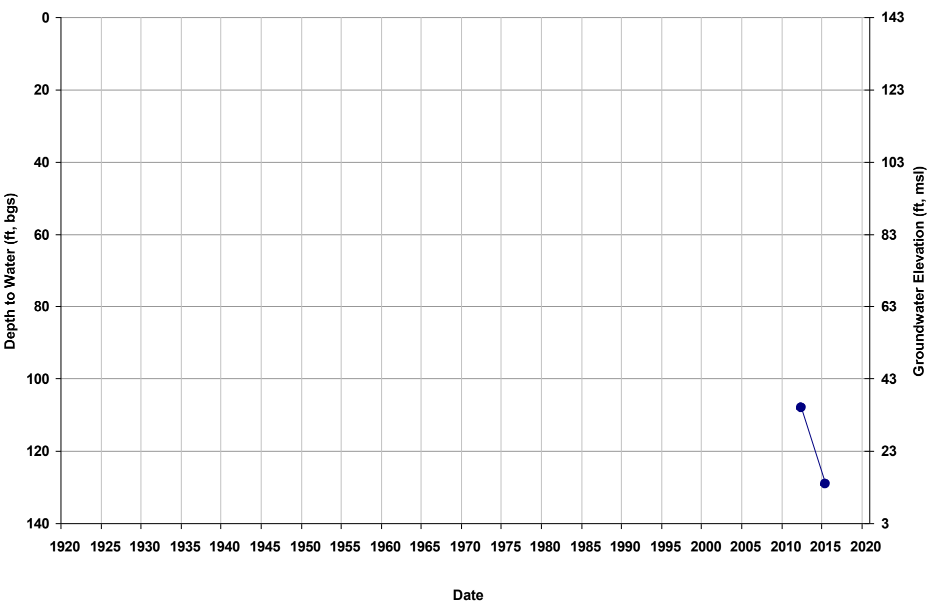
Well ID: TTR-48
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 143
Total Depth (ft): 233
Perf Top (ft): 190
Perf Bottom (ft): 233



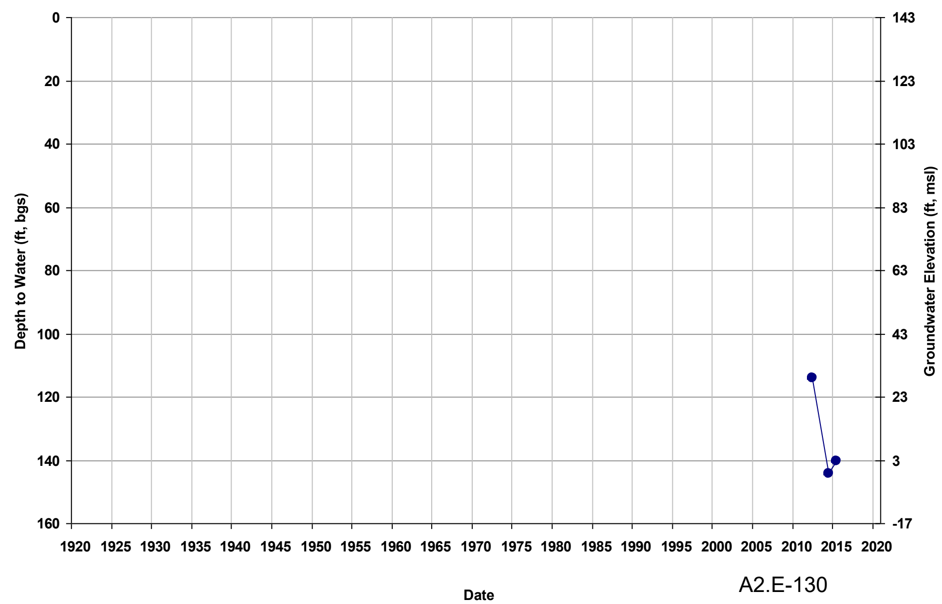
Well ID: TTR-49
Depth Zone: Composite; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 143
Total Depth (ft): 327
Perf Top (ft): 199
Perf Bottom (ft): 327



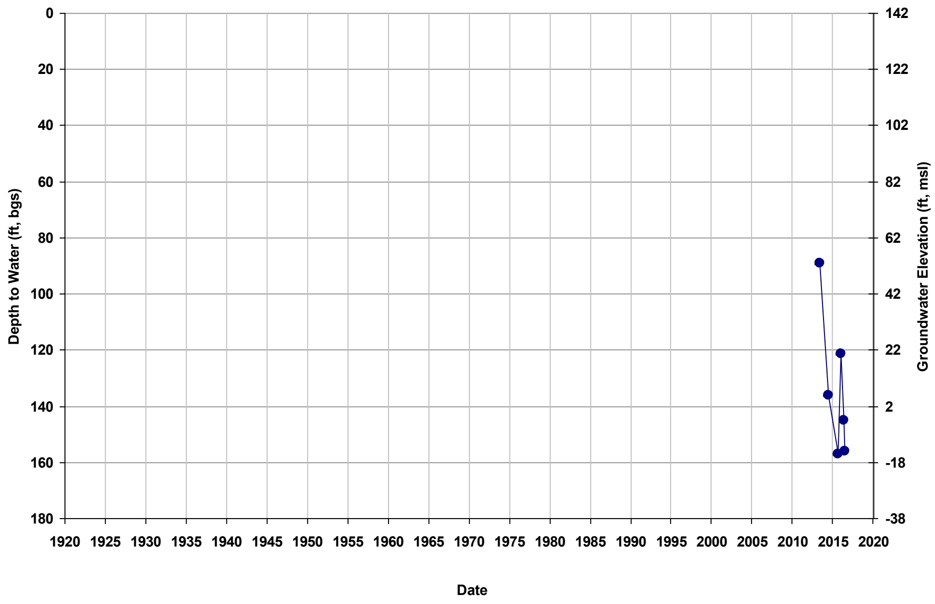
Well ID: TTR-50
Depth Zone: Composite; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 143
Total Depth (ft): 408
Perf Top (ft): 192
Perf Bottom (ft): 408



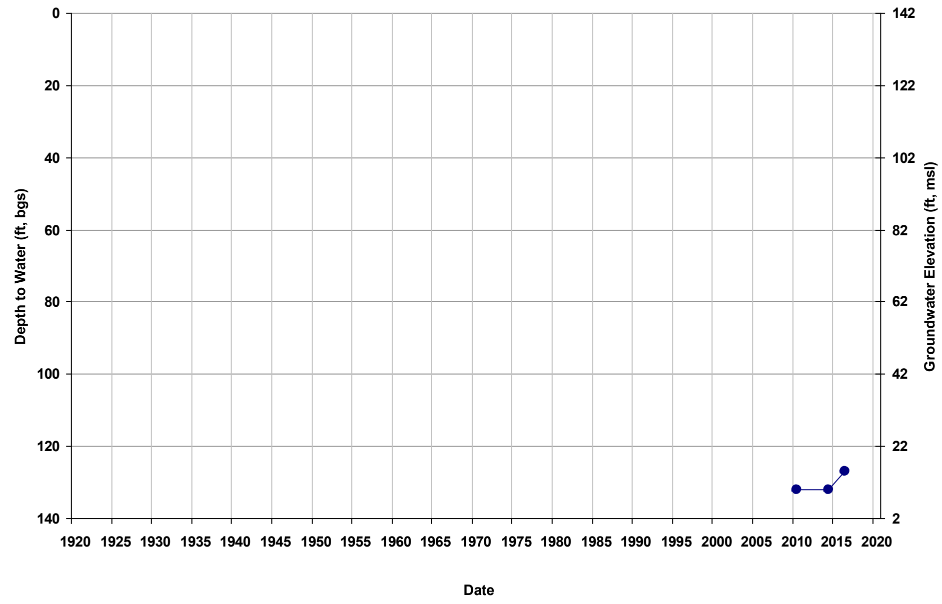
Well ID: TTR-51
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 141
Total Depth (ft): 203
Perf Top (ft): 143
Perf Bottom (ft): 203



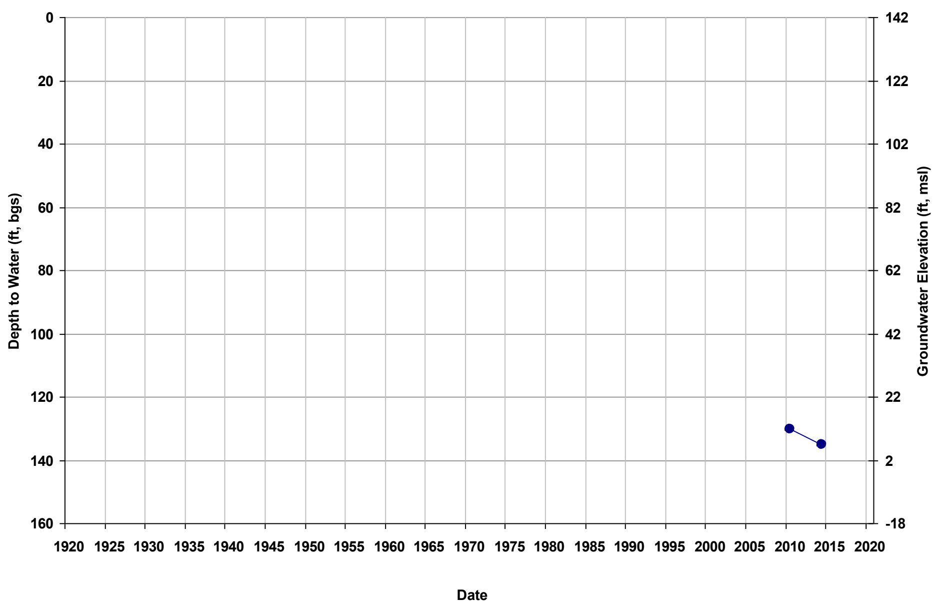
Well ID: TTR-52
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 142
Total Depth (ft): 165
Perf Top (ft): 93
Perf Bottom (ft): 172



Well ID: TTR-53
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 142
Total Depth (ft): 217
Perf Top (ft): 118
Perf Bottom (ft): 217

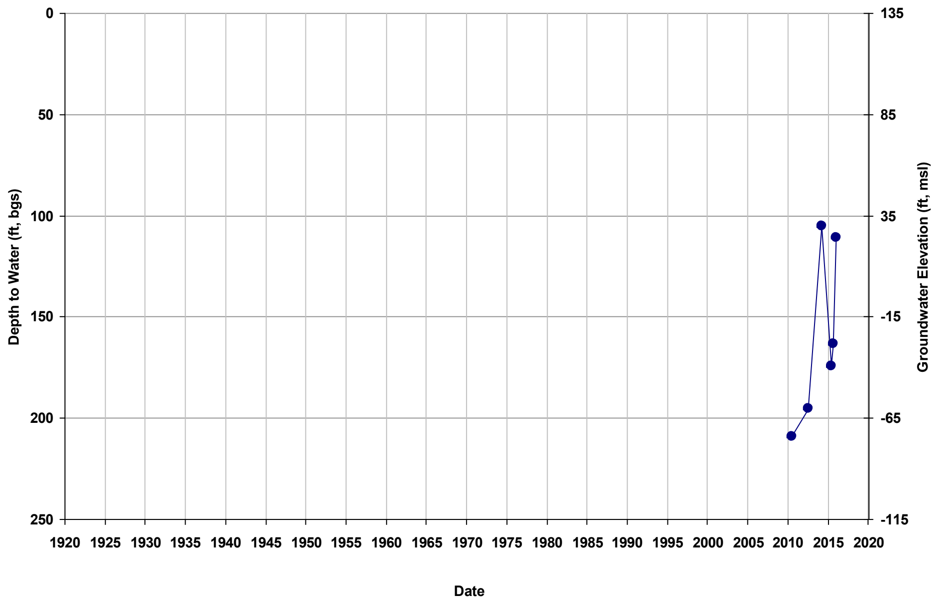


Well ID: TTR-54
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 134
Total Depth (ft): NA
Perf Top (ft): 216
Perf Bottom (ft): NA

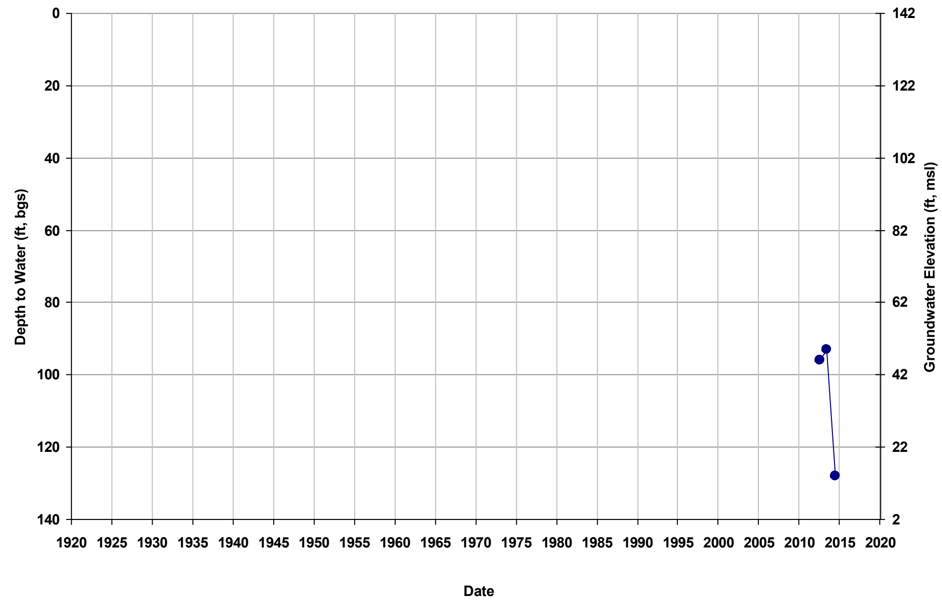
Well ID: TTR-55
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 135
Total Depth (ft): 850
Perf Top (ft): 325
Perf Bottom (ft): 580



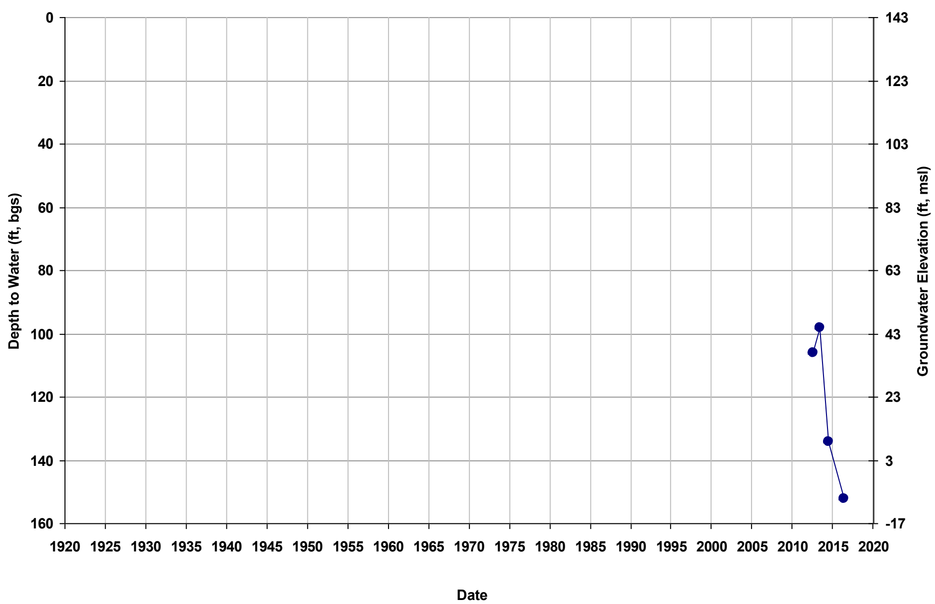
Well ID: TTR-56
Depth Zone: Composite; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 142
Total Depth (ft): 490
Perf Top (ft): 203
Perf Bottom (ft): 490



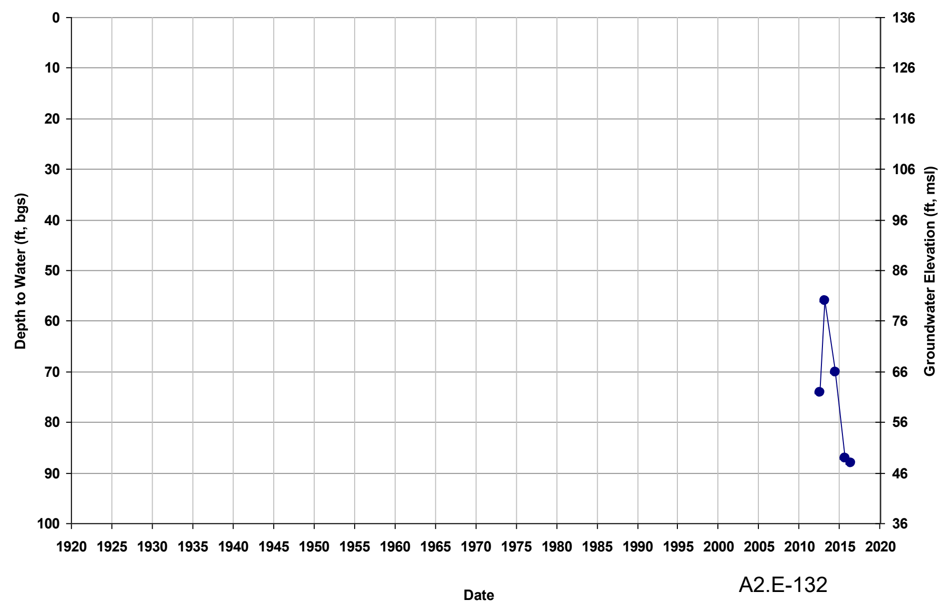
Well ID: TTR-57
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 143
Total Depth (ft): 272
Perf Top (ft): 175
Perf Bottom (ft): 272



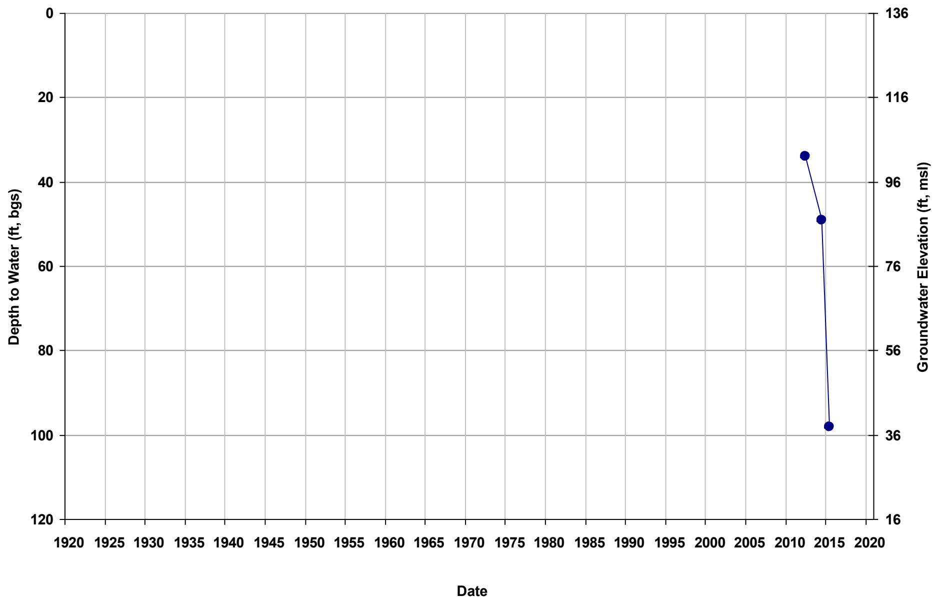
Well ID: TTR-58
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 136
Total Depth (ft): 212
Perf Top (ft): 138
Perf Bottom (ft): 220



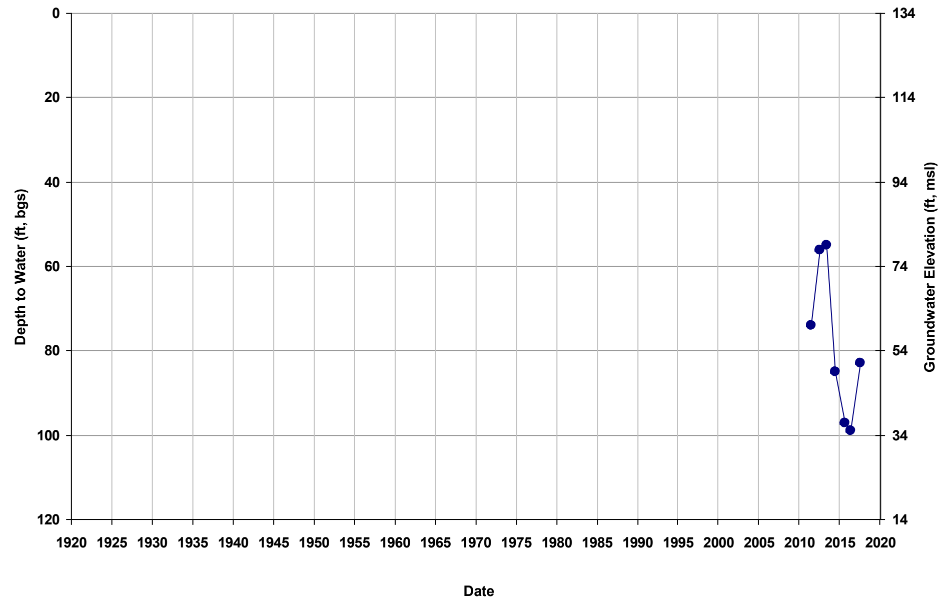
Well ID: TTR-59
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 135
Total Depth (ft): 143
Perf Top (ft): 72
Perf Bottom (ft): 143



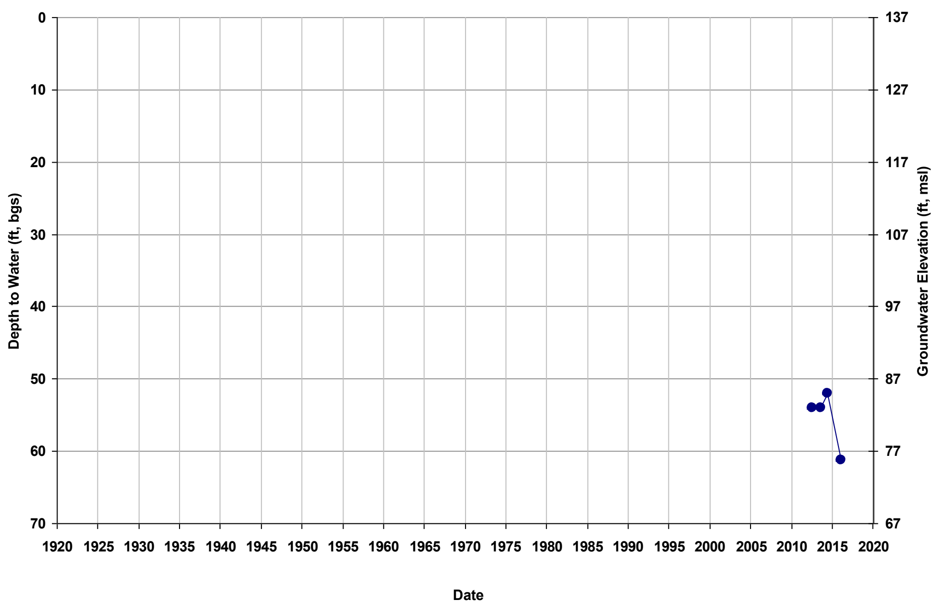
Well ID: TTR-6
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 134
Total Depth (ft): 196
Perf Top (ft): 158
Perf Bottom (ft): 192



Well ID: TTR-60
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 137
Total Depth (ft): 202
Perf Top (ft): 105
Perf Bottom (ft): 202

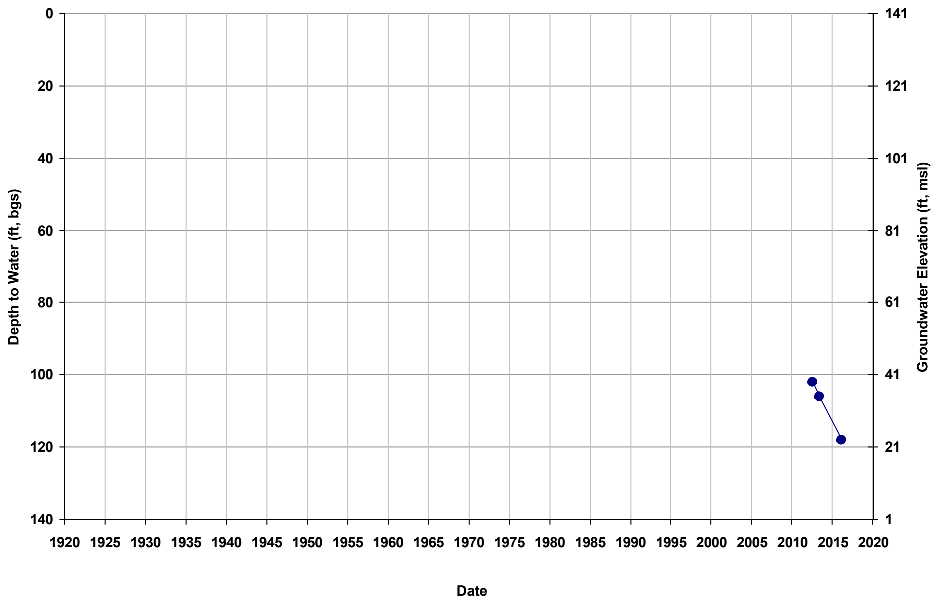


Well ID: TTR-61
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 137
Total Depth (ft): 840
Perf Top (ft): 320
Perf Bottom (ft): 820

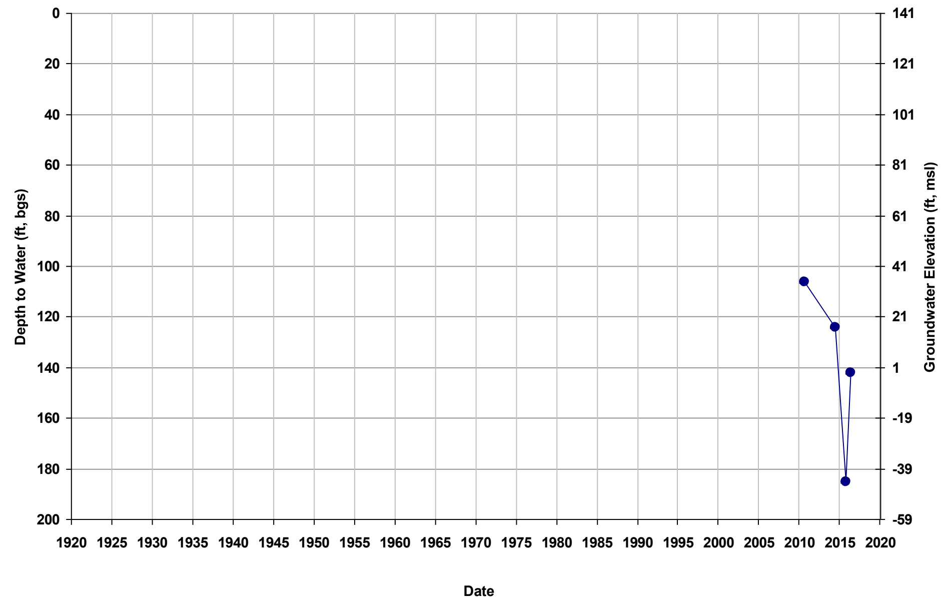
Well ID: TTR-62
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 141
Total Depth (ft): 284
Perf Top (ft): 168
Perf Bottom (ft): 235



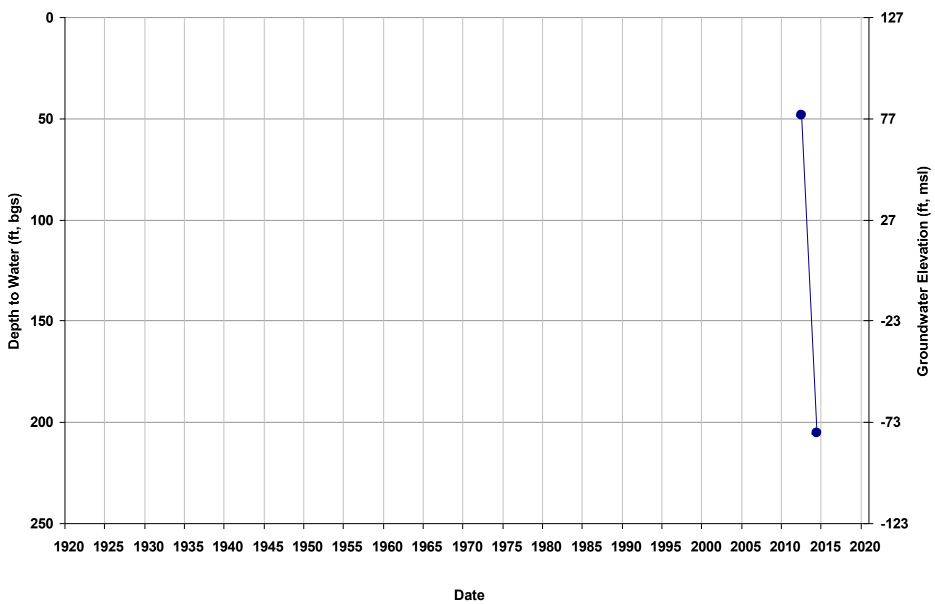
Well ID: TTR-63
Depth Zone: Upper; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 140
Total Depth (ft): 286
Perf Top (ft): 192
Perf Bottom (ft): 286



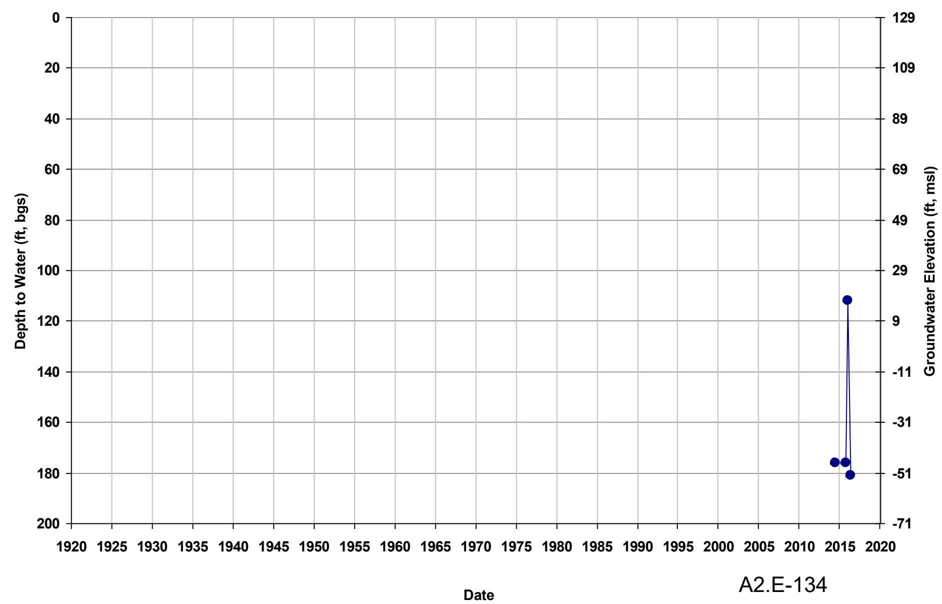
Well ID: TTR-64
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 127
Total Depth (ft): 870
Perf Top (ft): 295
Perf Bottom (ft): 850



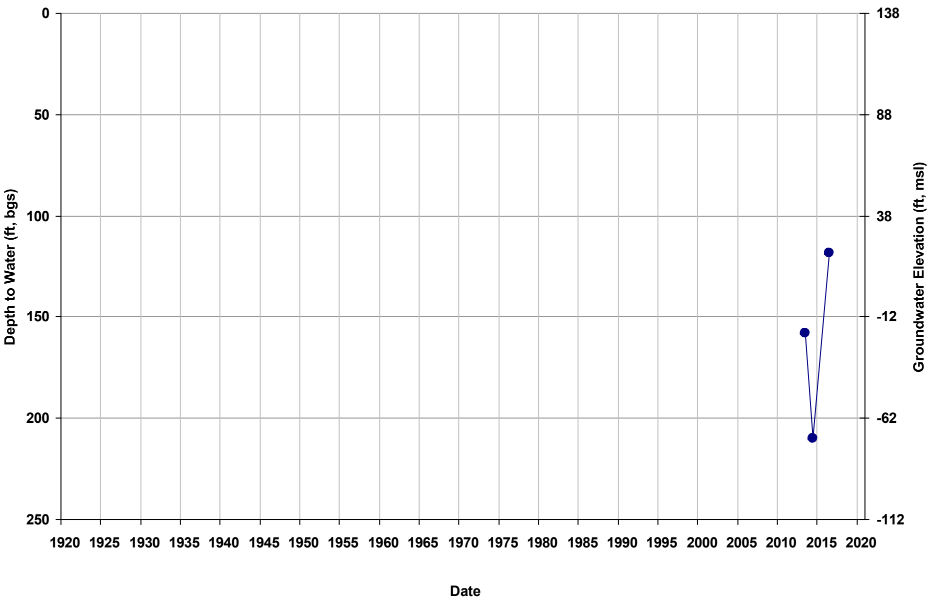
Well ID: TTR-66
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 128
Total Depth (ft): 870
Perf Top (ft): 300
Perf Bottom (ft): 850



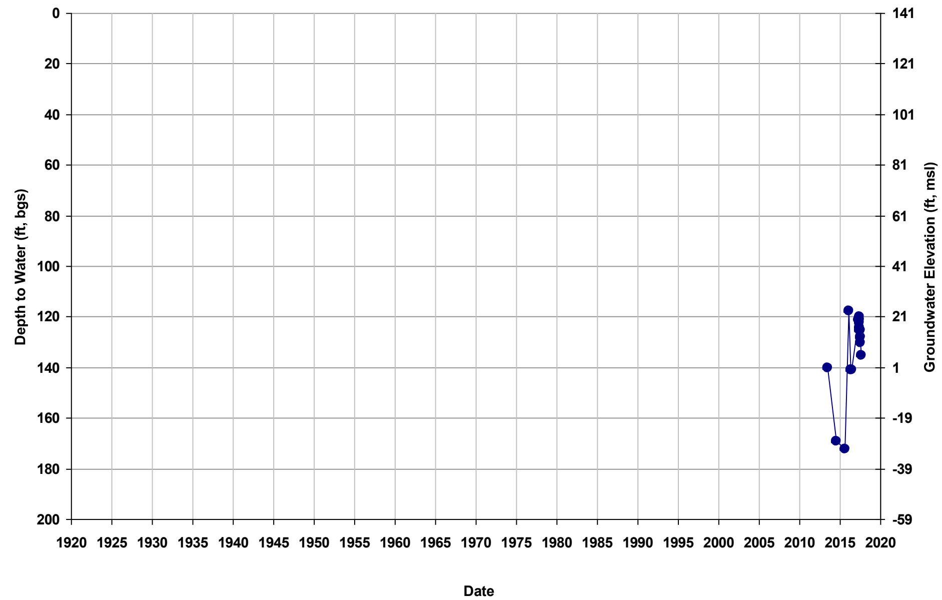
Well ID: TTR-67
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 138
Total Depth (ft): 850
Perf Top (ft): 325
Perf Bottom (ft): 830



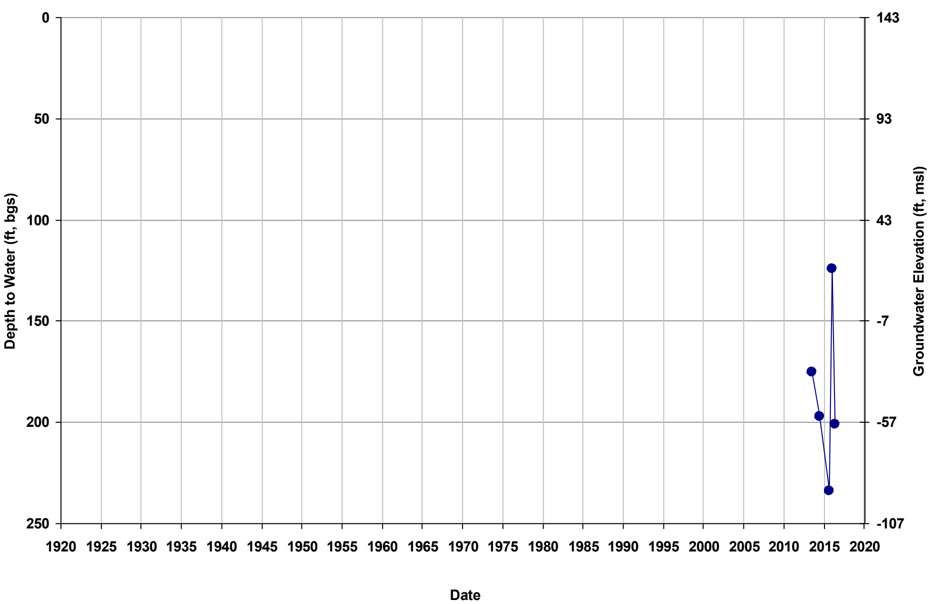
Well ID: TTR-68
Depth Zone: Composite; Within CC
Subbasin: Chowchilla

GSE (ft, msl): 140
Total Depth (ft): 840
Perf Top (ft): 190
Perf Bottom (ft): 810



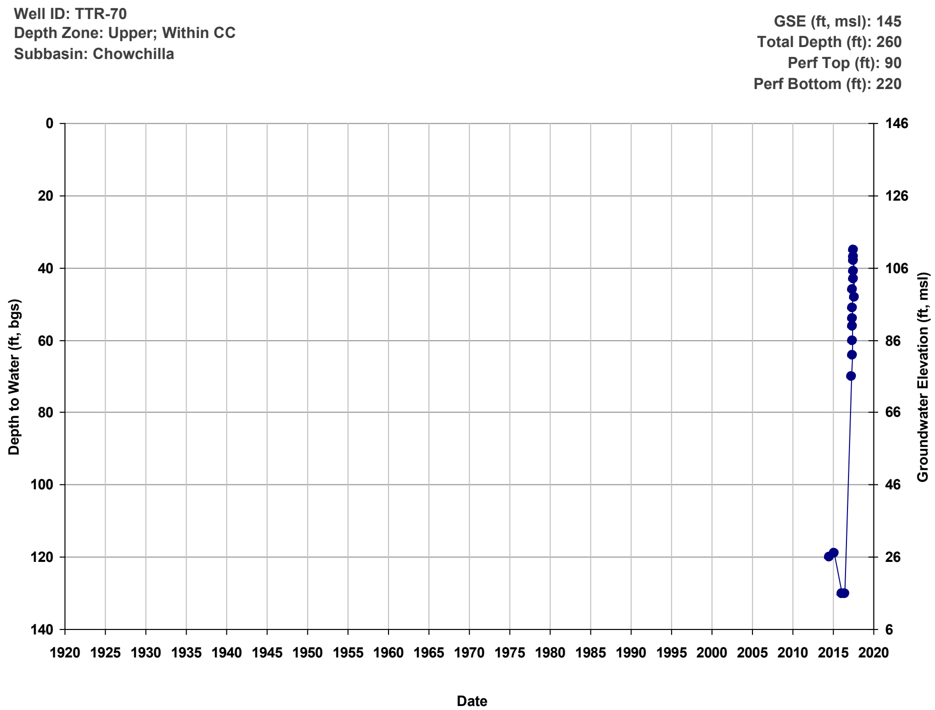
Well ID: TTR-69
Depth Zone: Composite; Within CC
Subbasin: Chowchilla

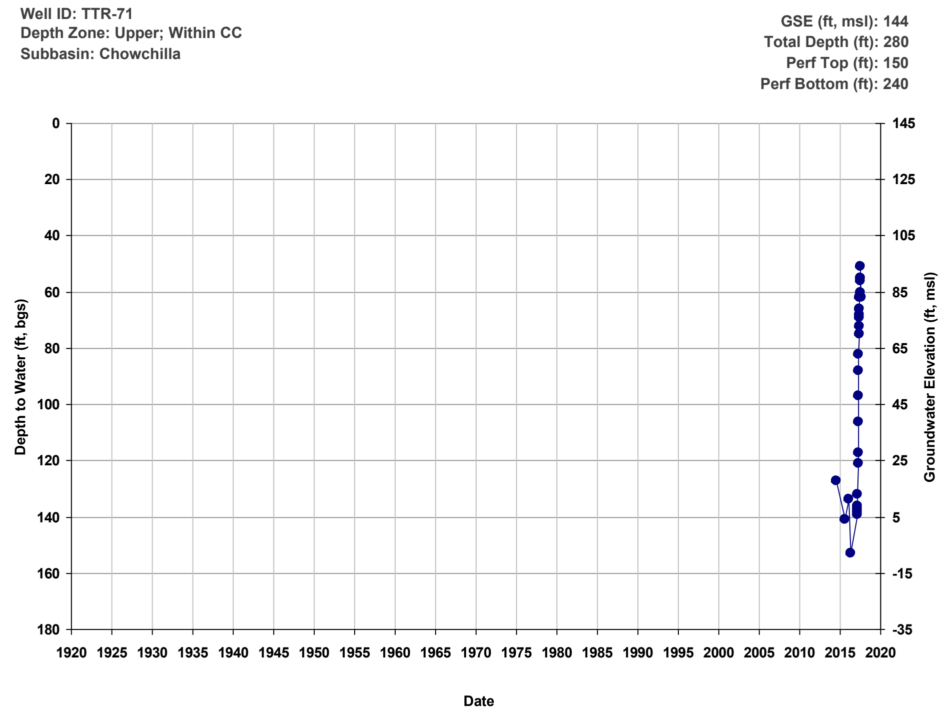
GSE (ft, msl): 143
Total Depth (ft): 750
Perf Top (ft): 190
Perf Bottom (ft): 730

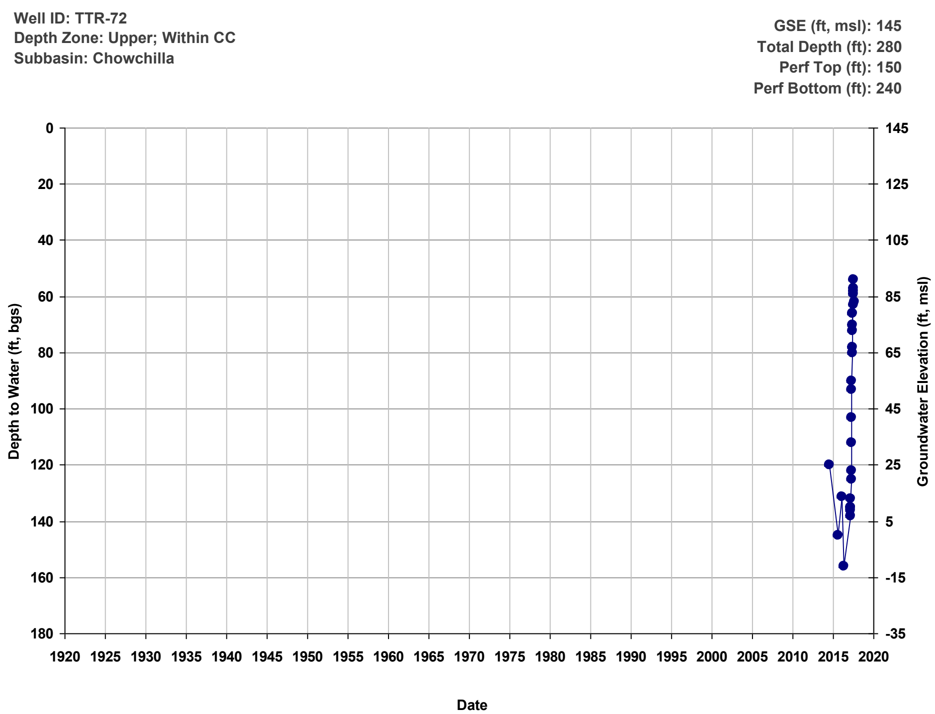


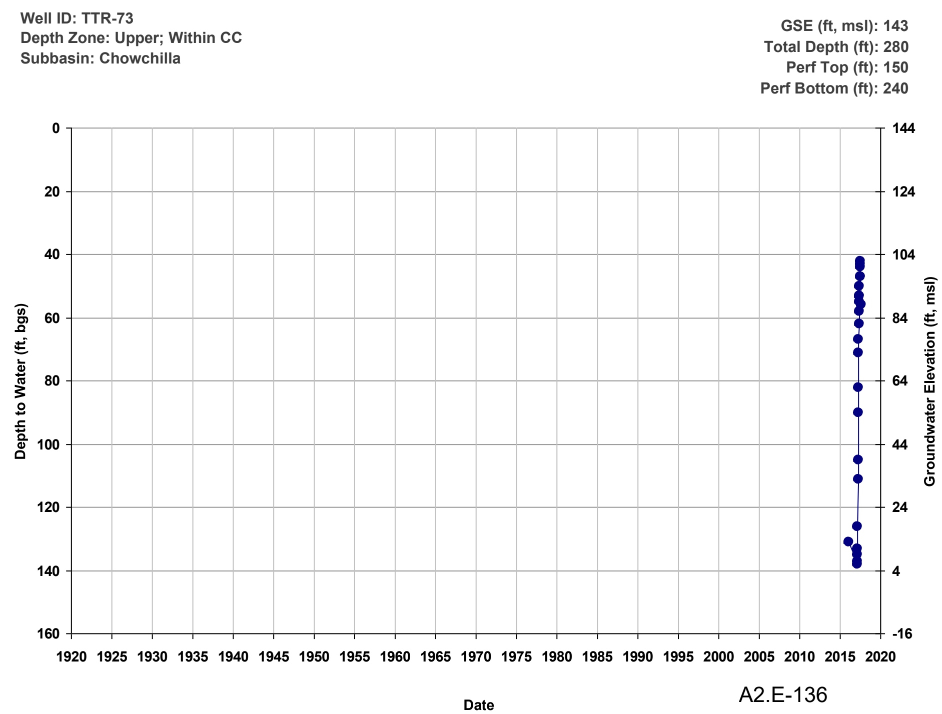
Well ID: TTR-7
Depth Zone: Lower; Within CC
Subbasin: Chowchilla

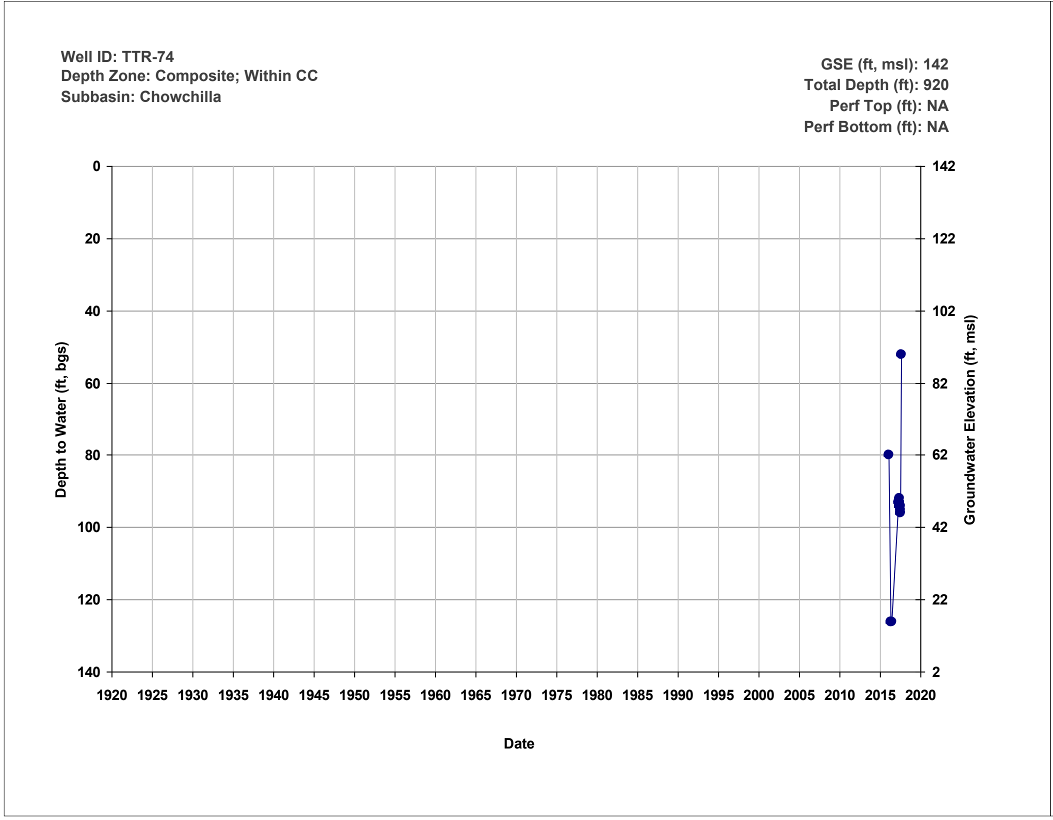
GSE (ft, msl): 136
Total Depth (ft): 795
Perf Top (ft): 290
Perf Bottom (ft): 775

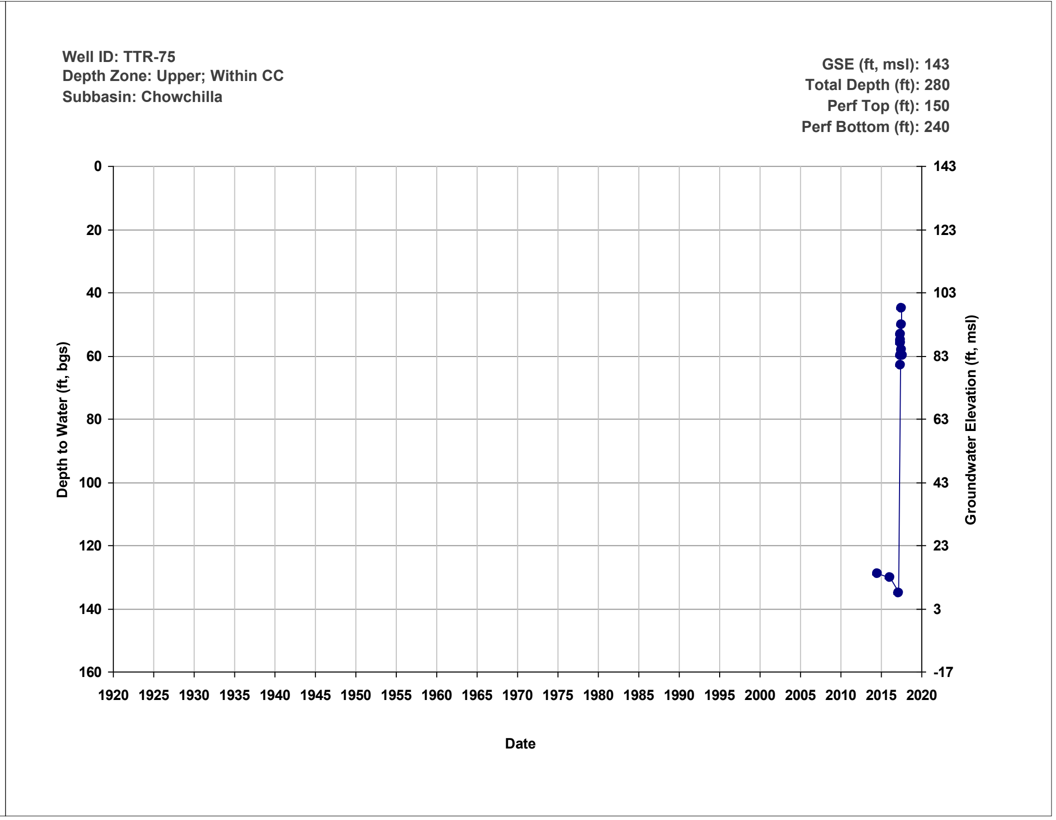

Well ID: TTR-70
Depth Zone: Upper; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 145
Total Depth (ft): 260
Perf Top (ft): 90
Perf Bottom (ft): 220
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: TTR-71
Depth Zone: Upper; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 144
Total Depth (ft): 280
Perf Top (ft): 150
Perf Bottom (ft): 240
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: TTR-72
Depth Zone: Upper; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 145
Total Depth (ft): 280
Perf Top (ft): 150
Perf Bottom (ft): 240
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

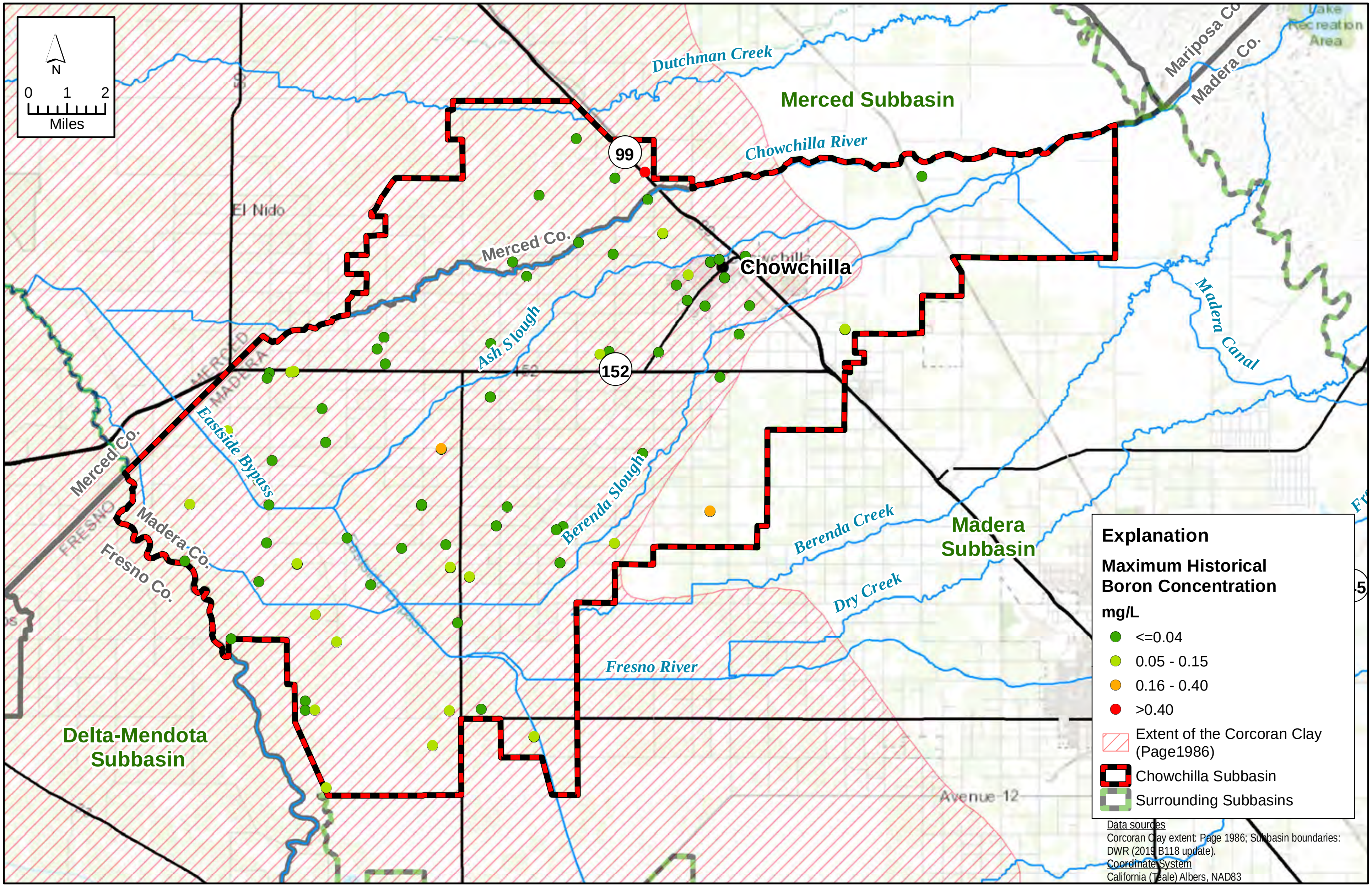

Well ID: TTR-73
Depth Zone: Upper; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 143
Total Depth (ft): 280
Perf Top (ft): 150
Perf Bottom (ft): 240
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: TTR-74
Depth Zone: Composite; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 142
Total Depth (ft): 920
Perf Top (ft): NA
Perf Bottom (ft): NA
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date


Well ID: TTR-75
Depth Zone: Upper; Within CC
Subbasin: Chowchilla
GSE (ft, msl): 143
Total Depth (ft): 280
Perf Top (ft): 150
Perf Bottom (ft): 240
Depth to Water (ft, bgs)
Groundwater Elevation (ft, msl)
Date

Groundwater Quality

Maps



X:\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Appendix 2.E Chowchilla Subbasin GW Quality Map Boron All Wells_20190712.mxd

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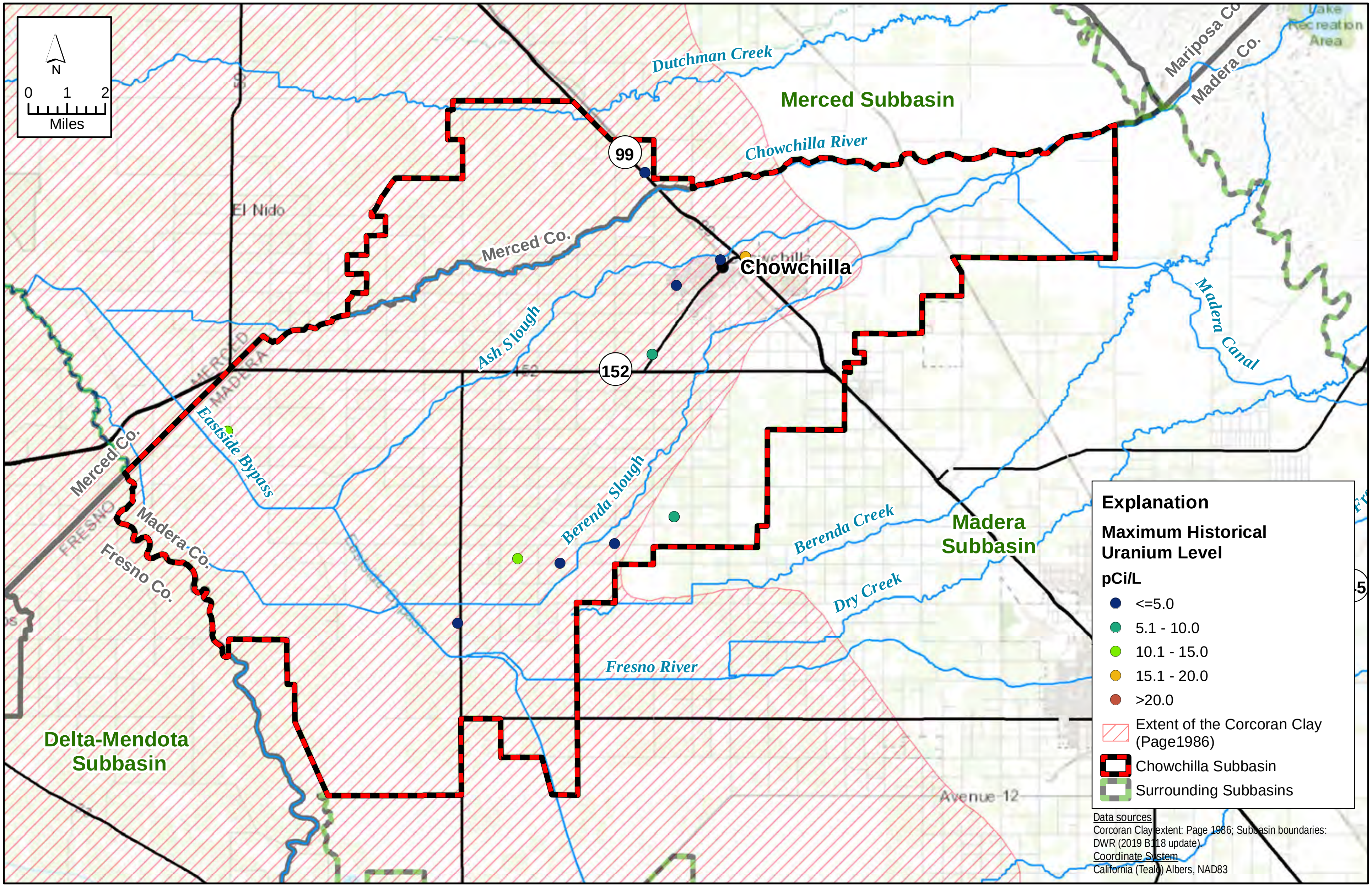
APPENDIX 2.E
Groundwater Quality Map: Boron Concentrations in All Wells



X:\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Appendix 2.E Chowchilla Subbasin GW Quality Map Uranium All Wells.mxd

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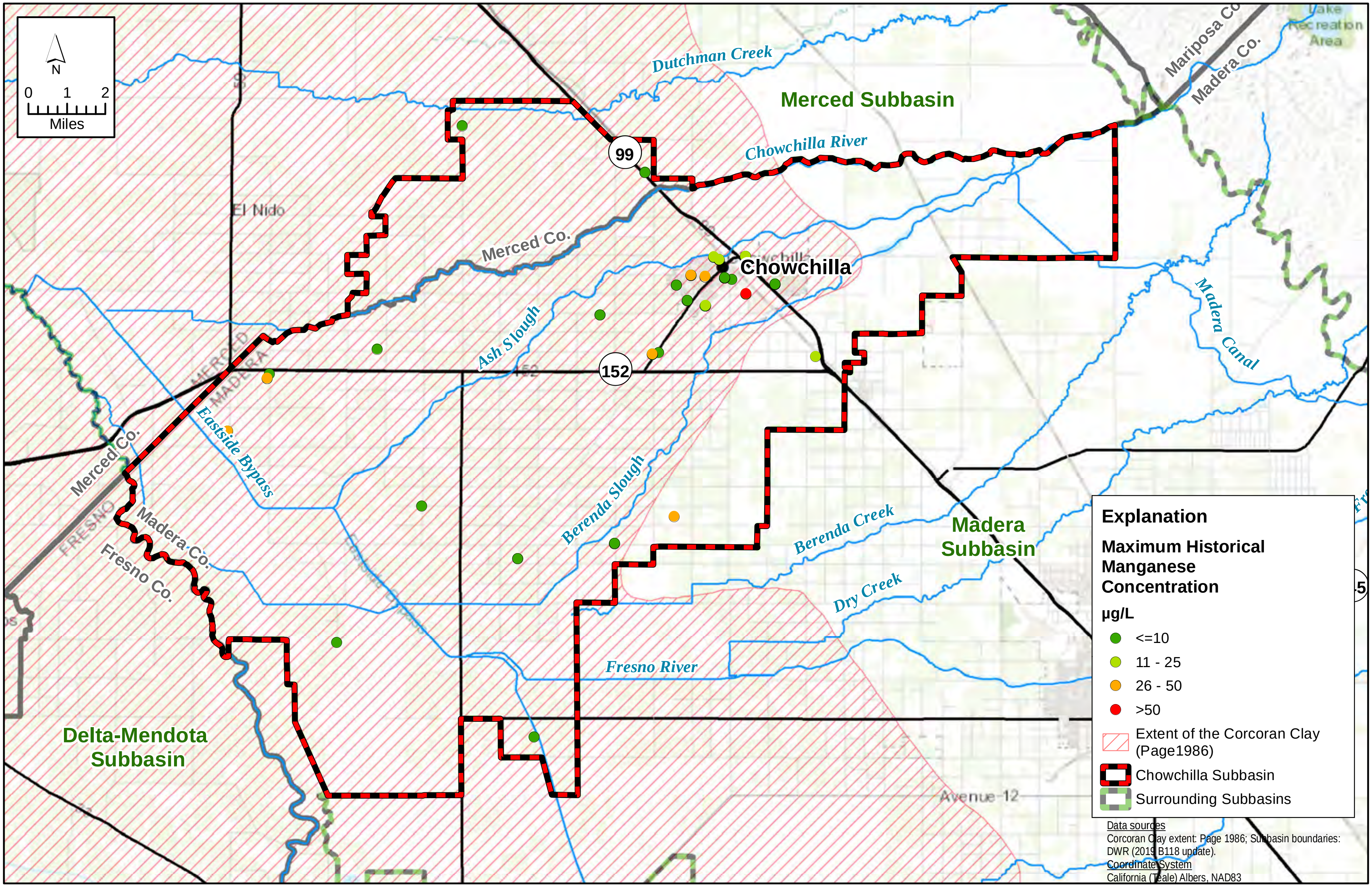
APPENDIX 2.E
Groundwater Quality Map: Uranium Levels in All Wells



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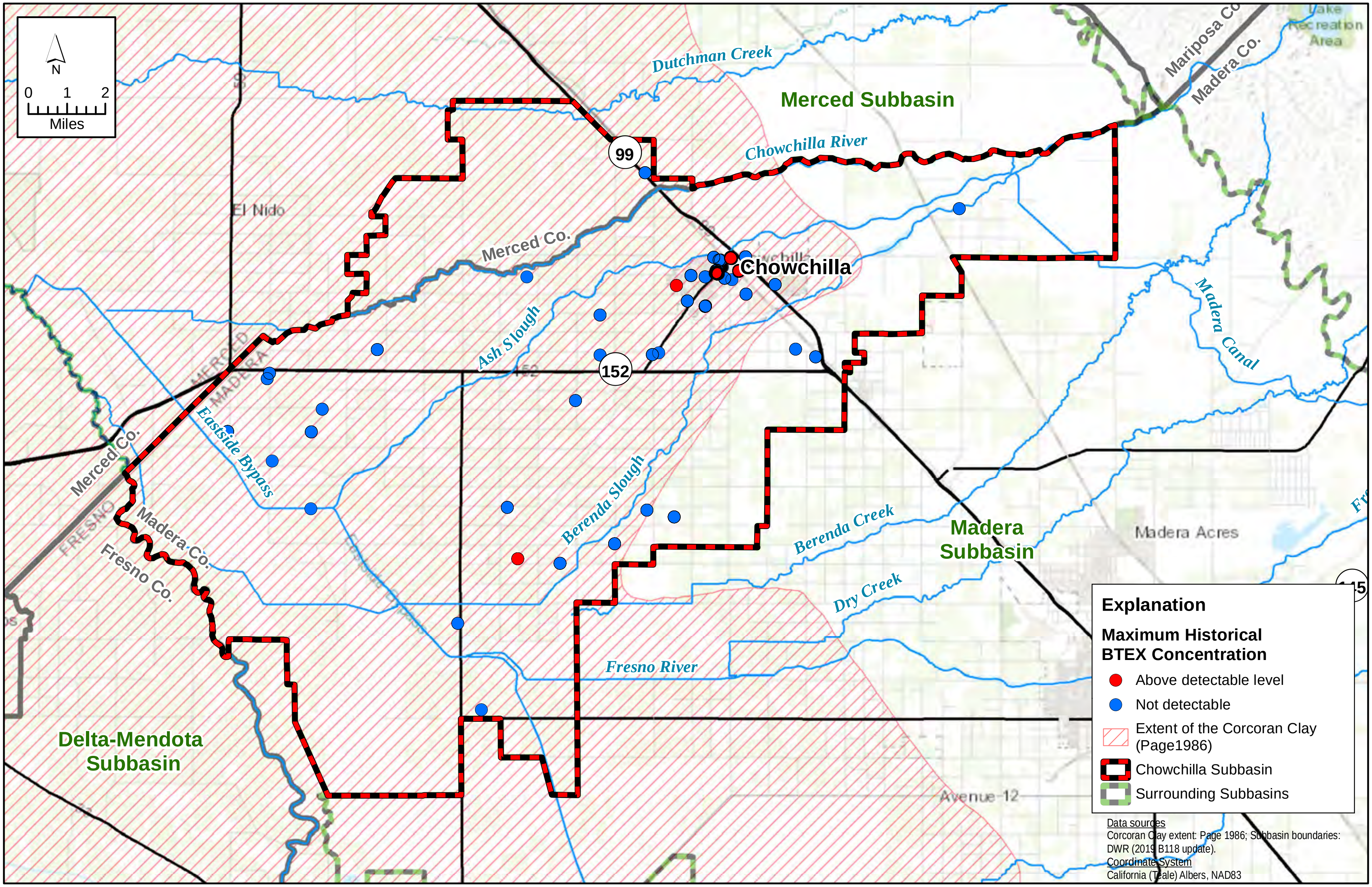
APPENDIX 2.E
Groundwater Quality Map: Manganese Concentrations in All Wells



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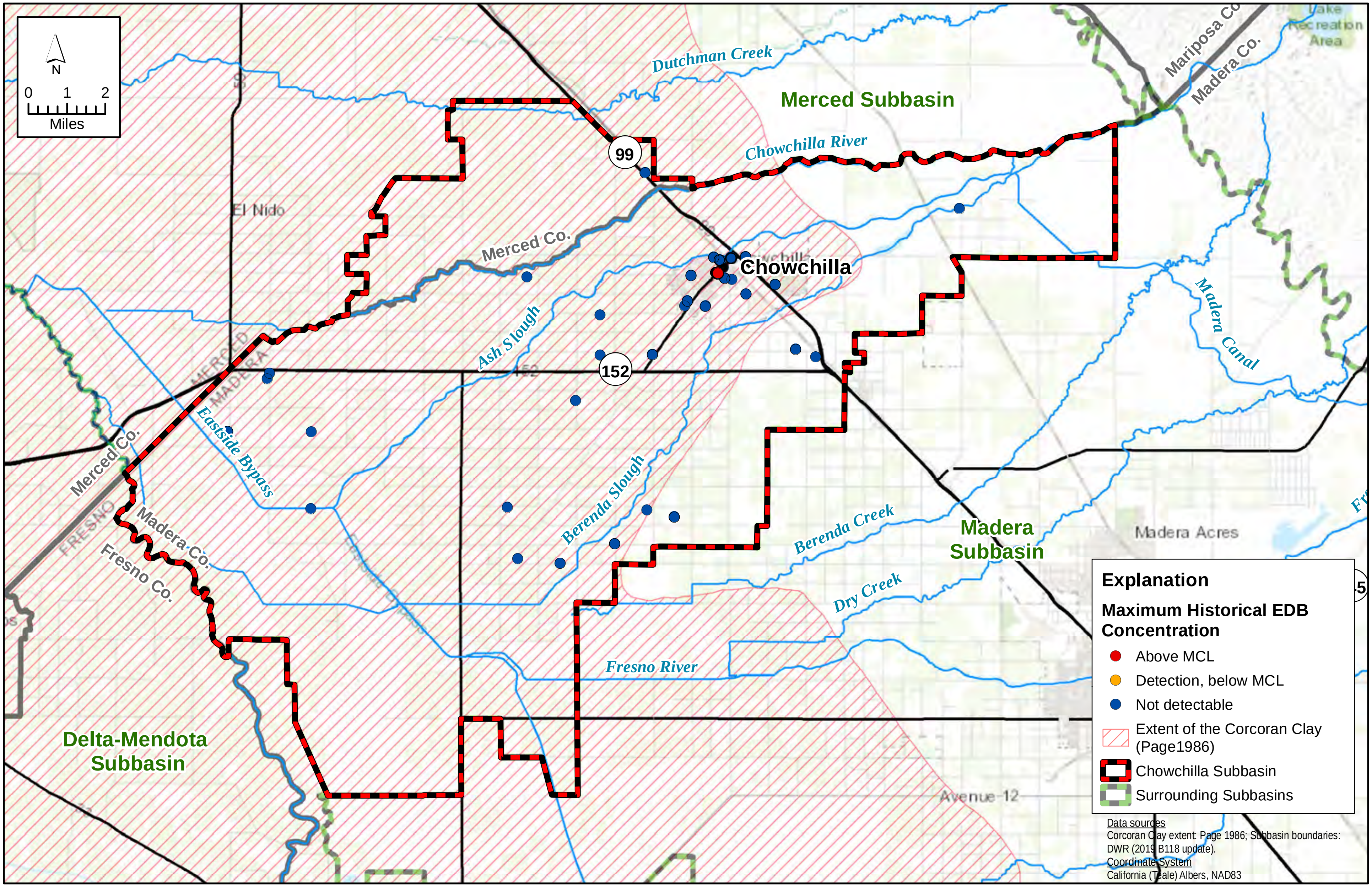
APPENDIX 2.E
Map of Groundwater Quality: BTEX (Benzene, Toluene, Ethylbenze, Xylene) in All Wells



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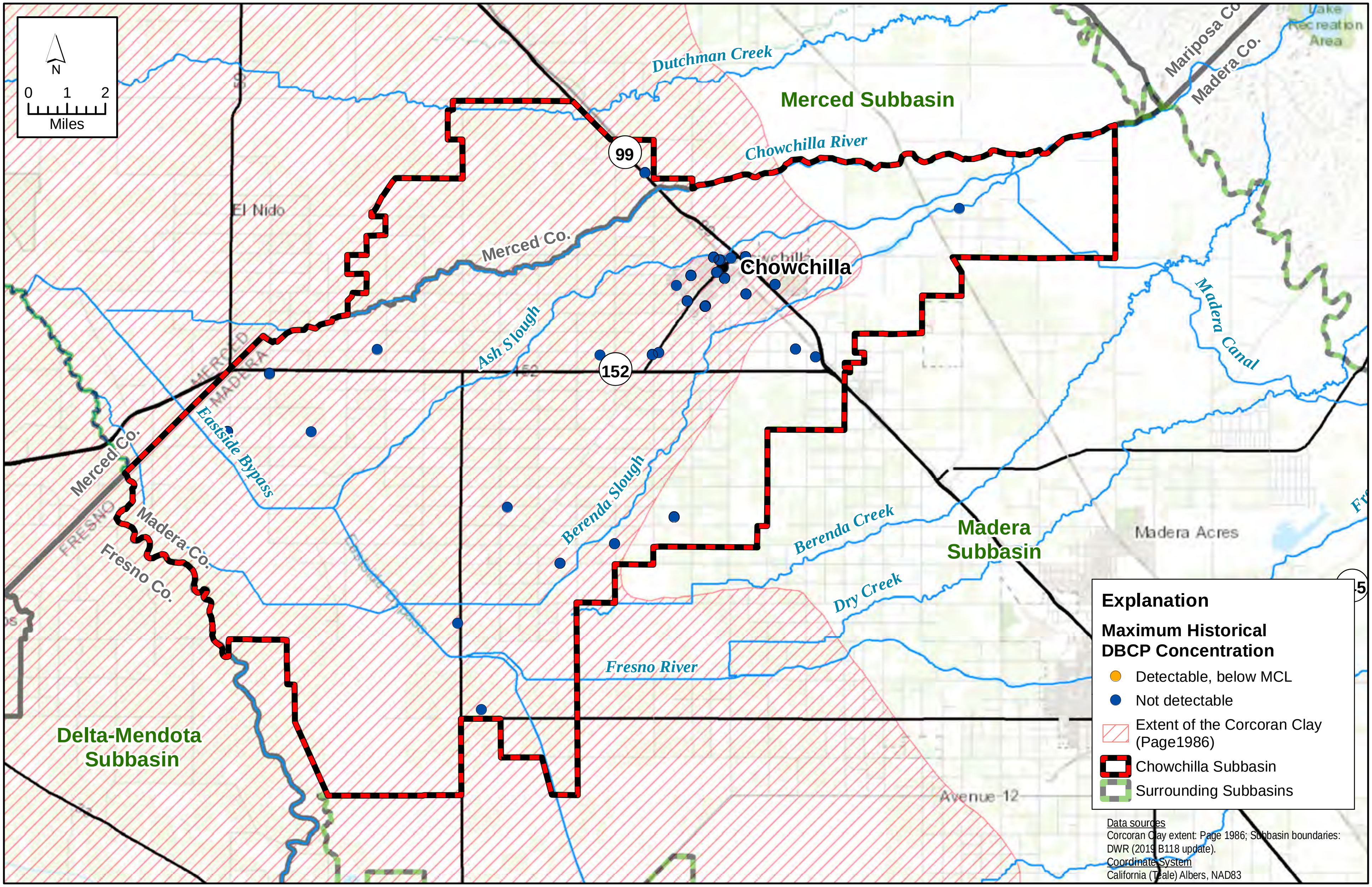
APPENDIX 2.E
Groundwater Quality Map: Ethylene Dibromide Concentrations in All Wells



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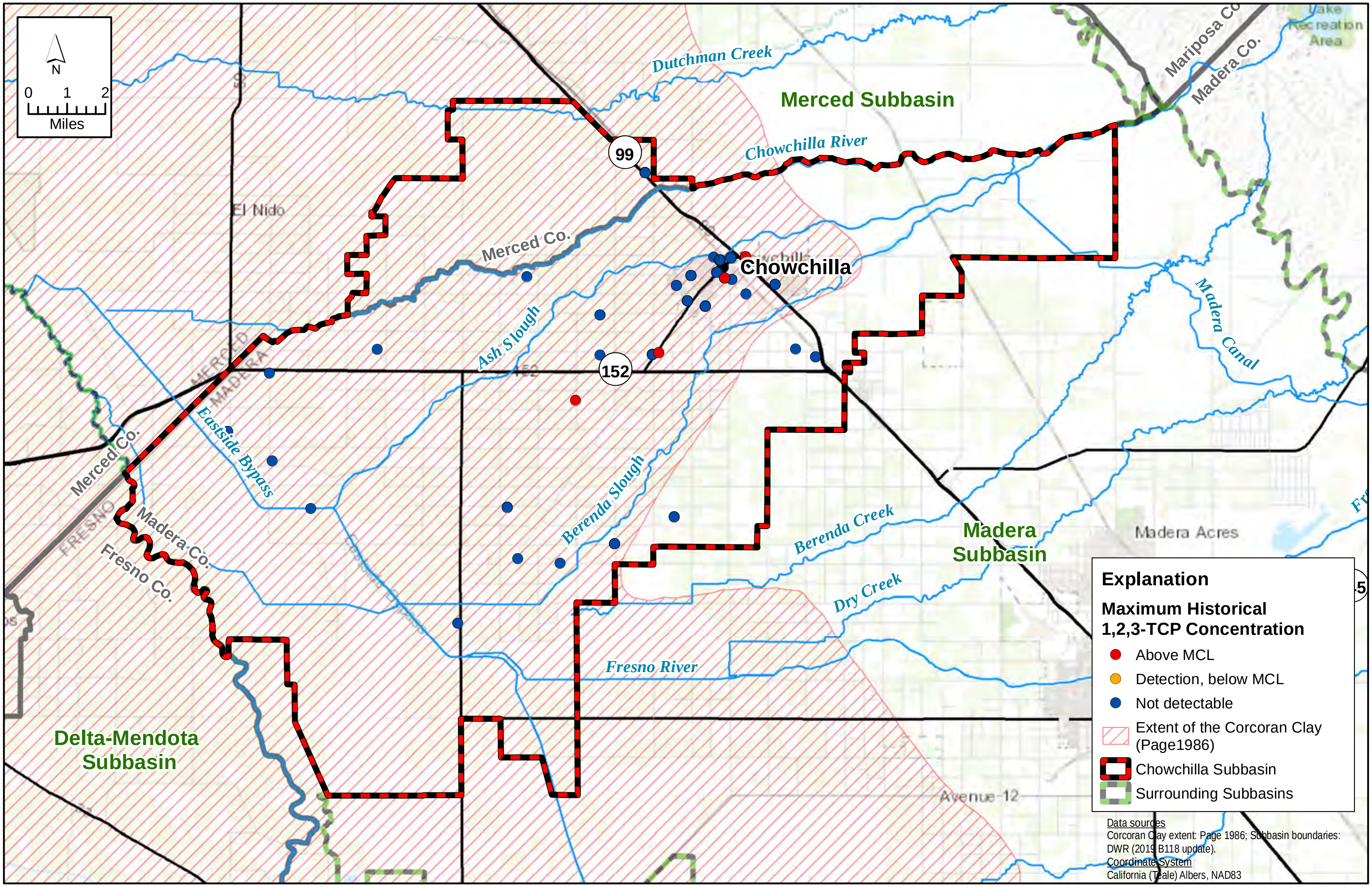
APPENDIX 2.E
Groundwater Quality Map: DBCP Concentrations in All Wells



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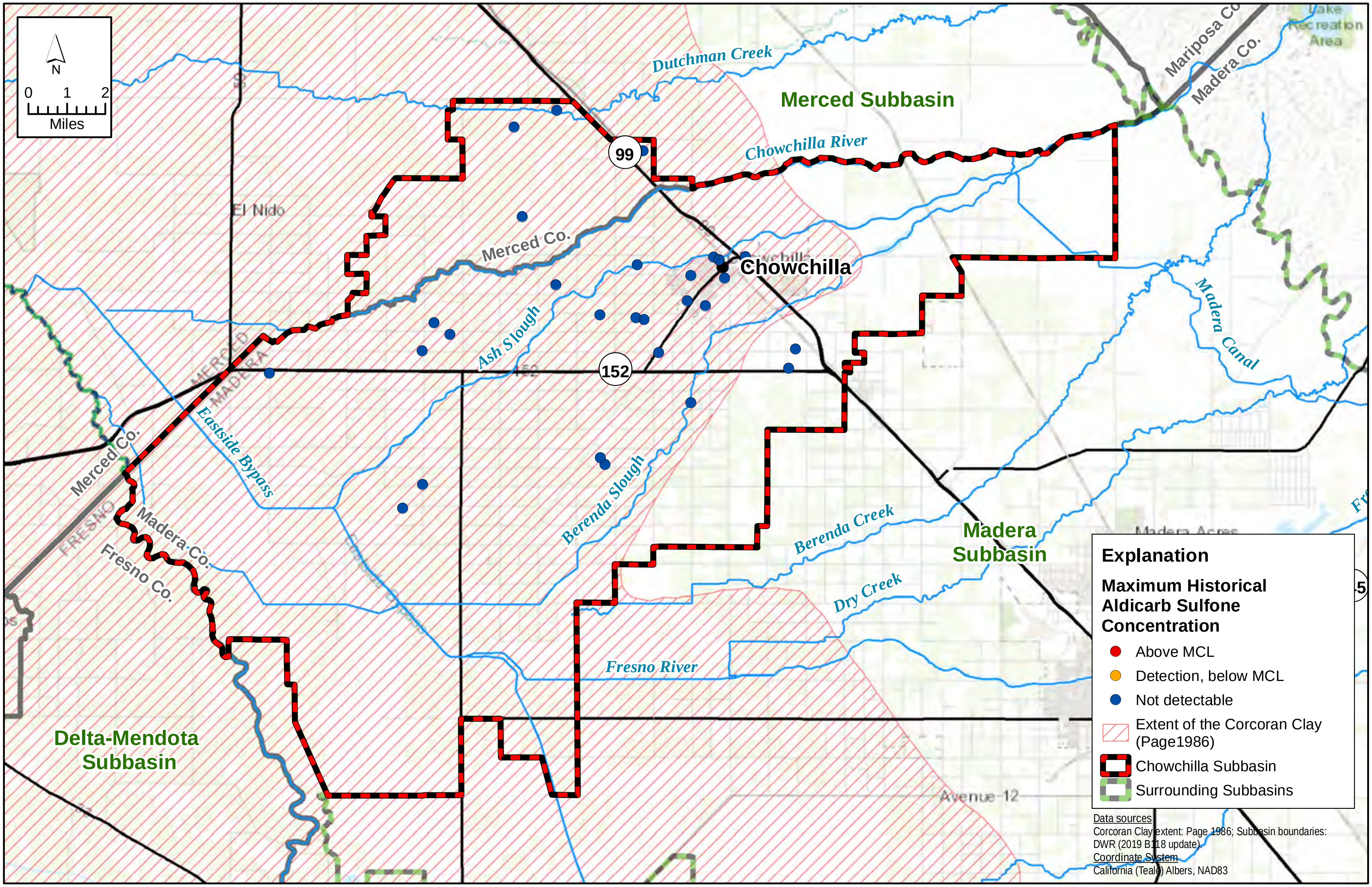
APPENDIX 2.E
Groundwater Quality Map:1,2,3-Trichloropropane (TCP) Concentrations in All Wells



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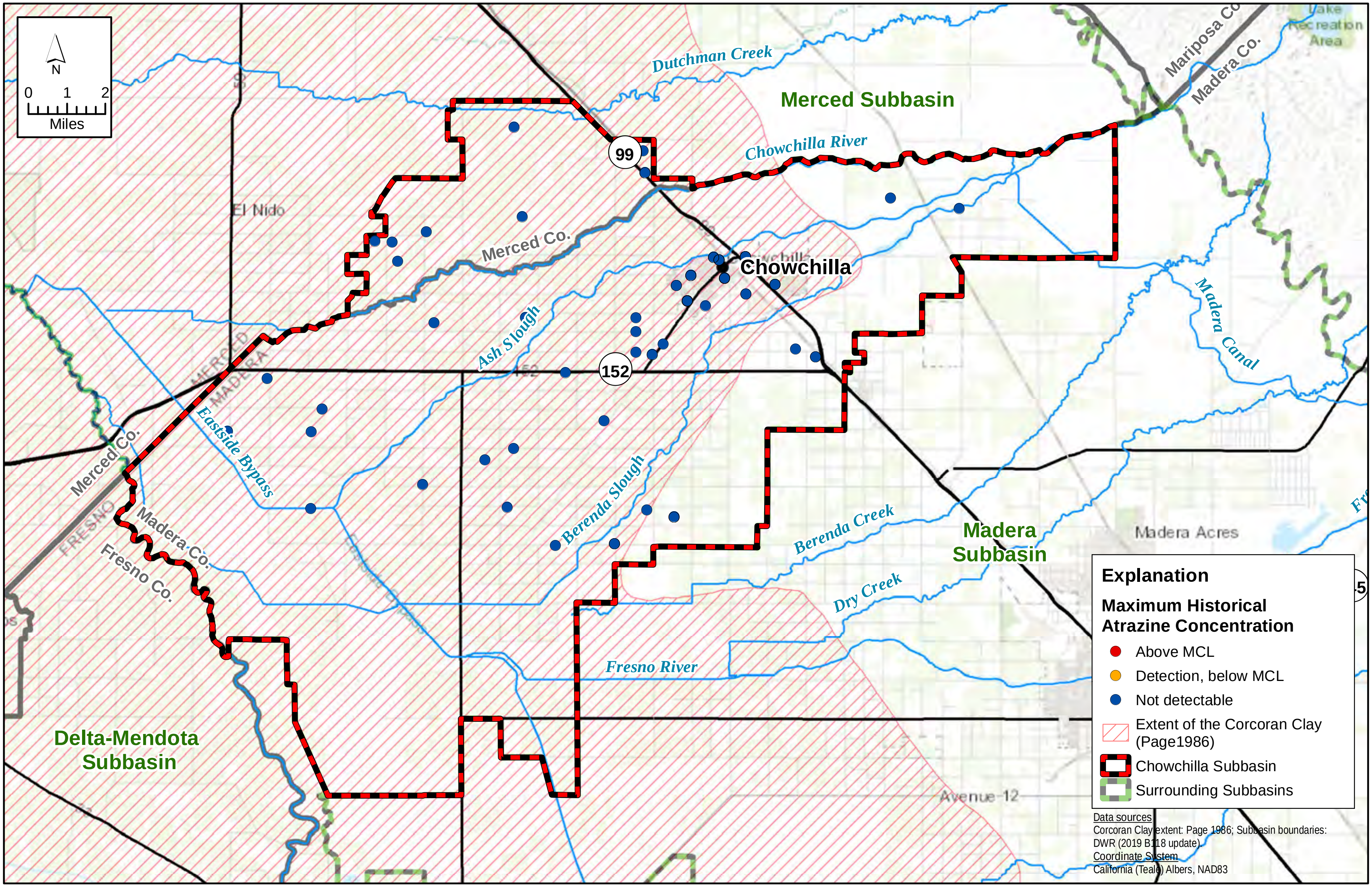
APPENDIX 2.E
Groundwater Quality Map: Aldicarb Sulfone Concentrations in All Wells



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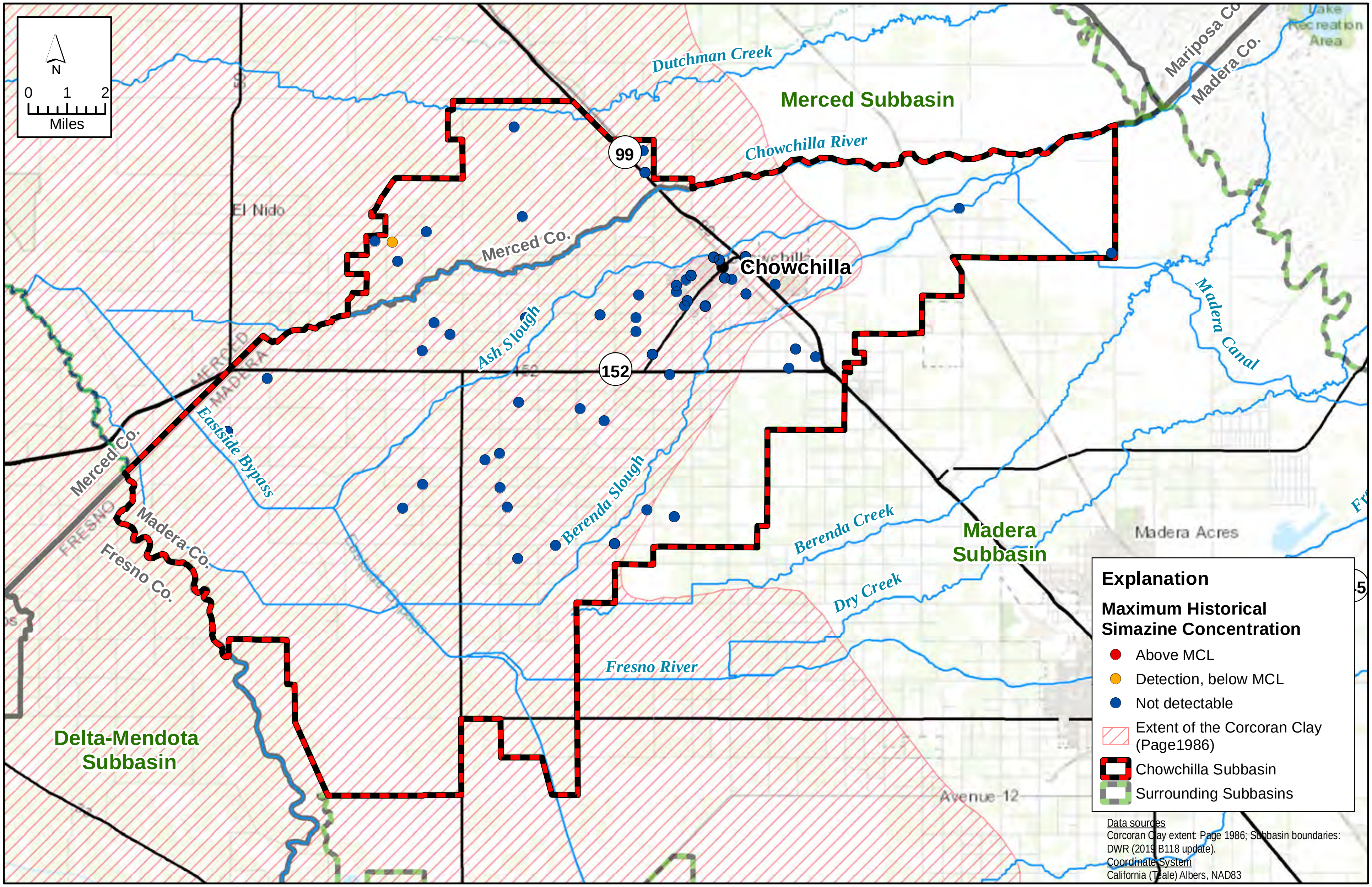
APPENDIX 2.E
Groundwater Quality Map: Atrazine Concentrations in All Wells



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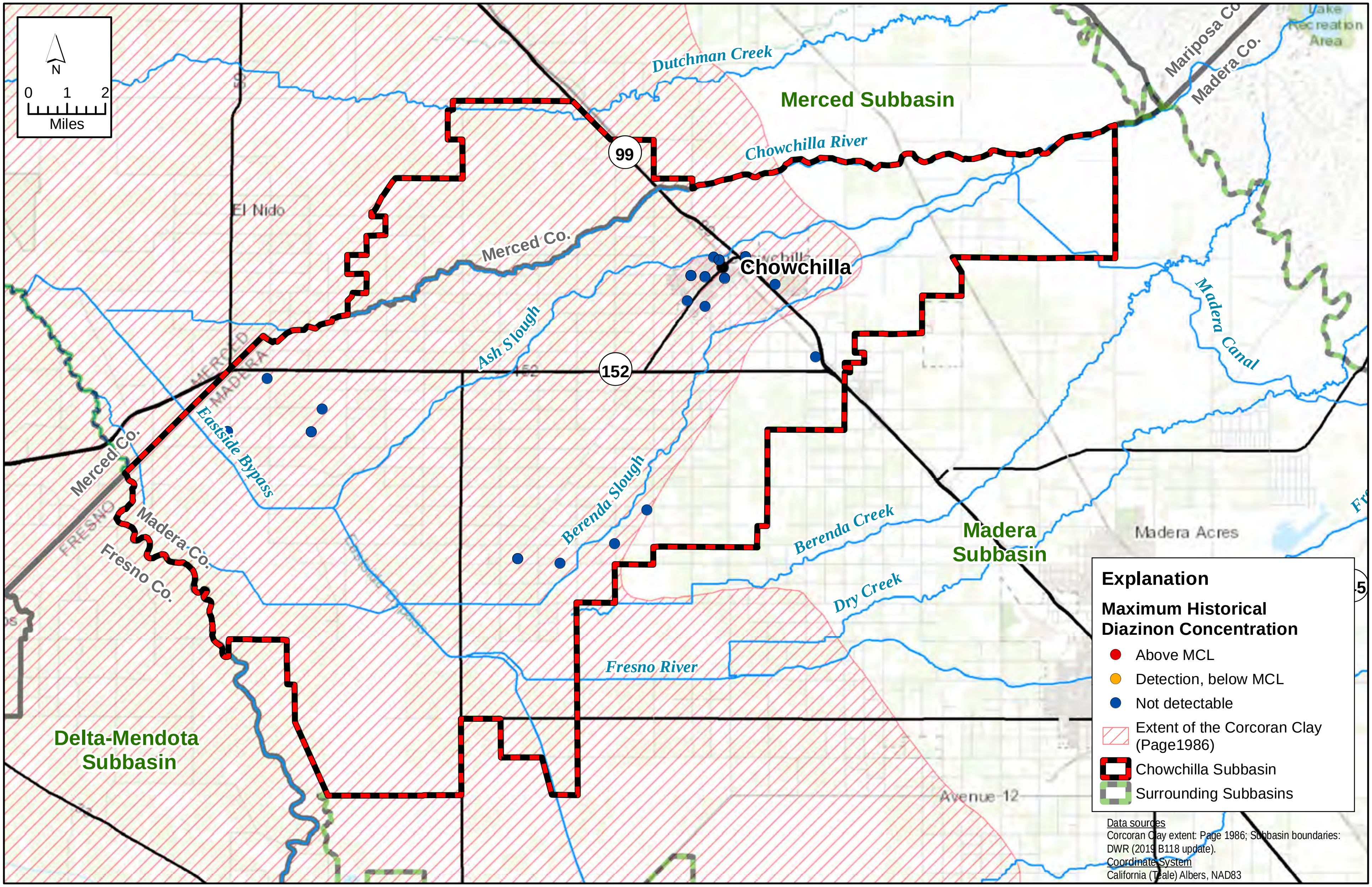
APPENDIX 2.E
Groundwater Quality Map: Simazine Concentrations in All Wells

Chowchilla Subbasin A2.E-148
Groundwater Sustainability Plan



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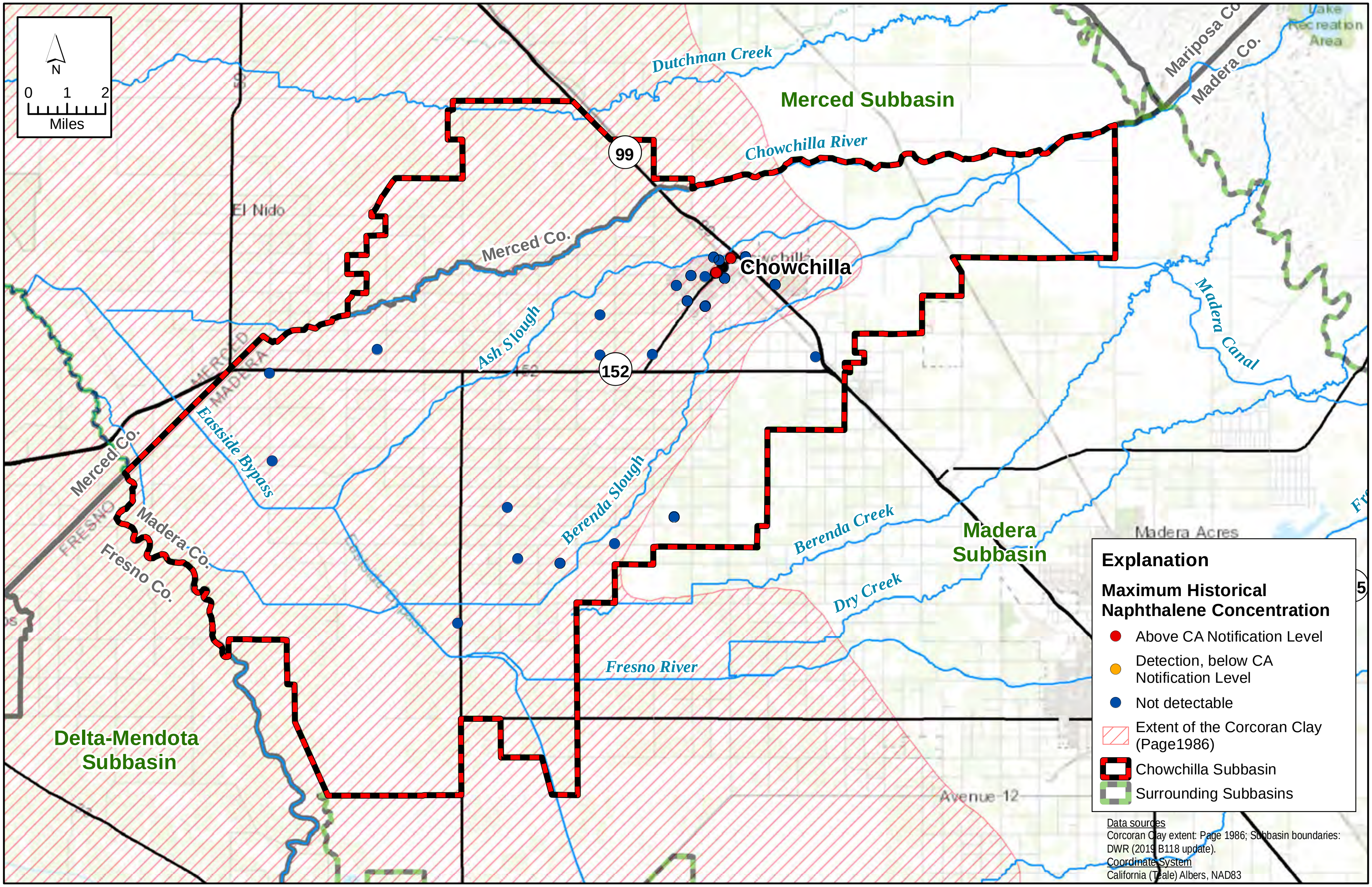
APPENDIX 2.E
Groundwater Quality Map: Diazinon Concentrations in All Wells



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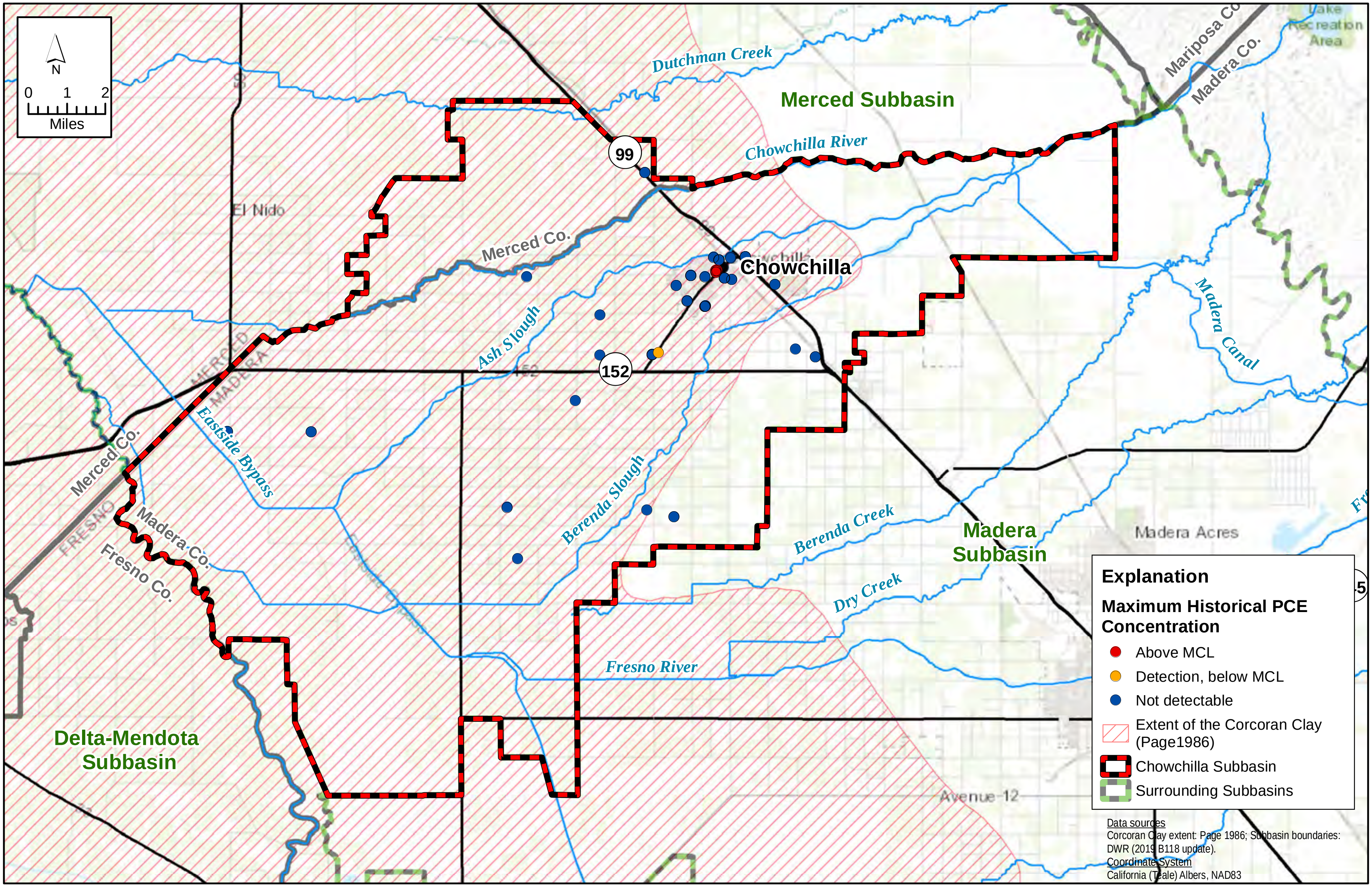
APPENDIX 2.E
Groundwater Quality Map: Naphthalene Concentrations in All Wells



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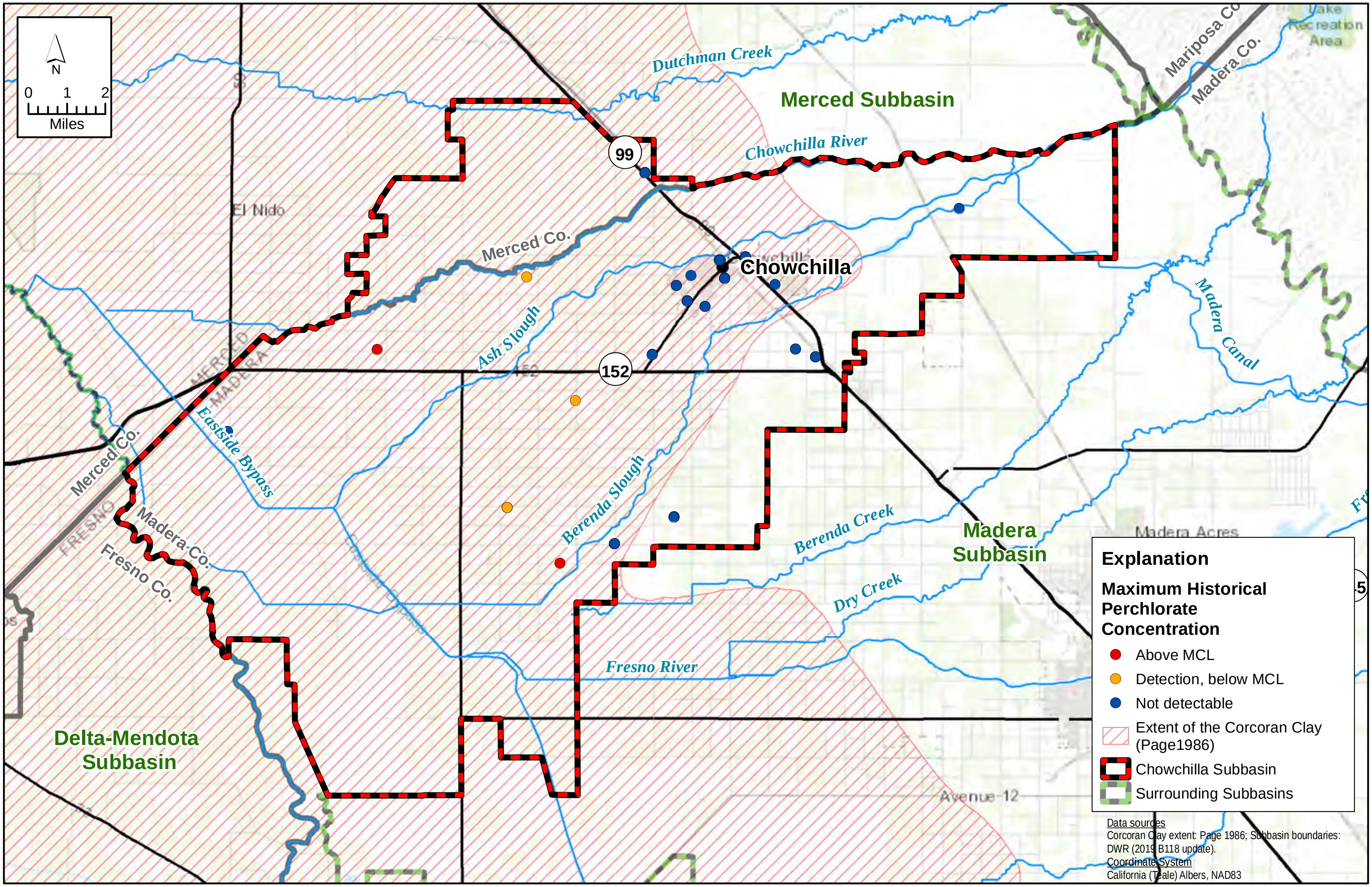
APPENDIX 2.E
Groundwater Quality Map: Tetrachloroethylene (PCE) Concentrations in All Wells



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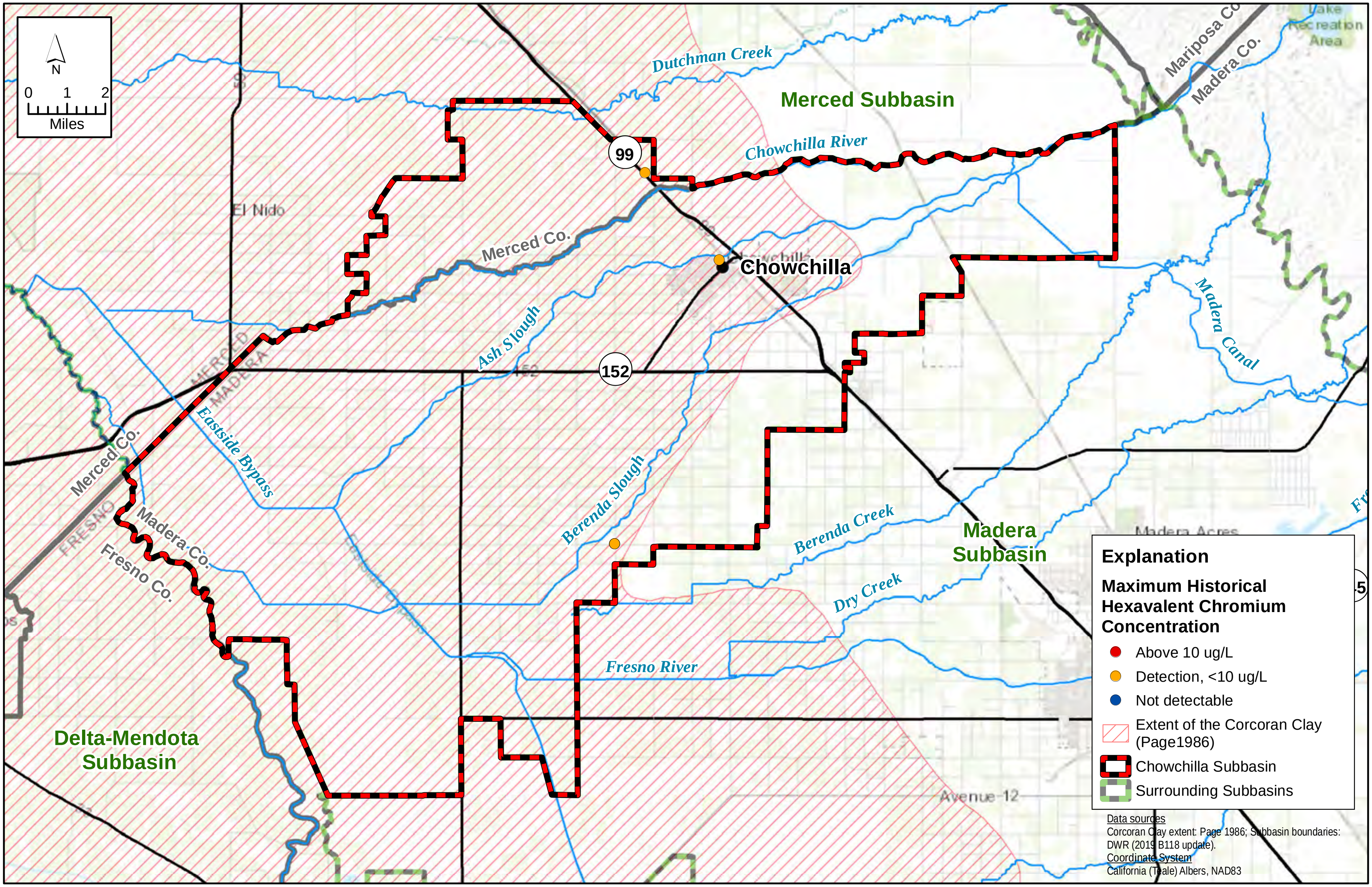
APPENDIX 2.E
Groundwater Quality Map: Perchlorate Concentrations in All Wells



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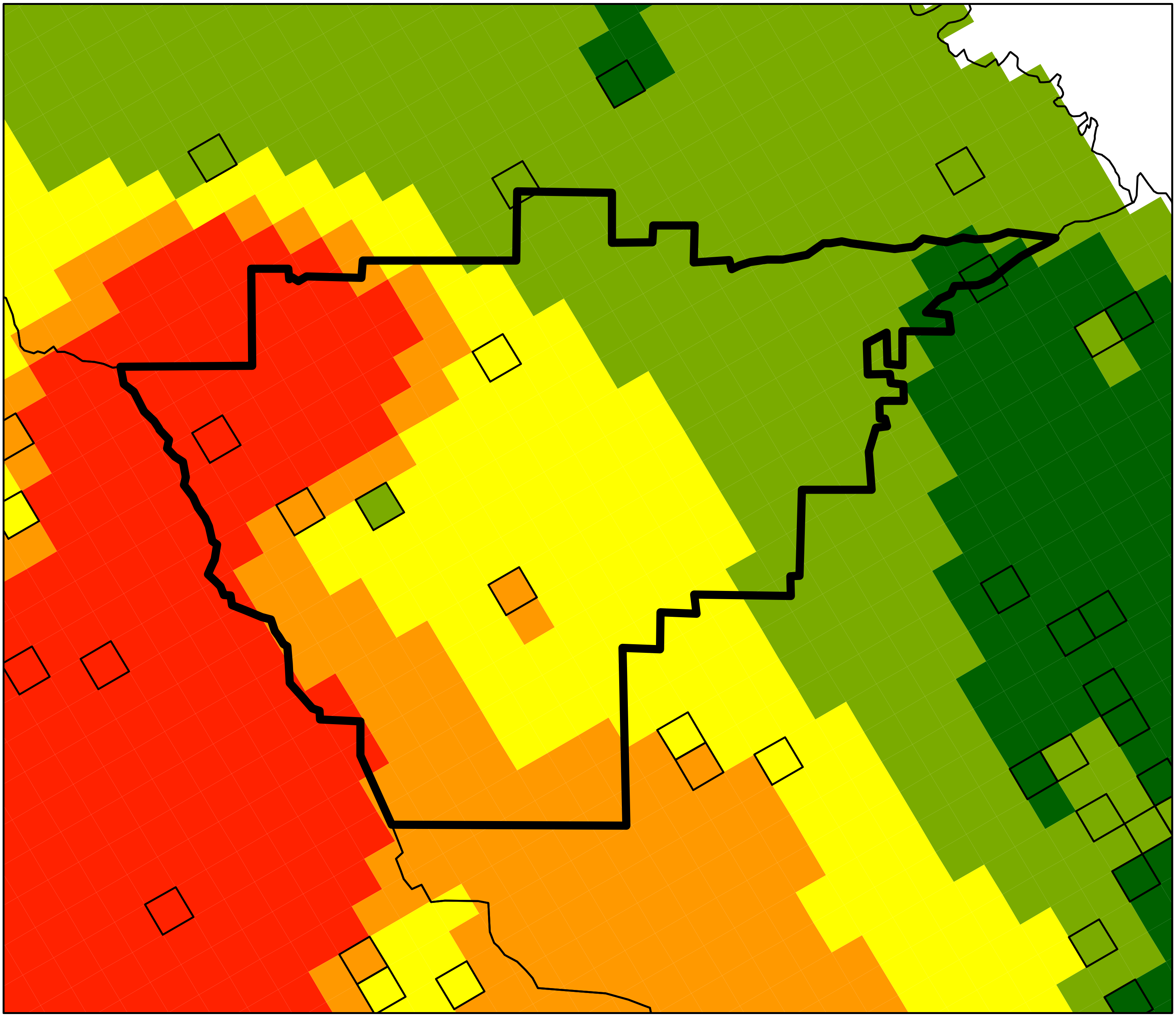
Luhdorff & Scalmanini Consulting Engineers

APPENDIX 2.E
Groundwater Quality Map: Chromium-6 (Hexavalent Chromium) Concentrations in All Wells



Ambient Conditions (Data: 2000-2016)

Cells With Data (1 sq mi)

Upper Zone

TDS (mg/L)

- 1 - 250
- 251 - 500
- 501 - 750
- 751 - 1,000
- >1,000
- Region 5
- DWR B118 Basins

N

0 3 6 Miles

DWR B118 Code:5-22.05

Groundwater Basin:
SAN JOAQUIN VALLEY

Groundwater Subbasin:
CHOWCHILLA

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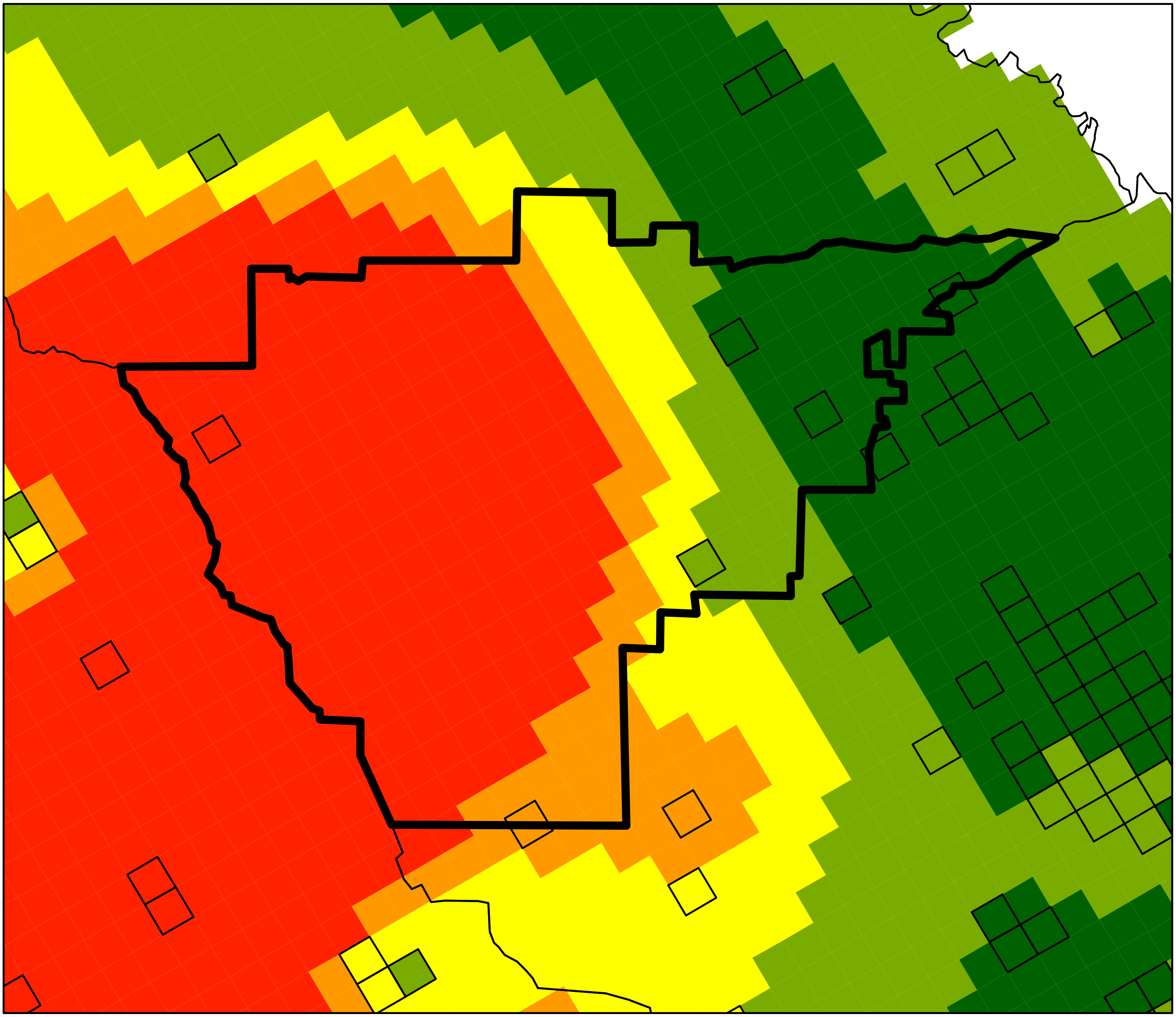
Figure 156



Ambient Conditions (Data: 2000-2016)

Cells With Data (1 sq mi)

Lower Zone

TDS (mg/L)

- 1 - 250
- 251 - 500
- 501 - 750
- 751 - 1,000
- >1,000
- Region 5
- DWR B118 Basins

N

0 3 6 Miles

DWR B118 Code:5-22.05

Groundwater Basin:
SAN JOAQUIN VALLEY

Groundwater Subbasin:
CHOWCHILLA

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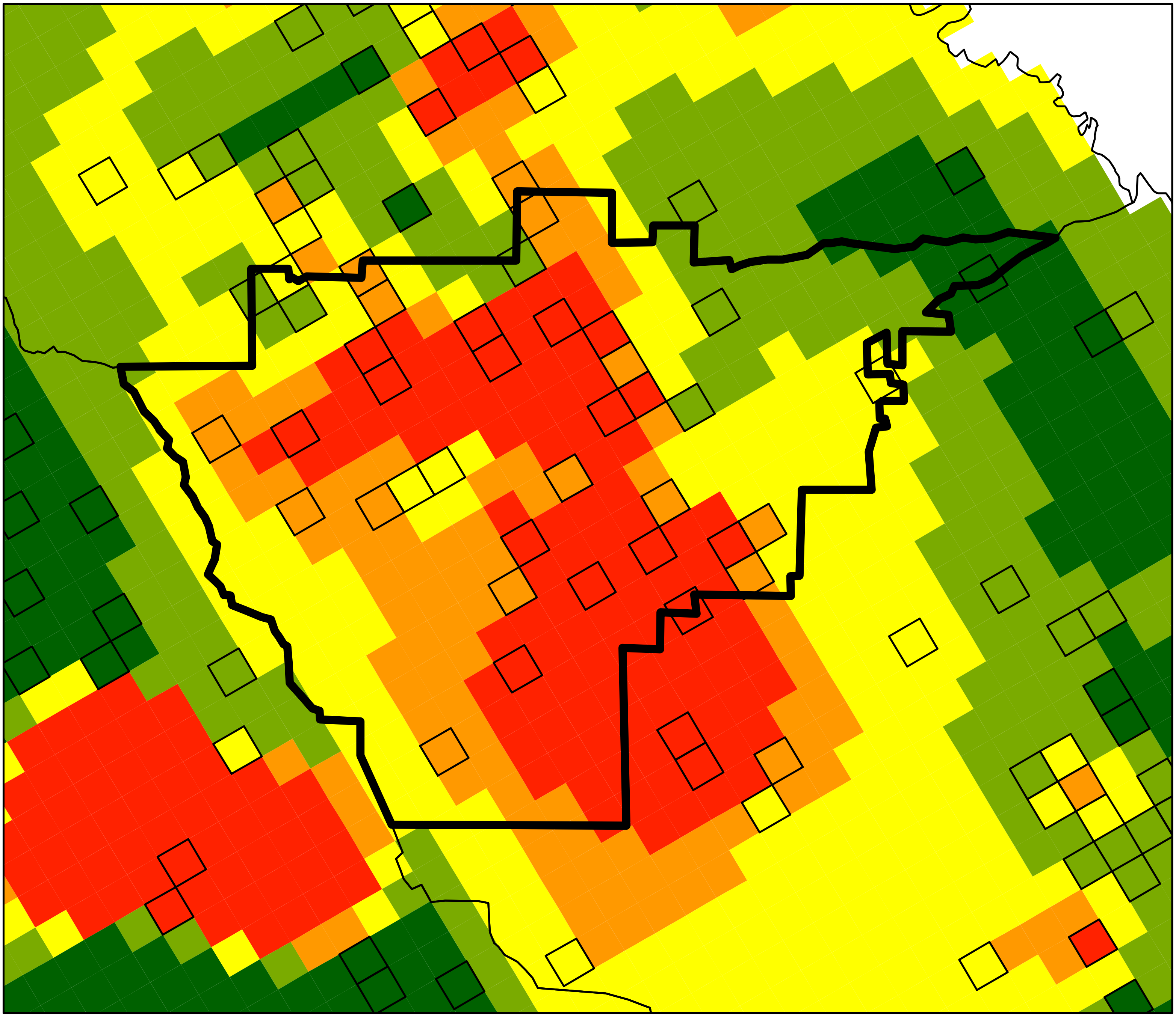
Figure 197



Ambient Conditions (Data: 2000-2016)

Cells With Data (1 sq mi)

Upper Zone

Nitrate (mg/L as N)

- 0.1 - 2.5
- 2.6 - 5.0
- 5.1 - 7.5
- 7.6 - 10.0
- >10
- Region 5
- DWR B118 Basins

N

0 3 6 Miles

DWR B118 Code:5-22.05

Groundwater Basin:
SAN JOAQUIN VALLEY

Groundwater Subbasin:
CHOWCHILLA

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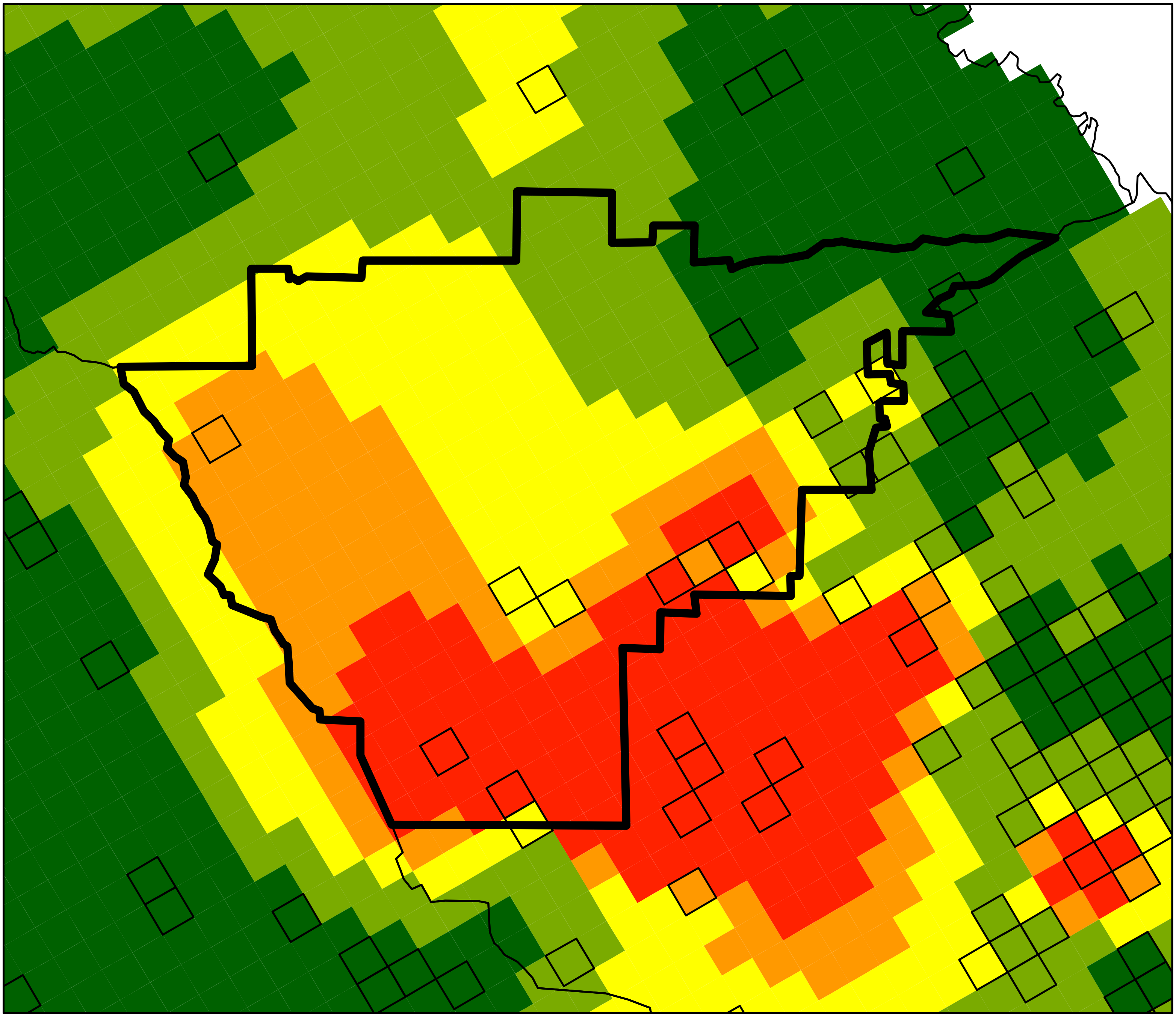
Figure 33



Ambient Conditions (Data: 2000-2016)

Cells With Data (1 sq mi)

Lower Zone

Nitrate (mg/L as N)

- 0.1 - 2.5
- 2.6 - 5.0
- 5.1 - 7.5
- 7.6 - 10.0
- >10
- Region 5
- DWR B118 Basins

N

0 3 6 Miles

DWR B118 Code:5-22.05

Groundwater Basin:
SAN JOAQUIN VALLEY

Groundwater Subbasin:
CHOWCHILLA

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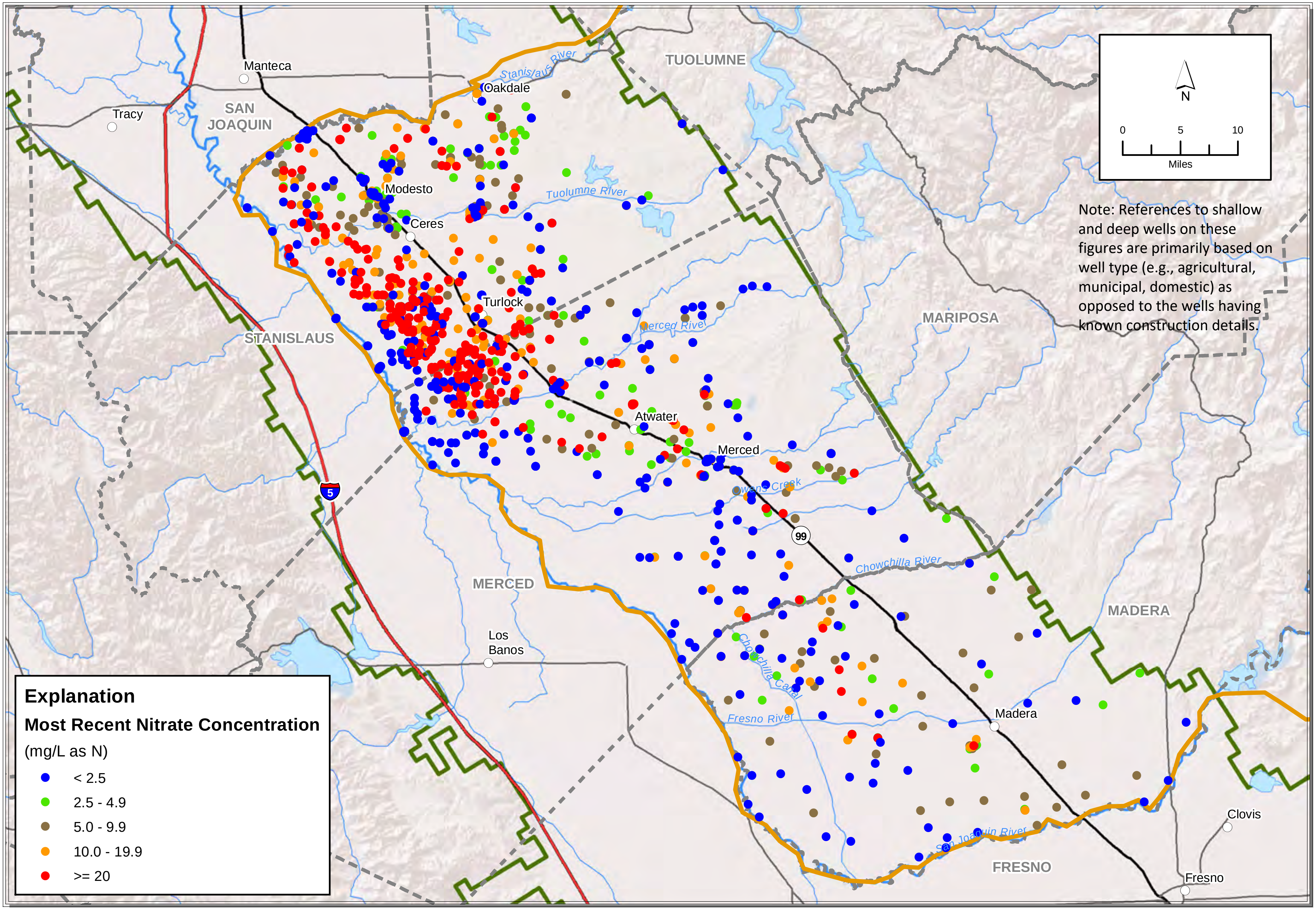
Figure 74



Path: X:\2012 Job Files\12-118\Report\Figures\Final GIS Map Files\Figure 5-4 Nitrate Concentrations in Central Valley Floor Shallow Wells.mxd

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Figure 5-4

Nitrate Concentrations in the Central Valley Floor: Shallow Wells

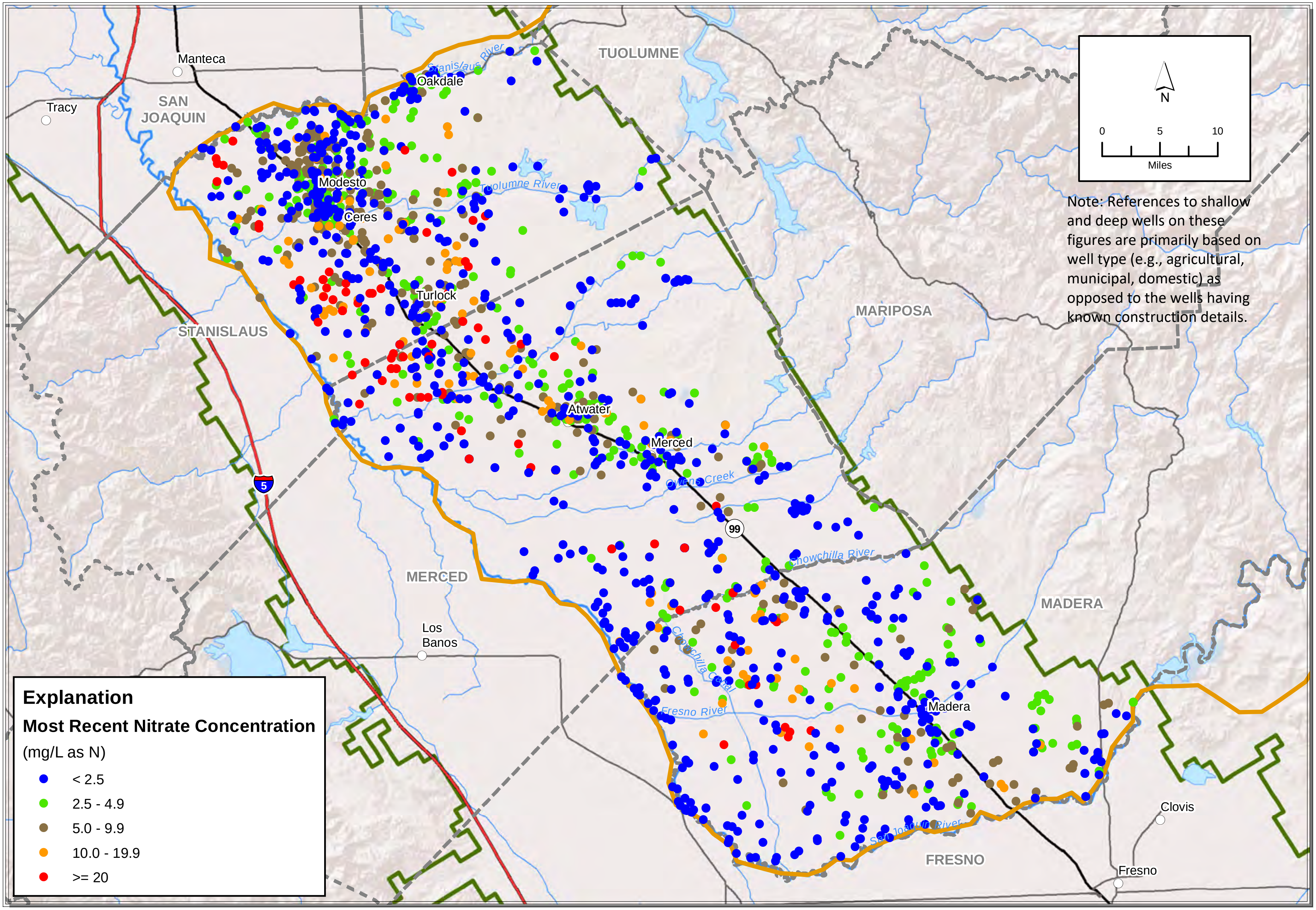

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Figure 5-5
Nitrate Concentrations in the Central Valley Floor: Deep Wells

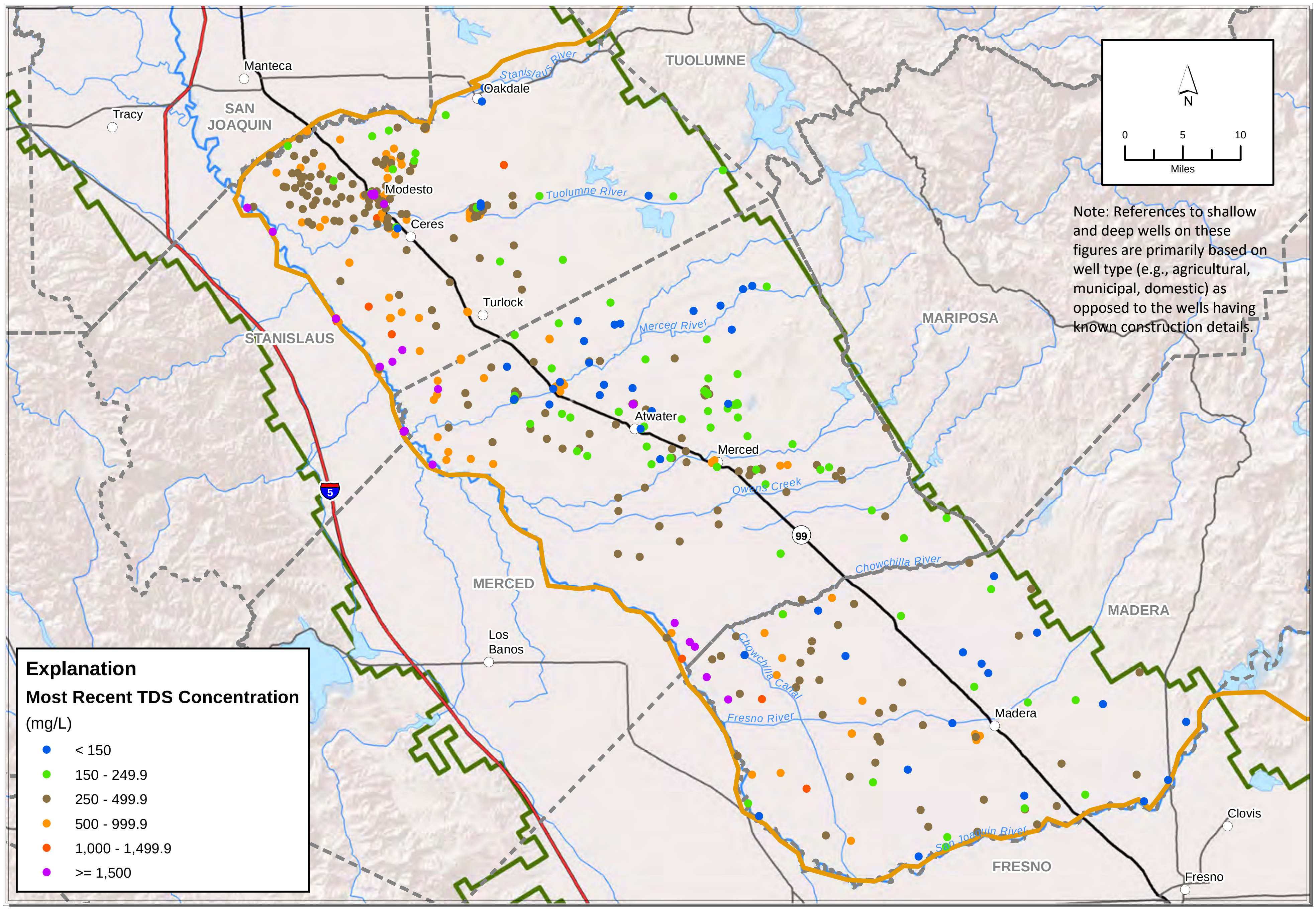

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Figure 5-7

TDS Concentrations in the Central Valley Floor: Shallow Wells

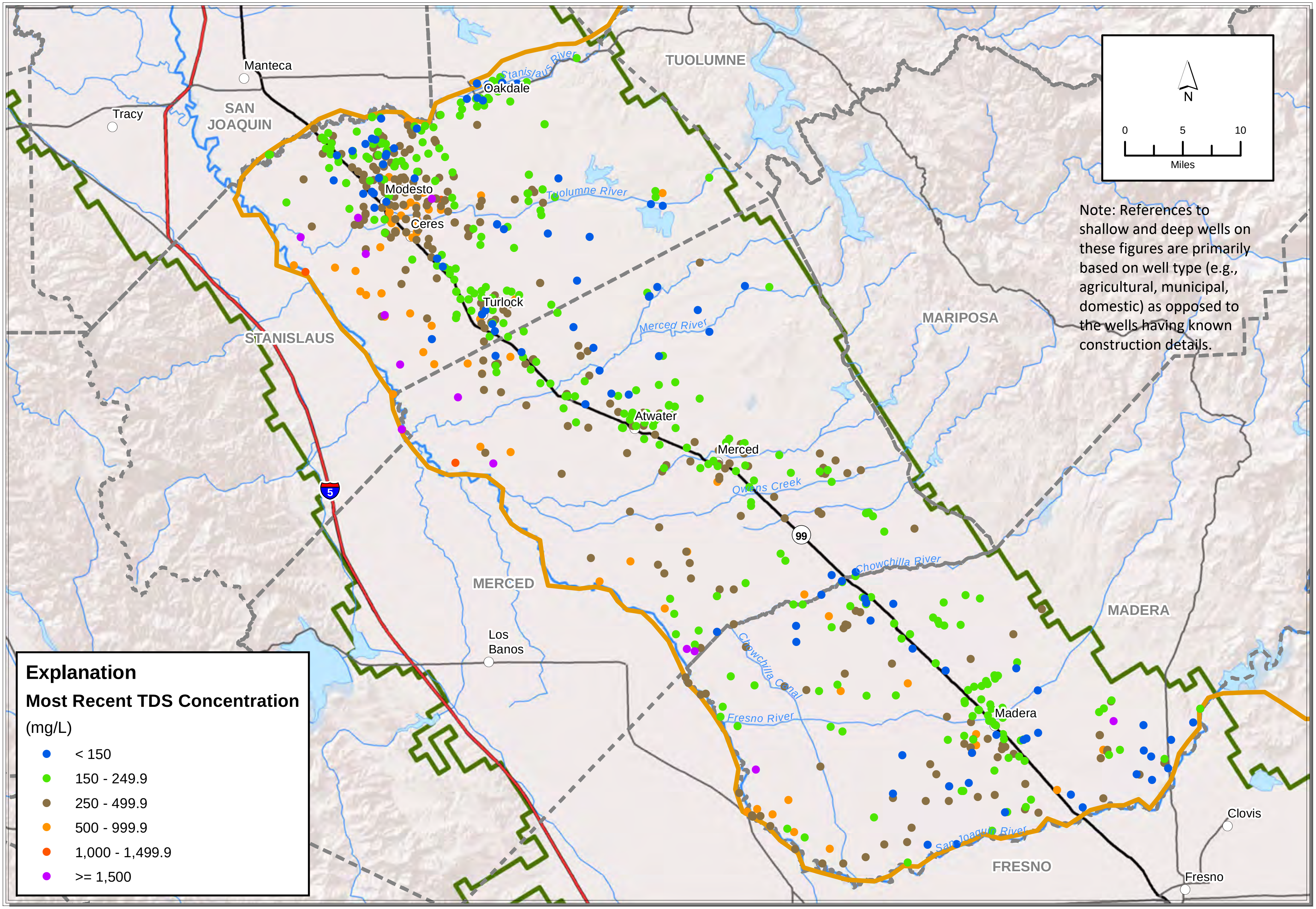

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Figure 5-8

TDS Concentrations in the Central Valley Floor: Deep Wells

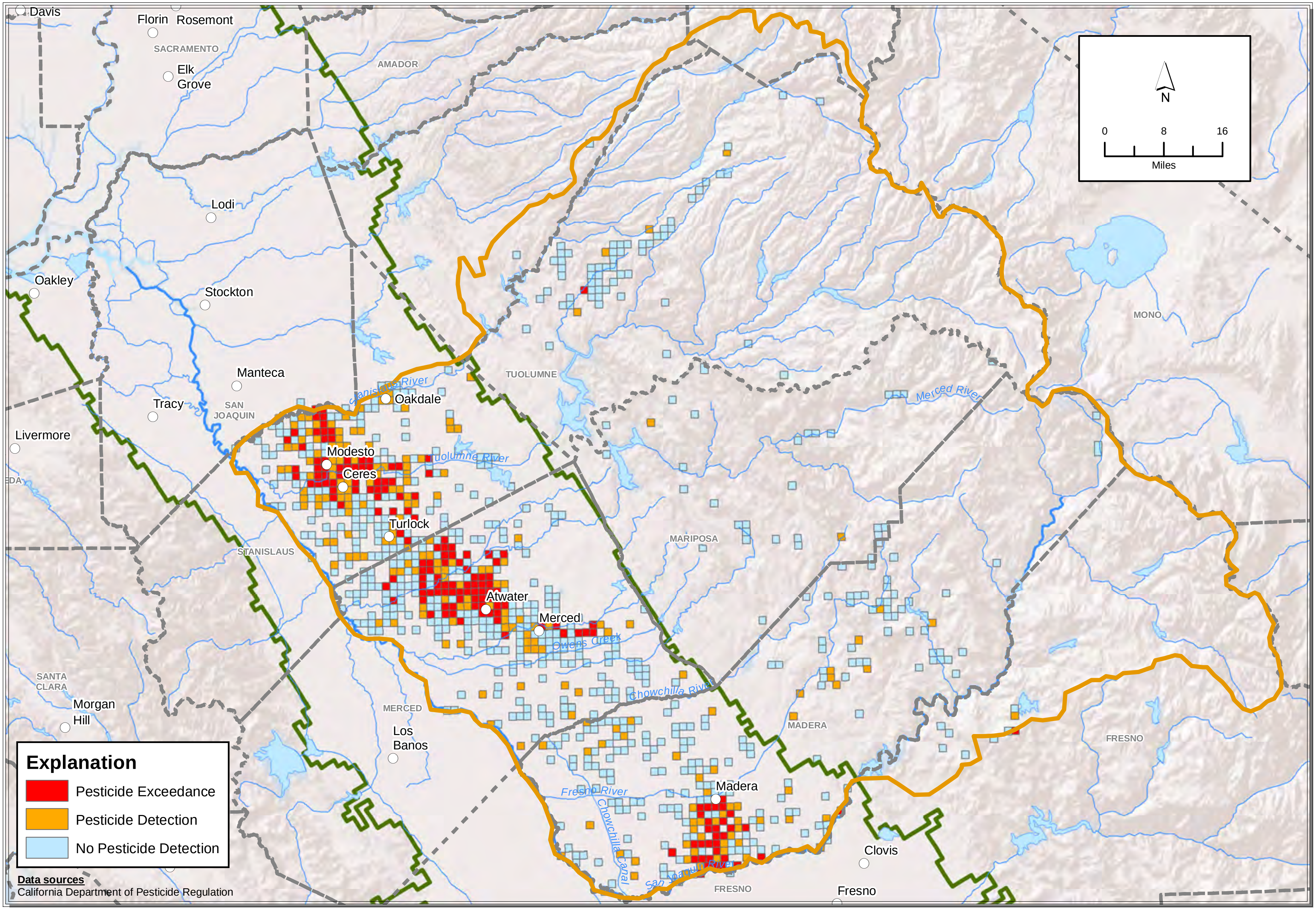

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Figure 5-10c
Pesticide Detection Or Exceedance By Section

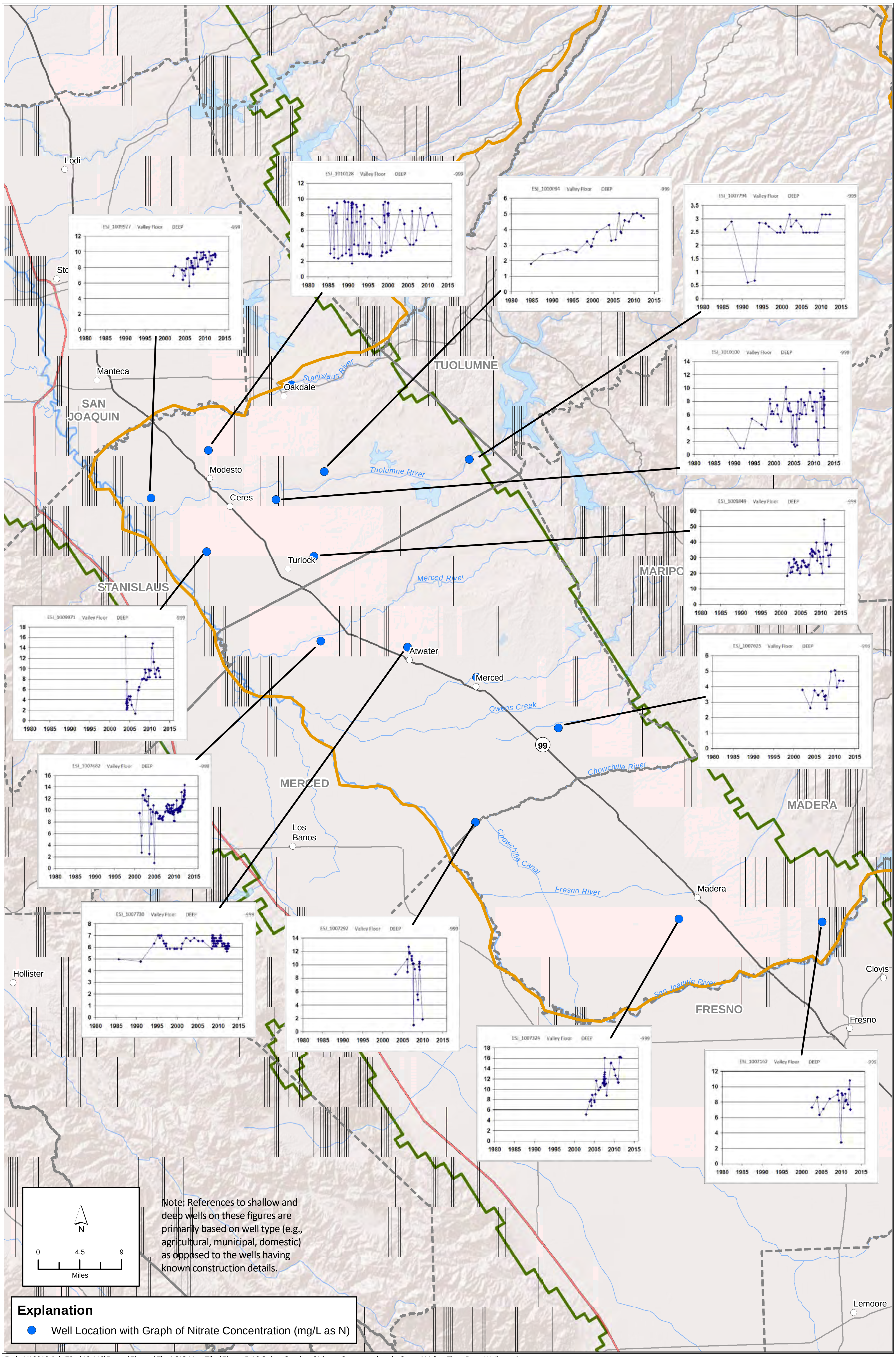

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Figure 5-12
Select Graphs of Nitrate Concentrations in the Central Valley Floor: Deep Wells

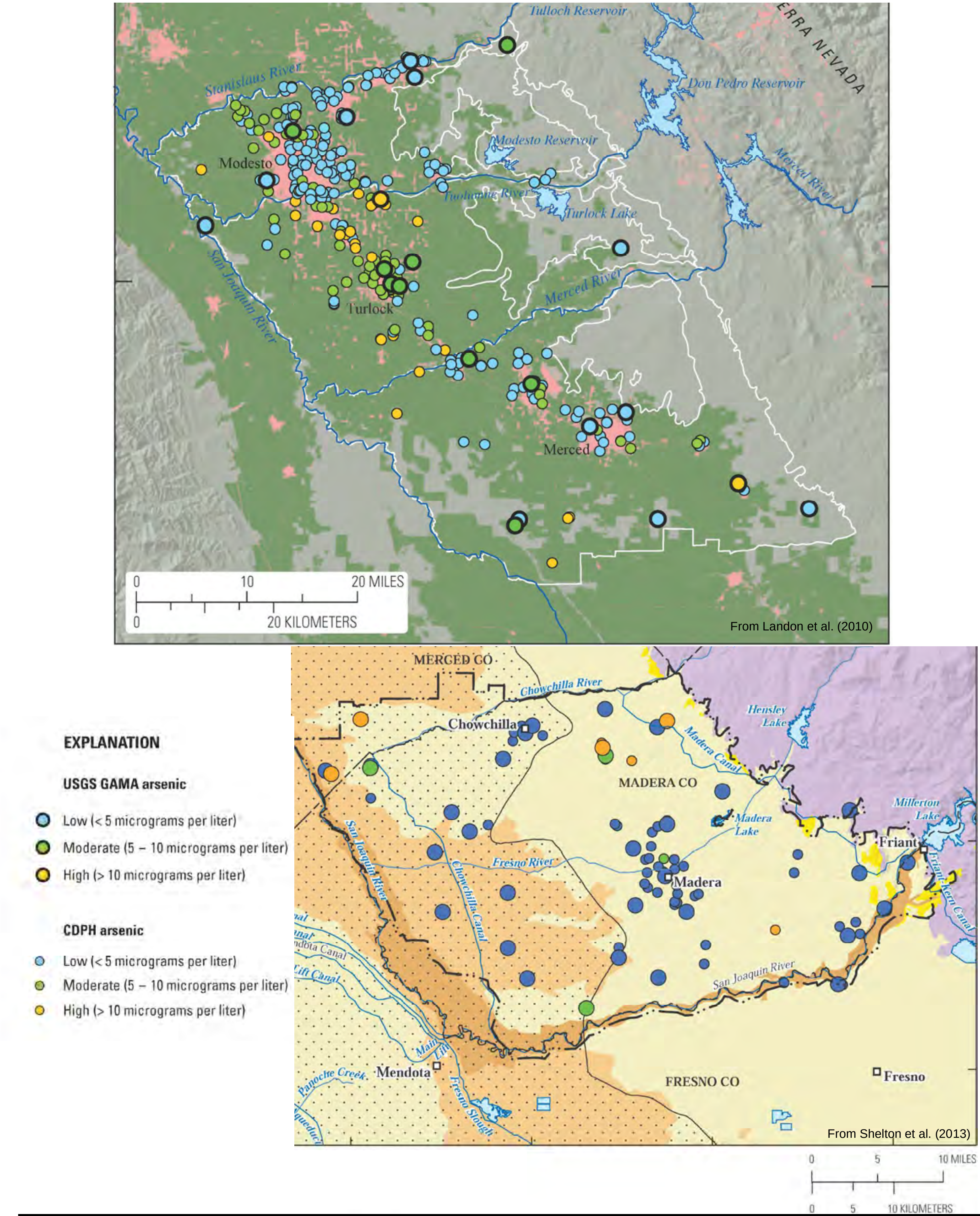


Figure 5-23a
Other Groundwater Quality Data: Arsenic

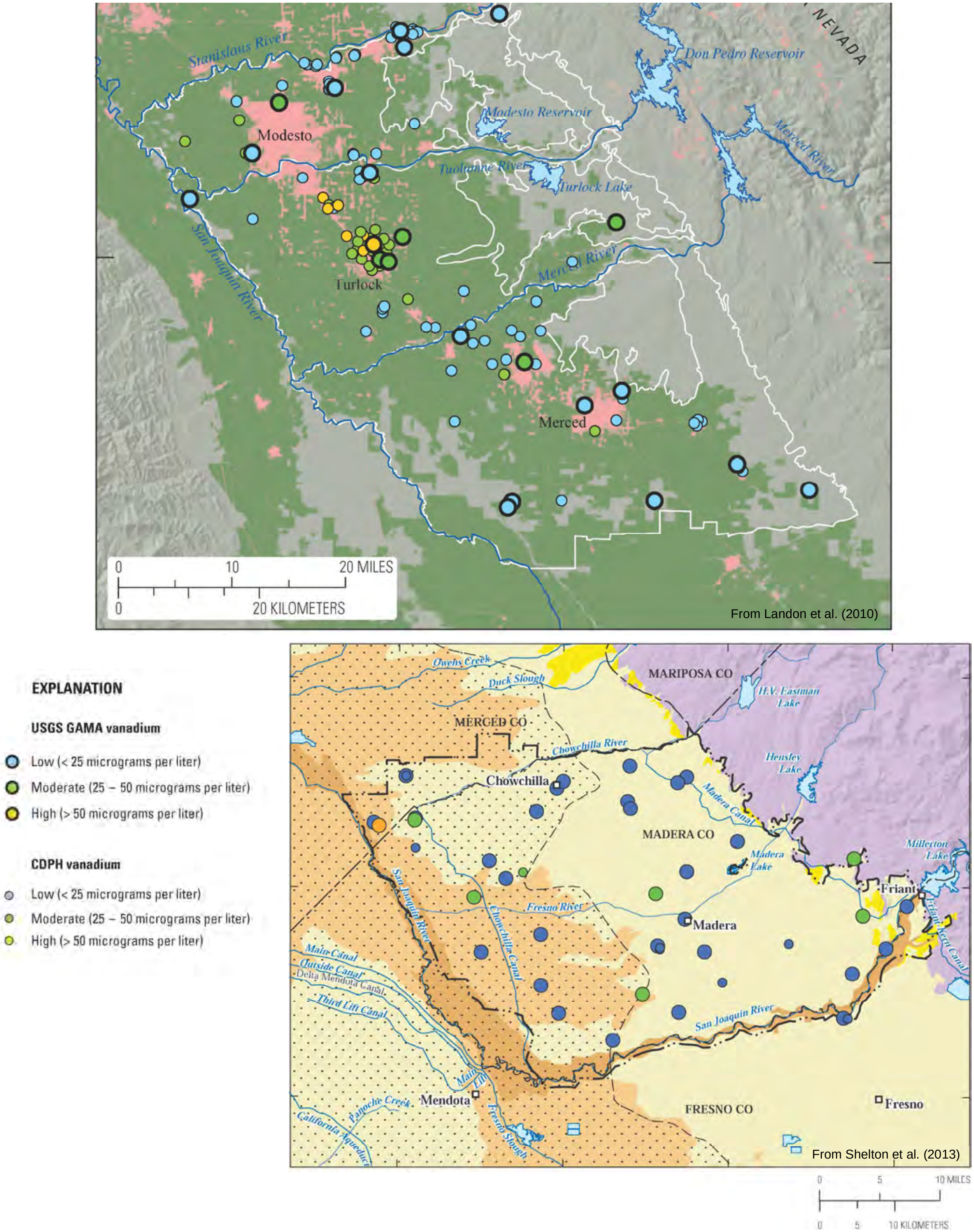
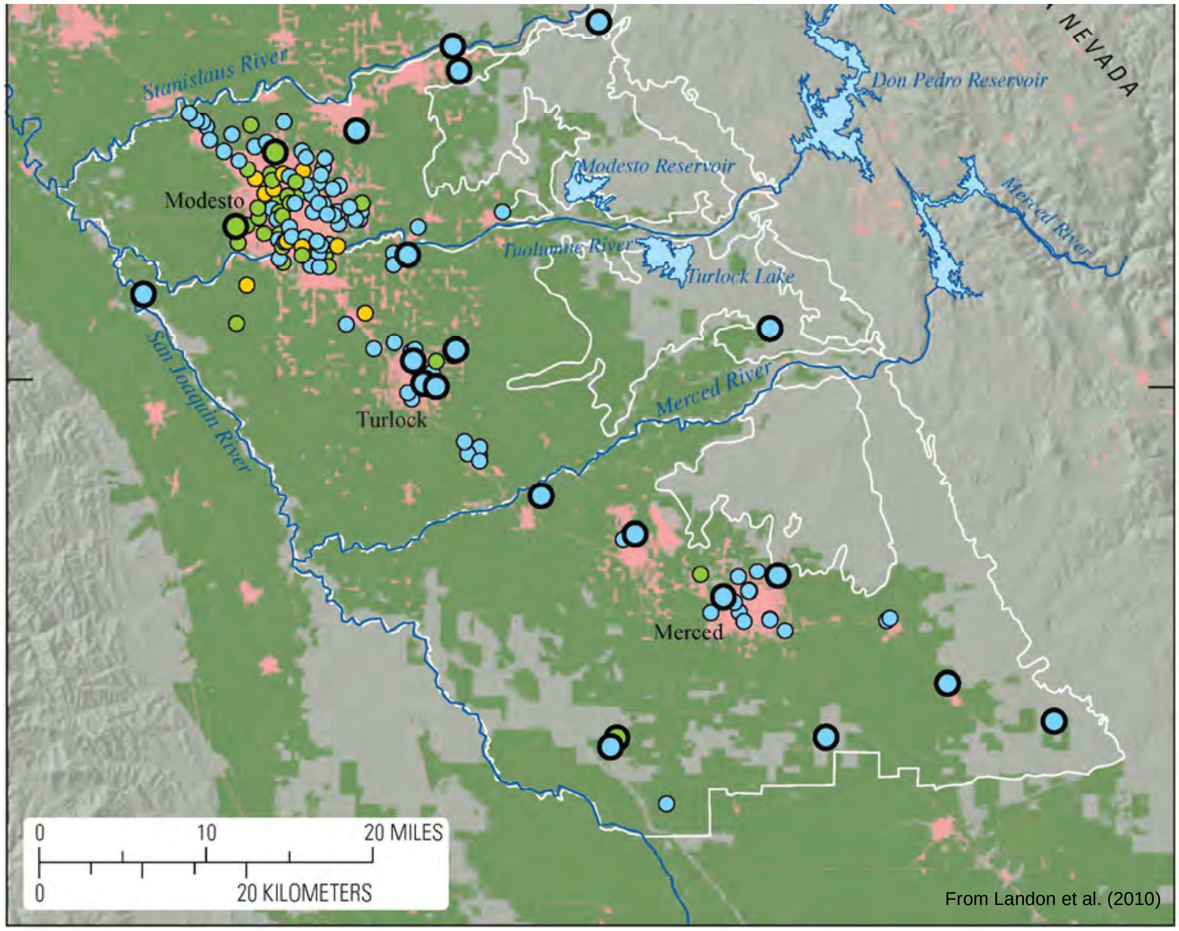


Figure 5-23b
Other Groundwater Quality Data: Vanadium



EXPLANATION

USGS GAMA uranium

- Low (< 15 micrograms per liter)
- Moderate (15 – 30 micrograms per liter)
- High (> 30 micrograms per liter)

CDPH uranium

- Low (< 15 micrograms per liter)
- Moderate (15 – 30 micrograms per liter)
- High (> 30 micrograms per liter)

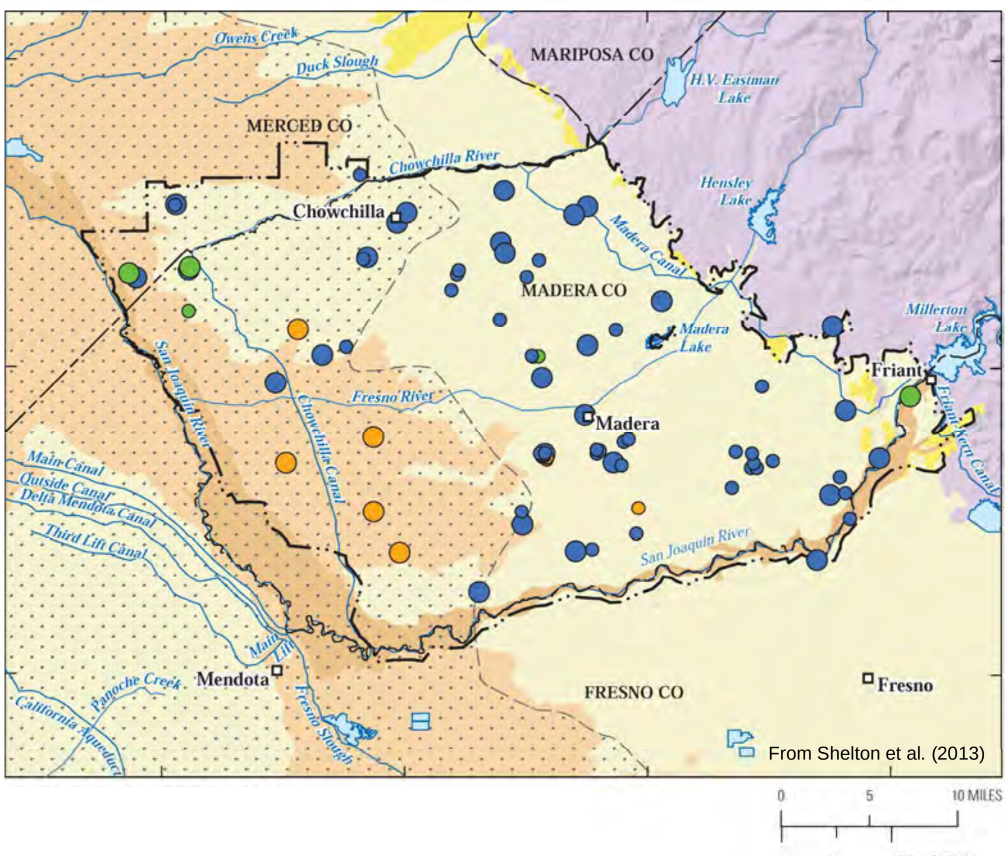


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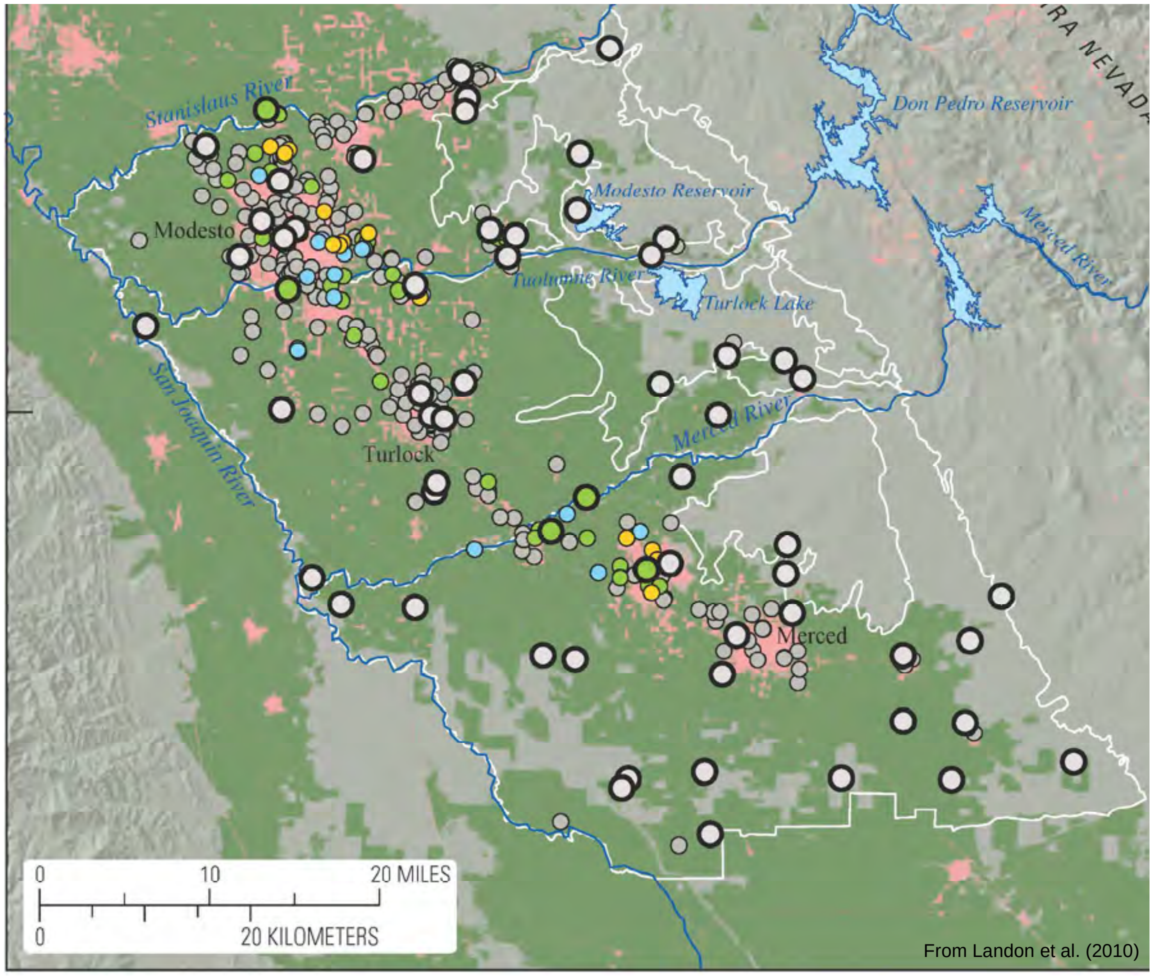
Figure 5-23c

Other Groundwater Quality Data: Uranium



EXPLANATION

USGS GAMA DBCP

- Not detected (< 0.03 micrograms per liter)
- Moderate (0.03 – 0.20 micrograms per liter)

CDPH DBCP

- Low or not detected (< 0.01 micrograms per liter)
- Low (0.01 - 0.02 micrograms per liter)
- Moderate (0.03 – 0.20 micrograms per liter)
- High (> 0.20 micrograms per liter)

Fumigants
Maximum relative-concentration (RC) by well

RC category*	Wells USGS GAMA	Wells CDPH (data in 3-year period 2/12/2005–2/12/2008)
Not detected	○	●
Low	●	●
Moderate		●
High	●	

Fumigants include:
1,2-dibromo-3-chloropropane (DBCP)
1,2-dibromoethane (EDB)
1,2,3-trichloropropane (1,2,3-TCP)
1,2-dichloropropane (1,2-DCP)

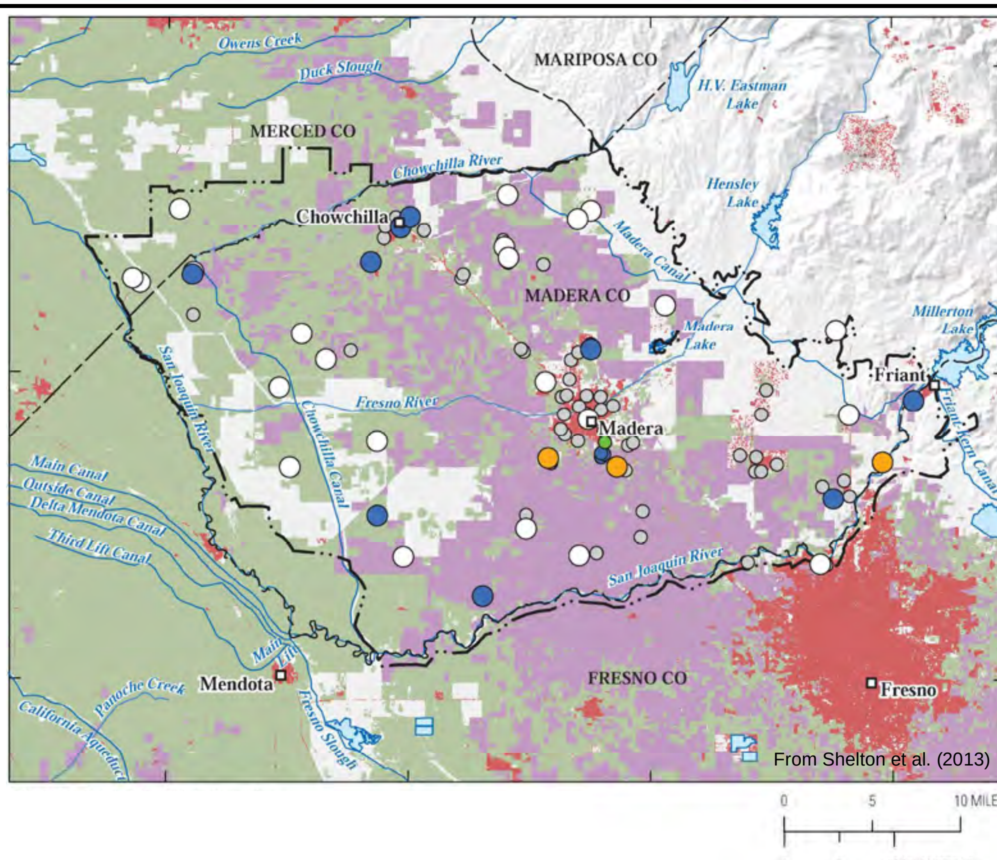
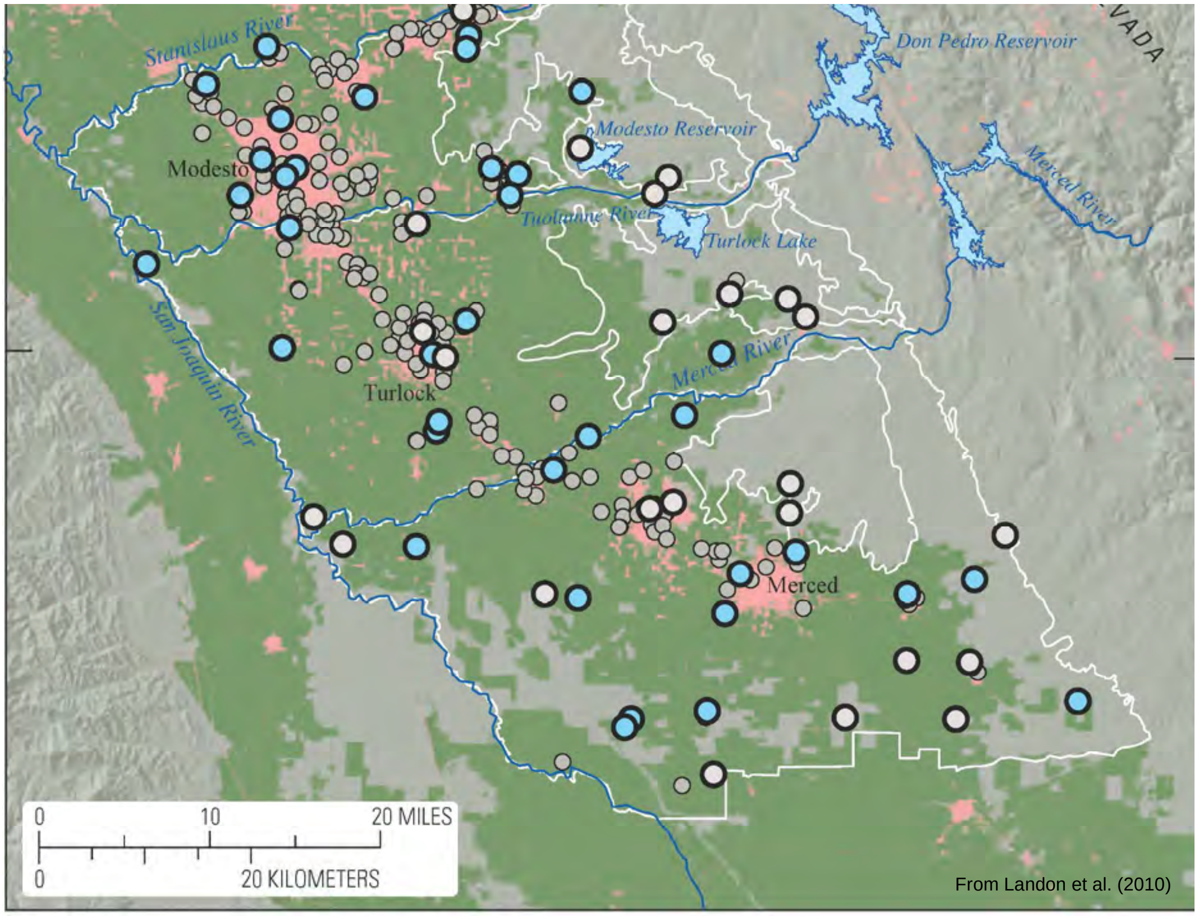


Figure 5-23d
Other Groundwater Quality Data: DBCP/Fumigants



EXPLANATION

USGS GAMA herbicides

Not detected

Low (< 0.01 – 0.10 micrograms per liter)

CDPH herbicides

Not high (< 0.1 micrograms per liter)

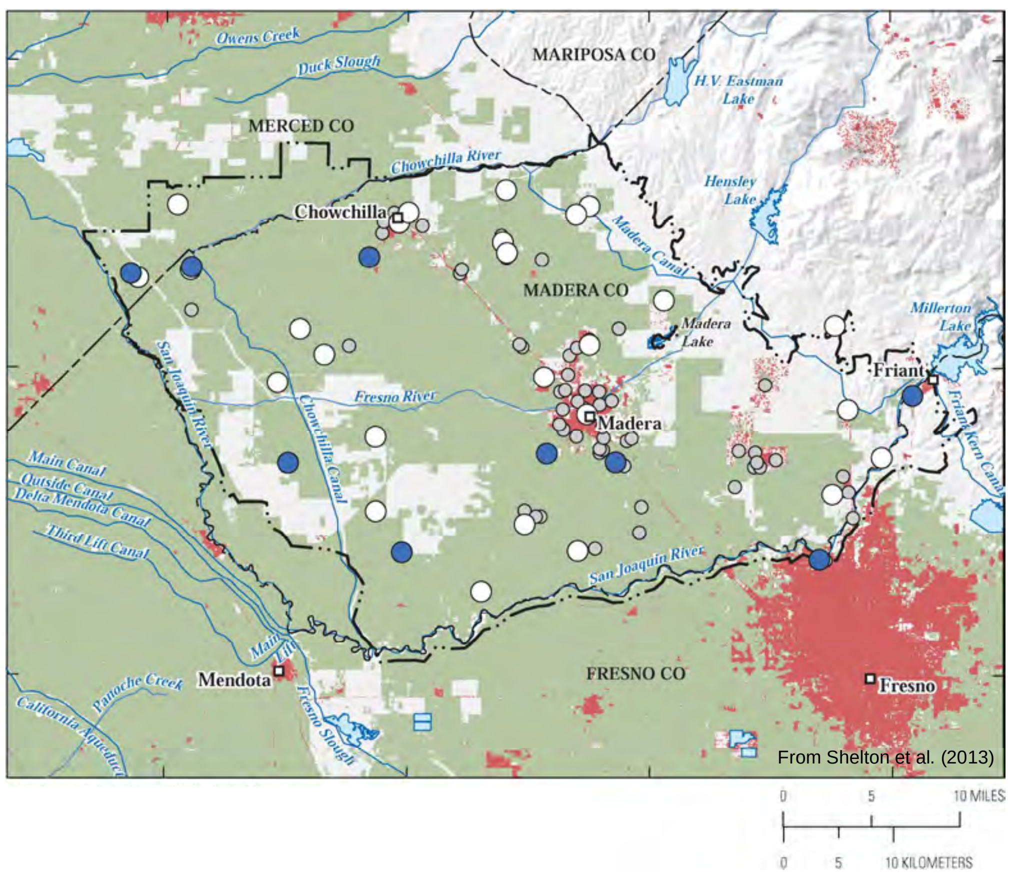


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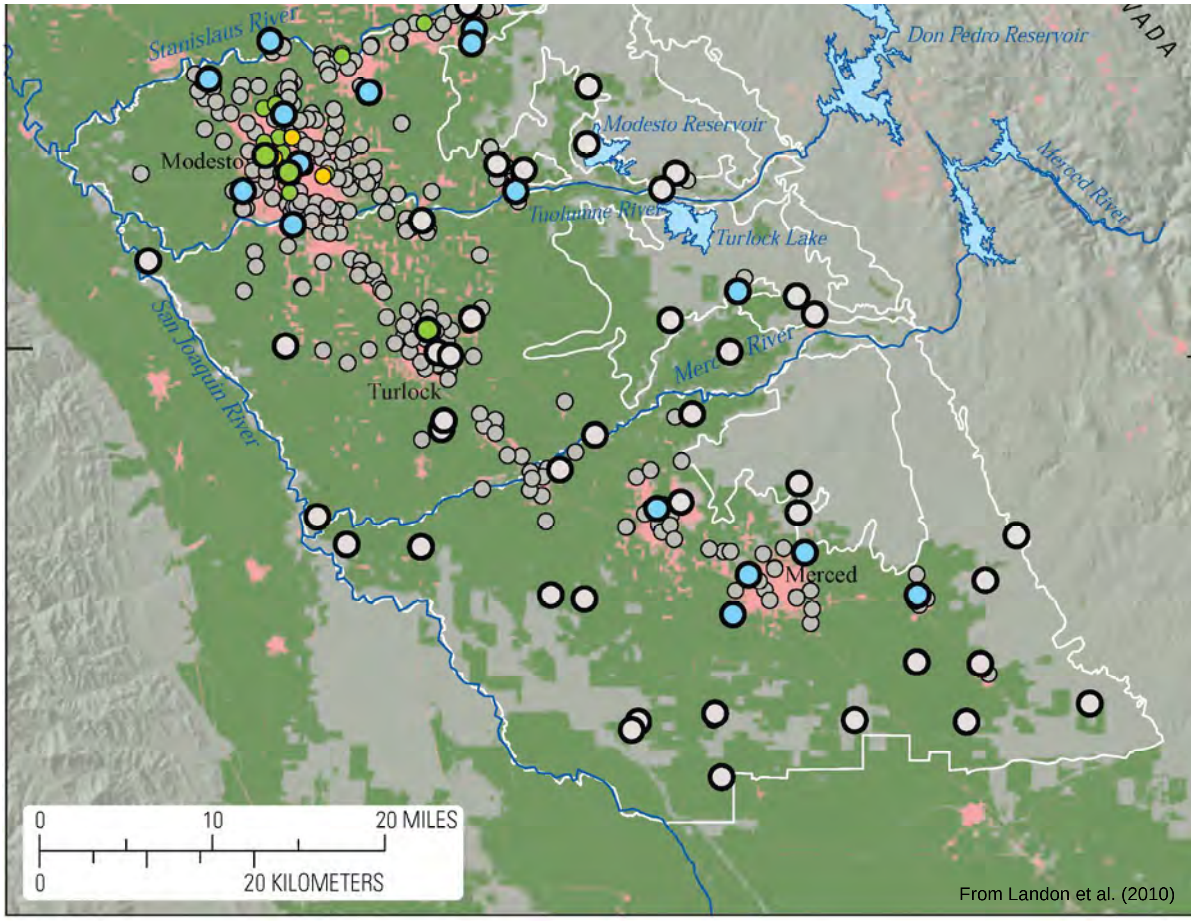
Figure 5-23e
Other Groundwater Quality Data: Herbicides



USGS GAMA solvents

- Not detected
- Low (< 0.1)
- Moderate (> 0.1 – 1.0)

CDPH solvents

- Low or not detected (< 0.1)
- Moderate (0.1 – 1.0)
- High (> 1.0)

Solvents include:
tetrachloroethylene (PCE)
carbon tetrachloride
trichloroethylene (TCE)
dichloromethane
dibromomethane
cis-1,2-dichloroethene
n-propylbenzene

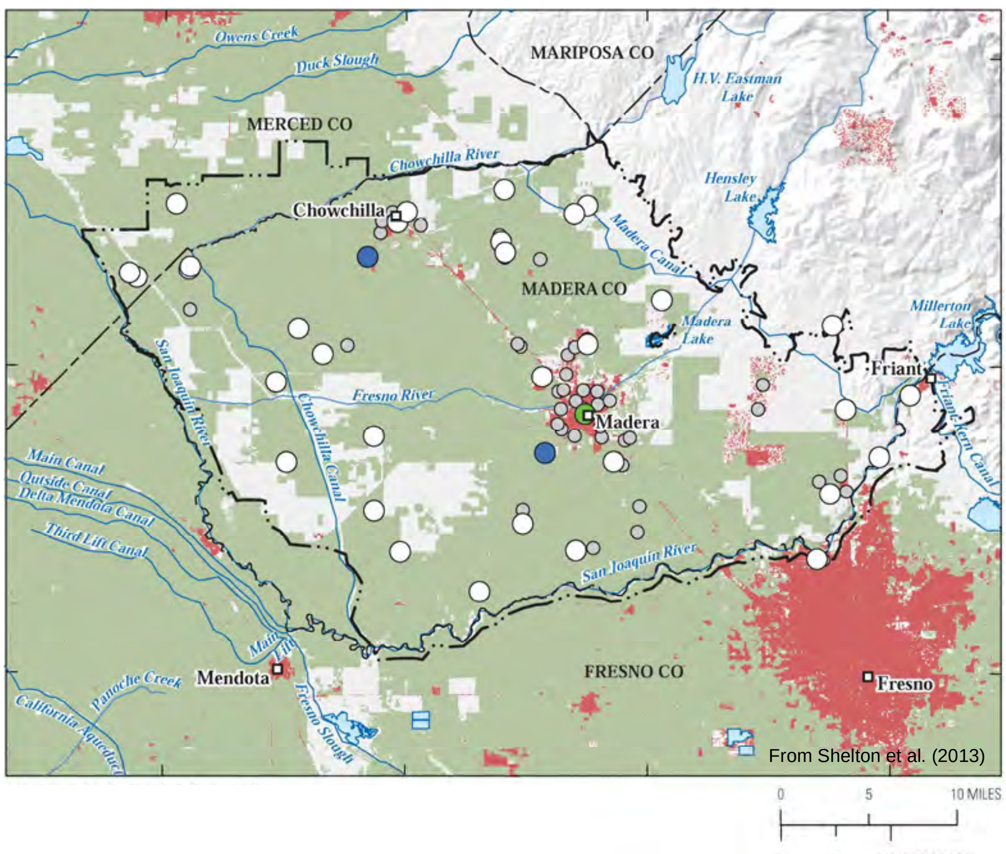
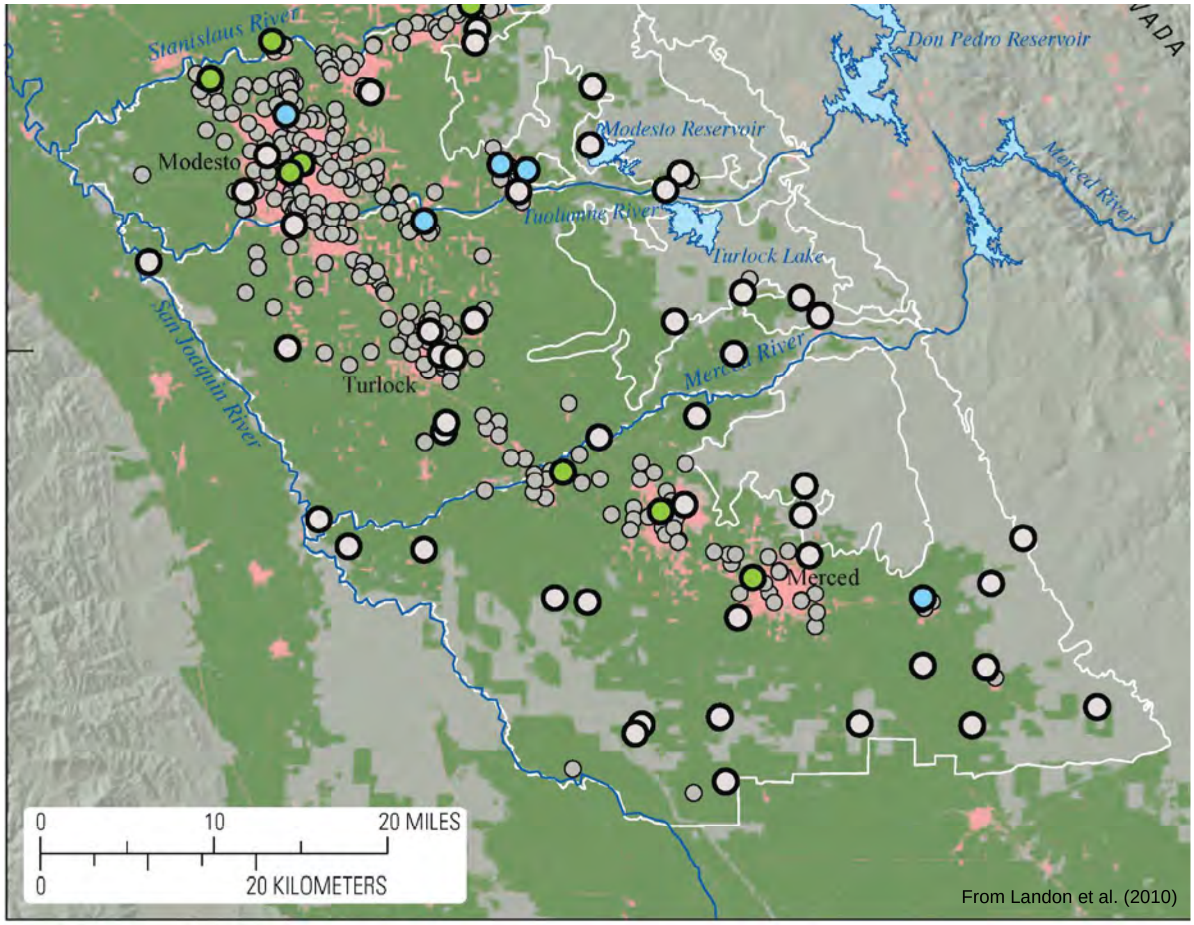


Figure 5-23f
Other Groundwater Quality Data: Solvents



EXPLANATION

USGS GAMA perchlorate

- Not detected (< 0.5 micrograms per liter)
- Low (0.5 – 0.6 micrograms per liter)
- Moderate (0.6 – 1.5 micrograms per liter)

CDPH perchlorate

- Not detected (< 4.0 micrograms per liter)

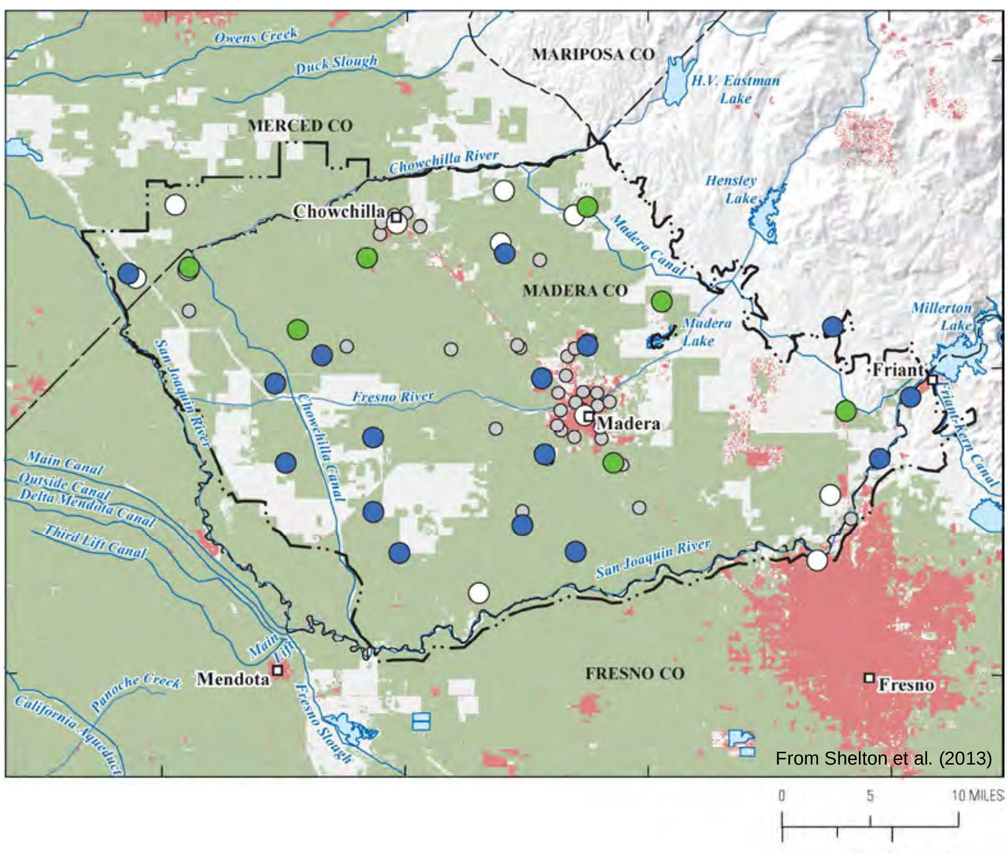


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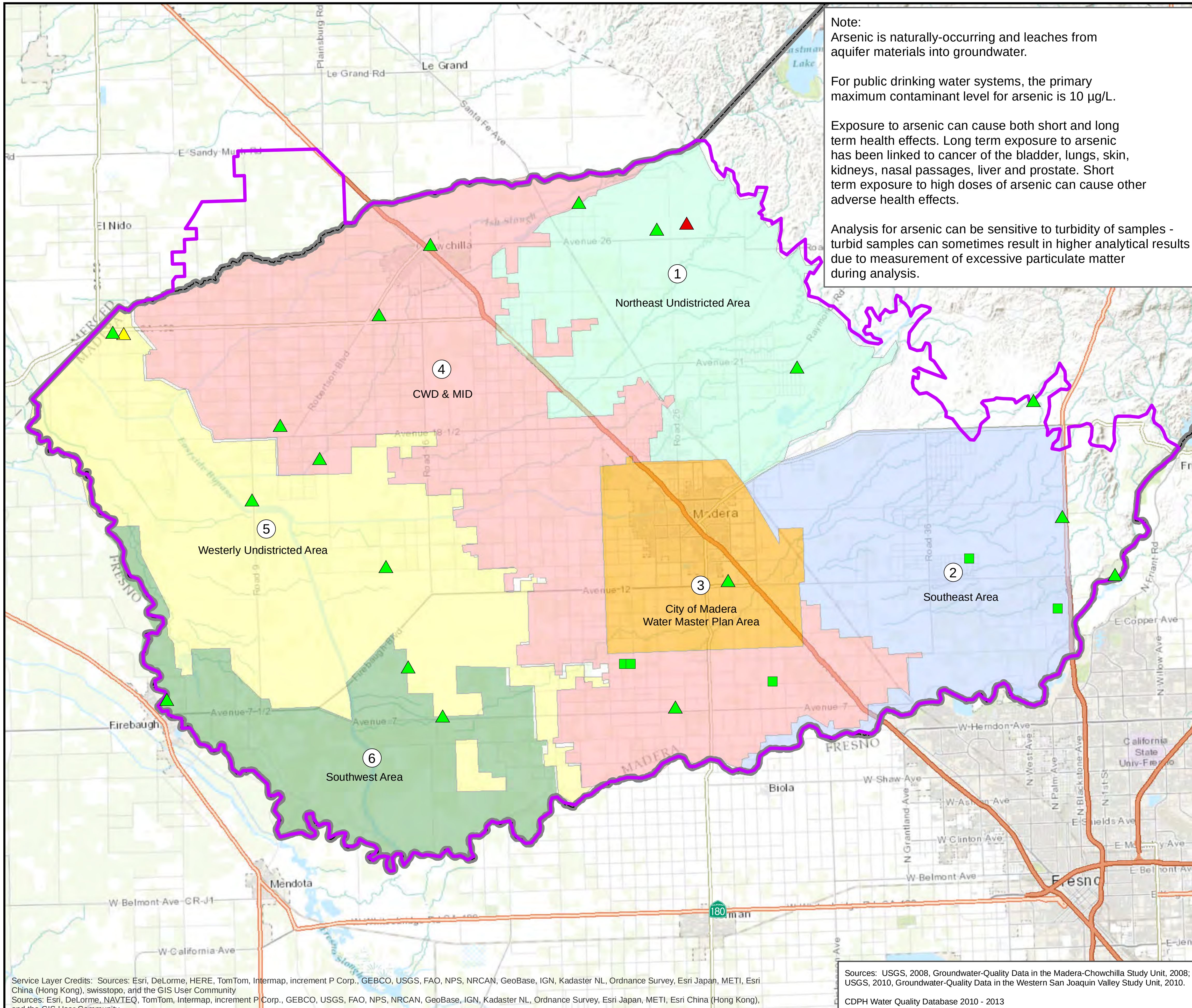
Figure 5-23g
Other Groundwater Quality Data: Perchlorate

MAP OF ARSENIC CONCENTRATION IN SHALLOW WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014



Note:
Arsenic is naturally-occurring and leaches from aquifer materials into groundwater.

For public drinking water systems, the primary maximum contaminant level for arsenic is 10 µg/L.

Exposure to arsenic can cause both short and long term health effects. Long term exposure to arsenic has been linked to cancer of the bladder, lungs, skin, kidneys, nasal passages, liver and prostate. Short term exposure to high doses of arsenic can cause other adverse health effects.

Analysis for arsenic can be sensitive to turbidity of samples - turbid samples can sometimes result in higher analytical results due to measurement of excessive particulate matter during analysis.

Arsenic (µg/L) in City Wells < 400 feet
- < 5
- 5 - 10
- > 10

Arsenic (µg/L) in County Wells < 400 feet
- < 5
- 5 - 10
- > 10

Arsenic (µg/L) in USGS GAMA Wells < 400 feet
- < 5
- 5 - 10
- > 10

Groundwater Management Plan Boundary

Madera County Boundary

Note: All wells are classified by total well depth. The represented wells may have different sanitary seal depths and perforation intervals and therefore may represent unique water quality or composite water quality of the shallow aquifers.

Sources: USGS, 2008, Groundwater-Quality Data in the Madera-Chowchilla Study Unit, 2008; USGS, 2010, Groundwater-Quality Data in the Western San Joaquin Valley Study Unit, 2010.

CDPH Water Quality Database 2010 - 2013

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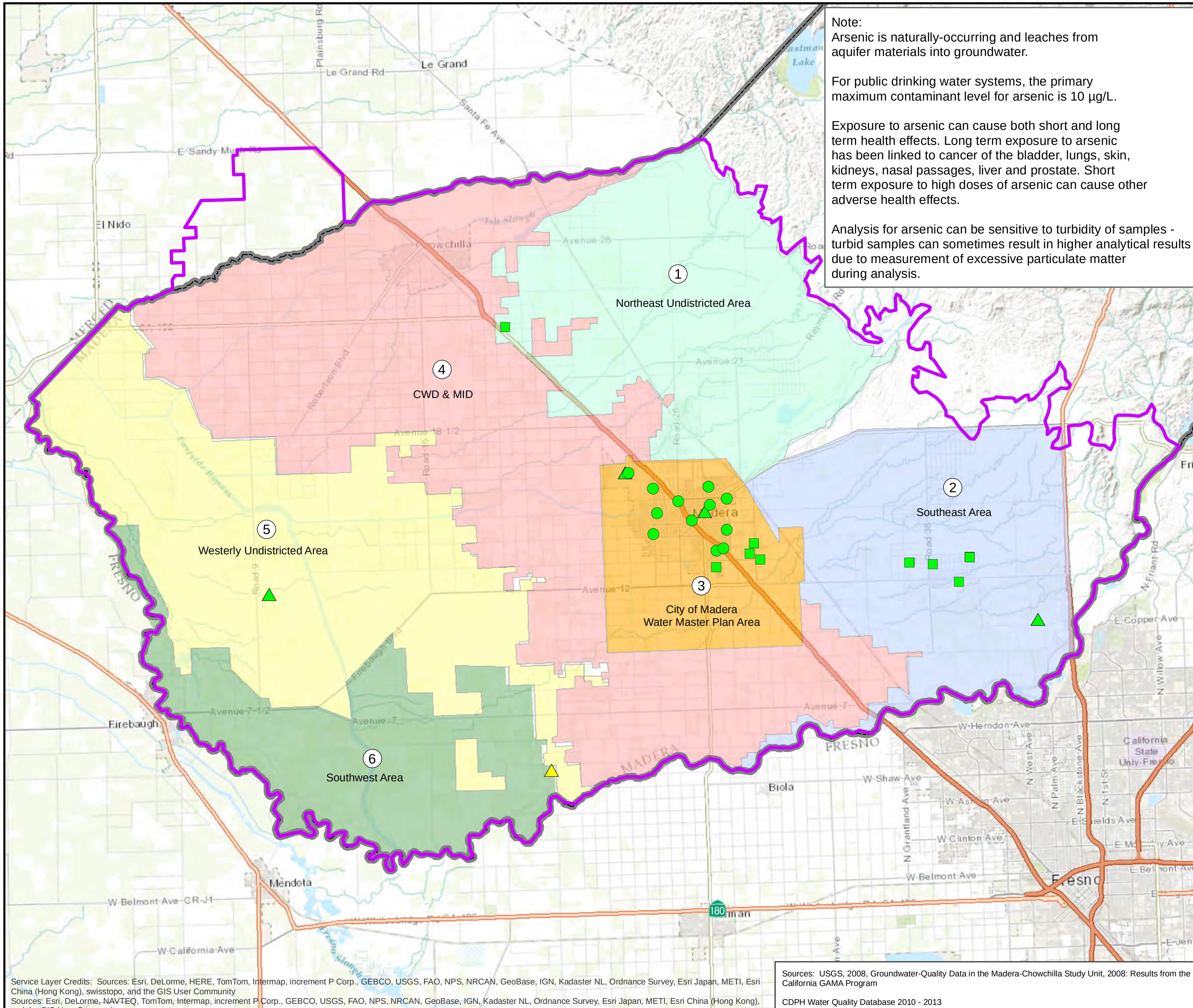
A2 F-171

Document Path: J:\Jobs\8489_Madera_County\8489.005_Madera_County_GMP\GIS\Tasks\Water_Quality_Maps\20140402_Updated_Figures\Madera_Arsenic_Map_1_Shallow_20140407.mxd

MAP OF ARSENIC CONCENTRATION IN INTERMEDIATE WELLS

MADERA REGIONAL GROUNDWATER MANAGEMENT PLAN
APRIL 2014



Note:
Arsenic is naturally-occurring and leaches from aquifer materials into groundwater.

For public drinking water systems, the primary maximum contaminant level for arsenic is 10 µg/L.

Exposure to arsenic can cause both short and long term health effects. Long term exposure to arsenic has been linked to cancer of the bladder, lungs, skin, kidneys, nasal passages, liver and prostate. Short term exposure to high doses of arsenic can cause other adverse health effects.

Analysis for arsenic can be sensitive to turbidity of samples - turbid samples can sometimes result in higher analytical results due to measurement of excessive particulate matter during analysis.

Arsenic (µg/L) in City Wells 400 - 600 feet

- < 5
- 5 - 10
- > 10

Arsenic (µg/L) in County Wells 400 - 600 feet

- < 5
- 5 - 10
- > 10

Arsenic (µg/L) in USGS GAMA Wells 400 - 600 feet

- < 5
- 5 - 10
- > 10

Groundwater Management Plan Boundary
Madera County Boundary

Note: All wells are classified by total well depth. Some wells may have screen perforations that begin shallower than the depth classification and therefore may represent composite water quality across two or more aquifers.

Sources: USGS, 2008, Groundwater-Quality Data in the Madera-Chowchilla Study Unit, 2008: Results from the California GAMA Program

CDPH Water Quality Database 2010 - 2013

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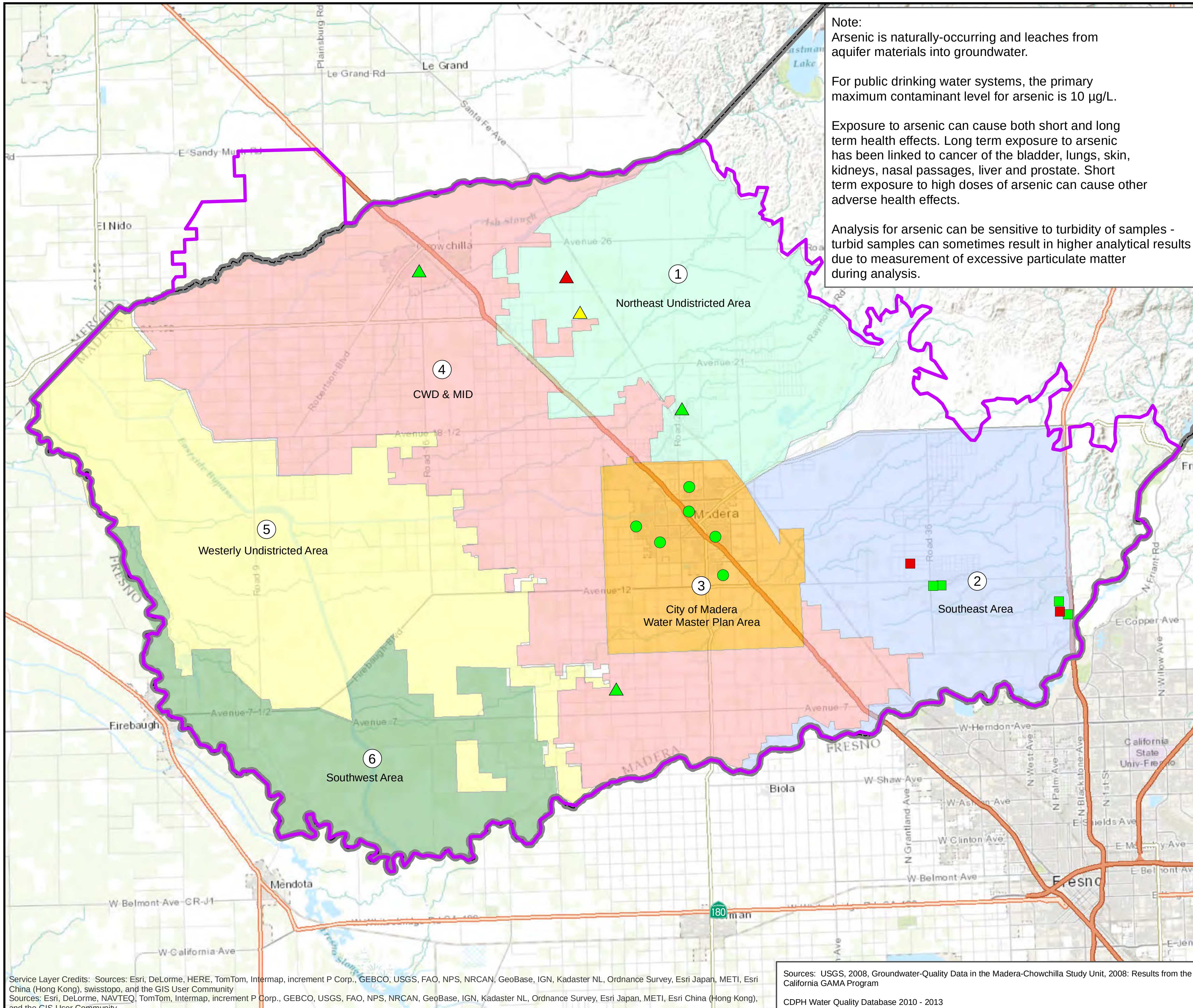
MAP OF ARSENIC CONCENTRATION IN DEEP WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014



Note:
Arsenic is naturally-occurring and leaches from aquifer materials into groundwater.

For public drinking water systems, the primary maximum contaminant level for arsenic is 10 µg/L.

Exposure to arsenic can cause both short and long term health effects. Long term exposure to arsenic has been linked to cancer of the bladder, lungs, skin, kidneys, nasal passages, liver and prostate. Short term exposure to high doses of arsenic can cause other adverse health effects.

Analysis for arsenic can be sensitive to turbidity of samples - turbid samples can sometimes result in higher analytical results due to measurement of excessive particulate matter during analysis.

Arsenic (µg/L) in City Wells > 600 feet
- < 5
- 5 - 10
- > 10

Arsenic (µg/L) in County Wells > 600 feet
- < 5
- 5 - 10
- > 10

Arsenic (µg/L) in USGS GAMA Wells > 600 feet
- < 5
- 5 - 10
- > 10

Groundwater Management Plan Boundary

Madera County Boundary

Note: All wells are classified by total well depth. Some wells may have screen perforations that begin shallower than the depth classification and therefore may represent composite water quality across two or more aquifers.

Sources: USGS, 2008, Groundwater-Quality Data in the Madera-Chowchilla Study Unit, 2008: Results from the California GAMA Program

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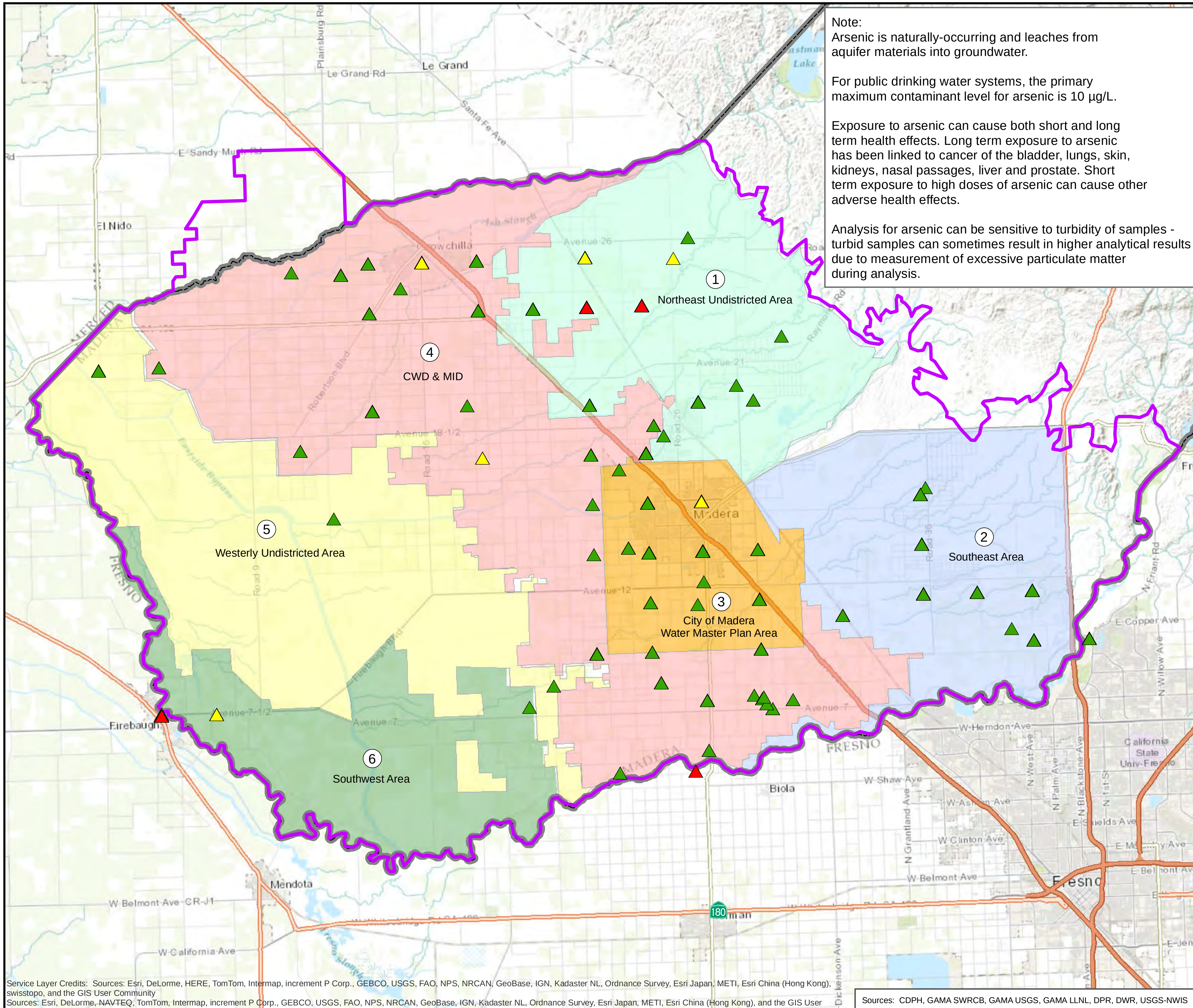
MAP OF ARSENIC CONCENTRATION IN WELLS OF UNKNOWN DEPTH

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014



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Analysis for arsenic can be sensitive to turbidity of samples - turbid samples can sometimes result in higher analytical results due to measurement of excessive particulate matter during analysis.

NORTH

0 2 4
MILES

Arsenic (µg/L) in Other USGS GAMA Wells

- < 5
- 5 - 10
- > 10
- Groundwater Management Plan Boundary
- Madera County Boundary

Note: Well construction records were not available for these wells. Some wells may have screen perforations that connect two or more aquifers and may therefore represent composite water quality.

Service Layer Credits: Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community
Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), and the GIS User Community

Sources: CDPH, GAMA SWRCB, GAMA USGS, GAMA LLNL, DPR, DWR, USGS-NWIS

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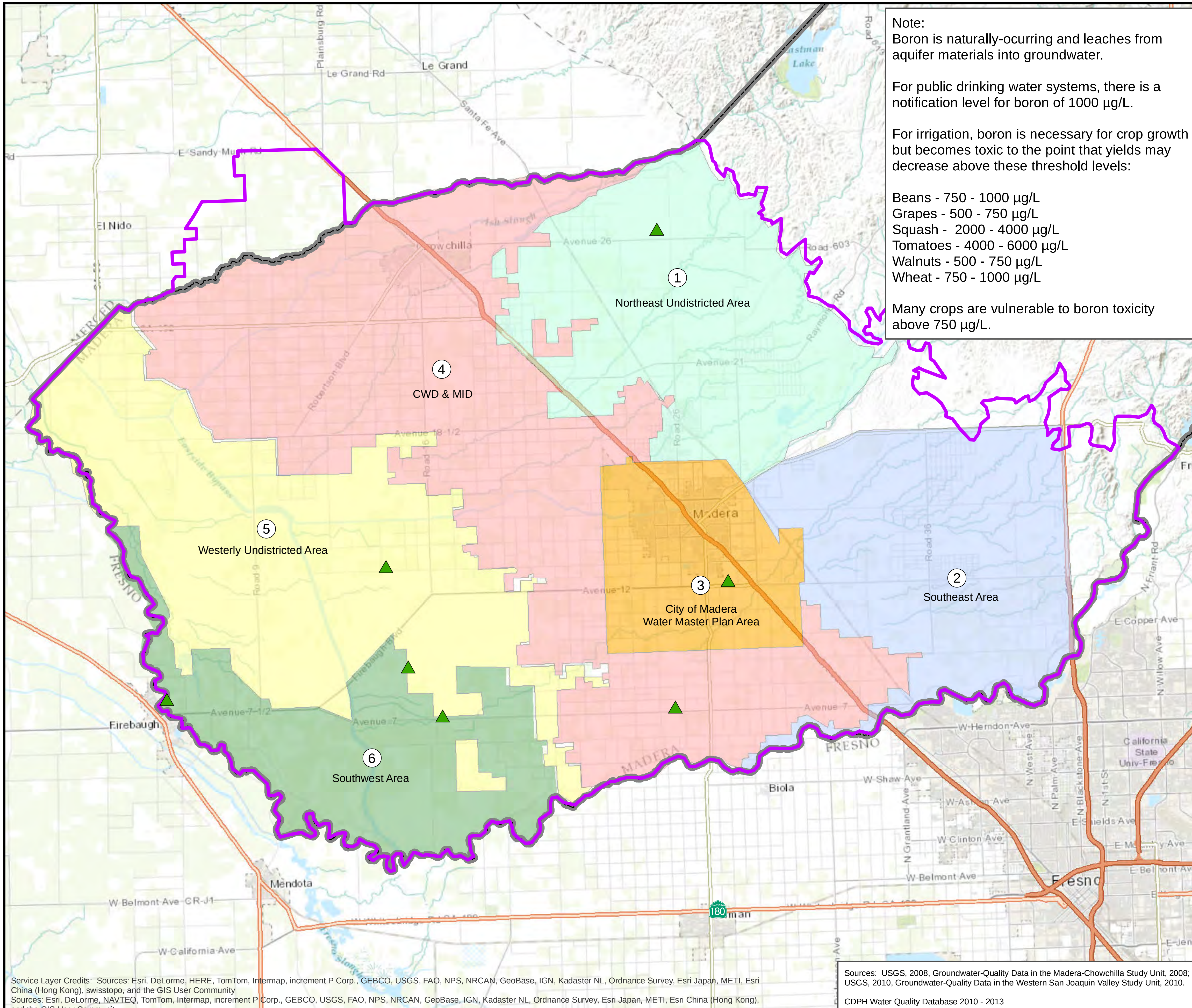
MAP OF BORON CONCENTRATION IN SHALLOW WELLS

MADERA REGIONAL GROUNDWATER MANAGEMENT PLAN
APRIL 2014



Note:
Boron is naturally-ocurring and leaches from aquifer materials into groundwater.

For public drinking water systems, there is a notification level for boron of 1000 µg/L.

For irrigation, boron is necessary for crop growth but becomes toxic to the point that yields may decrease above these threshold levels:

Beans - 750 - 1000 µg/L
Grapes - 500 - 750 µg/L
Squash - 2000 - 4000 µg/L
Tomatoes - 4000 - 6000 µg/L
Walnuts - 500 - 750 µg/L
Wheat - 750 - 1000 µg/L

Many crops are vulnerable to boron toxicity above 750 µg/L.

NORTH

0 2 4
MILES

Boron (µg/L) in City Wells < 400 feet
- < 500
- 500 - 750
- 750 - 1000
- 1000 - 2000
- > 2000

Boron (µg/L) in County Wells < 400 feet
- < 500
- 500 - 750
- 750 - 1000
- 1000 - 2000
- > 2000

Boron (µg/L) in USGS GAMA Wells < 400 feet
- < 500
- 500 - 750
- 750 - 1000
- 1000 - 2000
- > 2000

Groundwater Management Plan Boundary
Madera County Boundary

Service Layer Credits: Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community
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Sources: USGS, 2008, Groundwater-Quality Data in the Madera-Chowchilla Study Unit, 2008; USGS, 2010, Groundwater-Quality Data in the Western San Joaquin Valley Study Unit, 2010.

CDPH Water Quality Database 2010 - 2013

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MAP OF BORON CONCENTRATION IN INTERMEDIATE WELLS

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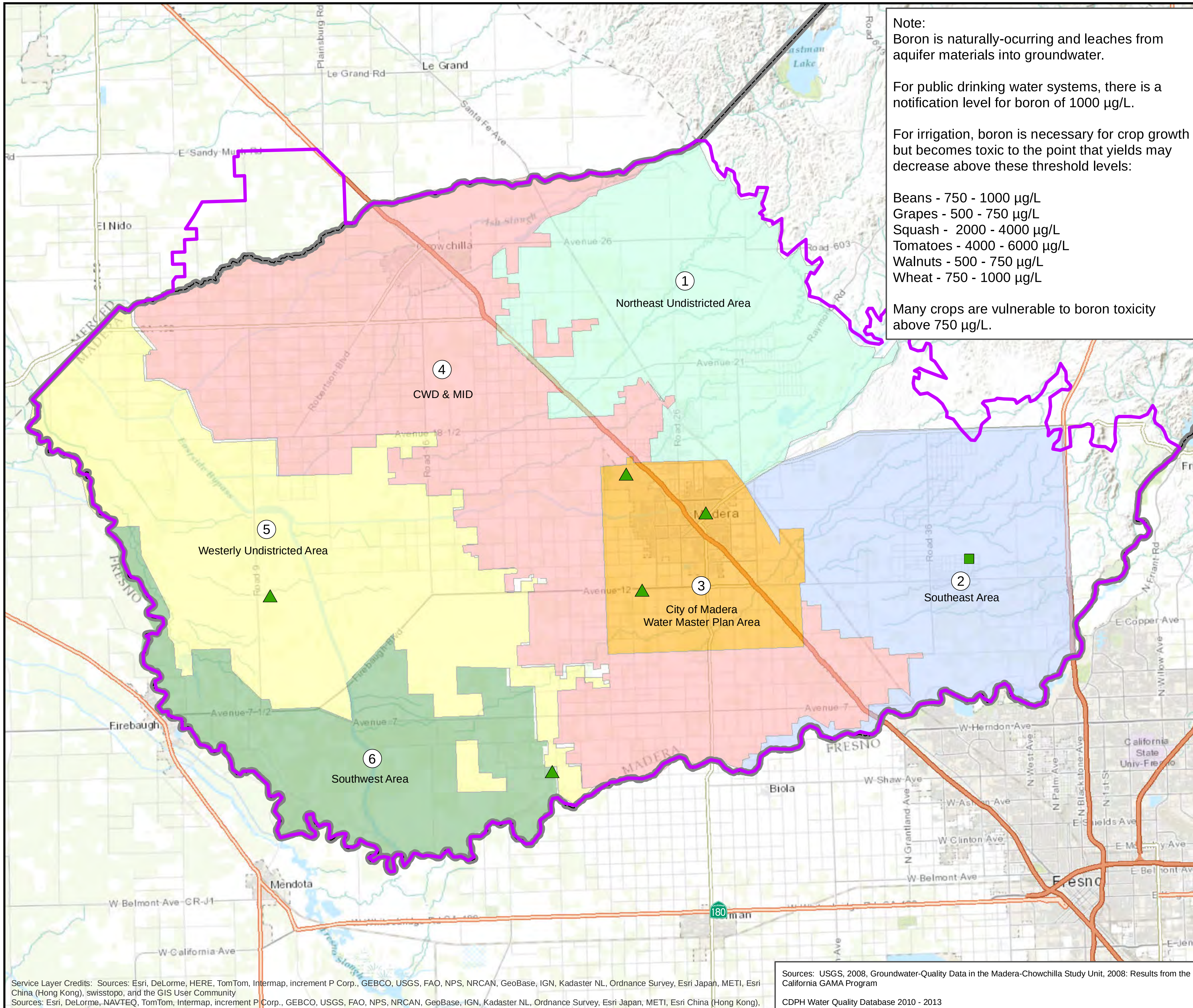
GROUNDWATER MANAGEMENT PLAN
APRIL 2014



NORTH

0 2 4
MILES

Boron (µg/L) in County Wells 400 - 600 feet
- < 500
- 500 - 750
- 750 - 1000
- 1000 - 2000
- > 2000

Boron (µg/L) in City Wells 400 - 600 feet
- < 500
- 500 - 750
- 750 - 1000
- 1000 - 2000
- > 2000

Boron (µg/L) in USGS GAMA Wells 400 - 600 feet
- < 500
- 500 - 750
- 750 - 1000
- 1000 - 2000
- > 2000

Groundwater Management Plan Boundary
Madera County Boundary

Note: All wells are classified by total well depth. Some wells may have screen perforations that begin shallower than the depth classification and therefore may represent composite water quality across two or more aquifers.

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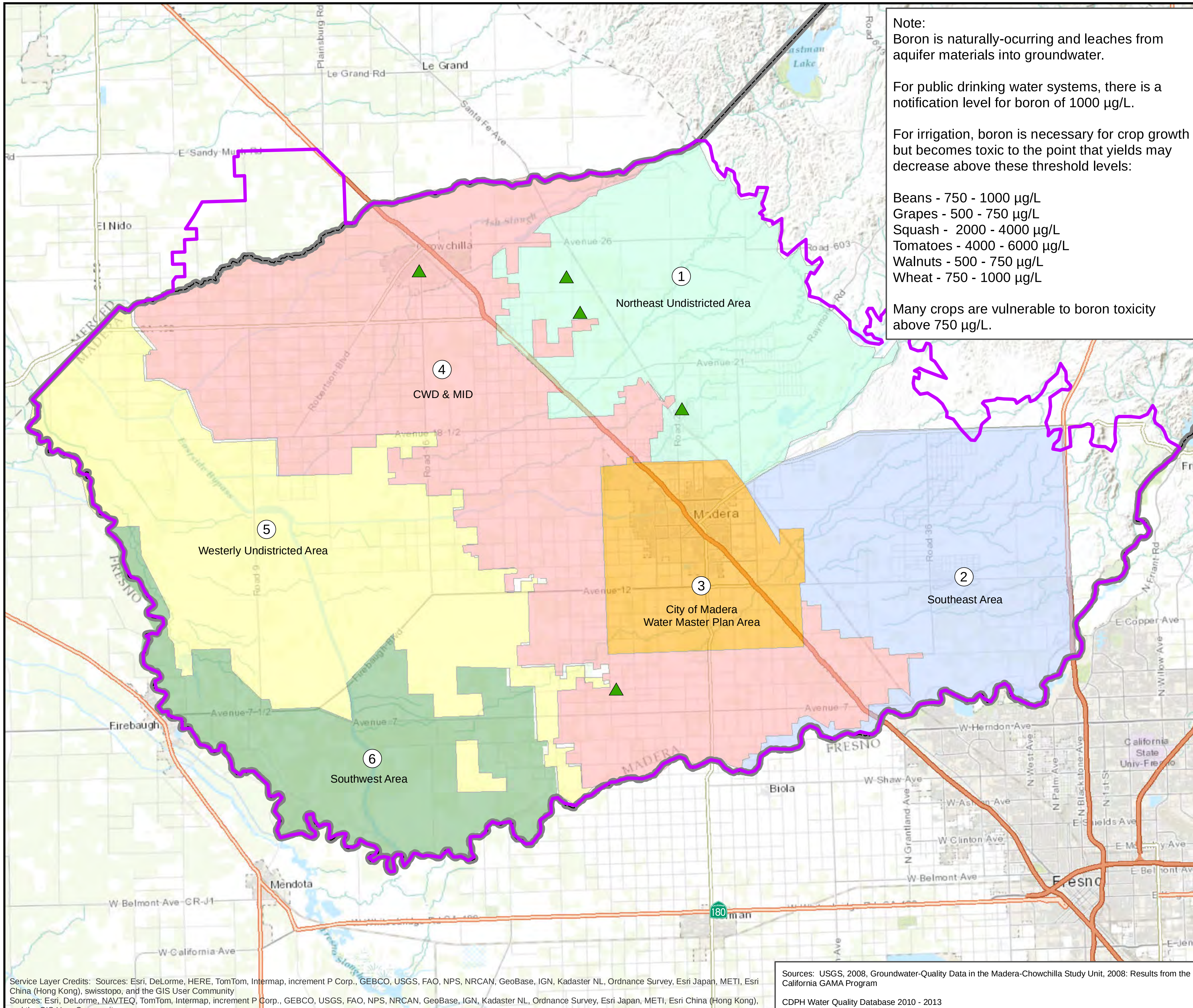
MAP OF BORON CONCENTRATION IN DEEP WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014



Note:
Boron is naturally-ocurring and leaches from aquifer materials into groundwater.

For public drinking water systems, there is a notification level for boron of 1000 µg/L.

For irrigation, boron is necessary for crop growth but becomes toxic to the point that yields may decrease above these threshold levels:

Beans - 750 - 1000 µg/L
Grapes - 500 - 750 µg/L
Squash - 2000 - 4000 µg/L
Tomatoes - 4000 - 6000 µg/L
Walnuts - 500 - 750 µg/L
Wheat - 750 - 1000 µg/L

Many crops are vulnerable to boron toxicity above 750 µg/L.

NORTH

0 2 4
MILES

Boron (µg/L) in City Wells > 600 feet

- < 500
- 500 - 750
- 750 - 1000
- 1000 - 2000
- > 2000

Boron (µg/L) in County Wells > 600 feet

- < 500
- 500 - 750
- 750 - 1000
- 1000 - 2000
- > 2000

Boron (µg/L) in USGS GAMA Wells > 600 feet

- < 500
- 500 - 750
- 750 - 1000
- 1000 - 2000
- > 2000

Groundwater Management Plan Boundary
Madera County Boundary

Note: All wells are classified by total well depth. Some wells may have screen perforations that begin shallower than the depth classification and therefore may represent composite water quality across two or more aquifers.

Sources: USGS, 2008, Groundwater-Quality Data in the Madera-Chowchilla Study Unit, 2008: Results from the California GAMA Program

CDPH Water Quality Database 2010 - 2013

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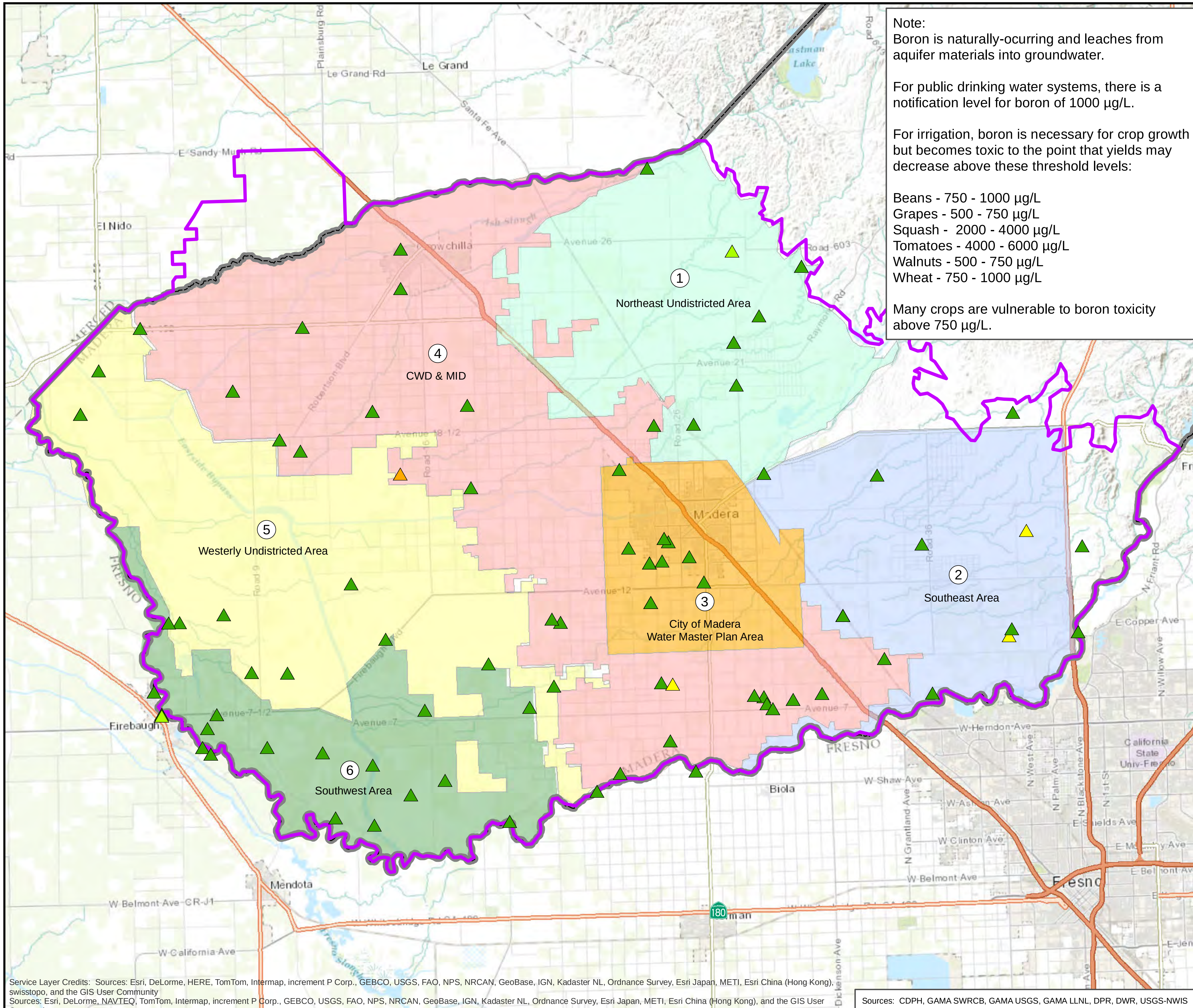
MAP OF BORON CONCENTRATION IN WELLS OF UNKNOWN DEPTH

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014



Note:
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Grapes - 500 - 750 µg/L
Squash - 2000 - 4000 µg/L
Tomatoes - 4000 - 6000 µg/L
Walnuts - 500 - 750 µg/L
Wheat - 750 - 1000 µg/L

Many crops are vulnerable to boron toxicity above 750 µg/L.

NORTH

0 2 4
MILES

Boron (µg/L) in Other USGS GAMA Wells

- < 500
- 500 - 750
- 750 - 1000
- 1000 - 2000
- > 2000
- Groundwater Management Plan Boundary
- Madera County Boundary

Note: Well construction records were not available for these wells. Some wells may have screen perforations that connect two or more aquifers and may therefore represent composite water quality.

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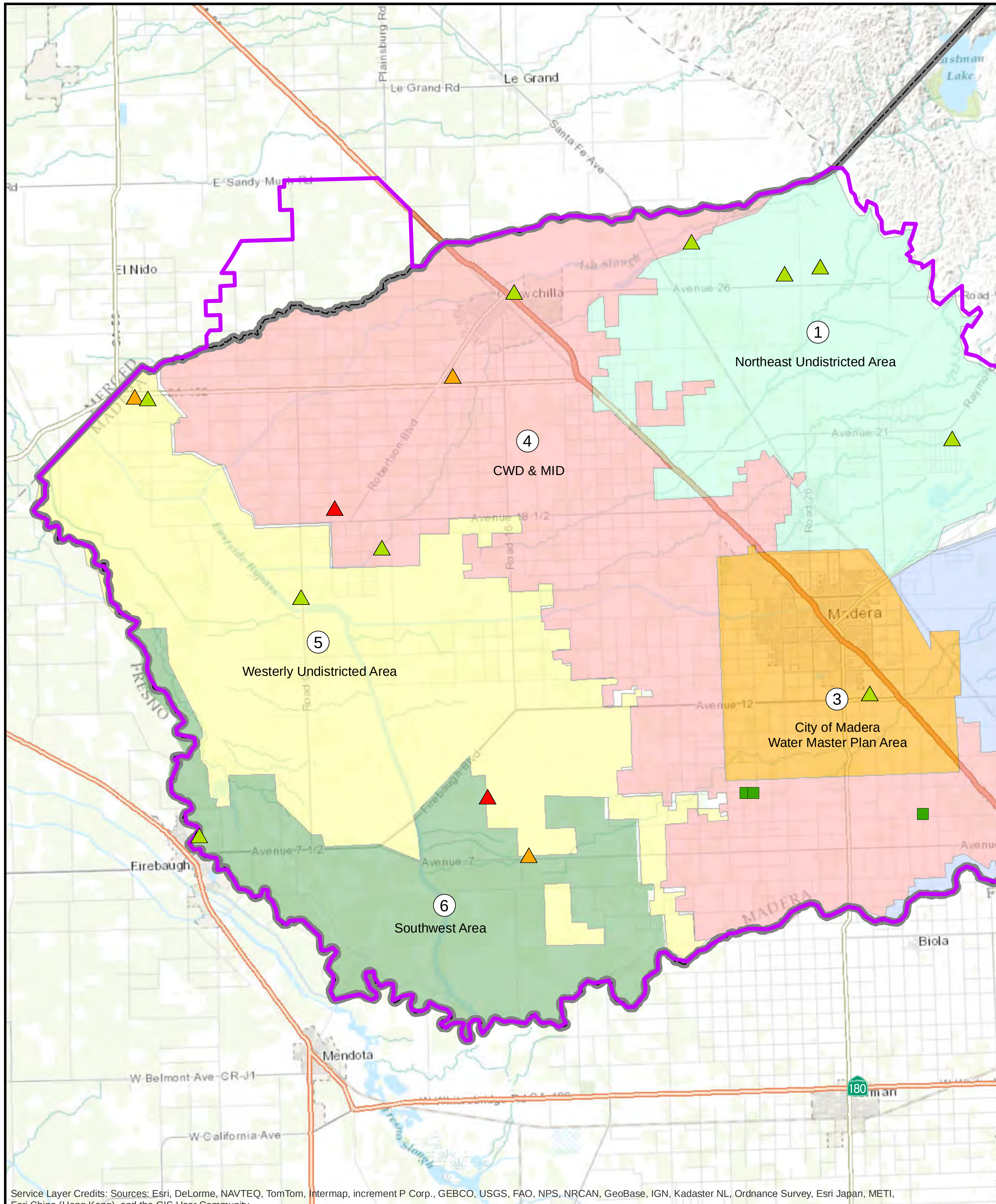
MAP OF SPECIFIC CONDUCTANCE IN SHALLOW WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014



NORTH

0 2 4
MILES

Note:
"EC" is an abbreviation for specific conductance, which is related to the salt content of a water sample.

For public drinking water systems, the secondary (aesthetic) maximum contaminant levels for EC are 900 µmhos/cm (recommended), 1600 µmhos/cm (upper), and 2200 µmhos/cm (short-term).

For irrigation, crop yields decrease above a threshold EC value, which is crop-dependent. Crop yield potential decreases above these threshold levels:

Almonds - 1000 µmhos/cm
Beans - 700 µmhos/cm
Squash - 2100-3100 µmhos/cm
Tomatoes - 1700 µmhos/cm
Wheat - 4000 µmhos/cm

EC (µmhos/cm) in County Wells < 400 feet
- < 600
- 600 - 900
- 900 - 1600
- > 1600

EC (µmhos/cm) in City Wells < 400 feet
- < 600
- 600 - 900
- 900 - 1600
- > 1600

EC (µmhos/cm) in USGS GAMA Wells < 400 feet
- < 600
- 600 - 900
- 900 - 1600
- > 1600

Groundwater Management Plan Boundary
Madera County Boundary

Sources: USGS, 2008, Groundwater-Quality Data in the Madera-Chowchilla Study Unit, 2008; USGS, 2010, Groundwater-Quality Data in the Western San Joaquin Valley Study Unit, 2010.

CDPH Water Quality Database 2010 - 2013

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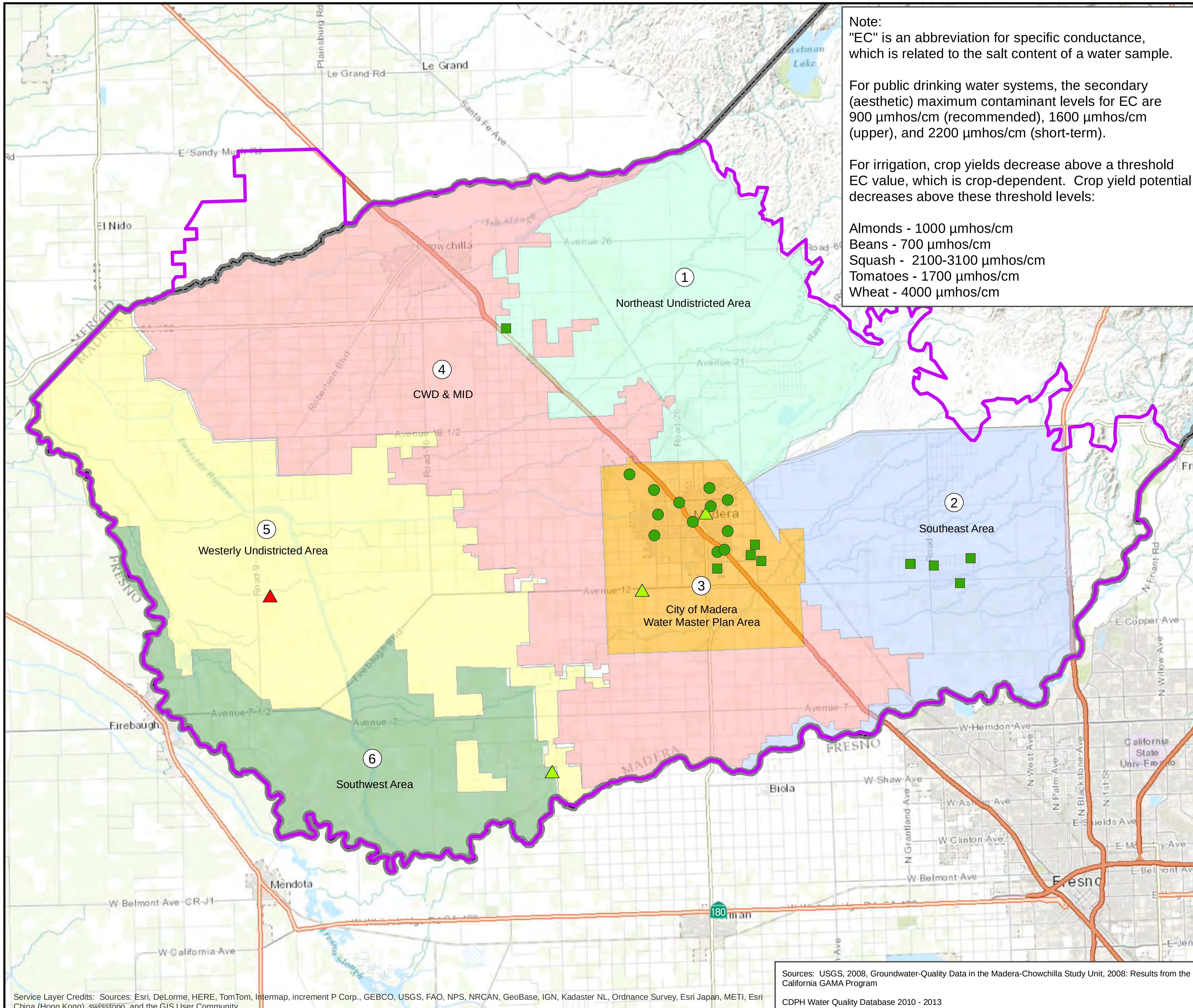

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MAP OF SPECIFIC CONDUCTANCE IN INTERMEDIATE WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014

NORTH

0 2 4
MILES

EC (µmhos/cm) in City Wells 400 - 600 feet
- < 600
- 600 - 900
- 900 - 1600
- > 1600

EC (µmhos/cm) in County Wells 400 - 600 feet
- < 600
- 600 - 900
- 900 - 1600
- > 1600

EC (µmhos/cm) in USGS GAMA Wells 400 - 600 feet
- < 600
- 600 - 900
- 900 - 1600
- > 1600

Groundwater Management Plan Boundary
Madera County Boundary

Note: All wells are classified by total well depth. Some wells may have screen perforations that begin shallower than the depth classification and therefore represent composite water quality across two or more aquifers.

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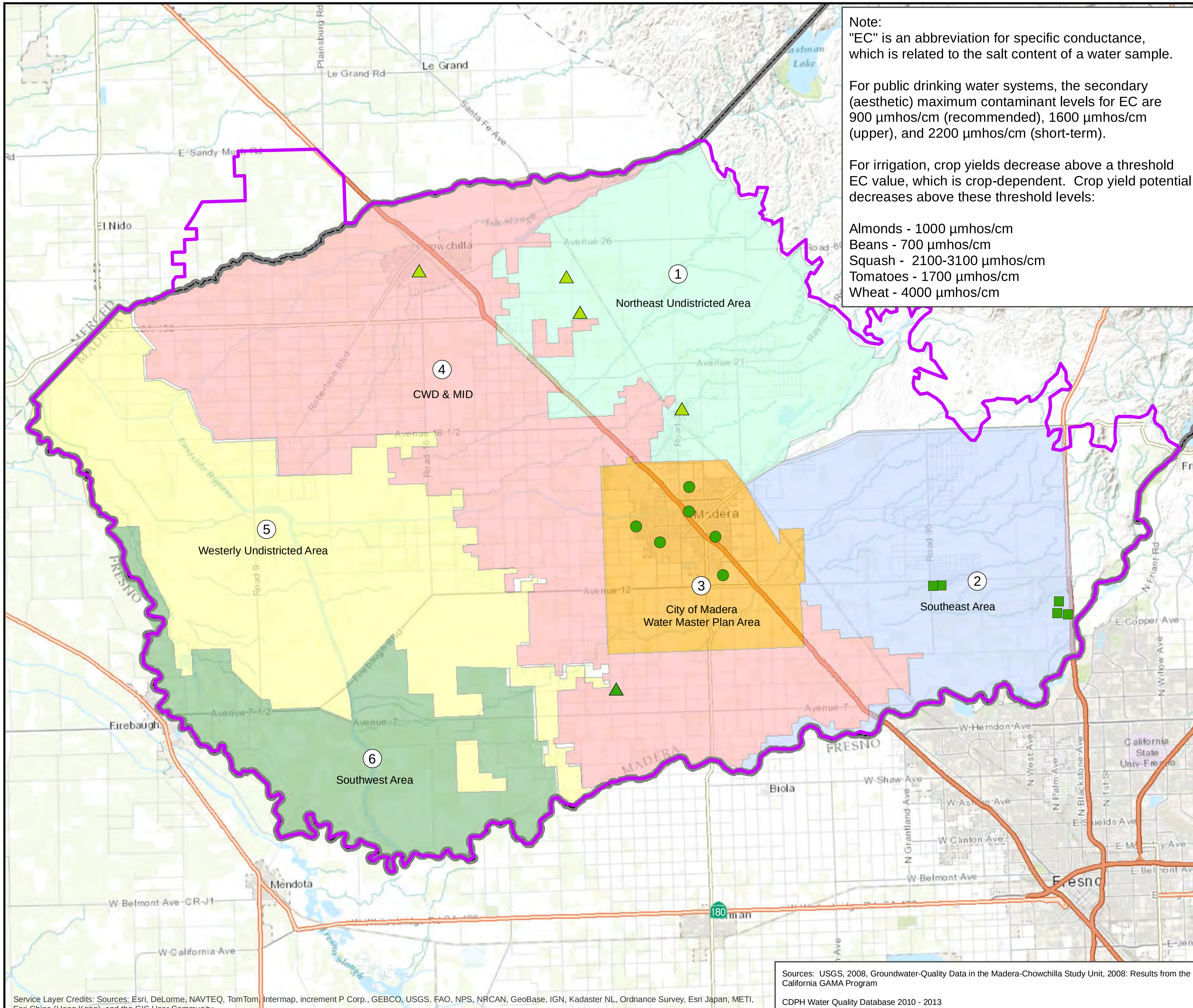
MAP OF SPECIFIC CONDUCTANCE IN DEEP WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014



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Beans - 700 µmhos/cm
Squash - 2100-3100 µmhos/cm
Tomatoes - 1700 µmhos/cm
Wheat - 4000 µmhos/cm

NORTH

0 2 4
MILES

EC (µmhos/cm) in City Wells > 600 feet

- < 600
- 600 - 900
- 900 - 1600
- > 1600

EC (µmhos/cm) in County Wells > 600 feet

- < 600
- 600 - 900
- 900 - 1600
- > 1600

EC (µmhos/cm) in USGS GAMA Wells > 600 feet

- < 600
- 600 - 900
- 900 - 1600
- > 1600

Groundwater Management Plan Boundary
Madera County Boundary

Note: All wells are classified by total well depth. Some wells may have screen perforations that begin shallower than the depth classification and therefore may represent composite water quality across two or more aquifers.

Sources: USGS, 2008, Groundwater-Quality Data in the Madera-Chowchilla Study Unit, 2008: Results from the California GAMA Program

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Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), and the GIS User Community

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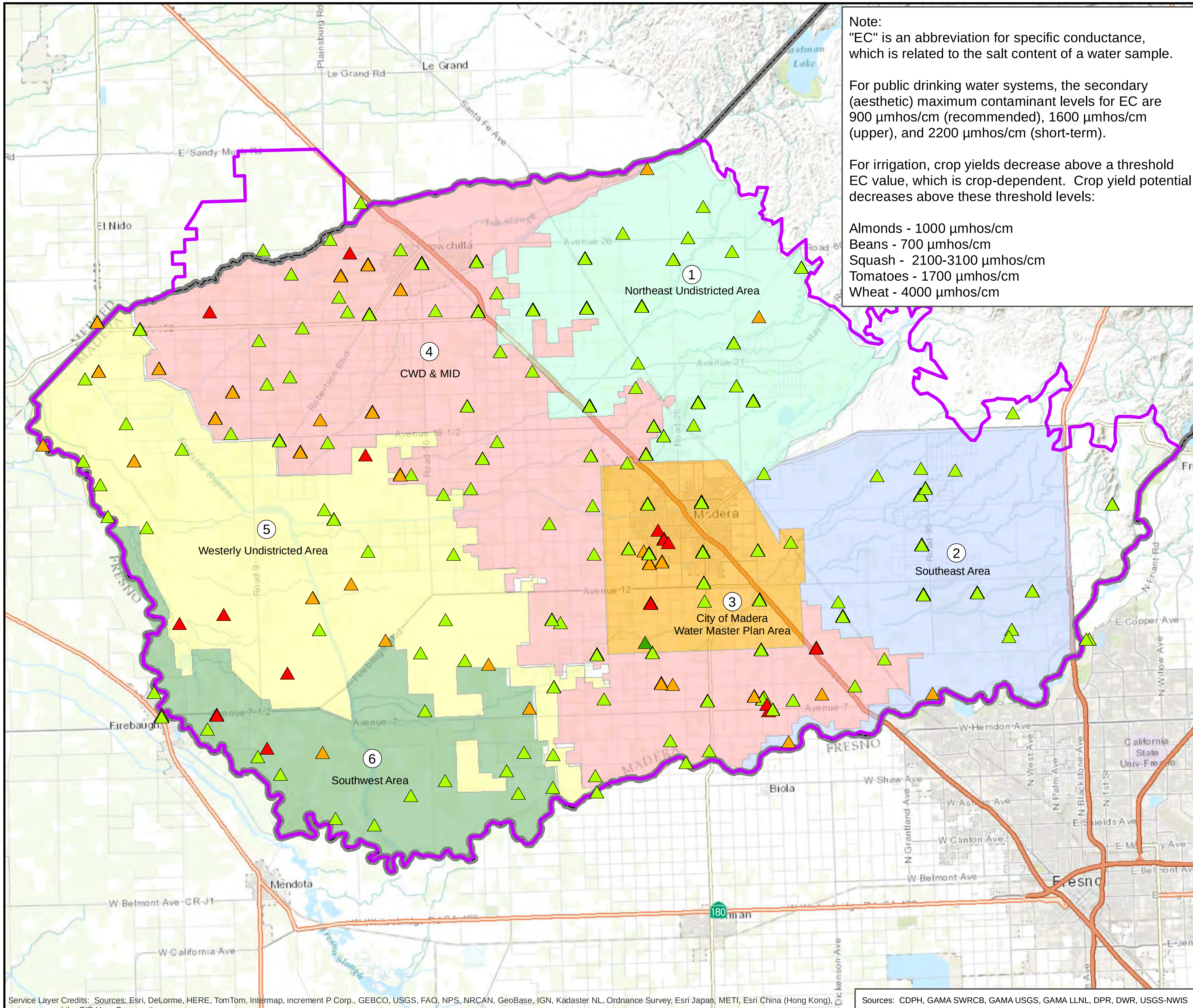
MAP OF SPECIFIC CONDUCTANCE IN WELLS OF UNKNOWN DEPTH

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014



NORTH

0 2 4
MILES

EC (µmhos/cm) in Other USGS GAMA Wells

- < 600
- 600 - 900
- 900 - 1600
- > 1600
- Groundwater Management Plan Boundary
- Madera County Boundary

Note: Well construction records were not available for these wells. Some wells may have screen perforations that connect two or more aquifers and may therefore represent composite water quality.

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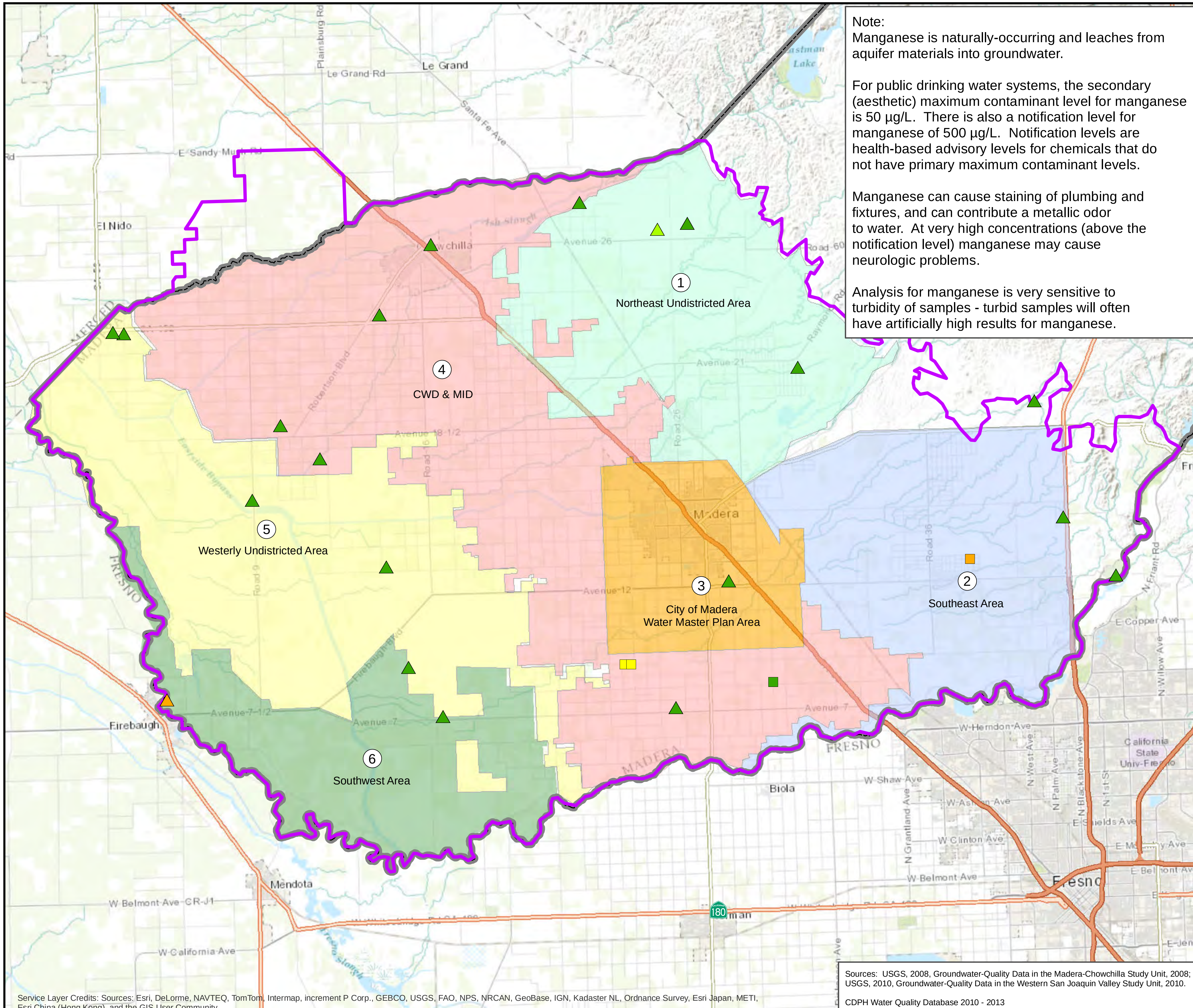

Note:
Manganese is naturally-occurring and leaches from aquifer materials into groundwater.

For public drinking water systems, the secondary (aesthetic) maximum contaminant level for manganese is 50 µg/L. There is also a notification level for manganese of 500 µg/L. Notification levels are health-based advisory levels for chemicals that do not have primary maximum contaminant levels.

Manganese can cause staining of plumbing and fixtures, and can contribute a metallic odor to water. At very high concentrations (above the notification level) manganese may cause neurologic problems.

Analysis for manganese is very sensitive to turbidity of samples - turbid samples will often have artificially high results for manganese.

Sources: USGS, 2008, Groundwater-Quality Data in the Madera-Chowchilla Study Unit, 2008; USGS, 2010, Groundwater-Quality Data in the Western San Joaquin Valley Study Unit, 2010.

CDPH Water Quality Database 2010 - 2013

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), and the GIS User Community

MAP OF MANGANESE CONCENTRATION IN SHALLOW WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014

NORTH

0 2 4
MILES

Manganese (µg/L) in City Wells < 400 feet
- < 25
- 25 - 50
- 50 - 150
- 150 - 500
- > 500

Manganese (µg/L) in County Wells < 400 feet
- < 25
- 25 - 50
- 50 - 150
- 150 - 500
- > 500

Manganese (µg/L) in USGS GAMA Wells < 400 feet
- < 25
- 25 - 50
- 50 - 150
- 150 - 500
- > 500

Groundwater Management Plan Boundary
Madera County Boundary

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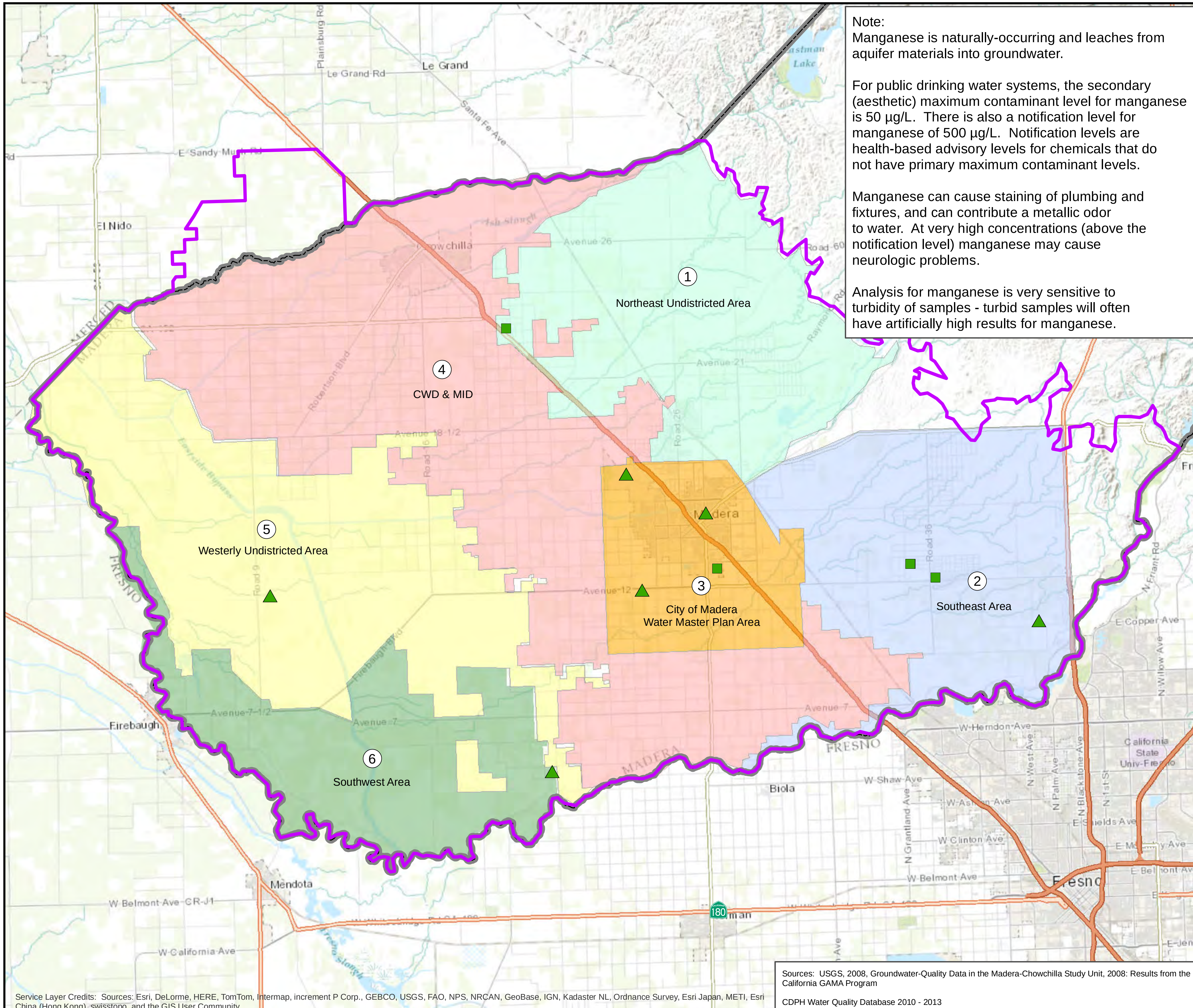
MAP OF MANGANESE CONCENTRATION IN INTERMEDIATE WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014



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Manganese can cause staining of plumbing and fixtures, and can contribute a metallic odor to water. At very high concentrations (above the notification level) manganese may cause neurologic problems.

Analysis for manganese is very sensitive to turbidity of samples - turbid samples will often have artificially high results for manganese.

Manganese (µg/L) in City Wells 400 - 600 feet

- < 25
- 25 - 50
- 50 - 150
- 150 - 500
- > 500

Manganese (µg/L) in County Wells 400 - 600 feet

- < 25
- 25 - 50
- 50 - 150
- 150 - 500
- > 500

Manganese (µg/L) in USGS GAMA Wells 400 - 600 feet

- < 25
- 25 - 50
- 50 - 150
- 150 - 500
- > 500

Groundwater Management Plan Boundary

Madera County Boundary

Note: All wells are classified by total well depth. Some wells may have screen perforations that begin shallower than the depth classification and therefore represent composite water quality across two or more aquifers.

Sources: USGS, 2008, Groundwater-Quality Data in the Madera-Chowchilla Study Unit, 2008: Results from the California GAMA Program

CDPH Water Quality Database 2010 - 2013

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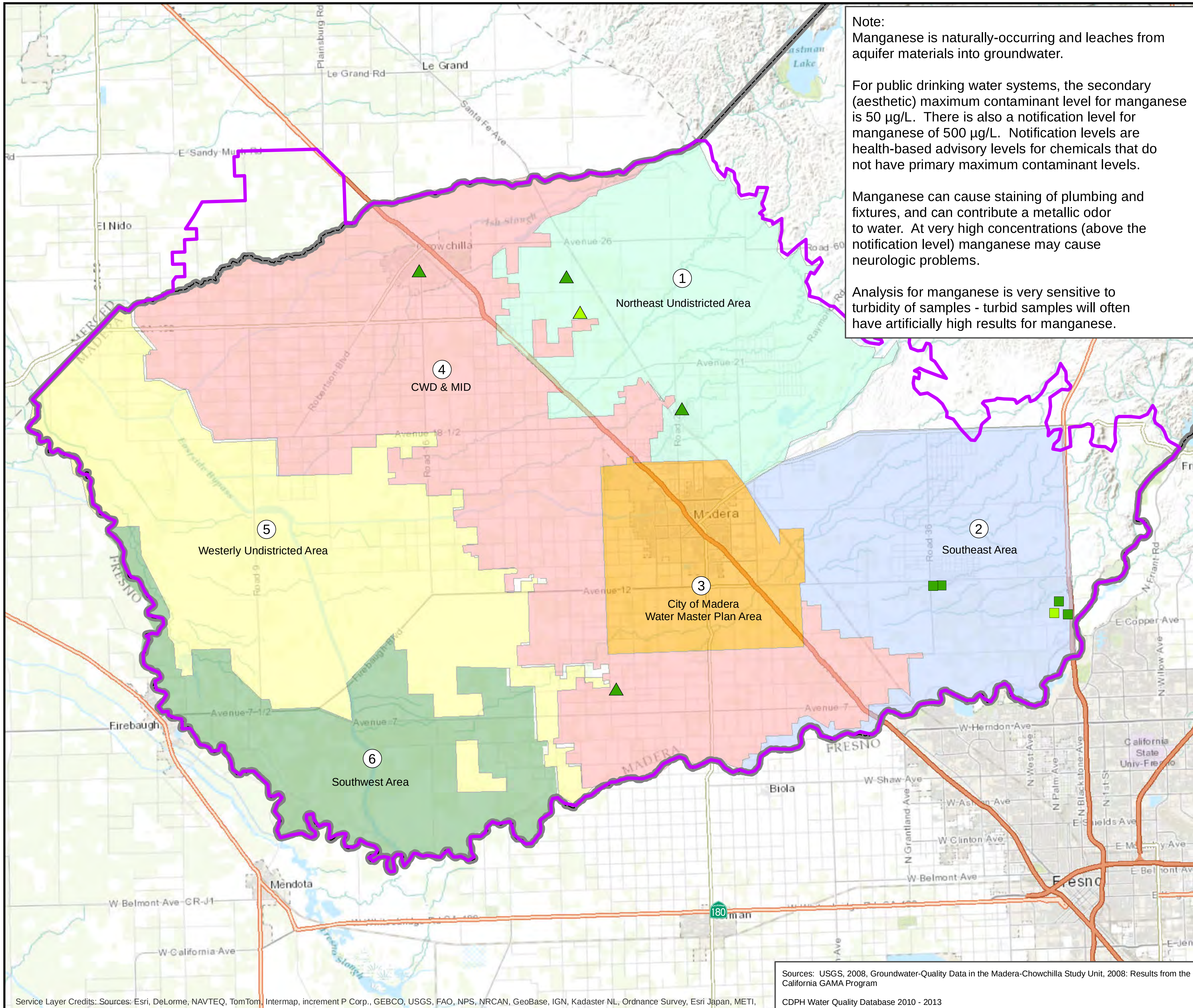
MAP OF MANGANESE CONCENTRATION IN DEEP WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014



Note:
Manganese is naturally-occurring and leaches from aquifer materials into groundwater.

For public drinking water systems, the secondary (aesthetic) maximum contaminant level for manganese is 50 µg/L. There is also a notification level for manganese of 500 µg/L. Notification levels are health-based advisory levels for chemicals that do not have primary maximum contaminant levels.

Manganese can cause staining of plumbing and fixtures, and can contribute a metallic odor to water. At very high concentrations (above the notification level) manganese may cause neurologic problems.

Analysis for manganese is very sensitive to turbidity of samples - turbid samples will often have artificially high results for manganese.

NORTH

0 2 4
MILES

Manganese (µg/L) in City Wells > 600 feet
- < 25
- 25 - 50
- 50 - 150
- 150 - 500
- > 500

Manganese (µg/L) in County Wells > 600 feet
- < 25
- 25 - 50
- 50 - 150
- 150 - 500
- > 500

Manganese (µg/L) in USGS GAMA Wells > 600 feet
- < 25
- 25 - 50
- 50 - 150
- 150 - 500
- > 500

Groundwater Management Plan Boundary
Madera County Boundary

Note: All wells are classified by total well depth. Some wells may have screen perforations that begin shallower than the depth classification and therefore represent composite water quality across two or more aquifers.

Sources: USGS, 2008, Groundwater-Quality Data in the Madera-Chowchilla Study Unit, 2008: Results from the California GAMA Program

CDPH Water Quality Database 2010 - 2013

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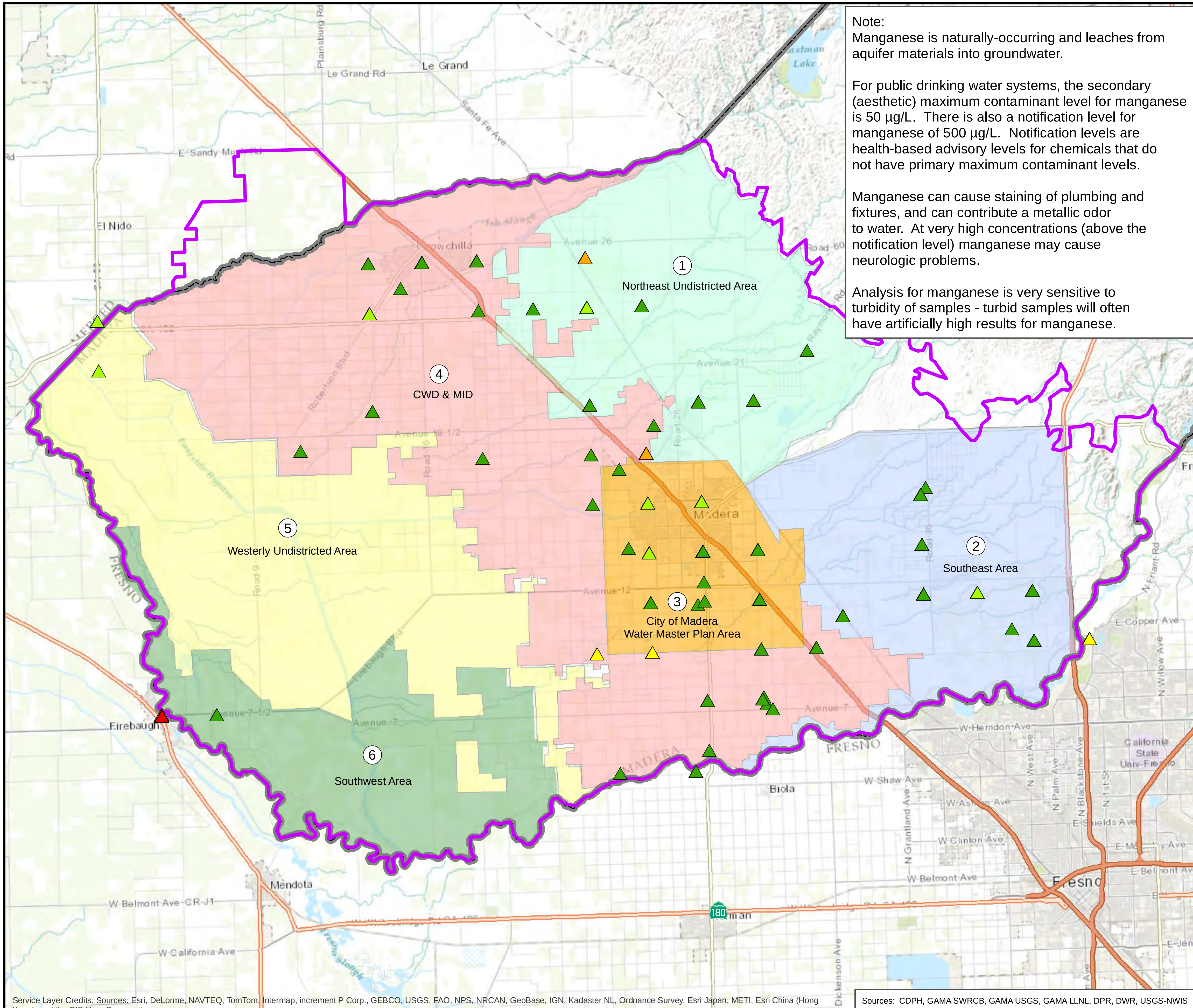

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Manganese is naturally-occurring and leaches from aquifer materials into groundwater.

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Manganese can cause staining of plumbing and fixtures, and can contribute a metallic odor to water. At very high concentrations (above the notification level) manganese may cause neurologic problems.

Analysis for manganese is very sensitive to turbidity of samples - turbid samples will often have artificially high results for manganese.

MAP OF MANGANESE CONCENTRATION IN WELLS OF UNKNOWN DEPTH

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014

NORTH

0 2 4
MILES

Manganese (µg/L) in Other USGS GAMA Wells

- < 25
- 25 - 50
- 50 - 150
- 150 - 500
- > 500
- Groundwater Management Plan Boundary
- Madera County Boundary

Note: Well construction records were not available for these wells. Some wells may have screen perforations that connect two or more aquifers and may therefore represent composite water quality.

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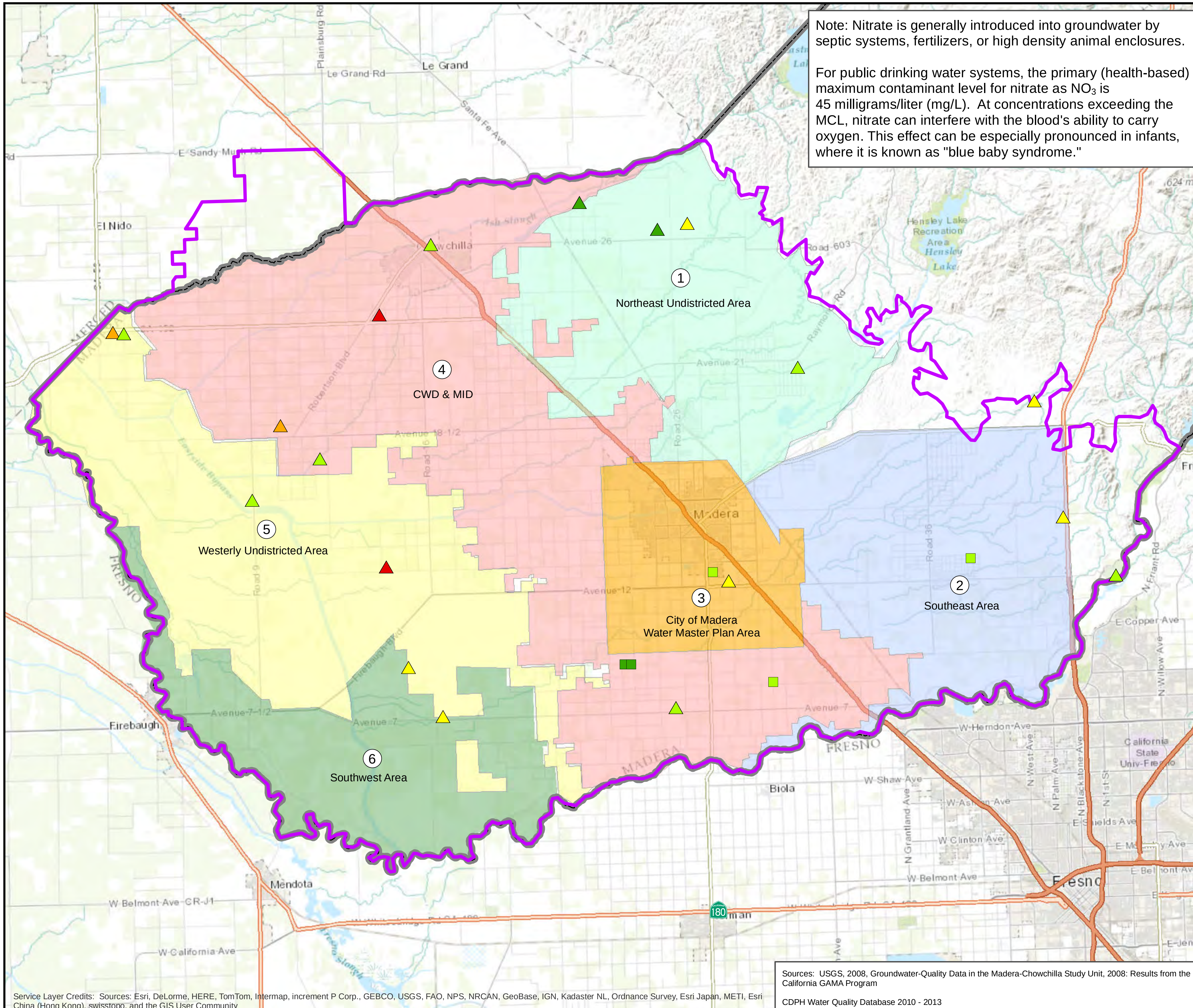
MAP OF NITRATE (AS NO_3) CONCENTRATION IN SHALLOW WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014

Note: Nitrate is generally introduced into groundwater by septic systems, fertilizers, or high density animal enclosures.

For public drinking water systems, the primary (health-based) maximum contaminant level for nitrate as NO_3 is 45 milligrams/liter (mg/L). At concentrations exceeding the MCL, nitrate can interfere with the blood's ability to carry oxygen. This effect can be especially pronounced in infants, where it is known as "blue baby syndrome."



Nitrate as NO3 (mg/L) in City Wells < 400 feet

- < 5
- 5 - 15
- 15 - 30
- 30 - 45
- > 45

Nitrate as NO3 (mg/L) in County Wells < 400 feet

- < 5
- 5 - 15
- 15 - 30
- 30 - 45
- > 45

Nitrate as NO3 (mg/L) in USGS GAMA Wells < 400 feet

- < 5
- 5 - 15
- 15 - 30
- 30 - 45
- > 45

Groundwater Management Plan Boundary

Madera County Boundary

Sources: USGS, 2008, Groundwater-Quality Data in the Madera-Chowchilla Study Unit, 2008: Results from the California GAMA Program

CDPH Water Quality Database 2010 - 2013

Service Layer Credits: Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

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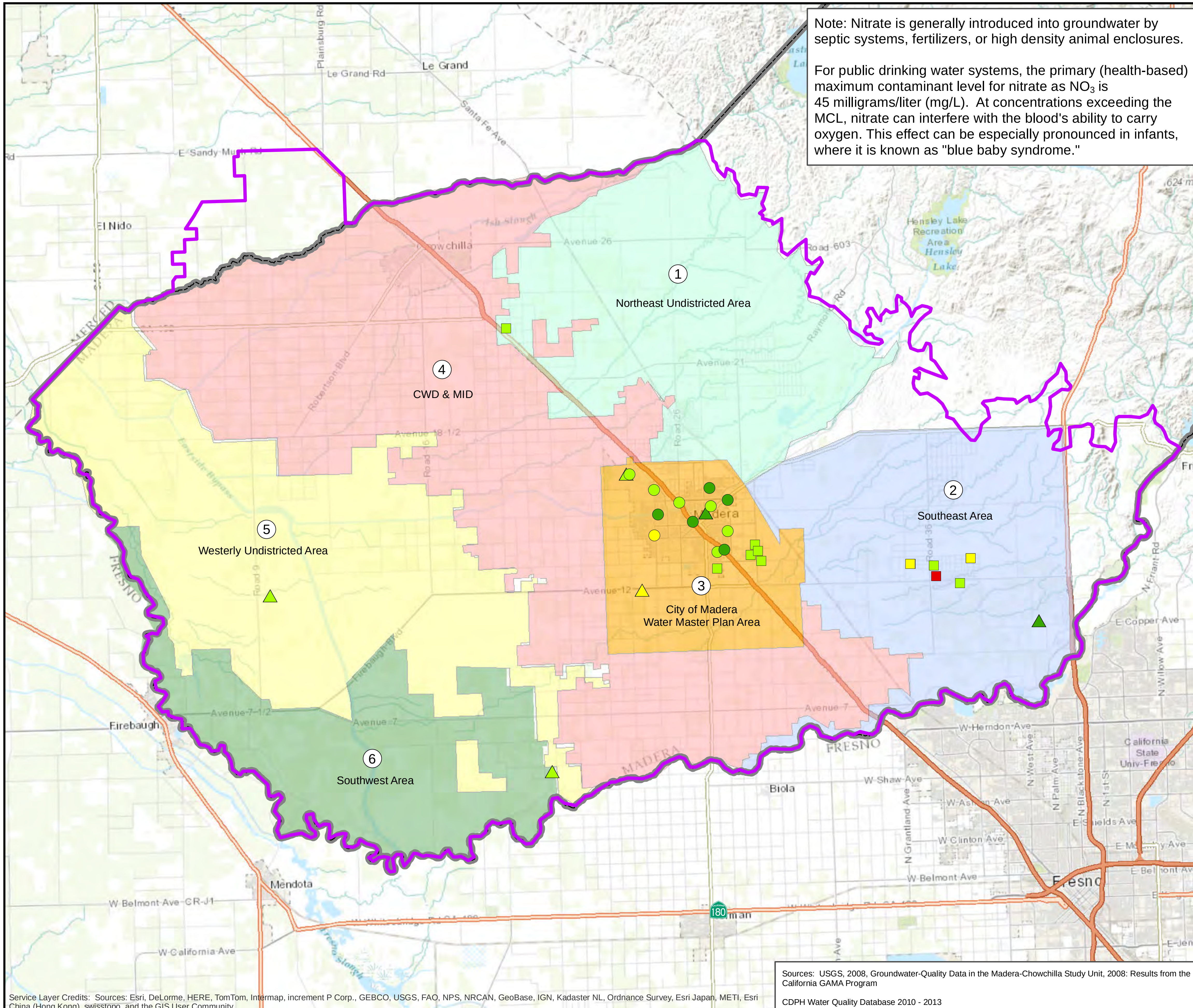

Note: Nitrate is generally introduced into groundwater by septic systems, fertilizers, or high density animal enclosures.

For public drinking water systems, the primary (health-based) maximum contaminant level for nitrate as NO_3 is 45 milligrams/liter (mg/L). At concentrations exceeding the MCL, nitrate can interfere with the blood's ability to carry oxygen. This effect can be especially pronounced in infants, where it is known as "blue baby syndrome."

MAP OF NITRATE (AS NO_3) CONCENTRATION IN INTERMEDIATE WELLS

MADERA REGIONAL GROUNDWATER MANAGEMENT PLAN
APRIL 2014

NORTH

0 2 4
MILES

Nitrate as NO_3 (mg/L) in City Wells 400-600 feet

- < 5
- 5 - 15
- 15 - 30
- 30 - 45
- > 45

Nitrate as NO_3 (mg/L) in County Wells 400-600 feet

- < 5
- 5 - 15
- 15 - 30
- 30 - 45
- > 45

Nitrate as NO_3 (mg/L) in USGS GAMA Wells 400-600 feet

- < 5
- 5 - 15
- 15 - 30
- 30 - 45
- > 45

Groundwater Management Plan Boundary

Madera County Boundary

Note: All wells are classified by total well depth. Some wells may have screen perforations that begin shallower than the depth classification and therefore represent composite water quality across two or more aquifers.

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Sources: USGS, 2008, Groundwater-Quality Data in the Madera-Chowchilla Study Unit, 2008: Results from the California GAMA Program

CDPH Water Quality Database 2010 - 2013

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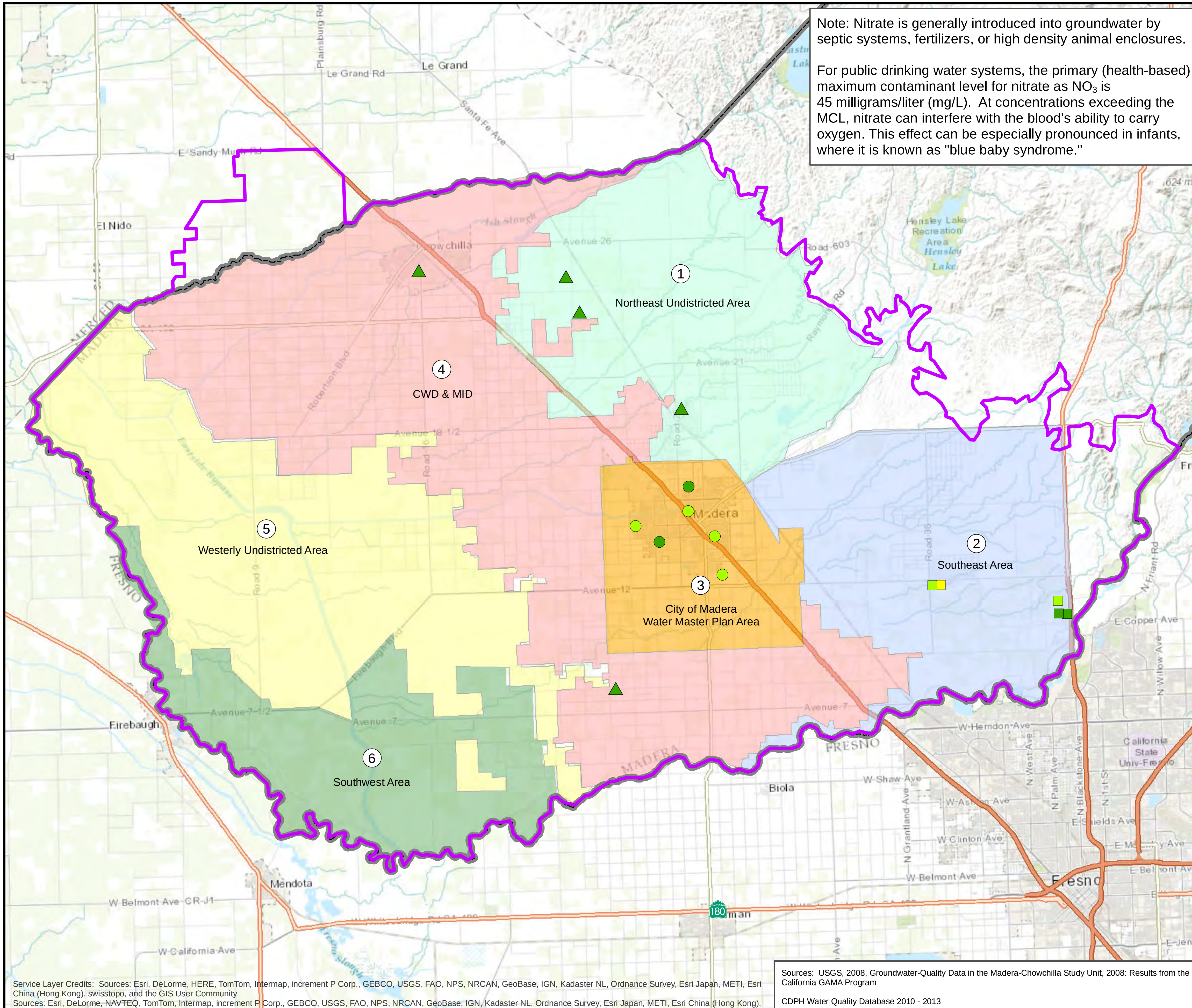
MAP OF NITRATE (AS NO_3) CONCENTRATION IN DEEP WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014



Note: Nitrate is generally introduced into groundwater by septic systems, fertilizers, or high density animal enclosures.

For public drinking water systems, the primary (health-based) maximum contaminant level for nitrate as NO_3 is 45 milligrams/liter (mg/L). At concentrations exceeding the MCL, nitrate can interfere with the blood's ability to carry oxygen. This effect can be especially pronounced in infants, where it is known as "blue baby syndrome."

Sources: USGS, 2008, Groundwater-Quality Data in the Madera-Chowchilla Study Unit, 2008: Results from the California GAMA Program

CDPH Water Quality Database 2010 - 2013

Service Layer Credits: Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community
Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), and the GIS User Community

NORTH

0 2 4
MILES

Nitrate as NO_3 (mg/L) in City Wells > 600 feet

- < 5
- 5 - 15
- 15 - 30
- 30 - 45
- > 45

Nitrate as NO_3 (mg/L) in County Wells > 600 feet

- < 5
- 5 - 15
- 15 - 30
- 30 - 45
- > 45

Nitrate as NO_3 (mg/L) in USGS GAMA Wells > 600 feet

- < 5
- 5 - 15
- 15 - 30
- 30 - 45
- > 45

Groundwater Management Plan Boundary

Madera County Boundary

Note: All wells are classified by total well depth. Some wells may have screen perforations that begin shallower than the depth classification and therefore represent composite water quality across two or more aquifers.

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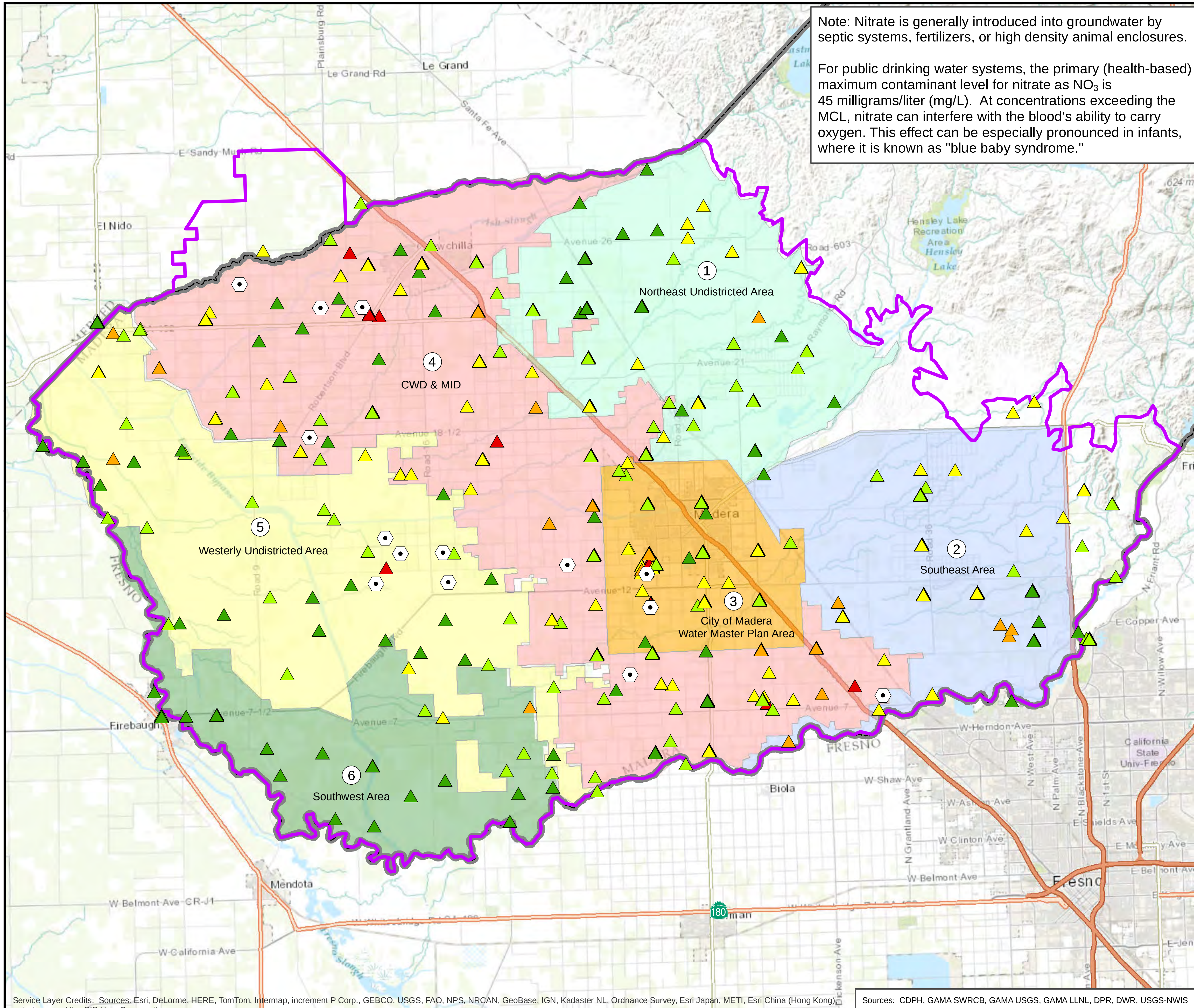
MAP OF NITRATE (AS NO_3) CONCENTRATION IN WELLS OF UNKNOWN DEPTH

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014

Note: Nitrate is generally introduced into groundwater by septic systems, fertilizers, or high density animal enclosures.

For public drinking water systems, the primary (health-based) maximum contaminant level for nitrate as NO_3 is 45 milligrams/liter (mg/L). At concentrations exceeding the MCL, nitrate can interfere with the blood's ability to carry oxygen. This effect can be especially pronounced in infants, where it is known as "blue baby syndrome."



NORTH

0 2 4
MILES

Land-Use that may contribute to Nitrate contamination

Nitrate as NO_3 (mg/L) in Other USGS GAMA Wells

- < 5
- 5 - 15
- 15 - 30
- 30 - 45
- > 45

Groundwater Management Plan Boundary

Madera County Boundary

Note: Well construction records were not available for these wells. Some wells may have screen perforations that connect two or more aquifers and may therefore represent composite water quality.

Service Layer Credits: Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

Sources: CDPH, GAMA SWRCB, GAMA USGS, GAMA LLNL, DPR, DWR, USGS-NWIS

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APPENDIX 2.F. WATER BUDGET INFORMATION

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020

GSP Team:

Davids Engineering, Inc
Luhdorff & Scalmanini
ERA Economics
Stillwater Sciences and
California State University, Sacramento

2.F. Water Budget Information

2.F.a. Surface Water System Water Budget: Chowchilla Water District GSA

2.F.b. Surface Water System Water Budget: Madera County East GSA

2.F.c. Surface Water System Water Budget: Madera County West GSA

2.F.d. Surface Water System Water Budget: Sierra Vista Mutual Water Company

2.F.e. Surface Water System Water Budget: Triangle T Water District GSA

2.F.f. Daily Reference Evapotranspiration and Precipitation Quality Control

2.F.g. Development of Daily Time Step IDC Root Zone Water Budget Model

APPENDIX 2.F. WATER BUDGET INFORMATION

2.F.a. Surface Water System Water Budget: Chowchilla Water District GSA

Prepared as part of the

Groundwater Sustainability Plan
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January 2020

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Davids Engineering, Inc
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TABLE OF CONTENTS

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1 INTRODUCTION

To ensure sustainable groundwater management throughout California's groundwater basins, the Sustainable Groundwater Management Act of 2014 (SGMA) requires Groundwater Sustainability Agencies (GSAs) to prepare and adopt Groundwater Sustainability Plans (GSPs) with strategies to achieve subbasin groundwater sustainability within 20 years of plan adoption. Integral to each GSP is a water budget used to quantify the subbasin's groundwater overdraft (if applicable) and sustainable yield.

In 2016, Chowchilla Water District (CWD) GSA formed to manage approximately 85,200 acres of the Chowchilla Subbasin. This document presents results of the surface water system (SWS) water budgets developed for historical and current land use conditions in CWD GSA. The CWD GSA water budgets were integrated with separate water budgets developed for four (4) other subregions of the Chowchilla Subbasin representing the three (3) other subbasin GSAs. Together, these water budgets provide the boundary water budget for the Chowchilla Subbasin SWS. Results of the subbasin boundary water budget are reported in the Chowchilla Subbasin GSP Section 2.2.3 and were integrated with a subbasin groundwater model (GSP Appendix 6.E) to estimate subbasin sustainable yield (GSP Section 2.2.3).

2 WATER BUDGET CONCEPTUAL MODEL

A water budget is defined as a complete accounting of all water flowing into and out of a defined volume (e.g., a subbasin or a GSA) over a specified period of time. The conceptual model (or structure) of the CWD GSA water budget developed for this investigation is consistent with the GSP Regulations defined under Title 23 of California Code of Regulations[1] (CCR) and adheres to sound water budget principles and practices defined by California Department of Water Resources (DWR) in the Water Budget Best Management Practice (BMP) guidelines (DWR, 2016).

The lateral extent of CWD GSA is defined by the boundaries indicated in Figure A2.F.a-1. The vertical extent of CWD GSA is the land surface (top) and the base of fresh water at the bottom of the basin (bottom), as described in the hydrogeologic conceptual model (HCM) developed in GSP Section 2.2.1. The vertical extent of Chowchilla Subbasin and its GSAs is subdivided into a surface water system (SWS) and the underlying groundwater system (GWS), with separate but related water budgets prepared for each that together represent the overall subbasin water budget.

A conceptual representation of the CWD GSA water budget is represented in Figure A2-F.a-2. This document details only the SWS portion of the CWD GSA water budget. The SWS is divided into three primary accounting centers: the Land Surface System, the Rivers and Streams System, and the Canal System. The Land Surface System is further divided into four accounting centers representing CWD GSA's water use sectors: Agricultural Land, Native Vegetation Land, and Urban Land (urban, semi-agricultural, and industrial), and Managed Recharge Land.

[1] California Code of Regulations Title 23. Waters, Division 2. Department of Water Resources, Chapter 1.5. Groundwater Management, Subchapter 2. Groundwater Sustainability Plans.

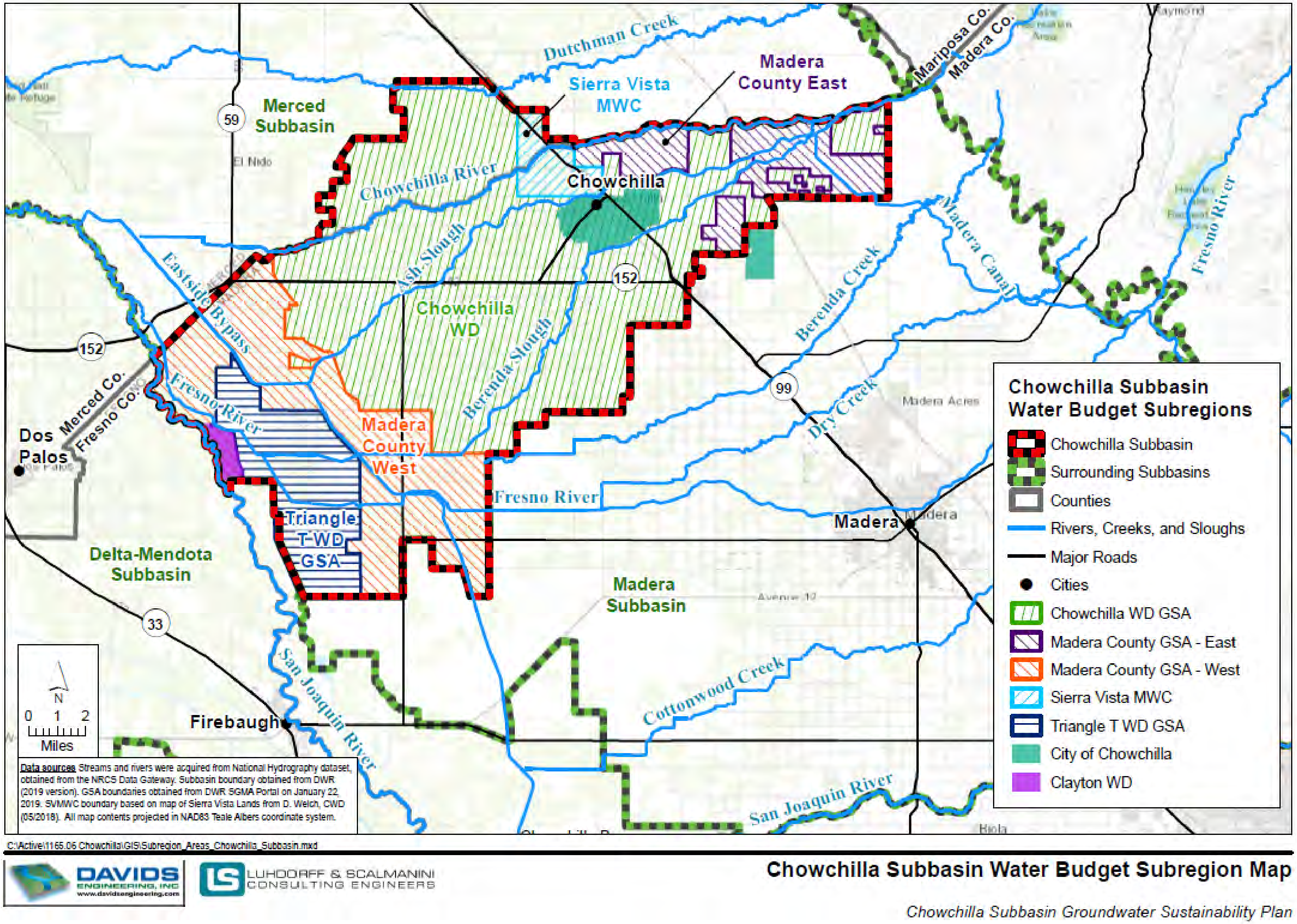

Figure A2.F.a-1. Chowchilla Subbasin Water Budget Subregion Map

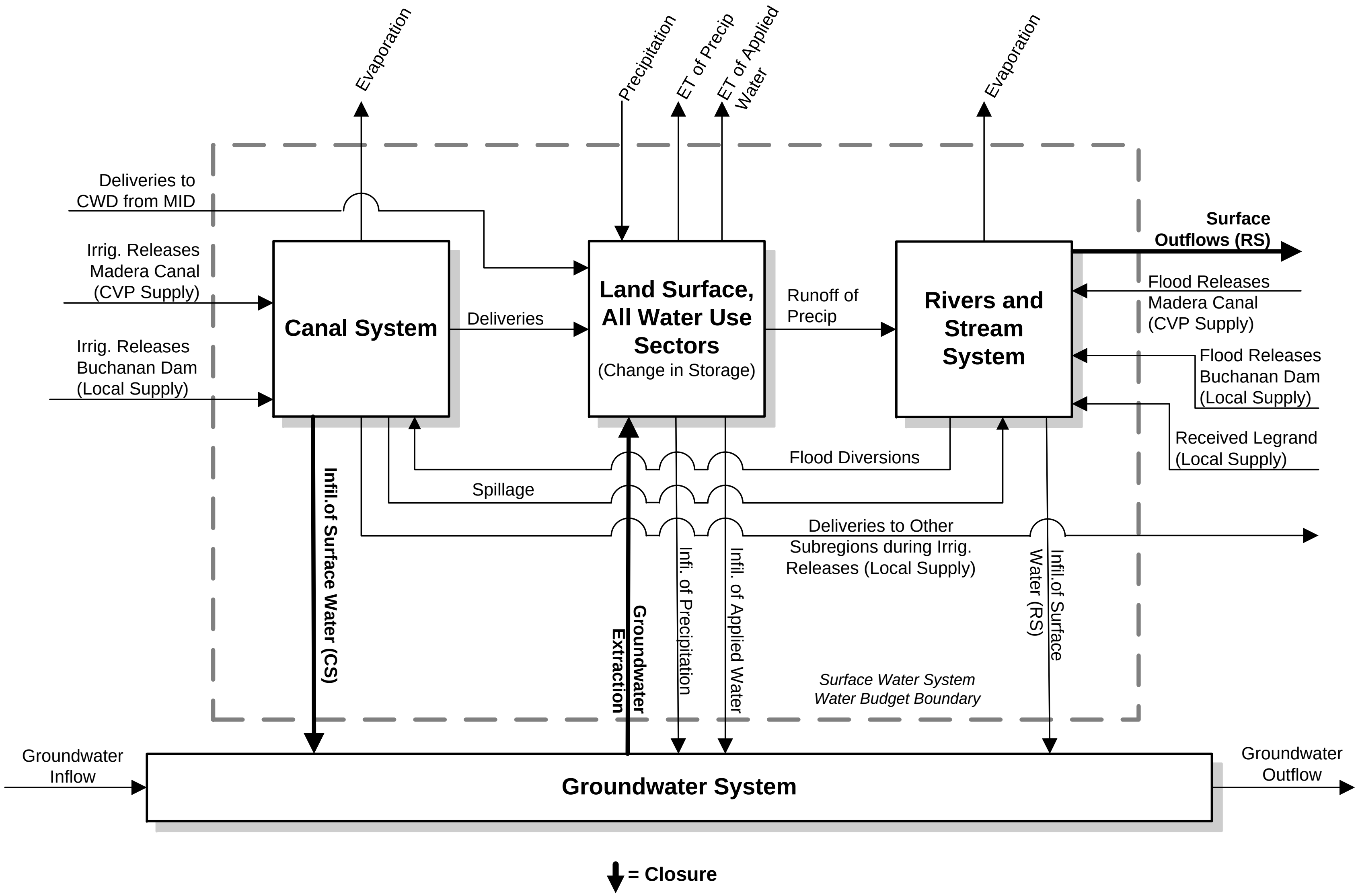

Figure A2.F.a-2. Chowchilla Water District GSA Water Budget Structure

Water budget components, or directional flow of water between accounting centers and across the SWS boundary, are indicated by arrows. Inflows and outflows were calculated using measurements and other historical data or were calculated as the water budget closure term – the difference between all other estimated or measured inflows and outflows from each accounting center or water use sector (bold arrows).

Inflows to the SWS include precipitation, surface water inflows (in various canals, rivers, and streams), and groundwater extraction. Outflows from the SWS include evapotranspiration (ET), surface water outflows (in various canals and streams), and infiltration to the groundwater system (seepage and deep percolation). Also represented in Figure A2.F.a-2 are inflows and outflows from the GWS, which are discussed and quantified at the subbasin level in the GWS water budget in GSP Section 2.2.3. Subsurface GWS inflows and outflows are not quantified on the water budget subregion scale.

Inflows and outflows were quantified following the process described in GSP Section 2.2.3 on a monthly time step for water years in the historical water budget base period (1989-2014 hydrologic and land use conditions), the current water budget (2015 land use using 1989-2014 average hydrologic conditions), and projected water budget. Four projected water budgets were prepared for the years 2019 through 2090 based on 1965 through 2015 hydrologic conditions, projected water supplies, and 2017 land use adjusted for urban area projected growth from 2017-2070 (areas were held constant from 2071-2090):

1. Historical hydrologic conditions and water supply data, with adjustment for projected alteration of available Friant releases by the San Joaquin River Restoration Program (SJRRP)[2]
    a. Without projects and management actions, and
    b. With projects and management actions
2. Historical hydrologic conditions and water supply data, with adjustment for projected alteration of available Friant releases by the SJRRP and adjustment for anticipated climate change per DWR-provided 2030 climate change factors
    a. Without projects and management actions, and
    b. With projects and management actions.

Information regarding the data sources and adjustments used to prepare the historical, current, and projected water budgets are described in GSP Section 2.2.3.

3 WATER BUDGET ANALYSIS

The historical water budget and current land use water budget for CWD GSA are presented below following a summary of land use data relevant to water budget development. Land use data is provided for the 1989-2014 historical water budget period and for 2015, the current land use water budget period.

[2] Adjustments were based on the Friant Report ("Estimate of Future Friant Division Supplies for use in Groundwater Sustainability Plans, California," Friant Water Authority, 2018). Although the Friant Report accounts for climate change, it is considered the best available estimate of projected Friant releases under SJRRP. For comparison, projected Madera Canal deliveries under SJRRP were also estimated without account for climate change from the Kondolf Hydrographs (in "Effects to Water Supply and Friant Operations Resulting From Plaintiffs' Friant Release Requirements," Steiner, 2005). These estimates were approximately equal to the Friant Report 2030 climate change adjusted deliveries. Thus, the Friant Report projections were used instead to maintain consistent assumptions in estimating Madera Canal deliveries across all projected simulations.

3.1 Land Use

Land use estimates for 1989 through 2015 corresponding to water use sectors (as defined by the GSP Regulations) are summarized in Figure A2.F.a-3 and Table A2.F.a-1 for the CWD GSA. According to GSP Regulations (23 CCR § 351(al)):

> *"Water use sector" refers to categories of water demand based on the general land uses to which the water is applied, including urban, industrial, agricultural, managed wetlands, managed recharge, and native vegetation.*

In CWD GSA, water use sectors include agricultural, native vegetation, urban, and managed recharge land use. The urban land use category includes urban and semi-agricultural[3] lands as well as industrial land, which covers only a small area in the subbasin. In CWD GSA, the managed recharge water use sector represents a portion of agricultural lands that receive flood water for recharge during non-irrigation season months. As no land in the GSA is purposed exclusively for managed recharge, managed recharge acreage is not summarized below.

As indicated, the majority of land in CWD GSA is used for agriculture, covering an average of approximately 73,100 acres between 1989 and 2014. Agricultural acreage has gradually been reduced over time with the expansion of urban lands from 4,400 acres in 1989 to over 9,000 acres in 2015.

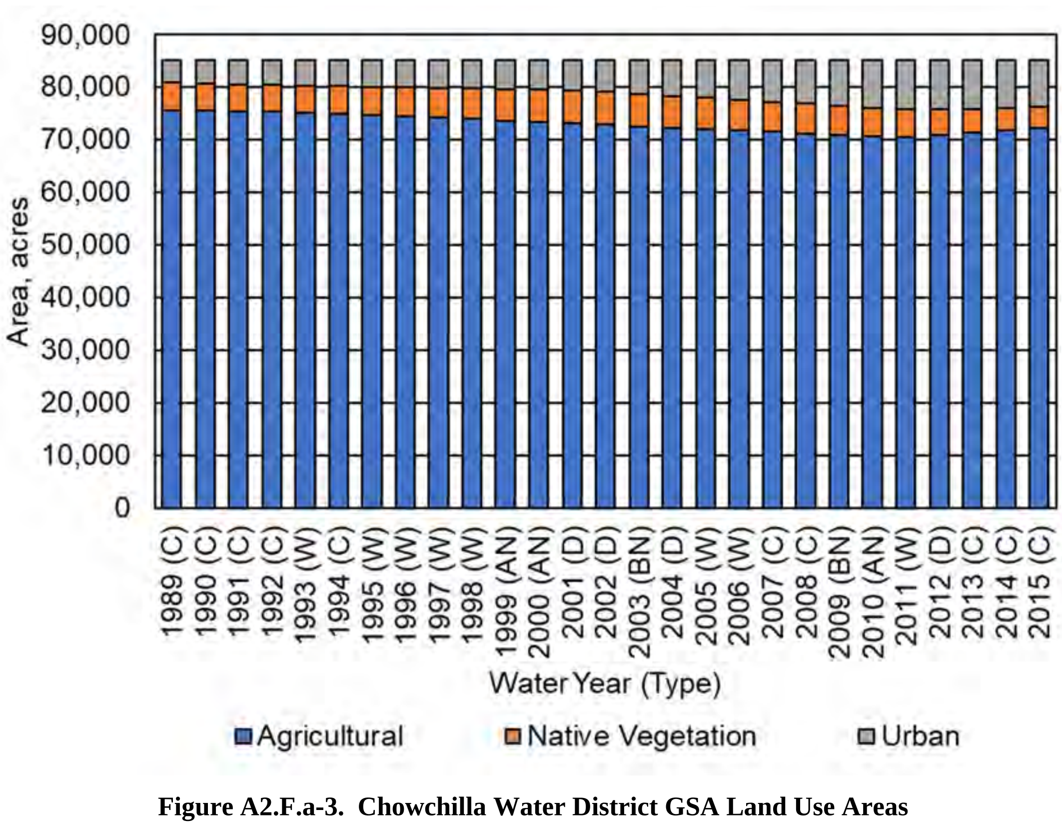

Figure A2.F.a-3. Chowchilla Water District GSA Land Use Areas

[3] As defined in the DWR county land use surveys, semi-agricultural land use subclasses include farmsteads, livestock feed lot operations, dairies, poultry farms, and miscellaneous semi-agricultural land use incidental to agriculture (small roads, ditches, non-planted areas of cropped fields (DWR, 2009).

Table A2.F.a-1. Chowchilla Water District GSA Land Use Areas, acres

Water Year (Type)	Agricultural	Native Vegetation[1]	Urban[2]	Total
1989 (C)	75,658	5,175	4,396	85,229
1990 (C)	75,524	5,193	4,513	85,229
1991 (C)	75,400	5,189	4,640	85,229
1992 (C)	75,267	5,185	4,778	85,229
1993 (W)	75,148	5,163	4,918	85,229
1994 (C)	74,980	5,190	5,060	85,229
1995 (W)	74,769	5,257	5,203	85,229
1996 (W)	74,494	5,429	5,306	85,229
1997 (W)	74,218	5,602	5,409	85,229
1998 (W)	73,942	5,774	5,512	85,229
1999 (AN)	73,667	5,947	5,615	85,229
2000 (AN)	73,392	6,119	5,718	85,229
2001 (D)	73,116	6,292	5,821	85,229
2002 (D)	72,843	6,233	6,153	85,229
2003 (BN)	72,571	6,132	6,526	85,229
2004 (D)	72,299	6,032	6,898	85,229
2005 (W)	72,026	5,932	7,271	85,229
2006 (W)	71,754	5,832	7,643	85,229
2007 (C)	71,482	5,731	8,016	85,229
2008 (C)	71,210	5,631	8,388	85,229
2009 (BN)	70,938	5,531	8,761	85,229
2010 (AN)	70,665	5,431	9,133	85,229
2011 (W)	70,393	5,330	9,505	85,229
2012 (D)	70,832	4,932	9,466	85,229
2013 (C)	71,293	4,560	9,377	85,229
2014 (C)	71,752	4,189	9,287	85,229
2015 (C)	72,332	3,836	9,061	85,229
Average (1989-2014)	73,063	5,501	6,666	85,229

[1] Area includes land classified as native vegetation and water surfaces.
[2] Area includes land classified as urban, industrial, and semi-agricultural.

Agricultural land uses are further detailed in Figure A2.F.a-4 and Table A2.F.a-2. Historically, a majority of the agricultural area in CWD has been used to cultivate orchard crops, mixed pasture, alfalfa, and corn. While mixed pasture and alfalfa acreage has decreased since the early 1990s, orchard acreage more than doubled between 1989 and 2015.

3.2 Surface Water System Water Budget

This section presents surface water system water budget components within CWD GSA as per GSP regulations. These are followed by a summary of the water budget results by accounting center.

3.2.1 Inflows

3.2.1.1 Surface Water Inflow by Water Source Type

Surface water inflows include surface water flowing into CWD across the subregion boundary. Per the Regulations, surface inflows must be reported by water source type. According to the Regulations:

> *"Water source type" represents the source from which water is derived to meet the applied beneficial uses, including groundwater, recycled water, reused water, and surface water sources identified as Central Valley Project, the State Water Project, the Colorado River Project, local supplies, and local imported supplies.*

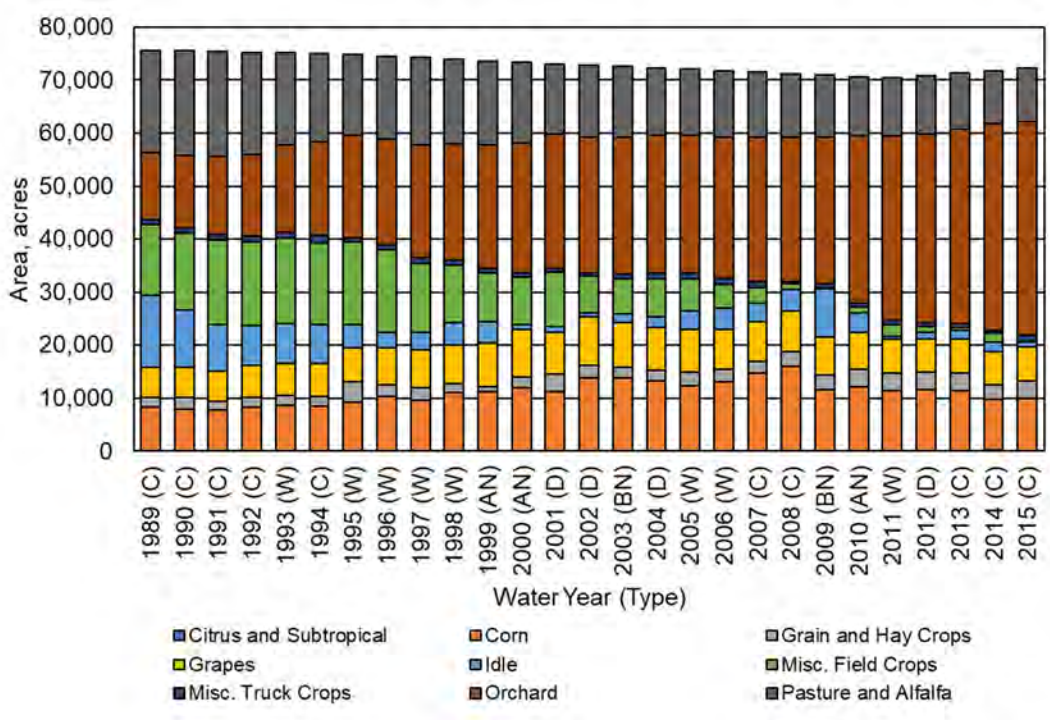

Figure A2.F.a-4. Chowchilla Water District GSA Agricultural Land Use Areas

Table A2.F.a-2. Chowchilla Water District GSA Agricultural Land Use Areas

Water Year (Type)	Citrus and Subtropical	Corn	Grain and Hay Crops	Grapes	Idle	Misc. Field Crops	Misc. Truck Crops	Orchard	Pasture and Alfalfa	Total
1989 (C)	29	8,340	1,718	5,773	13,578	13,369	807	12,801	19,243	75,658
1990 (C)	29	7,971	2,116	5,755	10,797	14,398	976	13,733	19,749	75,524
1991 (C)	31	7,695	1,645	5,781	8,643	16,127	1,015	14,699	19,763	75,400
1992 (C)	30	8,264	1,897	6,009	7,571	15,691	1,121	15,360	19,324	75,267
1993 (W)	29	8,638	1,842	6,071	7,451	16,102	1,243	16,438	17,335	75,148
1994 (C)	27	8,496	1,749	6,315	7,313	15,324	1,613	17,542	16,601	74,980
1995 (W)	25	9,184	3,836	6,393	4,515	15,565	664	19,472	15,114	74,769
1996 (W)	67	10,231	2,262	6,858	3,012	15,548	950	19,993	15,574	74,494
1997 (W)	73	9,451	2,343	7,259	3,278	12,968	1,132	21,222	16,493	74,218
1998 (W)	19	10,992	1,587	7,395	4,248	10,785	895	22,117	15,904	73,942
1999 (AN)	7	11,231	914	8,167	4,069	9,174	1,013	23,222	15,871	73,667
2000 (AN)	35	11,877	2,136	8,891	888	9,109	736	24,565	15,154	73,392
2001 (D)	14	11,167	3,319	7,945	1,140	10,177	716	25,301	13,336	73,116
2002 (D)	40	13,678	2,504	9,038	798	6,901	680	25,718	13,484	72,843
2003 (BN)	12	13,770	1,994	8,407	1,676	6,687	783	25,983	13,257	72,571
2004 (D)	10	13,199	2,083	8,082	1,961	7,226	1,068	25,931	12,739	72,299
2005 (W)	10	12,353	2,565	7,970	3,467	6,115	1,139	25,952	12,455	72,026
2006 (W)	9	12,980	2,502	7,417	4,072	4,403	1,289	26,674	12,409	71,754
2007 (C)	8	14,745	2,228	7,475	3,388	2,980	1,202	27,305	12,152	71,482
2008 (C)	6	16,021	2,763	7,608	4,158	941	367	27,484	11,861	71,210
2009 (BN)	5	11,664	2,583	7,172	9,200	276	622	27,792	11,624	70,938
2010 (AN)	4	12,130	3,345	6,862	3,648	1,210	646	31,537	11,283	70,665
2011 (W)	6	11,393	3,376	6,294	604	2,246	657	34,880	10,938	70,393
2012 (D)	34	11,596	3,237	6,263	1,188	1,267	674	35,520	11,052	70,832
2013 (C)	58	11,346	3,394	6,238	1,781	482	741	36,727	10,527	71,293
2014 (C)	172	9,520	2,849	6,213	1,864	1,546	648	38,973	9,967	71,752
2015 (C)	112	9,803	3,387	6,295	909	239	1,108	40,279	10,199	72,332
Average (1989-2014)	30	11,074	2,415	7,063	4,397	8,331	900	24,498	14,354	73,063

Additionally, runoff of precipitation from upgradient areas adjacent to the subregion represents a potential source of surface water inflow.

Local Supplies

Local supplies to CWD GSA include water received from Legrand Dam. Local supplies to SVMWC, which include pre-1914, riparian, and prescriptive water rights deliveries, also pass through CWD along Chowchilla River.

CVP Supplies

CVP supplies to CWD GSA include irrigation releases and flood releases from Buchanan Dam along the Chowchilla River and from Millerton Reservoir along Madera Canal. Both irrigation and flood releases from Millerton Reservoir are diverted to CWD at Madera Canal Miles 33.6 and 35.6. Irrigation releases are accounted as inflows to the water budget Canal System, while flood releases are accounted as inflows to the Rivers and Stream System.

Recycling and Reuse

Recycling and reuse are not a significant source of supply within CWD.

Other Surface Inflows

For the water budgets presented herein, precipitation runoff from outside the subregion is considered relatively minimal and is expected to pass through the waterways accounted above following relatively large storm events. Precipitation runoff from lands inside the subregion is internal to the surface water system and is thus not considered as surface inflows to the subregion boundary.

Summary of Surface Inflows

The surface water inflows described above are summarized by water source type in Figure A2.F.a-5 and Table A2.F.a-3. During the study period, total surface inflows vary by water year type, averaging 256 taf during wet years and 73 taf during critical years.

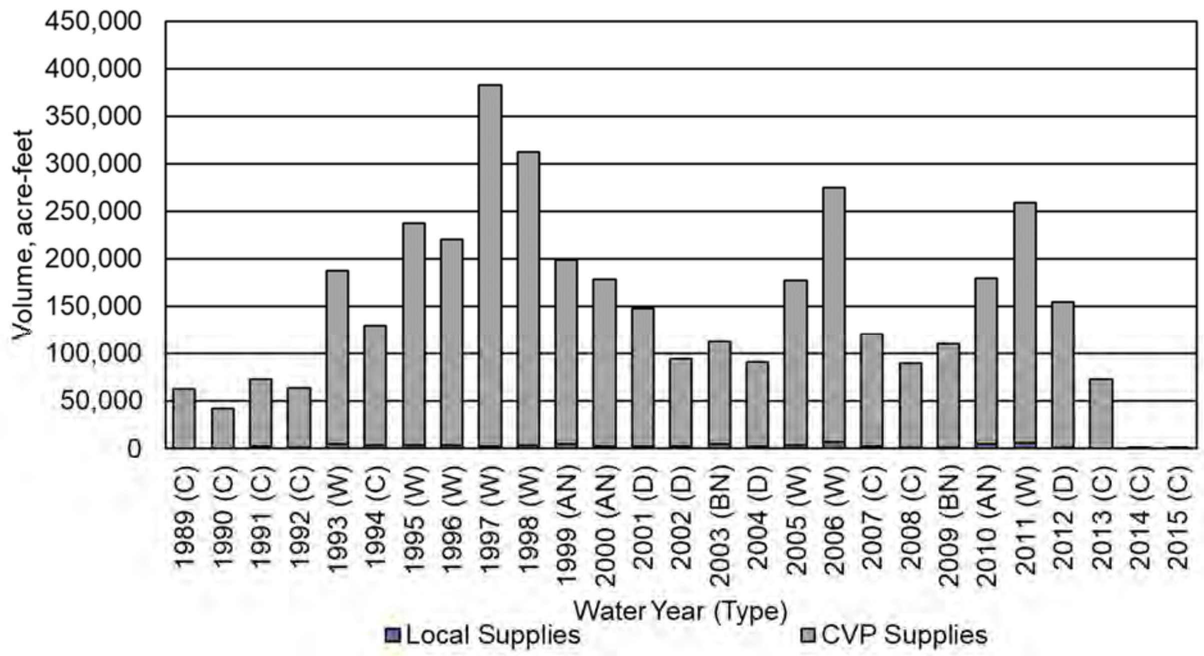

Figure A2.F.a-5. Chowchilla Water District GSA Surface Water Inflows by Water Source Type.

Table A2.F.a-3. Chowchilla Water District GSA Surface Water Inflows by Water Source Type (Acre-Feet).

Water Year (Type)	Local Supply	CVP Supply[1]	Total
1989 (C)	0	62,620	62,620
1990 (C)	0	42,270	42,270
1991 (C)	2,270	71,070	73,340
1992 (C)	1,650	62,570	64,220
1993 (W)	4,320	183,200	187,520
1994 (C)	3,550	126,060	129,610
1995 (W)	3,890	232,970	236,860
1996 (W)	3,680	217,160	220,840
1997 (W)	2,330	380,110	382,440
1998 (W)	3,360	309,450	312,810
1999 (AN)	4,850	194,270	199,120
2000 (AN)	2,600	176,300	178,890
2001 (D)	2,460	145,830	148,280
2002 (D)	2,760	91,120	93,880
2003 (BN)	5,030	107,190	112,220
2004 (D)	2,970	88,490	91,450
2005 (W)	3,570	173,440	177,010
2006 (W)	6,540	267,870	274,410
2007 (C)	2,070	118,440	120,510
2008 (C)	1,680	87,840	89,520

Water Year (Type)	Local Supply	CVP Supply[1]	Total
2009 (BN)	1,590	109,170	110,760
2010 (AN)	5,210	174,400	179,610
2011 (W)	5,730	253,280	259,000
2012 (D)	1,370	152,750	154,120
2013 (C)	80	72,990	73,070
2014 (C)	0	440	440
2015 (C)	0	530	530
Average (1989-2014)	2,830	150,050	152,880
Average (1989-2014) W	4,180	252,180	256,360
Average (1989-2014) AN	4,220	181,660	185,870
Average (1989-2014) BN	3,310	108,180	111,490
Average (1989-2014) D	2,390	119,540	121,930
Average (1989-2014) C	1,260	71,590	72,850

[1.] CVP Supply is considered as all water supply released from CVP storage facilities. The volume of CVP Supply includes CVP deliveries to CWD, and flood releases from CVP facilities that pass through the subbasin.

3.2.1.2 Precipitation

Precipitation estimates for CWD GSA are provided in Figure A2.F.a-6 and Table A2.F.a-4. Precipitation estimates are reported by water use sector.

Total precipitation is highly variable between years in the study area, ranging from approximately 54 taf (7.6 inches) during average dry years to 102 taf (14.4 inches) during average wet years.

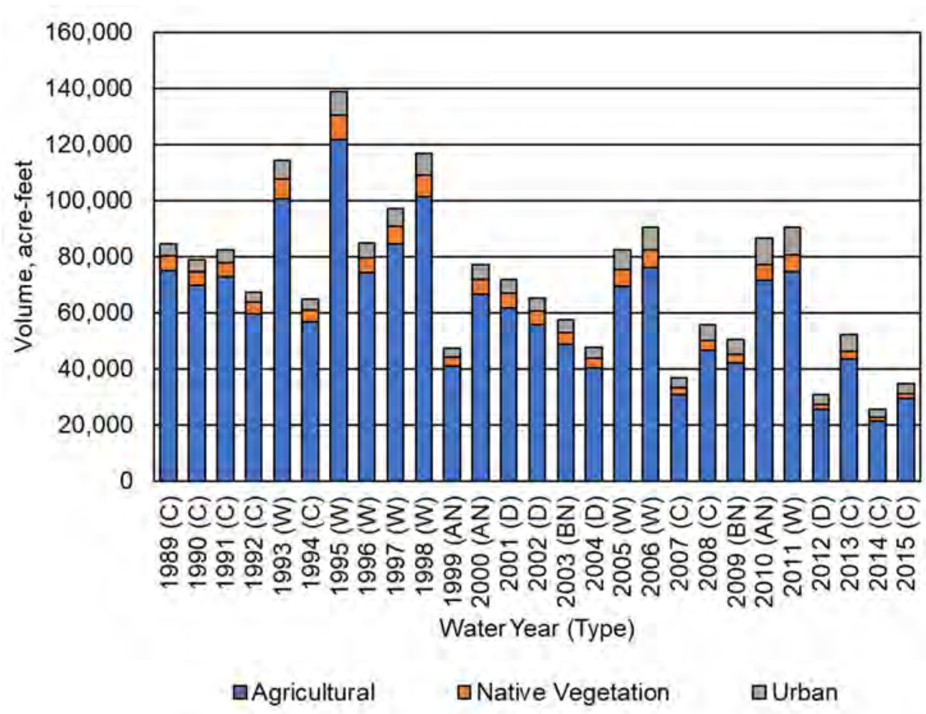

Figure A2.F.a-6. Chowchilla Water District GSA Precipitation by Water Use Sector.

Table A2.F.a-4. Chowchilla Water District GSA Precipitation by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	75,130	5,160	4,380	84,670
1990 (C)	69,950	4,830	4,190	78,970
1991 (C)	73,000	5,040	4,500	82,540
1992 (C)	59,550	4,110	3,790	67,450
1993 (W)	100,740	6,940	6,610	114,290
1994 (C)	56,960	3,950	3,850	64,760
1995 (W)	121,930	8,600	8,510	139,040
1996 (W)	74,270	5,430	5,300	85,000
1997 (W)	84,540	6,400	6,180	97,110
1998 (W)	101,250	7,930	7,570	116,740
1999 (AN)	40,910	3,310	3,130	47,350
2000 (AN)	66,460	5,550	5,190	77,200
2001 (D)	61,770	5,330	4,930	72,020
2002 (D)	55,840	4,790	4,730	65,360
2003 (BN)	48,880	4,140	4,410	57,420
2004 (D)	40,460	3,380	3,870	47,710
2005 (W)	69,510	5,740	7,040	82,280
2006 (W)	76,280	6,220	8,150	90,640
2007 (C)	30,780	2,470	3,460	36,720
2008 (C)	46,580	3,690	5,500	55,770
2009 (BN)	41,880	3,280	5,190	50,350
2010 (AN)	71,720	5,530	9,290	86,540
2011 (W)	74,830	5,680	10,120	90,630
2012 (D)	25,630	1,790	3,430	30,850
2013 (C)	43,580	2,800	5,740	52,110
2014 (C)	21,420	1,250	2,780	25,450
2015 (C)	29,480	1,570	3,700	34,750
Average (1989-2014)	62,840	4,740	5,460	73,040
Average (1989-2014) W	87,920	6,610	7,430	101,970
Average (1989-2014) AN	59,700	4,800	5,870	70,360
Average (1989-2014) BN	45,380	3,710	4,800	53,890
Average (1989-2014) D	45,920	3,820	4,240	53,990
Average (1989-2014) C	52,990	3,700	4,250	60,940

3.2.1.3 Groundwater Extraction by Water Use Sector

Estimates of groundwater extraction by water use sector are provided in Figure A2.F.a-7 and Table A2.F.a-5. For agricultural and urban (urban, semi-agricultural, industrial) lands, groundwater extraction represents pumping, while for native lands, groundwater extraction by riparian vegetation was considered to be negligible. In all water use sector water budgets, groundwater extraction served as the water budget closure term. Groundwater extraction is dominated by irrigated agriculture, varying substantially from year to year based on variability and/or uncertainty in surface water supplies.

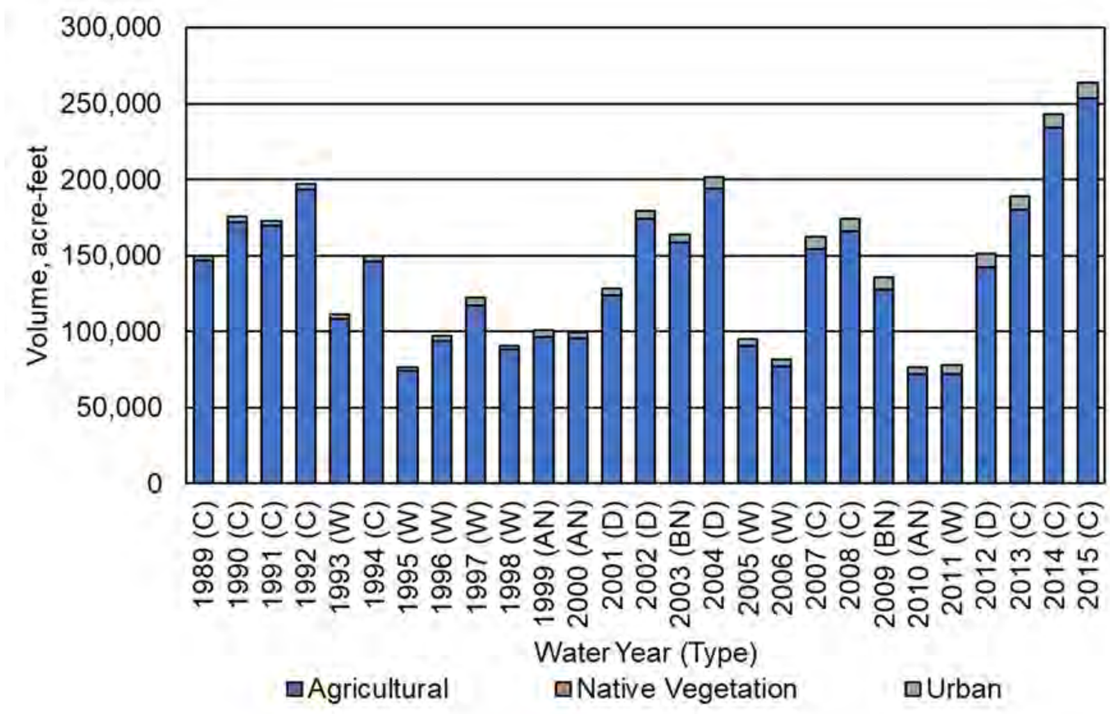

Figure A2.F.a-7. Chowchilla Water District GSA Groundwater Extraction by Water Use Sector.

Table A2.F.a-5. Chowchilla Water District GSA Groundwater Extraction by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	146,590	0	2,940	149,540
1990 (C)	172,140	0	3,210	175,360
1991 (C)	169,450	0	3,260	172,710
1992 (C)	193,130	0	4,220	197,350
1993 (W)	108,100	0	3,350	111,440
1994 (C)	145,860	0	4,160	150,020
1995 (W)	74,280	0	2,260	76,540
1996 (W)	93,530	0	3,410	96,940
1997 (W)	117,060	0	5,620	122,680
1998 (W)	88,050	0	2,900	90,960
1999 (AN)	96,300	0	4,690	100,990
2000 (AN)	95,730	0	4,110	99,840
2001 (D)	124,090	0	3,950	128,040
2002 (D)	174,170	0	5,390	179,570
2003 (BN)	158,620	0	5,460	164,080
2004 (D)	194,300	0	7,190	201,490
2005 (W)	90,380	0	4,720	95,110
2006 (W)	77,020	0	4,740	81,760
2007 (C)	154,600	0	7,810	162,410
2008 (C)	166,120	0	8,020	174,140
2009 (BN)	127,920	0	8,090	136,010
2010 (AN)	71,860	0	4,790	76,650

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
2011 (W)	72,460	0	5,310	77,770
2012 (D)	142,410	0	8,940	151,350
2013 (C)	180,310	0	8,960	189,270
2014 (C)	233,860	0	8,830	242,690
2015 (C)	253,730	0	9,760	263,480
Average (1989-2014)	133,400	0	5,240	138,640
Average (1989-2014) W	90,110	0	4,040	94,150
Average (1989-2014) AN	87,960	0	4,530	92,490
Average (1989-2014) BN	143,270	0	6,770	150,050
Average (1989-2014) D	158,740	0	6,370	165,110
Average (1989-2014) C	173,560	0	5,710	179,280

3.2.1.4 Groundwater Discharge to Surface Water Sources

The depth to groundwater is greater than 100-200 ft across much of the Chowchilla Subbasin. Given the depth to the water table in the Chowchilla Subbasin, groundwater discharge to surface water sources is negligible.

3.2.2 Outflows

3.2.2.1 Evapotranspiration by Water Use Sector

Evapotranspiration (ET) by water use sector is reported in Figures A2.F.a-8 to A2.F.a-10 and Tables A2.F.a-6 to A2.F.a-8. First, total ET is reported, followed by ET from applied water and ET from precipitation.

Total ET varies between years, with the lowest observed in 1989, at approximately 188 taf, and greatest in 2004, at approximately 241 taf. Agricultural ET tends to increase in drier years, while native ET decreases.

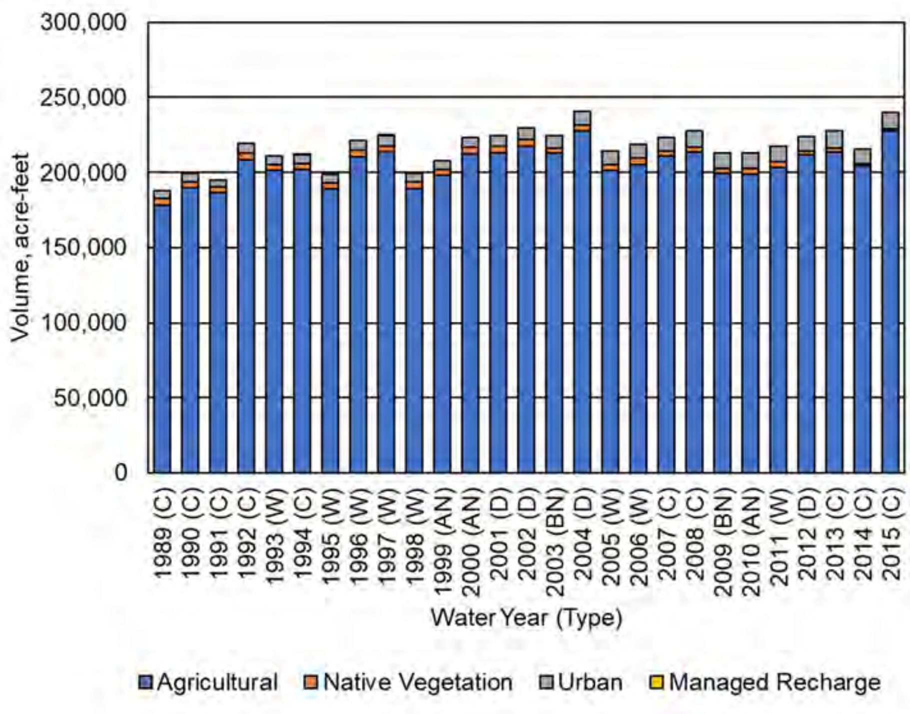

Figure A2.F.a-8. Chowchilla Water District GSA Evapotranspiration by Water Use Sector.

Table A2.F.a-6. Chowchilla Water District GSA Evapotranspiration by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Managed Recharge	Total
1989 (C)	178,550	3,980	5,100	0	187,630
1990 (C)	189,820	3,960	5,450	0	199,230
1991 (C)	186,710	3,530	4,950	0	195,190
1992 (C)	208,710	4,250	6,190	0	219,150
1993 (W)	201,120	4,160	6,060	0	211,340
1994 (C)	202,290	3,420	6,150	10	211,870
1995 (W)	189,100	4,170	5,770	0	199,040
1996 (W)	210,270	4,470	6,320	0	221,060
1997 (W)	213,540	4,050	6,790	20	224,400
1998 (W)	189,450	4,020	6,050	30	199,550
1999 (AN)	198,160	3,670	6,220	0	208,050
2000 (AN)	212,340	4,240	6,740	0	223,320
2001 (D)	212,800	4,730	6,770	0	224,300
2002 (D)	217,510	4,430	7,660	0	229,600
2003 (BN)	212,940	3,520	7,850	0	224,310
2004 (D)	227,920	3,710	9,210	0	240,840
2005 (W)	201,340	4,220	8,460	0	214,020
2006 (W)	205,540	4,530	9,050	0	219,120
2007 (C)	210,920	3,170	9,430	0	223,520
2008 (C)	213,710	3,290	10,670	0	227,670
2009 (BN)	199,680	2,770	10,870	0	213,320

Water Year (Type)	Agricultural	Native Vegetation	Urban	Managed Recharge	Total
2010 (AN)	198,630	3,950	10,120	0	212,700
2011 (W)	203,050	4,140	10,620	0	217,810
2012 (D)	211,970	2,110	9,890	0	223,970
2013 (C)	213,790	2,480	11,500	0	227,770
2014 (C)	204,430	1,260	9,610	0	215,300
2015 (C)	227,950	1,320	10,740	0	240,010
Average (1989-2014)	204,400	3,700	7,830	0	215,930
Average (1989-2014) W	201,680	4,220	7,390	10	213,300
Average (1989-2014) AN	203,050	3,950	7,700	0	214,700
Average (1989-2014) BN	206,310	3,150	9,360	0	218,820
Average (1989-2014) D	217,540	3,740	8,380	0	229,660
Average (1989-2014) C	200,990	3,260	7,670	0	211,920

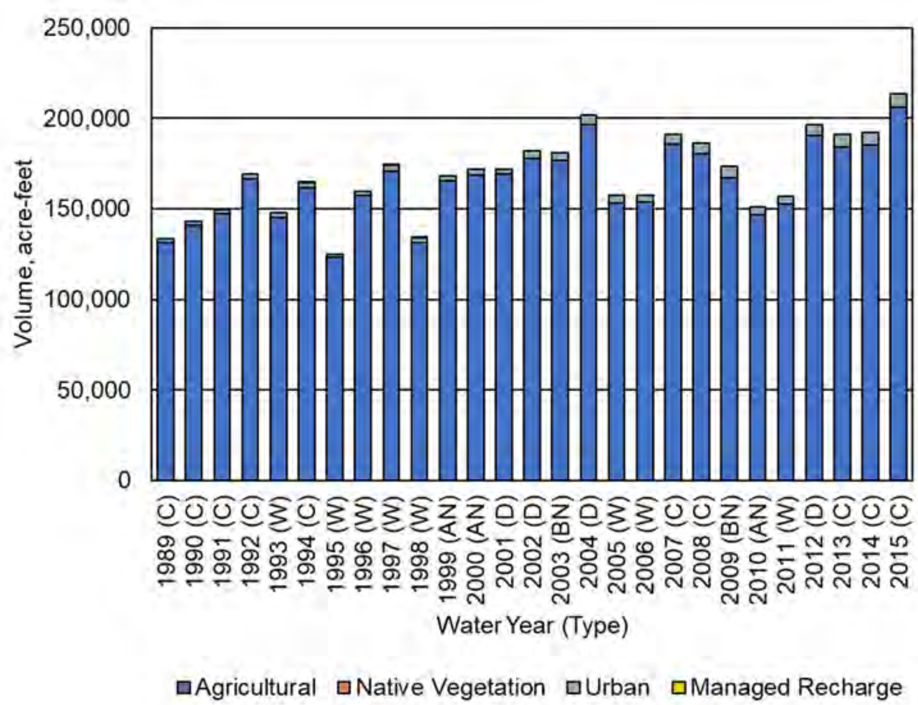

Figure A2.F.a-9. Chowchilla Water District GSA Evapotranspiration of Applied Water by Water Use Sector.

Table A2.F.a-7. Chowchilla Water District GSA Evapotranspiration of Applied Water by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Managed Recharge	Total
1989 (C)	131,170	0	2,230	0	133,400
1990 (C)	140,700	0	2,330	0	143,030
1991 (C)	147,320	0	2,300	0	149,620
1992 (C)	166,440	0	2,950	0	169,390
1993 (W)	145,110	0	2,490	0	147,600
1994 (C)	161,510	0	3,110	10	164,630
1995 (W)	123,080	0	1,890	0	124,970
1996 (W)	157,560	0	2,180	0	159,740
1997 (W)	170,730	0	3,190	20	173,940
1998 (W)	131,250	0	2,510	30	133,790
1999 (AN)	165,320	0	3,060	0	168,380
2000 (AN)	168,400	0	3,300	0	171,700
2001 (D)	169,070	0	2,960	0	172,030
2002 (D)	177,880	0	3,880	0	181,760
2003 (BN)	176,590	0	4,380	0	180,970
2004 (D)	196,430	0	5,470	0	201,900
2005 (W)	153,270	0	3,990	0	157,260
2006 (W)	153,680	0	3,920	0	157,600
2007 (C)	185,560	0	5,310	0	190,870
2008 (C)	180,250	0	6,270	0	186,520
2009 (BN)	166,910	0	6,730	0	173,640
2010 (AN)	146,840	0	4,450	0	151,290
2011 (W)	152,750	0	4,060	0	156,810
2012 (D)	190,440	0	5,820	0	196,260
2013 (C)	183,930	0	7,050	0	190,980
2014 (C)	185,340	0	6,890	0	192,230
2015 (C)	205,820	0	7,850	0	213,670
Average (1989-2014)	162,600	0	3,950	0	166,550
Average (1989-2014) W	148,430	0	3,030	10	151,470
Average (1989-2014) AN	160,190	0	3,610	0	163,800
Average (1989-2014) BN	171,750	0	5,560	0	177,310
Average (1989-2014) D	183,450	0	4,530	0	187,980
Average (1989-2014) C	164,690	0	4,270	0	168,960

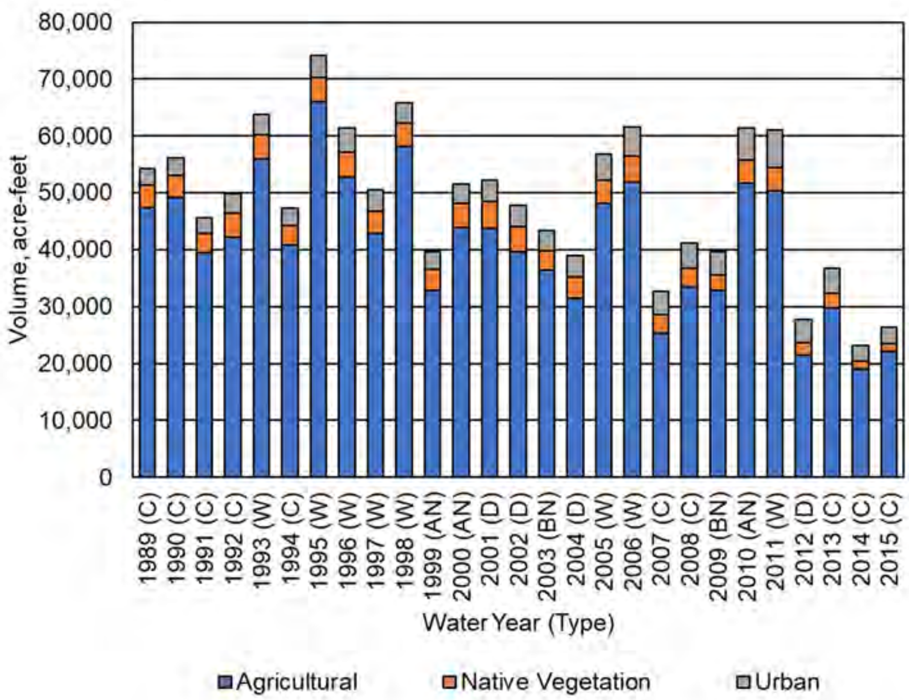

Figure A2.F.a-10. Chowchilla Water District GSA Evapotranspiration of Precipitation by Water Use Sector.

Table A2.F.a-8. Chowchilla Water District GSA Evapotranspiration of Precipitation by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	47,380	3,980	2,870	54,230
1990 (C)	49,120	3,960	3,120	56,200
1991 (C)	39,390	3,530	2,650	45,570
1992 (C)	42,270	4,250	3,240	49,760
1993 (W)	56,010	4,160	3,570	63,740
1994 (C)	40,780	3,420	3,040	47,240
1995 (W)	66,020	4,170	3,880	74,070
1996 (W)	52,710	4,470	4,140	61,320
1997 (W)	42,810	4,050	3,600	50,460
1998 (W)	58,200	4,020	3,540	65,760
1999 (AN)	32,840	3,670	3,160	39,670
2000 (AN)	43,940	4,240	3,440	51,620
2001 (D)	43,730	4,730	3,810	52,270
2002 (D)	39,630	4,430	3,780	47,840
2003 (BN)	36,350	3,520	3,470	43,340
2004 (D)	31,490	3,710	3,740	38,940
2005 (W)	48,070	4,220	4,470	56,760
2006 (W)	51,860	4,530	5,130	61,520
2007 (C)	25,360	3,170	4,120	32,650
2008 (C)	33,460	3,290	4,400	41,150
2009 (BN)	32,770	2,770	4,140	39,680
2010 (AN)	51,790	3,950	5,670	61,410

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
2011 (W)	50,300	4,140	6,560	61,000
2012 (D)	21,530	2,110	4,070	27,710
2013 (C)	29,860	2,480	4,450	36,790
2014 (C)	19,090	1,260	2,720	23,070
2015 (C)	22,130	1,320	2,890	26,340
Average (1989-2014)	41,800	3,700	3,880	49,380
Average (1989-2014) W	53,250	4,220	4,360	61,830
Average (1989-2014) AN	42,860	3,950	4,090	50,900
Average (1989-2014) BN	34,560	3,150	3,800	41,510
Average (1989-2014) D	34,090	3,740	3,850	41,680
Average (1989-2014) C	36,300	3,260	3,400	42,960

In addition to ET from land surfaces, estimates of evaporation from CWD canals and rivers and streams are reported in Figure A2.F.a-11 and Table A2.F.a-9. Evaporation from the Rivers and Streams System includes evaporation of both surface inflows and of precipitation runoff within local sloughs and depressions. Evaporation from the canals includes evaporation of irrigation releases in CWD canals and waterways. Evaporation from the Rivers and Streams system includes evaporation of flood releases and natural flows along waterways in the district, varying between years according to water availability. Total evaporation from all sources averaged approximately 2 taf per year between 1989 and 2014.

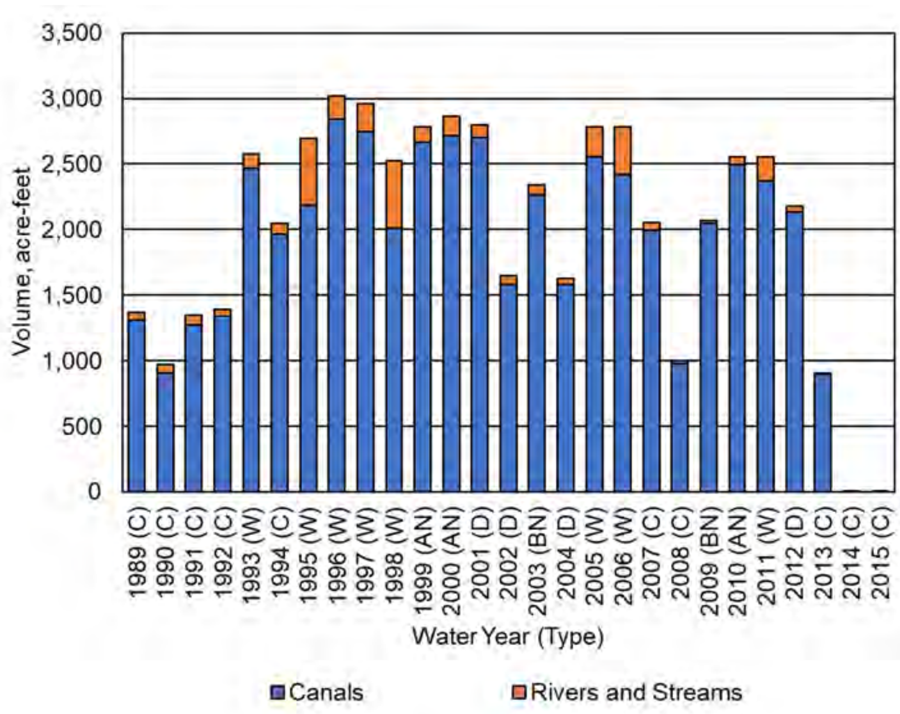

Figure A2.F.a-11. Chowchilla Water District GSA Evaporation from the Surface Water System.

Table A2.F.a-9. Chowchilla Water District GSA Evaporation from the Surface Water System (Acre-Feet).

Water Year (Type)	Canals	Rivers and Streams[1]	Total
1989 (C)	1,310	60	1,370
1990 (C)	910	60	970
1991 (C)	1,270	80	1,350
1992 (C)	1,340	50	1,390
1993 (W)	2,460	110	2,570
1994 (C)	1,970	80	2,050
1995 (W)	2,190	510	2,700
1996 (W)	2,840	180	3,020
1997 (W)	2,750	210	2,960
1998 (W)	2,010	510	2,520
1999 (AN)	2,660	120	2,780
2000 (AN)	2,720	140	2,860
2001 (D)	2,710	90	2,800
2002 (D)	1,590	60	1,650
2003 (BN)	2,270	70	2,340
2004 (D)	1,580	50	1,630
2005 (W)	2,560	230	2,790
2006 (W)	2,420	360	2,780
2007 (C)	2,000	60	2,060
2008 (C)	980	30	1,010
2009 (BN)	2,050	30	2,080
2010 (AN)	2,490	60	2,550
2011 (W)	2,370	180	2,550
2012 (D)	2,140	40	2,180
2013 (C)	900	10	910
2014 (C)	0	0	0
2015 (C)	0	10	10
Average (1989-2014)	1,940	130	2,070
Average (1989-2014) W	2,450	290	2,740
Average (1989-2014) AN	2,630	110	2,740
Average (1989-2014) BN	2,160	50	2,210
Average (1989-2014) D	2,000	60	2,060
Average (1989-2014) C	1,190	50	1,240

[1] Includes evaporation of surface inflows and of precipitation runoff.

3.2.2.2 Surface Water Outflow by Water Source Type

Surface water outflows by water source type are summarized in Figure A2.F.a-12 and Table A2.F.a-10. In CWD GSA, runoff of applied water is assumed negligible and runoff of precipitation is collected in waterways within CWD GSA, with most infiltrating to the groundwater system except following the largest storm events. Thus, surface outflows from the GSA are expected to be primarily a mixture of CVP supplies along Chowchilla River, Ash Slough, and Berenda Slough and deliveries of local supplies to growers in other water budget subregions during irrigation releases into the CWD conveyance system. Between 1989 and 2014, these combined outflows averaged nearly 76 taf during wet years and less than 2 taf during below normal, dry, and critical years.

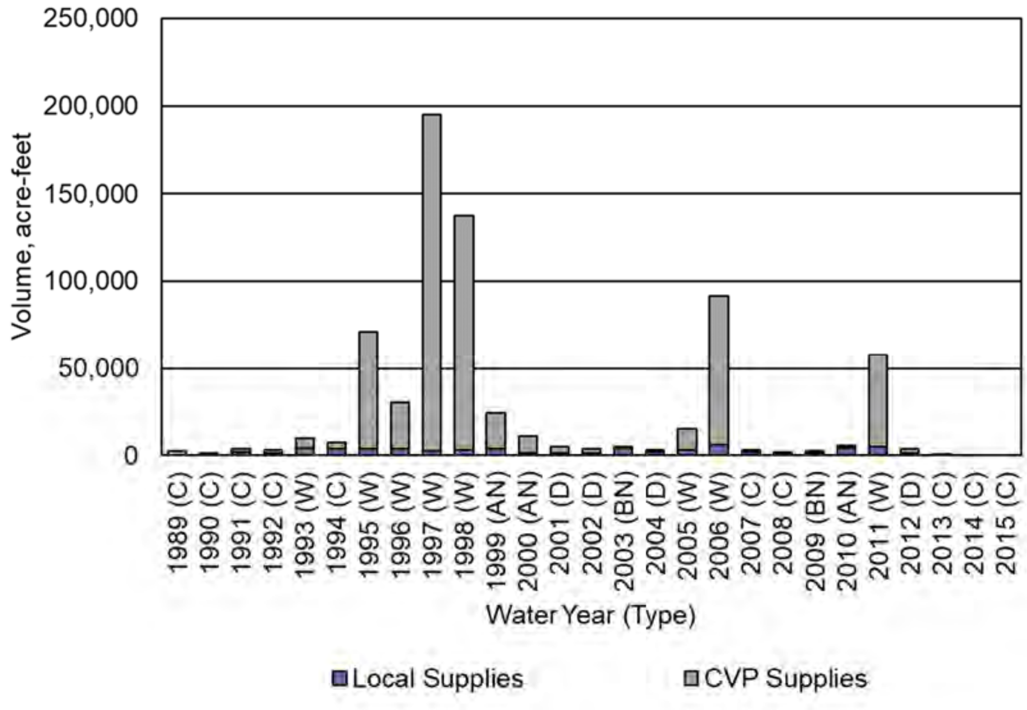

Figure A2.F.a-12. Chowchilla Water District GSA Surface Outflows by Water Source Type.

Table A2.F.a-10. Chowchilla Water District GSA Surface Outflows by Water Source Type (Acre-Feet).

Water Year (Type)	Local Supplies	CVP Supplies	Total
1989 (C)	0	2,730	2,730
1990 (C)	0	1,710	1,710
1991 (C)	2,270	1,530	3,800
1992 (C)	1,650	1,520	3,170
1993 (W)	4,320	5,500	9,820
1994 (C)	3,550	3,680	7,230
1995 (W)	3,890	66,910	70,800
1996 (W)	3,680	27,030	30,710
1997 (W)	2,330	192,310	194,640
1998 (W)	3,360	133,940	137,300
1999 (AN)	3,930	20,680	24,610
2000 (AN)	1,580	9,760	11,340
2001 (D)	1,580	3,540	5,120
2002 (D)	1,640	2,120	3,760
2003 (BN)	4,710	500	5,210
2004 (D)	2,280	650	2,930
2005 (W)	3,500	11,640	15,140
2006 (W)	6,000	85,640	91,640
2007 (C)	1,890	1,400	3,290
2008 (C)	1,680	250	1,930
2009 (BN)	1,590	1,310	2,900
2010 (AN)	4,690	1,100	5,790

Water Year (Type)	Local Supplies	CVP Supplies	Total
2011 (W)	5,190	52,660	57,850
2012 (D)	1,240	2,380	3,620
2013 (C)	0	1,020	1,020
2014 (C)	0	0	0
2015 (C)	0	0	0
Average (1989-2014)	2,560	24,290	26,850
Average (1989-2014) W	4,030	71,950	75,990
Average (1989-2014) AN	3,400	10,510	13,910
Average (1989-2014) BN	3,150	910	4,060
Average (1989-2014) D	1,690	2,170	3,860
Average (1989-2014) C	1,230	1,540	2,760

3.2.2.3 Infiltration of Precipitation

Estimated infiltration of precipitation (deep percolation of precipitation) by water use sector is provided in Figure A2.F.a-13 and Table A2.F.a-11. Infiltration of precipitation to the groundwater system is highly variable from year to year due to variation in the timing and amount of precipitation, ranging from less than 10 taf annually during some critical and dry years to nearly 50 taf during 1995.

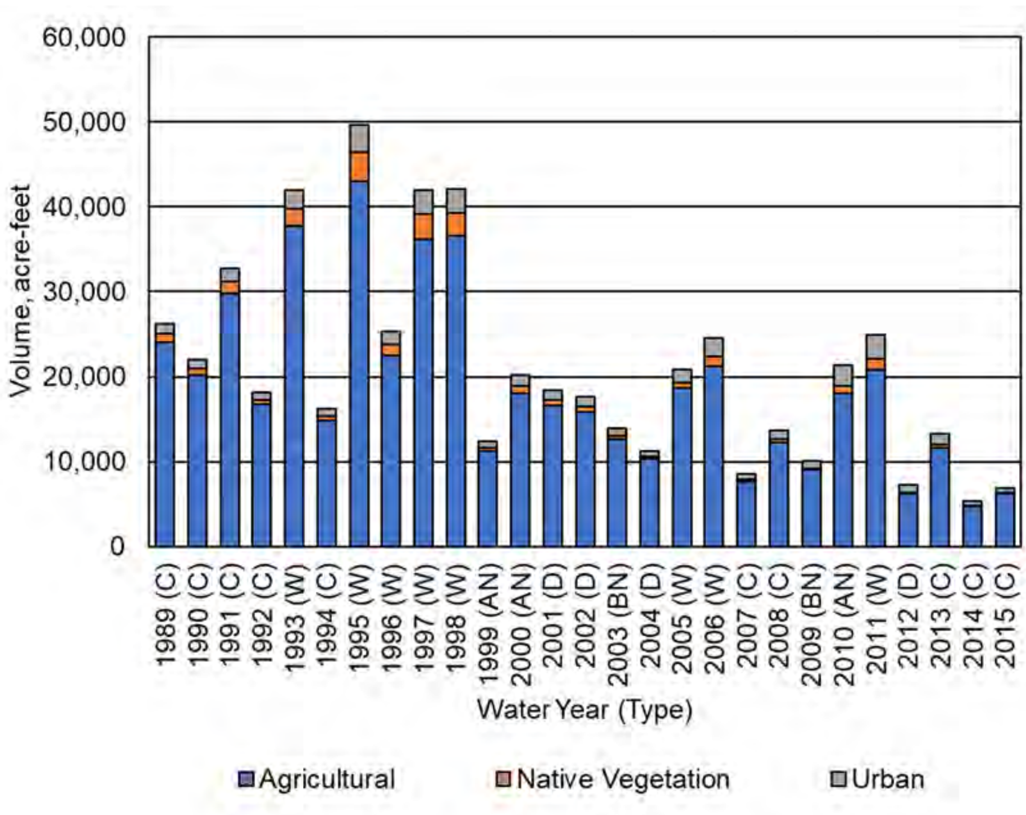

Figure A2.F.a-13. Chowchilla Water District GSA Infiltration of Precipitation by Water Use Sector.

Table A2.F.a-11. Chowchilla Water District GSA Infiltration of Precipitation by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	24,080	940	1,170	26,190
1990 (C)	20,190	820	990	22,000
1991 (C)	29,870	1,370	1,570	32,810
1992 (C)	16,770	520	830	18,120
1993 (W)	37,740	2,040	2,240	42,020
1994 (C)	14,860	520	860	16,240
1995 (W)	42,970	3,530	3,120	49,620
1996 (W)	22,490	1,300	1,540	25,330
1997 (W)	36,160	3,010	2,790	41,960
1998 (W)	36,610	2,670	2,770	42,050
1999 (AN)	11,260	400	740	12,400
2000 (AN)	18,060	880	1,230	20,170
2001 (D)	16,640	660	1,060	18,360
2002 (D)	15,890	590	1,100	17,580
2003 (BN)	12,600	430	890	13,920
2004 (D)	10,290	280	670	11,240
2005 (W)	18,630	690	1,550	20,870
2006 (W)	21,190	1,200	2,190	24,580
2007 (C)	7,650	220	700	8,570
2008 (C)	12,260	410	1,050	13,720
2009 (BN)	9,000	230	840	10,070
2010 (AN)	17,960	990	2,370	21,320
2011 (W)	20,860	1,210	2,810	24,880
2012 (D)	6,190	200	890	7,280
2013 (C)	11,580	360	1,300	13,240
2014 (C)	4,720	70	510	5,300
2015 (C)	6,180	130	620	6,930
Average (1989-2014)	19,096	982	1,452	21,530
Average (1989-2014) W	29,580	1,960	2,380	33,920
Average (1989-2014) AN	15,760	760	1,450	17,970
Average (1989-2014) BN	10,800	330	870	12,000
Average (1989-2014) D	12,250	430	930	13,610
Average (1989-2014) C	15,780	580	1,000	17,360

3.2.2.4 Infiltration of Surface Water

Estimated infiltration of surface water (seepage) by source is provided in Figure A2.F.a-14 and Table A2.F.a-12. Seepage from the Rivers and Streams System includes seepage of surface inflows during flood releases and natural flows, and seepage of precipitation runoff into local sloughs and depressions. Seepage from the Canals System includes seepage along CWD canals and seepage along rivers and sloughs used to transport irrigation deliveries to CWD and its customers. During non-flood releases, some seepage along reach C-2 of the Chowchilla River is allocated to SVMWC. Per an agreement between SVMWC and CWD, 70% of non-flood seepage along reach C-2 is allocated to SVMWC, and 30% is allocated to CWD.

The canal system predominantly contributes to seepage in CWD, with seepage averaging 29 taf per year between 1989 and 2014. Seepage from rivers and streams is comparatively lower, averaging approximately 13 taf per year between 1989 and 2014.

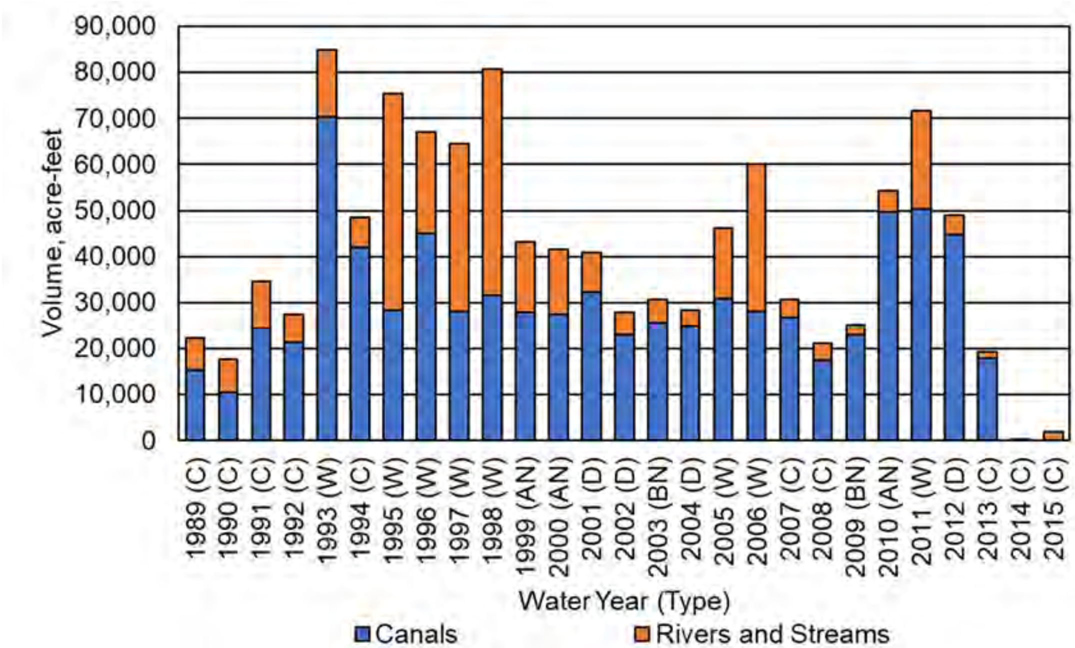

Figure A2.F.a-14. Chowchilla Water District GSA Infiltration of Surface Water.

Table A2.F.a-12. Chowchilla Water District GSA Infiltration of Surface Water (Acre-Feet).

Water Year (Type)	Canals	Rivers and Streams[1]	Total
1989 (C)	15,270	7,100	22,370
1990 (C)	10,580	7,200	17,780
1991 (C)	24,430	10,120	34,550
1992 (C)	21,310	6,130	27,440
1993 (W)	70,310	14,580	84,890
1994 (C)	41,950	6,650	48,600
1995 (W)	28,410	46,970	75,380
1996 (W)	45,020	21,950	66,970
1997 (W)	28,080	36,510	64,590
1998 (W)	31,610	49,170	80,780
1999 (AN)	27,820	15,430	43,250
2000 (AN)	27,450	14,110	41,560
2001 (D)	32,390	8,410	40,800
2002 (D)	22,890	5,040	27,930
2003 (BN)	25,580	5,080	30,660
2004 (D)	24,810	3,450	28,260
2005 (W)	30,980	15,290	46,270
2006 (W)	28,030	32,150	60,180
2007 (C)	26,760	3,900	30,660
2008 (C)	17,490	3,640	21,130

Water Year (Type)	Canals	Rivers and Streams[1]	Total
2009 (BN)	22,970	2,030	25,000
2010 (AN)	49,550	4,670	54,220
2011 (W)	50,360	21,380	71,740
2012 (D)	44,730	4,140	48,870
2013 (C)	17,930	1,430	19,360
2014 (C)	30	210	240
2015 (C)	10	1,950	1,960
Average (1989-2014)	29,490	13,340	42,830
Average (1989-2014) W	39,100	29,750	68,850
Average (1989-2014) AN	34,940	11,400	46,340
Average (1989-2014) BN	24,280	3,560	27,840
Average (1989-2014) D	31,210	5,260	36,470
Average (1989-2014) C	19,530	5,150	24,680

[1] Includes infiltration of surface inflows and of precipitation runoff within the subregion. To calculate Net Recharge from SWS below, Rivers and Streams System seepage is summed across the subbasin and redistributed to each subregion in proportion to gross area.

3.2.2.5 Infiltration of Applied Water

Estimated infiltration of applied water (deep percolation of applied water) by water use sector is provided in Figure A2.F.a-15 and Table A2.F.a-13. Infiltration of applied water is dominated by agricultural irrigation and has slowly decreased over time, likely due to increase use of drip and micro-irrigation systems in place of flood irrigation.

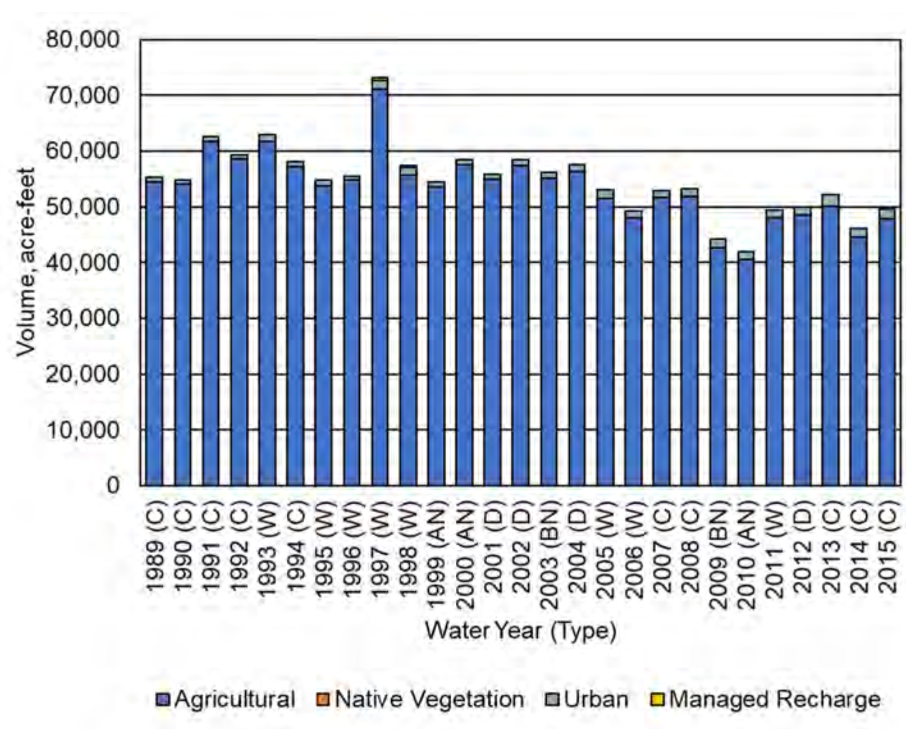

Figure A2.F.a-15. Chowchilla Water District GSA Infiltration of Applied Water by Water Use Sector.

Table A2.F.a-13. Chowchilla Water District GSA Infiltration of Applied Water by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Managed Recharge	Total
1989 (C)	54,400	0	850	0	55,250
1990 (C)	54,030	0	750	0	54,780
1991 (C)	61,680	0	860	0	62,540
1992 (C)	58,530	0	780	0	59,310
1993 (W)	61,750	0	1,200	0	62,950
1994 (C)	57,180	0	850	0	58,030
1995 (W)	53,720	0	1,030	0	54,750
1996 (W)	54,800	0	650	0	55,450
1997 (W)	71,100	0	1,580	530	73,210
1998 (W)	55,730	0	1,350	390	57,470
1999 (AN)	53,630	0	790	0	54,420
2000 (AN)	57,560	0	940	0	58,500
2001 (D)	54,930	0	880	0	55,810
2002 (D)	57,380	0	1,110	0	58,490
2003 (BN)	55,160	0	1,090	0	56,250
2004 (D)	56,410	0	1,170	0	57,580
2005 (W)	51,530	0	1,490	0	53,020
2006 (W)	48,020	0	1,170	0	49,190
2007 (C)	51,670	0	1,180	0	52,850
2008 (C)	51,770	0	1,510	0	53,280
2009 (BN)	42,700	0	1,450	0	44,150
2010 (AN)	40,620	0	1,410	0	42,030
2011 (W)	47,990	0	1,440	0	49,430
2012 (D)	48,530	0	1,410	0	49,940
2013 (C)	50,200	0	1,930	0	52,130
2014 (C)	44,650	0	1,420	0	46,070
2015 (C)	47,880	0	1,690	0	49,570
Average (1989-2014)	53,680	0	1,170	40	54,890
Average (1989-2014) W	55,580	0	1,240	120	56,940
Average (1989-2014) AN	50,600	0	1,050	0	51,650
Average (1989-2014) BN	48,930	0	1,270	0	50,200
Average (1989-2014) D	54,310	0	1,140	0	55,450
Average (1989-2014) C	53,790	0	1,130	0	54,920

3.2.3 Change in Surface Water System Storage

Estimates of change in SWS storage are provided in Figure A2.F.a-16 and Table A2.F.a-14. Inter-annual changes in storage within the surface water system consist primarily of root zone soil moisture storage changes, are relatively small, and tend to average near zero over many years.

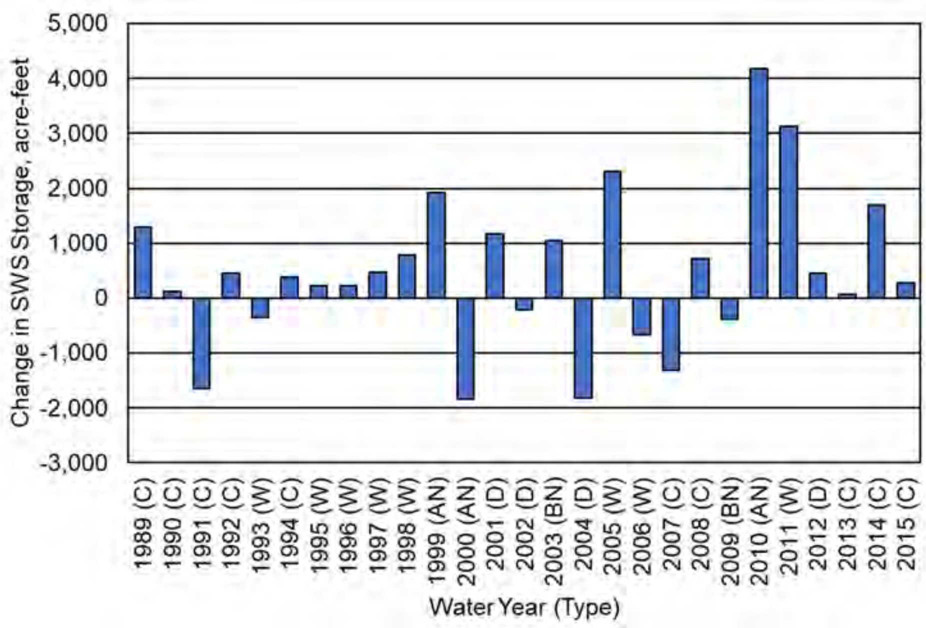

Figure A2.F.a-16. Chowchilla Water District GSA Change in Surface Water System Storage.

Table A2.F.a-14. Chowchilla Water District GSA Change in Surface Water System Storage (Acre-Feet).

Water Year (Type)	Change in SWS Storage
1989 (C)	1,300
1990 (C)	130
1991 (C)	-1,640
1992 (C)	460
1993 (W)	-350
1994 (C)	380
1995 (W)	220
1996 (W)	230
1997 (W)	480
1998 (W)	780
1999 (AN)	1,930
2000 (AN)	-1,830
2001 (D)	1,170
2002 (D)	-210
2003 (BN)	1,040
2004 (D)	-1,820
2005 (W)	2,300
2006 (W)	-670
2007 (C)	-1,310
2008 (C)	710
2009 (BN)	-390
2010 (AN)	4,180
2011 (W)	3,130
2012 (D)	460
2013 (C)	70
2014 (C)	1,700
2015 (C)	280
Average (1989-2014)	480
Average (1989-2014) W	770
Average (1989-2014) AN	1,430
Average (1989-2014) BN	330
Average (1989-2014) D	-100
Average (1989-2014) C	200

3.3 Historical Water Budget Summary

Annual inflows, outflows, and change in SWS storage during the historical water budget period (1989-2014) are summarized in Figure A2.F.a-17 and Table A2.F.a-15. Inflows are shown as positive values, while outflows and change in SWS storage are shown as negative values. Review of the variability in component volumes across years provides insight into the impacts of hydrology on the surface water system water budget.

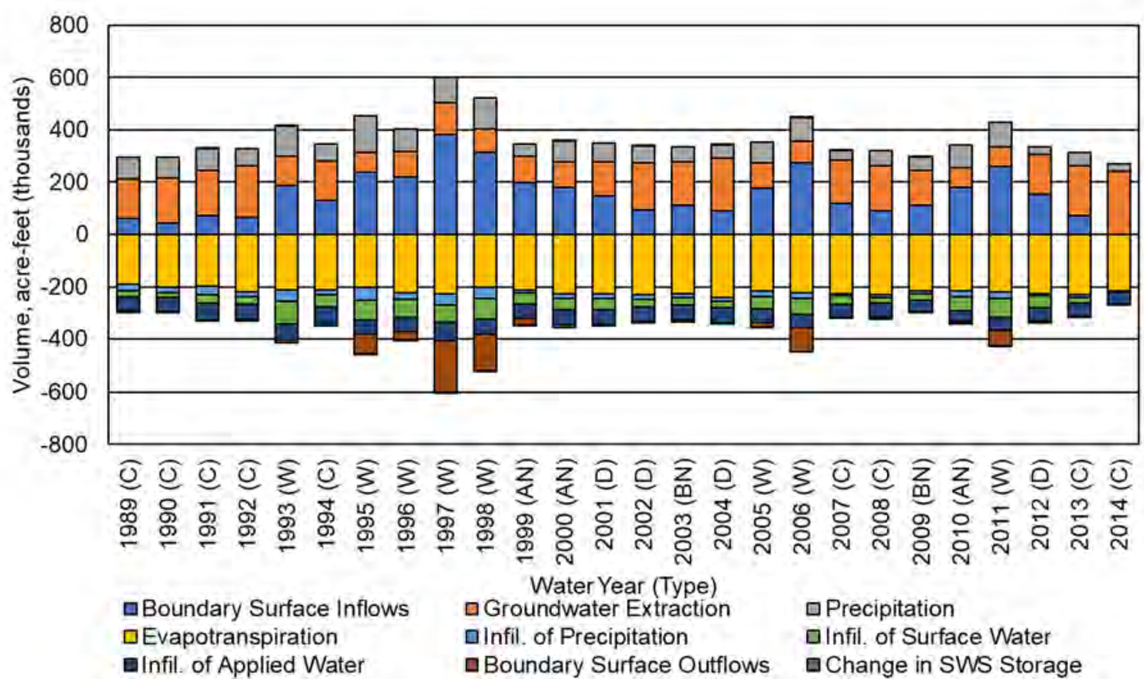

Figure A2.F.a-17. Chowchilla Water District GSA Surface Water System Historical Water Budget, 1989-2014.

Table A2.F.a-15. Chowchilla Water District GSA Surface Water System Historical Water Budget, 1989-2014 (Acre-Feet).

Water Year	Boundary Surface Inflows	Groundwater Extraction	Precipitation	Evapo-transpiration[1]	Infil. of Precipitation	Infil. of Surface Water[2]	Infil. of Applied Water	Boundary Surface Outflows	Change in SWS Storage
1989 (C)	62,620	149,540	84,670	-189,000	-26,180	-22,370	-55,240	-2,730	-1,300
1990 (C)	42,270	175,360	78,970	-200,190	-22,010	-17,780	-54,770	-1,710	-130
1991 (C)	73,340	172,710	82,540	-196,540	-32,810	-34,550	-62,530	-3,800	1,640
1992 (C)	64,220	197,350	67,450	-220,540	-18,110	-27,440	-59,310	-3,160	-460
1993 (W)	187,520	111,440	114,290	-213,920	-42,020	-84,890	-62,950	-9,820	350
1994 (C)	129,610	150,020	64,760	-213,910	-16,250	-48,600	-58,030	-7,230	-380
1995 (W)	236,930	76,540	139,040	-201,740	-49,610	-75,380	-54,750	-70,800	-220
1996 (W)	220,820	96,940	85,000	-224,080	-25,330	-66,960	-55,450	-30,710	-230
1997 (W)	382,420	122,680	97,110	-227,360	-41,950	-64,590	-73,210	-194,640	-480
1998 (W)	312,780	90,960	116,740	-202,080	-42,050	-80,780	-57,480	-137,300	-780
1999 (AN)	199,110	100,990	47,350	-210,850	-12,390	-43,250	-54,430	-24,610	-1,930
2000 (AN)	178,890	99,840	77,200	-226,190	-20,170	-41,560	-58,500	-11,340	1,830
2001 (D)	148,280	128,040	72,020	-227,090	-18,370	-40,800	-55,800	-5,120	-1,170
2002 (D)	93,880	179,570	65,360	-231,240	-17,580	-27,930	-58,500	-3,770	210
2003 (BN)	112,220	164,080	57,420	-226,660	-13,920	-30,660	-56,240	-5,210	-1,040
2004 (D)	91,450	201,490	47,710	-242,460	-11,240	-28,260	-57,580	-2,930	1,820
2005 (W)	177,010	95,110	82,280	-216,800	-20,870	-46,270	-53,020	-15,140	-2,300
2006 (W)	274,410	81,760	90,640	-221,900	-24,570	-60,180	-49,200	-91,640	670
2007 (C)	120,510	162,410	36,720	-225,580	-8,570	-30,660	-52,850	-3,280	1,310
2008 (C)	89,520	174,140	55,770	-228,670	-13,720	-21,130	-53,280	-1,930	-710
2009 (BN)	110,760	136,010	50,350	-215,390	-10,070	-25,010	-44,150	-2,890	390
2010 (AN)	179,610	76,650	86,540	-215,260	-21,320	-54,220	-42,030	-5,780	-4,180
2011 (W)	259,000	77,770	90,630	-220,380	-24,870	-71,740	-49,430	-57,840	-3,130
2012 (D)	154,120	151,350	30,850	-226,150	-7,280	-48,870	-49,950	-3,620	-460
2013 (C)	73,070	189,270	52,110	-228,660	-13,230	-19,360	-52,130	-1,020	-70
2014 (C)	470	242,690	25,450	-215,310	-5,300	-240	-46,070	0	-1,700
Average (1989-2014)	152,880	138,640	73,040	-218,000	-21,530	-42,830	-54,880	-26,850	-480
W	256,360	94,150	101,970	-216,030	-33,910	-68,850	-56,930	-75,990	-760
AN	185,870	92,490	70,360	-217,430	-17,960	-46,350	-51,650	-13,910	-1,430
BN	111,490	150,050	53,890	-221,020	-11,990	-27,830	-50,200	-4,050	-330
D	121,930	165,110	53,990	-231,740	-13,610	-36,460	-55,460	-3,860	100
C	72,850	179,280	60,940	-213,150	-17,350	-24,680	-54,910	-2,760	-200

[1]Includes ET of applied water, ET of precipitation, and evaporation from the Rivers and Streams System and Canal System.

[2]Includes infiltration from the Canal System and Rivers and Streams System. To calculate Net Recharge from SWS below, Rivers and Streams System seepage is summed across the subbasin and redistributed to each subregion in proportion to gross area.

3.4 Current Water Budget Summary

The current water budget was developed following a similar process to the historical water budget using the 2015 land use in Table A2.F.a-1 and the same 1989-2014 average hydrologic conditions of the historical base period, including surface water flows, precipitation, and weather parameters. This allowed quantification of groundwater inflows and outflows for current consumptive use in the context of average water supply conditions.

Annual inflows, outflows, and change in SWS storage from the current water budget are summarized in Figure A2.F.a-18 and Table A2.F.a-16. Inflows are shown as positive values, while outflows and change in SWS storage are shown as negative values.

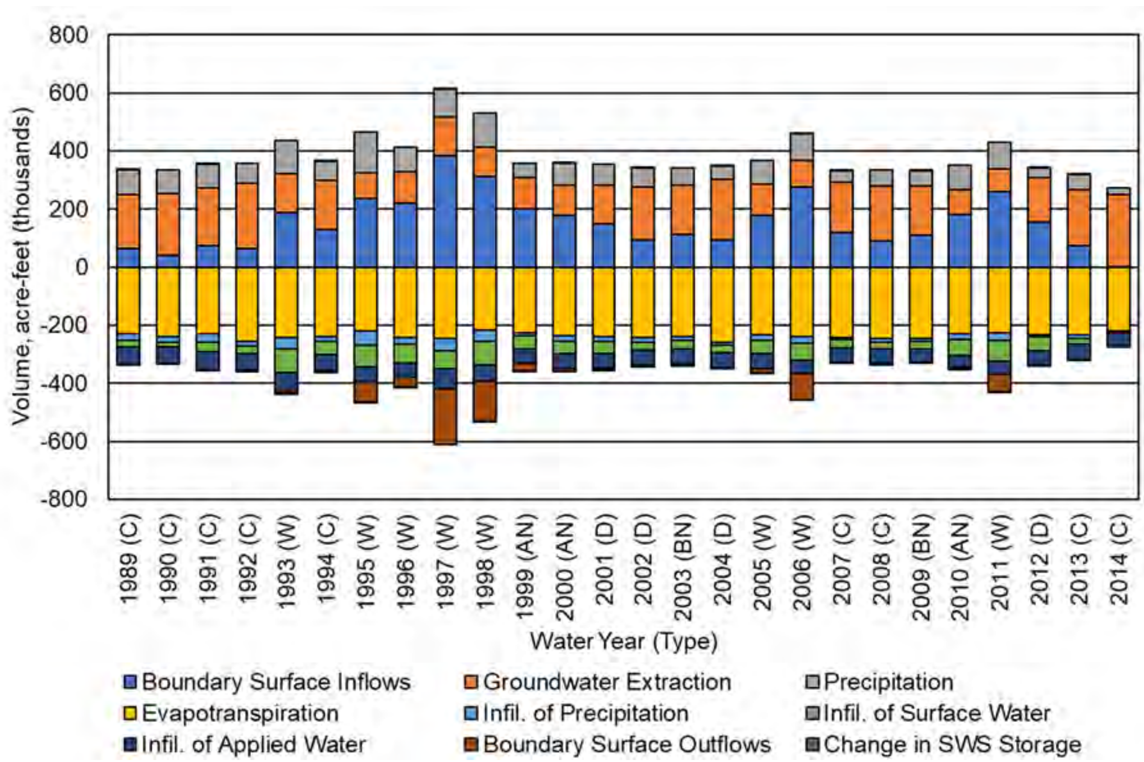

Figure A2.F.a-18. Chowchilla Water District GSA Surface Water System Current Water Budget.

Table A2.F.a-16. Chowchilla Water District GSA Surface Water System Current Water Budget (Acre-Feet).

Water Year	Boundary Surface Inflows	Groundwater Extraction	Precipitation	Evapo-transpiration[1]	Infil. of Precipitation	Infil. of Surface Water[2]	Infil. of Applied Water	Boundary Surface Outflows	Change in SWS Storage
1989 (C)	62,620	187,770	84,810	-229,580	-23,850	-20,390	-59,130	-2,730	490
1990 (C)	42,270	211,490	79,060	-238,420	-19,620	-15,880	-55,780	-1,710	-1,410
1991 (C)	73,340	199,180	82,610	-228,820	-30,210	-32,280	-61,420	-3,800	1,400
1992 (C)	64,220	225,010	67,510	-254,350	-16,250	-26,130	-56,150	-3,160	-690
1993 (W)	187,520	133,580	114,380	-241,660	-40,090	-82,360	-61,350	-9,810	-190
1994 (C)	129,610	167,770	64,810	-240,910	-14,100	-47,670	-53,390	-7,240	1,120
1995 (W)	236,930	87,950	139,120	-221,100	-47,040	-74,440	-52,040	-69,250	-130
1996 (W)	220,820	106,270	85,020	-241,270	-23,200	-66,640	-49,910	-30,070	-1,030
1997 (W)	382,420	132,900	97,140	-246,210	-41,010	-63,460	-67,930	-194,230	360
1998 (W)	312,780	99,420	116,790	-216,960	-39,910	-80,050	-54,820	-136,740	-490
1999 (AN)	199,110	109,690	47,370	-226,550	-11,100	-43,240	-50,270	-24,520	-490
2000 (AN)	178,890	101,860	77,220	-237,450	-18,790	-41,230	-52,260	-11,140	2,890
2001 (D)	148,280	132,960	72,040	-240,640	-16,690	-40,440	-50,280	-4,970	-260
2002 (D)	93,880	182,690	65,380	-242,810	-16,200	-27,620	-52,050	-3,720	450
2003 (BN)	112,220	169,630	57,440	-238,980	-12,580	-30,430	-50,970	-5,200	-1,120
2004 (D)	91,450	209,660	47,720	-258,020	-10,010	-28,000	-51,400	-3,000	1,600
2005 (W)	177,010	107,800	82,320	-233,420	-19,460	-45,790	-50,710	-15,050	-2,710
2006 (W)	274,410	92,950	90,690	-238,660	-22,860	-59,730	-46,970	-91,180	1,350
2007 (C)	120,510	172,950	36,730	-241,320	-7,580	-30,530	-48,450	-3,290	970
2008 (C)	89,520	188,050	55,810	-247,200	-12,690	-20,590	-50,030	-1,940	-930
2009 (BN)	110,760	169,180	50,420	-246,560	-9,520	-24,670	-47,320	-2,900	600
2010 (AN)	179,610	85,080	86,580	-228,980	-20,540	-53,840	-42,070	-5,790	-60
2011 (W)	259,000	79,440	90,620	-226,980	-24,190	-71,630	-48,020	-57,710	-520
2012 (D)	154,120	154,330	30,850	-232,350	-6,990	-48,810	-48,320	-3,620	800
2013 (C)	73,070	194,150	52,120	-234,600	-13,010	-19,260	-51,760	-1,020	310
2014 (C)	470	247,910	25,460	-219,780	-5,290	-220	-46,820	0	-1,740
Average (1989-2014)	152,880	151,910	73,080	-236,680	-20,110	-42,130	-52,290	-26,680	20
W	256,360	105,040	102,010	-233,280	-32,220	-68,010	-53,970	-75,500	-420
AN	185,870	98,880	70,390	-230,990	-16,810	-46,100	-48,200	-13,820	780
BN	111,490	169,410	53,930	-242,770	-11,050	-27,550	-49,140	-4,050	-260
D	121,930	169,910	54,000	-243,450	-12,470	-36,220	-50,510	-3,830	650
C	72,850	199,360	60,990	-237,220	-15,840	-23,660	-53,660	-2,770	-50

[1]Includes ET of applied water, ET of precipitation, and evaporation from the Rivers and Streams System and Canal System.
[2]Includes infiltration from the Canal System and Rivers and Streams System. To calculate Net Recharge from SWS below, Rivers and Streams System seepage is summed across the subbasin and redistributed to each subregion in proportion to gross area.

3.5 Net Recharge from SWS

Overdraft is defined in DWR Bulletin 118 as “the condition of a groundwater basin or subbasin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years, during which the water supply conditions approximate average conditions” (DWR 2003). The Chowchilla Subbasin water budget indicates that overdraft conditions occurred during the 1989-2014 historical base period. Per 23 CCR Section 354.18(b)(5), the subbasin overdraft has been quantified for this base period. The evaluation of overdraft conditions includes estimates of recharge from subsurface flows. However, estimates of recharge from subsurface flows are less accurate when estimated for areas less that an entire subbasin. Thus, for estimates of GSA level contribution to overdraft, the term net recharge from the SWS is defined as groundwater recharge minus groundwater extraction. Net recharge from the SWS is useful for understanding and analyzing the combined effects of land surface processes on the underlying GWS.

When calculated from the historical water budget, average net recharge from the SWS represents the average recharge (when positive) or shortage of recharge (when negative) based on historical cropping, land use practices, and average hydrologic conditions. When calculated from the current land use water budget, average net recharge represents the average recharge or shortage (when negative) based on current cropping, land use practices, and average hydrologic conditions.

Average net recharge from the SWS is presented below for the CWD GSA portion of the Chowchilla Subbasin. Table A2.F.a-17 shows the average net recharge from the SWS for 1989-2014 based on the historical water budget, and Table A2.F.a-18 shows the same for the current water budget. Historically, the average net recharge in CWD GSA was approximately -15.5 taf per year between 1989 and 2014. Under current land use conditions, the average net recharge in CWD GSA is approximately -33.4 taf, indicating shortage conditions.

Table A2.F.a-17. Historical Water Budget: Average Net Recharge from SWS by Water Year Type, 1989-2014 (Acre-Feet).

Year Type	Number of Years	Infiltration of Applied Water (a)	Infiltration of Precipitation (b)	Infiltration of Surface Water[1] (c)	Groundwater Extraction (d)	Net Recharge from SWS (a+b+c-d)
W	8	56,930	33,910	79,230	94,150	75,920
AN	3	51,650	17,960	48,970	92,490	26,090
BN	2	50,200	11,990	27,800	150,050	-60,060
D	4	55,460	13,610	37,300	165,110	-58,740
C	9	54,910	17,350	25,410	179,280	-81,610
Annual Average (1989-2014)	26	54,880	21,530	46,700	138,640	-15,530

[1] Includes infiltration from the CWD Canal System and the Rivers and Streams System, as calculated from the total subbasin Rivers and Streams System seepage summed and redistributed to each subregion in proportion to gross area.

Table A2.F.a-18. Current Water Budget: Average Net Recharge from SWS by Water Year Type (Acre-Feet).

Year Type	Number of Years	Infiltration of Applied Water (a)	Infiltration of Precipitation (b)	Infiltration of Surface Water[1] (c)	Groundwater Extraction (d)	Net Recharge from SWS (a+b+c-d)
W	8	53,970	32,220	78,570	105,040	59,720
AN	3	48,200	16,810	48,700	98,880	14,830
BN	2	49,140	11,050	27,440	169,410	-81,780
D	4	50,510	12,470	37,010	169,910	-69,920
C	9	53,660	15,840	24,570	199,360	-105,290
Annual Average (1989-2014)	26	52,290	20,110	46,100	151,910	-33,410

[1] Includes infiltration from the CWD Canal System and the Rivers and Streams System, as calculated from the total subbasin Rivers and Streams System seepage and redistributed to each subregion in proportion to gross area.

3.6 Uncertainties in Water Budget Components

Uncertainties associated with each water budget component were estimated as a percentage representing approximately a 95% confidence interval following the procedure described by Clemmens and Burt (1997). Uncertainties for all independently measured or estimated water budget components were estimated based on the measurement accuracy, typical values reported in technical literature, typical values calculated in other water budgets, and professional judgement.

Table A2.F.a-19 provides a summary of typical uncertainty values associated with major SWS inflow and outflow components. These uncertainties provide a basis for evaluating confidence in water budget results and help to identify data needs that may be addressed during GSP implementation.

Table A2.F.a-19. Estimated Uncertainty of GSA Water Budget Components.

Flowpath Direction (relative to SWS)	Water Budget Component	Data Source	Estimated Uncertainty (%)	Source
Inflows	Surface Water Inflows	Measurement	5%	Estimated streamflow measurement accuracy
	Deliveries	Measurement	6%	Estimated delivery measurement accuracy
	Precipitation	Calculation	30%	Clemmens, A.J. and C.M. Burt, 1997.
	Groundwater Extraction	Calculation	20%	Typical uncertainty calculated for Land Surface System water balance closure; Estimated accuracy of groundwater pumping measurements.
Outflows	Surface Water Outflows	Measurement	20%	Typical uncertainty calculated for Rivers and Streams System water balance closure.
	Evaporation	Calculation	20%	Estimated accuracy of calculation based on CIMIS reference ET and free water surface evaporation coefficient.
	ET of Applied Water	Calculation	10%	Estimated accuracy of daily IDC root zone water budget component based on CIMIS reference ET, estimated crop coefficients from SEBAL energy balance, and annual land use.
	ET of Precipitation	Calculation	10%	Estimated accuracy of daily IDC root zone water budget component based on CIMIS reference ET, precipitation, estimated crop coefficients from SEBAL energy balance, and annual land use.
	Infiltration of Applied Water	Calculation	20%	Estimated accuracy of daily IDC root zone water budget based on annual land use and NRCS soils characteristics.
	Infiltration of Precipitation	Calculation	20%	Estimated accuracy of daily IDC root zone water budget based on annual land use, NRCS soils characteristics, and CIMIS precipitation.
	Infiltration of Surface Water	Calculation	15%	Estimated accuracy of daily seepage calculation using NRCS soils characteristics and measured streamflow data compared to field measurements.
	Change in SWS Storage	Calculation	50%	Professional Judgment.
Net Recharge from SWS		Calculation	25%	Estimated water budget accuracy; typical value calculated for GSA-level net recharge from SWS.

APPENDIX 2.F. WATER BUDGET INFORMATION

2.F.b. Surface Water System Water Budget: Madera County GSA – East Subregion

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020

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1 INTRODUCTION

To ensure sustainable groundwater management throughout California's groundwater basins, the Sustainable Groundwater Management Act of 2014 (SGMA) requires Groundwater Sustainability Agencies (GSAs) to prepare and adopt Groundwater Sustainability Plans (GSPs) with strategies to achieve subbasin groundwater sustainability within 20 years of plan adoption. Integral to each GSP is a water budget used to quantify the subbasin's groundwater overdraft (if applicable) and sustainable yield.

In 2016, Madera County (Madera Co) GSA formed to manage approximately 45,100 acres of the Chowchilla Subbasin. Madera Co GSA includes noncontiguous areas on the eastern and western sides of the Chowchilla Subbasin. Portions of Madera Co GSA's eastern jurisdictional area also overlap with Sierra Vista Mutual Water Company (SVMWC). In the interests of separately accounting for inflows to each side of Madera County GSA and to SVMWC, two water budgets were prepared for Madera Co GSA: one for the western subregion, and one for the eastern subregion, excluding land in SVMWC.

This document presents results of the surface water system (SWS) water budgets developed for historical and current land use conditions in the Madera Co GSA – East Subregion. The Madera Co GSA – East water budgets were integrated with separate water budgets developed for four (4) other subregions covering the remainder of the Chowchilla Subbasin. Together, these water budgets provide the boundary water budget for the Chowchilla Subbasin SWS. Results of the subbasin boundary water budget are reported in the Chowchilla Subbasin GSP Section 2.2.3 and were integrated with a subbasin groundwater model (GSP Appendix 6.E) to estimate subbasin sustainable yield (GSP Section 2.2.3).

2 WATER BUDGET CONCEPTUAL MODEL

A water budget is defined as a complete accounting of all water flowing into and out of a defined volume (e.g., a subbasin or a GSA) over a specified period of time. The conceptual model (or structure) of the Madera Co GSA – East water budget developed for this investigation is consistent with the GSP Regulations defined under Title 23 of California Code of Regulations[1] (CCR) and adheres to sound water budget principles and practices defined by California Department of Water Resources (DWR) in the Water Budget Best Management Practice (BMP) guidelines (DWR, 2016).

The lateral extent of Madera Co GSA – East is defined by the boundaries indicated in Figure A2.F.b-1. The vertical extent of Madera Co GSA – East is the land surface (top) and the base of fresh water at the bottom of the basin (bottom), as described in the hydrogeologic conceptual model (HCM) developed in GSP Section 2.2.1. The vertical extent of Chowchilla Subbasin and its GSAs is subdivided into a surface water system (SWS) and the underlying groundwater system (GWS), with separate but related water budgets prepared for each that together represent the overall subbasin water budget.

[1] California Code of Regulations Title 23. Waters, Division 2. Department of Water Resources, Chapter 1.5. Groundwater Management, Subchapter 2. Groundwater Sustainability Plans.

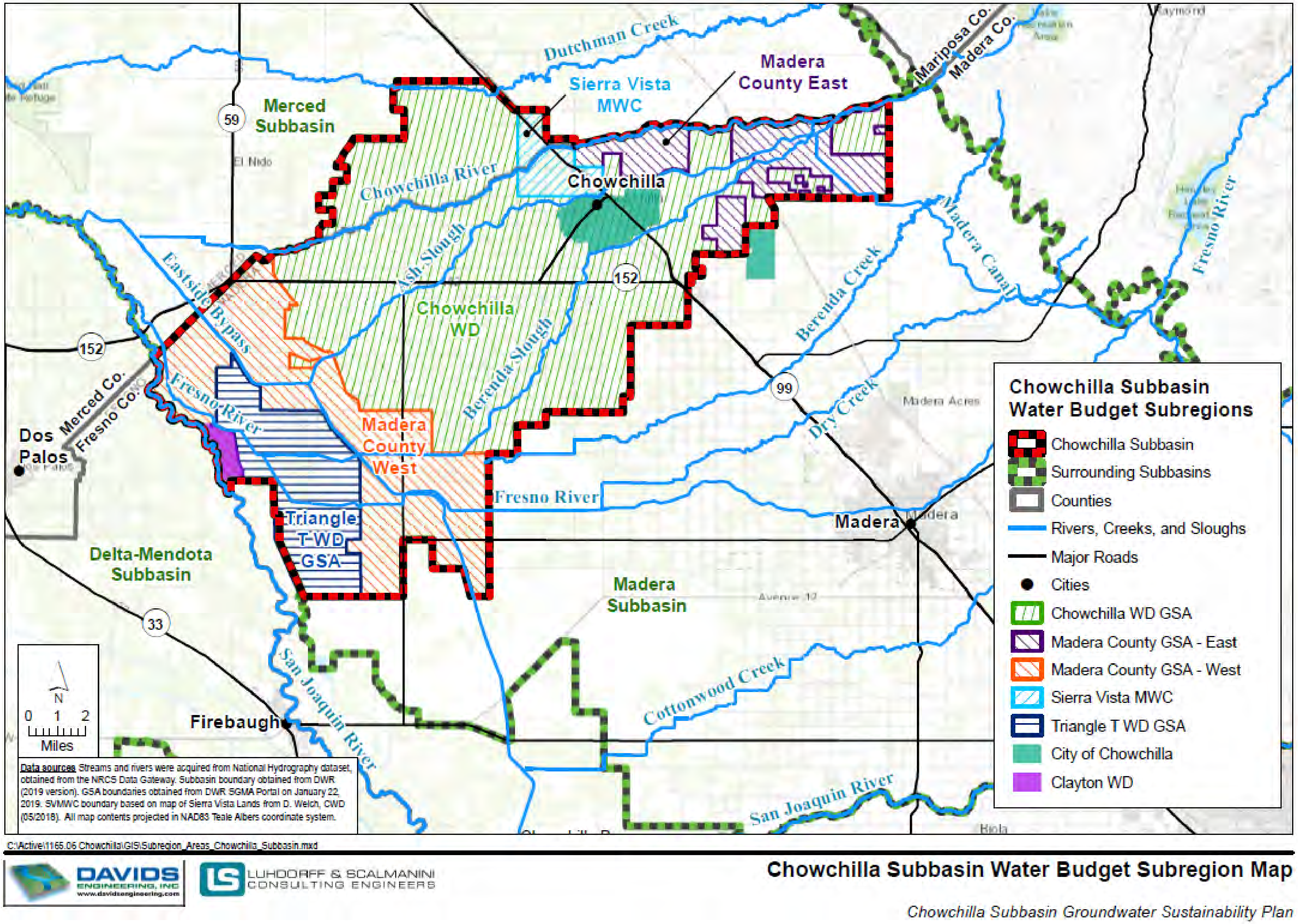

Figure A2.F.b-1. Chowchilla Subbasin Water Budget Subregion Map

A conceptual representation of the Madera Co GSA – East water budget is represented in Figure A2.F.b-2. This document details only the SWS portion of the Madera Co GSA – East water budget. The SWS is divided into two primary accounting centers: the Land Surface System and the Rivers and Streams System. The Land Surface System is further divided into three accounting centers representing the subregion water use sectors: Agricultural Land, Native Vegetation Land, and Urban Land (urban, industrial, and semi-agricultural).

Water budget components, or directional flow of water between accounting centers and across the SWS boundary, are indicated by arrows. Inflows and outflows were calculated using measurements and other historical data or were calculated as the water budget closure term – the difference between all other estimated or measured inflows and outflows from each accounting center or water use sector (bold arrows).

Inflows to the SWS include precipitation, surface water inflows (in various canals and streams), and groundwater extraction. Outflows from the SWS include evapotranspiration (ET), surface water outflows (in various canals and streams), and infiltration to the groundwater system (seepage and deep percolation). Also represented in Figure 2A.F.b-2 are inflows and outflows from the GWS, which are discussed and quantified at the subbasin level in the GWS water budget in GSP Section 2.2.3. Subsurface GWS inflows and outflows are not quantified on the water budget subregion scale.

Inflows and outflows were quantified following the process described in GSP Section 2.2.3 on a monthly time step for water years in the historical water budget base period (1989-2014 hydrologic and land use conditions), the current water budget (2015 land use using 1989-2014 average hydrologic conditions), and projected water budget. Four projected water budgets were prepared for the years 2019 through 2090 based on 1965 through 2015 hydrologic conditions, projected water supplies, and 2017 land use adjusted for urban area projected growth from 2017-2070 (areas were held constant from 2071-2090):

1. Historical hydrologic conditions and water supply data, with adjustment for projected alteration of available Friant releases by the San Joaquin River Restoration Program (SJRRP)[2]
    a. Without projects and management actions, and
    b. With projects and management actions
2. Historical hydrologic conditions and water supply data, with adjustment for projected alteration of available Friant releases by the SJRRP and adjustment for anticipated climate change per DWR-provided 2030 climate change factors
    a. Without projects and management actions, and
    b. With projects and management actions.

Information regarding the data sources and adjustments used to prepare the historical, current, and projected water budgets are described in GSP Section 2.2.3.

[2] Adjustments were based on the Friant Report ("Estimate of Future Friant Division Supplies for use in Groundwater Sustainability Plans, California," Friant Water Authority, 2018). Although the Friant Report accounts for climate change, it is considered the best available estimate of projected Friant releases under SJRRP. For comparison, projected Madera Canal deliveries under SJRRP were also estimated without account for climate change from the Kondolf Hydrographs (in "Effects to Water Supply and Friant Operations Resulting From Plaintiffs' Friant Release Requirements," Steiner, 2005). These estimates were approximately equal to the Friant Report 2030 climate change adjusted deliveries. Thus, the Friant Report projections were used instead to maintain consistent assumptions in estimating Madera Canal deliveries across all projected simulations.

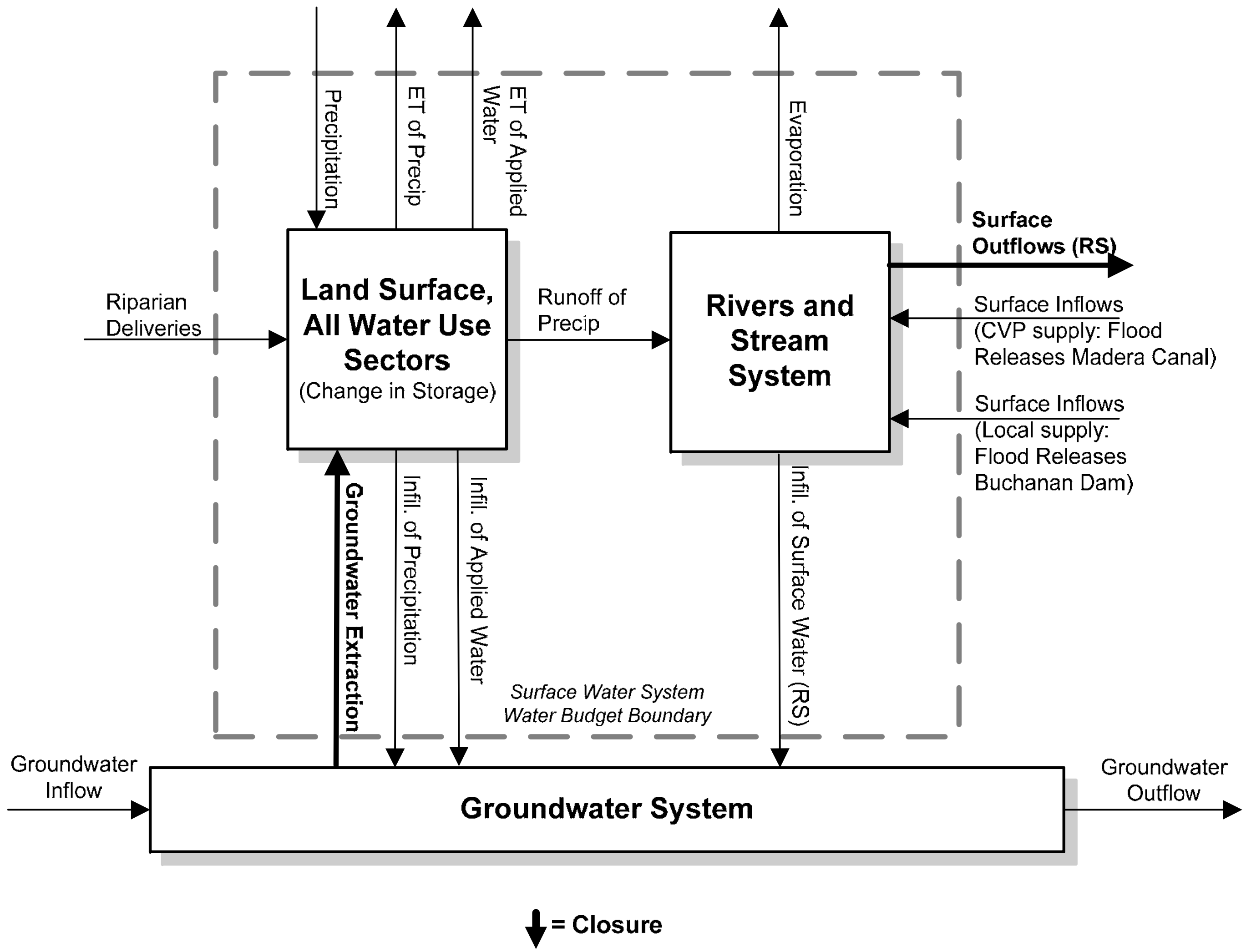

Figure A2.F.b-2. Madera County GSA – East Water Budget Structure

3 WATER BUDGET ANALYSIS

The historical water budget and current land use water budget for Madera Co GSA – East are presented below following a summary of land use data relevant to water budget development. Land use data is provided for the 1989-2014 historical water budget period and for 2015, the current land use water budget period.

3.1 Land Use

Land use estimates for 1989 through 2015 corresponding to water use sectors (as defined by the GSP Regulations) are summarized in Figure A2.F.b-3 and Table A2.F.b-1 for the Madera Co GSA – East subregion. According to GSP Regulations (23 CCR § 351(al)):

> *"Water use sector" refers to categories of water demand based on the general land uses to which the water is applied, including urban, industrial, agricultural, managed wetlands, managed recharge, and native vegetation.*

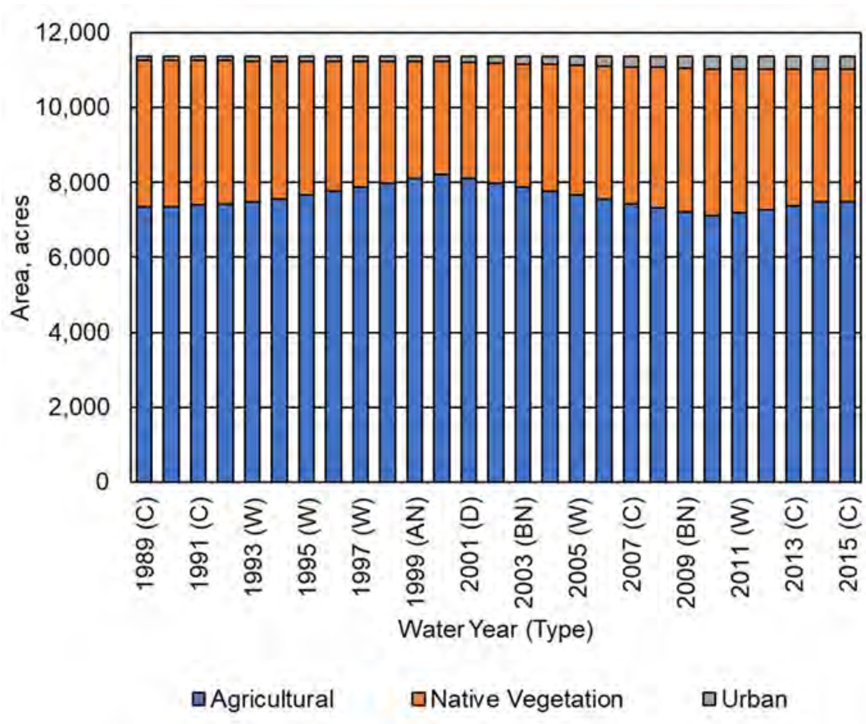

Figure A2.F.b-3. Madera County GSA – East Land Use Areas

Table A2.F.b-1. Madera County GSA – East Land Use Areas, acres

Water Year (Type)	Agricultural	Native Vegetation[1]	Urban[2]	Total
1989 (C)	7,354	3,905	103	11,362
1990 (C)	7,352	3,903	107	11,362
1991 (C)	7,403	3,849	110	11,362
1992 (C)	7,427	3,821	114	11,362
1993 (W)	7,477	3,767	118	11,362
1994 (C)	7,547	3,693	122	11,362
1995 (W)	7,657	3,579	125	11,362
1996 (W)	7,769	3,465	128	11,362
1997 (W)	7,880	3,351	131	11,362
1998 (W)	7,991	3,237	134	11,362
1999 (AN)	8,102	3,123	137	11,362
2000 (AN)	8,213	3,009	140	11,362
2001 (D)	8,102	3,100	159	11,362
2002 (D)	7,991	3,192	179	11,362
2003 (BN)	7,880	3,284	198	11,362
2004 (D)	7,768	3,375	218	11,362
2005 (W)	7,657	3,467	237	11,362
2006 (W)	7,546	3,559	257	11,362
2007 (C)	7,435	3,650	276	11,362
2008 (C)	7,324	3,742	296	11,362
2009 (BN)	7,213	3,834	315	11,362
2010 (AN)	7,102	3,925	334	11,362
2011 (W)	7,192	3,838	332	11,362
2012 (D)	7,282	3,750	329	11,362
2013 (C)	7,373	3,662	327	11,362
2014 (C)	7,486	3,537	338	11,362
2015 (C)	7,486	3,537	338	11,362
Average (1989-2014)	7,597	3,562	202	11,362

[1] Area includes land classified as native vegetation and water surfaces.
[2] Area includes land classified as urban, industrial, and semi-agricultural.

In Madera Co GSA – East, water use sectors include agricultural, native vegetation, and urban land use. The urban land use category includes urban and semi-agricultural[3] lands as well as industrial land, which covers only a small area in the subbasin.

[3] As defined in the DWR county land use surveys, semi-agricultural land use subclasses include farmsteads, livestock feed lot operations, dairies, poultry farms, and miscellaneous semi-agricultural land use incidental to agriculture (small roads, ditches, non-planted areas of cropped fields (DWR, 2009).

As indicated, the majority of land in Madera Co GSA – East is used for agriculture, covering an average of approximately 7,600 acres between 1989 and 2014. The remainder of the subregion is primarily native vegetation, averaging approximately 3,600 acres between 1989 and 2014.

Agricultural land uses are further detailed in Figure A2.F.b-4 and Table A2.F.b-2. Historically, a majority of the agricultural area in Madera Co has been used to cultivate permanent crops, including grapes and orchard crops. While the acreage of grapes and other crops have decreased since the 1990s, orchard acreage more than doubled between 1989 and 2015.

3.2 Surface Water System Water Budget

This section presents surface water system water budget components within Madera Co GSA – East as per GSP regulations. These are followed by a summary of the water budget results by accounting center.

3.2.1 Inflows

3.2.1.1 Surface Water Inflow by Water Source Type

Surface water inflows include surface water flowing into Madera Co GSA – East across the subregion boundary. Per the Regulations, surface inflows must be reported by water source type. According to the Regulations:

> *"Water source type" represents the source from which water is derived to meet the applied beneficial uses, including groundwater, recycled water, reused water, and surface water sources identified as Central Valley Project, the State Water Project, the Colorado River Project, local supplies, and local imported supplies.*

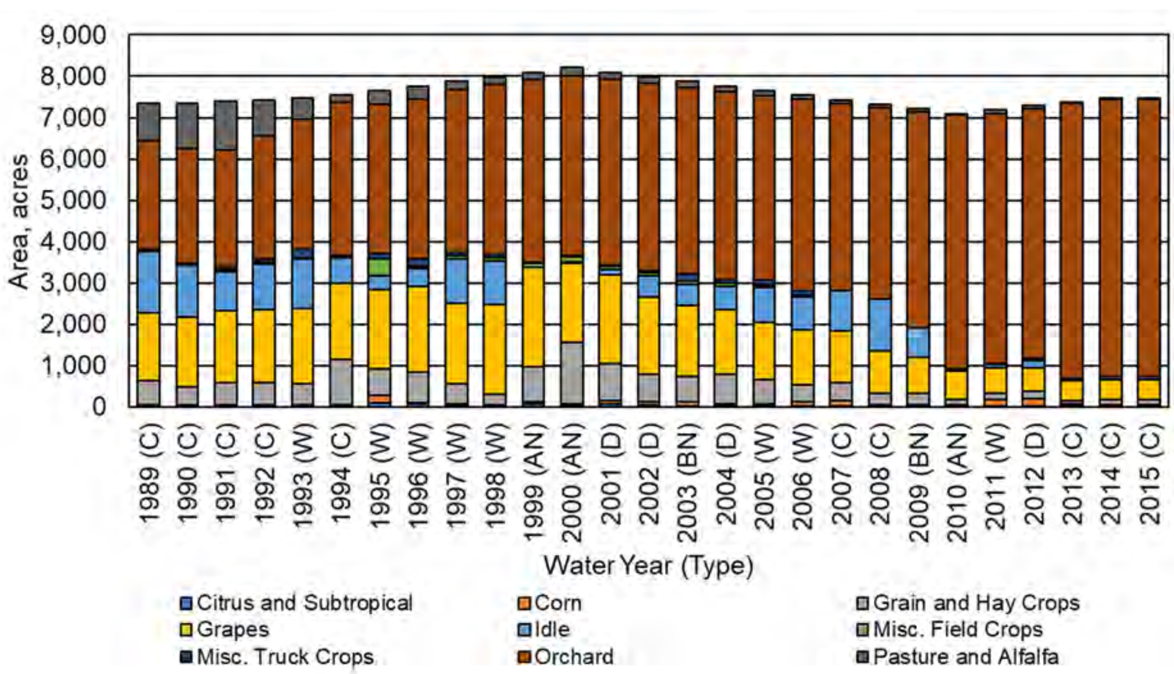

Figure A2.F.b-4. Madera County GSA – East Agricultural Land Use Areas

Table A2.F.b-2. Madera County GSA – East Agricultural Land Use Areas

Water Year (Type)	Citrus and Subtropical	Corn	Grain and Hay Crops	Grapes	Idle	Misc. Field Crops	Misc. Truck Crops	Orchard	Pasture and Alfalfa	Total
1989 (C)	30	9	588	1,647	1,493	45	8	2,630	905	7,354
1990 (C)	35	8	443	1,679	1,250	49	10	2,768	1,109	7,352
1991 (C)	36	10	534	1,740	963	46	33	2,861	1,181	7,403
1992 (C)	37	11	534	1,764	1,106	46	72	2,983	873	7,427
1993 (W)	38	11	503	1,833	1,185	43	205	3,136	523	7,477
1994 (C)	37	13	1,084	1,848	624	43	7	3,709	184	7,547
1995 (W)	87	171	666	1,921	315	418	120	3,622	337	7,657
1996 (W)	78	20	745	2,072	420	67	169	3,874	322	7,769
1997 (W)	35	29	487	1,950	1,074	72	88	3,954	189	7,880
1998 (W)	15	35	235	2,185	1,067	75	60	4,130	189	7,991
1999 (AN)	71	43	841	2,417	9	93	22	4,410	195	8,102
2000 (AN)	36	41	1,479	1,930	13	130	26	4,368	191	8,213
2001 (D)	57	84	901	2,144	143	81	26	4,489	177	8,102
2002 (D)	31	76	680	1,872	507	79	40	4,543	162	7,991
2003 (BN)	26	78	639	1,704	506	83	187	4,508	148	7,880
2004 (D)	27	35	712	1,568	574	67	90	4,562	134	7,768
2005 (W)	23	37	590	1,392	844	44	123	4,484	119	7,657
2006 (W)	22	87	430	1,322	806	27	118	4,630	105	7,546
2007 (C)	18	123	431	1,255	982	6	5	4,526	91	7,435
2008 (C)	14	18	294	1,034	1,243	1	5	4,639	76	7,324
2009 (BN)	13	17	280	885	721	5	3	5,227	62	7,213
2010 (AN)	18	12	151	670	49	0	0	6,155	48	7,102
2011 (W)	12	161	145	611	98	0	14	6,037	114	7,192
2012 (D)	12	183	188	552	191	0	31	6,062	63	7,282
2013 (C)	29	28	79	493	39	0	0	6,683	21	7,373
2014 (C)	17	29	112	492	18	0	69	6,717	33	7,486
2015 (C)	17	29	112	492	18	0	69	6,717	33	7,486
Average (1989-2014)	33	53	530	1,499	625	58	59	4,450	291	7,597

Additionally, runoff of precipitation from upgradient areas adjacent to the subregion represents a potential source of surface water inflow.

Local Supplies

Madera Co GSA – East does not receive local supplies for irrigation purposes.

CVP Supplies

CVP supply inflows to Madera Co GSA – East include flood releases from Buchanan Dam along the Chowchilla River (much of which flows through the subregion), riparian diversions from Chowchilla River by water rights users, and flood releases from Millerton Reservoir along Madera Canal.

Recycling and Reuse

Recycling and reuse are not a significant source of supply within Madera Co GSA – East.

Other Surface Inflows

For the water budgets presented herein, precipitation runoff from outside the subregion is considered relatively minimal and is expected to pass through the waterways accounted above following relatively large storm events. Precipitation runoff from lands inside the subregion is internal to the surface water system and is thus not considered as surface inflows to the subregion boundary.

Summary of Surface Inflows

The surface water inflows described above are summarized by water source type in Figure A2.F.b-5 and Table A2.F.b-3. During the study period, surface water inflows vary by water year type, averaging 95 taf per wet year.

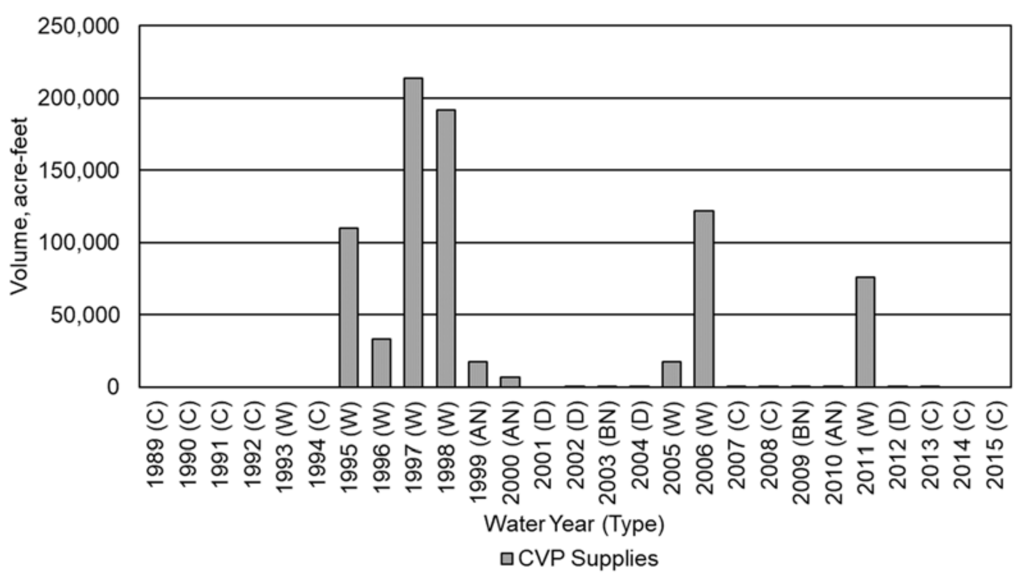

Figure A2.F.b-5. Madera County GSA – East Surface Water Inflows by Water Source Type.

Table A2.F.b-3. Madera County GSA – East Surface Water Inflows by Water Source Type (Acre-Feet).

Water Year (Type)	Local Supply	CVP Supply[1]	Total
1989 (C)	0	0	0
1990 (C)	0	0	0
1991 (C)	0	0	0
1992 (C)	0	0	0
1993 (W)	0	0	0
1994 (C)	0	0	0
1995 (W)	0	109,760	109,760
1996 (W)	0	32,950	32,950
1997 (W)	0	213,510	213,510
1998 (W)	0	191,690	191,690
1999 (AN)	0	17,620	17,620
2000 (AN)	0	6,850	6,850
2001 (D)	0	0	0
2002 (D)	0	530	530
2003 (BN)	0	280	280
2004 (D)	0	360	360
2005 (W)	0	17,540	17,540
2006 (W)	0	121,690	121,690
2007 (C)	0	360	360
2008 (C)	0	260	260
2009 (BN)	0	330	330
2010 (AN)	0	410	410
2011 (W)	0	76,050	76,050
2012 (D)	0	60	60
2013 (C)	0	110	110
2014 (C)	0	0	0
2015 (C)	0	0	0
Average (1989-2014)	0	30,400	30,400
Average (1989-2014) W	0	95,400	95,400
Average (1989-2014) AN	0	8,290	8,290
Average (1989-2014) BN	0	310	310
Average (1989-2014) D	0	240	240
Average (1989-2014) C	0	80	80

[1.] CVP Supply is considered as all water supply released from CVP storage facilities. The volume of CVP Supply includes CVP deliveries to CWD, and flood releases from CVP facilities that pass through the subbasin. In Madera County GSA - East, all CVP supply pass through the GSA.

3.2.1.2 Precipitation

Precipitation estimates for Madera Co GSA – East are provided in Figure A2.F.b-6 and Table A2.F.b-4. Precipitation estimates are reported by water use sector.

Total precipitation is highly variable between years in the study area, ranging from approximately 7 taf (7.6 inches) during average dry years to 14 taf (14.4 inches) during average wet years.

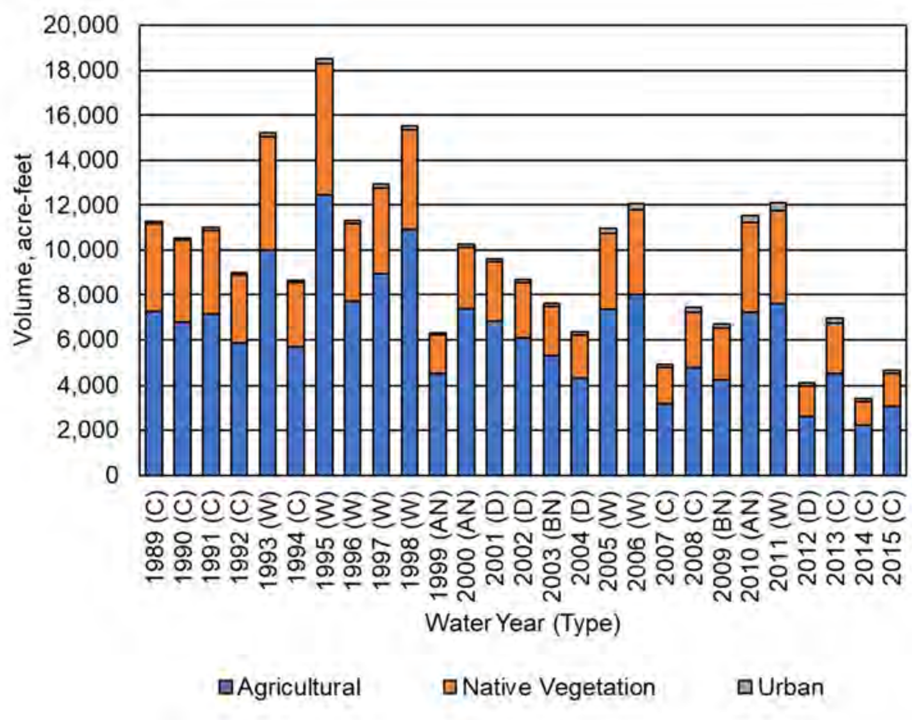

Figure A2.F.b-6. Madera County GSA – East Precipitation by Water Use Sector.

Table A2.F.b-4. Madera County GSA – East Precipitation by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	7,280	3,890	100	11,270
1990 (C)	6,790	3,630	100	10,520
1991 (C)	7,150	3,740	110	10,990
1992 (C)	5,860	3,030	90	8,980
1993 (W)	9,990	5,060	160	15,210
1994 (C)	5,720	2,810	90	8,620
1995 (W)	12,460	5,850	200	18,520
1996 (W)	7,720	3,460	130	11,310
1997 (W)	8,950	3,830	150	12,920
1998 (W)	10,910	4,440	180	15,530
1999 (AN)	4,490	1,740	80	6,300
2000 (AN)	7,410	2,730	130	10,270
2001 (D)	6,830	2,630	140	9,590
2002 (D)	6,110	2,460	140	8,700
2003 (BN)	5,290	2,220	130	7,650
2004 (D)	4,340	1,890	120	6,350
2005 (W)	7,380	3,350	230	10,960
2006 (W)	8,010	3,800	280	12,080
2007 (C)	3,200	1,580	120	4,890
2008 (C)	4,780	2,450	190	7,430
2009 (BN)	4,260	2,270	190	6,720
2010 (AN)	7,220	4,000	340	11,550
2011 (W)	7,650	4,090	350	12,090
2012 (D)	2,640	1,360	120	4,120
2013 (C)	4,510	2,240	200	6,960
2014 (C)	2,240	1,060	100	3,400
2015 (C)	3,050	1,440	140	4,640
Average (1989-2014)	6,510	3,060	160	9,730
Average (1989-2014) W	9,130	4,240	210	13,580
Average (1989-2014) AN	6,370	2,820	180	9,370
Average (1989-2014) BN	4,780	2,240	160	7,180
Average (1989-2014) D	4,980	2,080	130	7,190
Average (1989-2014) C	5,280	2,710	120	8,120

3.2.1.3 Groundwater Extraction by Water Use Sector

Estimates of groundwater extraction by water use sector are provided in Figure A2.F.b-7 and Table A2.F.b-5. For agricultural and urban (urban, semi-agricultural, industrial) lands, groundwater extraction represents pumping, while for native lands, groundwater extraction by riparian vegetation was considered to be negligible. In all water use sector water budgets, groundwater extraction served as the water budget closure term. Groundwater extraction is dominated by irrigated agriculture and increases over time, following the trend of increasing orchard acreage in the subregion. The consumptive water use of orchards is higher than most other crops grown in the subbasin, and groundwater serves as a major source of supply for the pressurized irrigation systems typical of orchards.

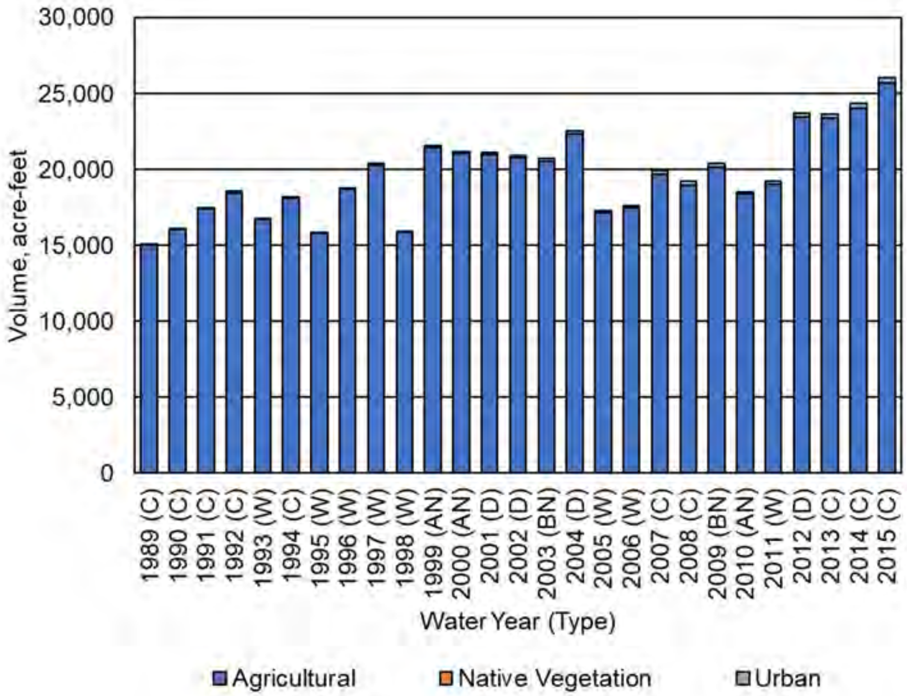

Figure A2.F.b-7. Madera County GSA – East Groundwater Extraction by Water Use Sector.

Table A2.F.b-5. Madera County GSA – East Groundwater Extraction by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	15,010	0	70	15,080
1990 (C)	16,060	0	70	16,130
1991 (C)	17,430	0	80	17,500
1992 (C)	18,470	0	100	18,570
1993 (W)	16,710	0	80	16,790
1994 (C)	18,120	0	100	18,220
1995 (W)	15,770	0	50	15,820
1996 (W)	18,690	0	80	18,760
1997 (W)	20,300	0	130	20,430
1998 (W)	15,840	0	70	15,910
1999 (AN)	21,460	0	100	21,560
2000 (AN)	21,070	0	100	21,170
2001 (D)	20,990	0	110	21,100
2002 (D)	20,760	0	150	20,910
2003 (BN)	20,550	0	160	20,710
2004 (D)	22,340	0	220	22,560
2005 (W)	17,160	0	140	17,300
2006 (W)	17,470	0	150	17,620
2007 (C)	19,710	0	260	19,970
2008 (C)	18,950	0	270	19,220
2009 (BN)	20,160	0	270	20,430
2010 (AN)	18,380	0	160	18,550

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
2011 (W)	19,060	0	180	19,230
2012 (D)	23,430	0	300	23,730
2013 (C)	23,380	0	300	23,680
2014 (C)	24,070	0	300	24,370
2015 (C)	25,740	0	340	26,080
Average (1989-2014)	19,280	0	150	19,430
Average (1989-2014) W	17,620	0	110	17,730
Average (1989-2014) AN	20,300	0	120	20,430
Average (1989-2014) BN	20,350	0	220	20,570
Average (1989-2014) D	21,880	0	190	22,080
Average (1989-2014) C	19,020	0	170	19,190

3.2.1.4 Groundwater Discharge to Surface Water Sources

The depth to groundwater is greater than 100-200 ft across much of the Chowchilla Subbasin. Given the depth to the water table in the Chowchilla Subbasin, groundwater discharge to surface water sources is negligible.

3.2.2 Outflows

3.2.2.1 Evapotranspiration by Water Use Sector

Evapotranspiration (ET) by water use sector is reported in Figures A2.F.b-8 to A2.F.b-10 and Tables A2.F.b-6 to A2.F.b-8. First, total ET is reported, followed by ET from applied water and ET from precipitation.

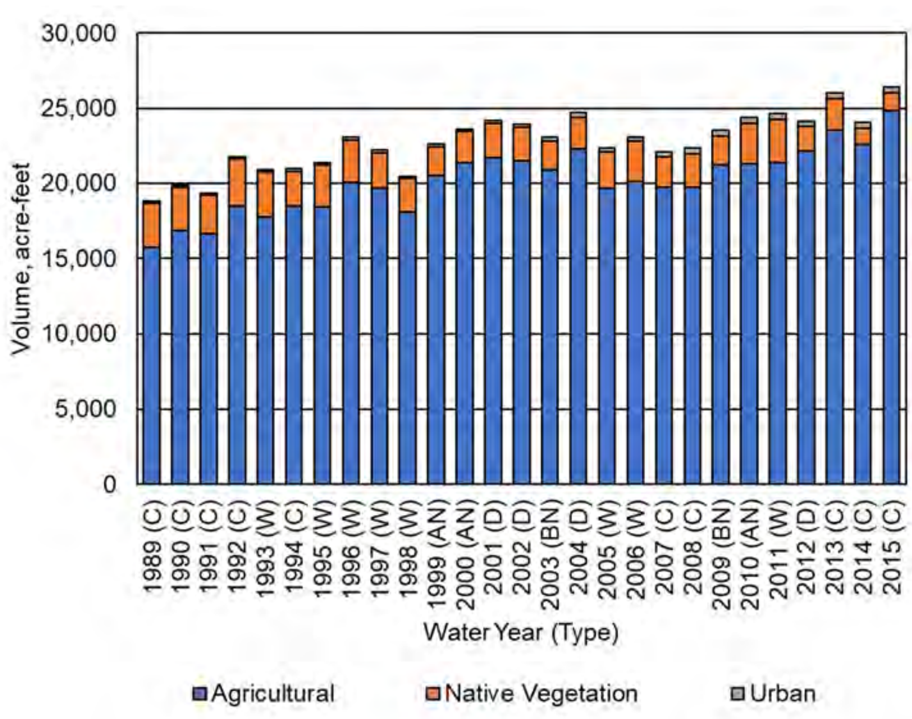

Figure A2.F.b-8. Madera County GSA – East Evapotranspiration by Water Use Sector.

Table A2.F.b-6. Madera County GSA – East Evapotranspiration by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	15,720	2,990	120	18,830
1990 (C)	16,840	2,920	130	19,890
1991 (C)	16,670	2,580	110	19,360
1992 (C)	18,530	3,090	150	21,770
1993 (W)	17,800	3,010	140	20,950
1994 (C)	18,470	2,350	140	20,970
1995 (W)	18,440	2,800	140	21,380
1996 (W)	20,050	2,850	150	23,050
1997 (W)	19,650	2,400	160	22,230
1998 (W)	18,110	2,220	150	20,510
1999 (AN)	20,560	1,890	150	22,600
2000 (AN)	21,400	2,060	160	23,620
2001 (D)	21,720	2,300	180	24,200
2002 (D)	21,500	2,240	220	23,960
2003 (BN)	20,950	1,860	240	23,050
2004 (D)	22,320	2,100	290	24,710
2005 (W)	19,650	2,420	270	22,340
2006 (W)	20,110	2,690	300	23,100
2007 (C)	19,710	2,050	320	22,080
2008 (C)	19,760	2,210	380	22,350
2009 (BN)	21,260	1,870	390	23,520
2010 (AN)	21,300	2,700	370	24,370
2011 (W)	21,390	2,880	370	24,640
2012 (D)	22,170	1,650	340	24,160
2013 (C)	23,560	2,060	400	26,020
2014 (C)	22,650	1,050	340	24,040
2015 (C)	24,850	1,210	390	26,450
Average (1989-2014)	20,010	2,360	240	22,610
Average (1989-2014) W	19,400	2,660	210	22,280
Average (1989-2014) AN	21,080	2,220	220	23,520
Average (1989-2014) BN	21,100	1,870	310	23,280
Average (1989-2014) D	21,930	2,070	260	24,260
Average (1989-2014) C	19,100	2,370	230	21,700

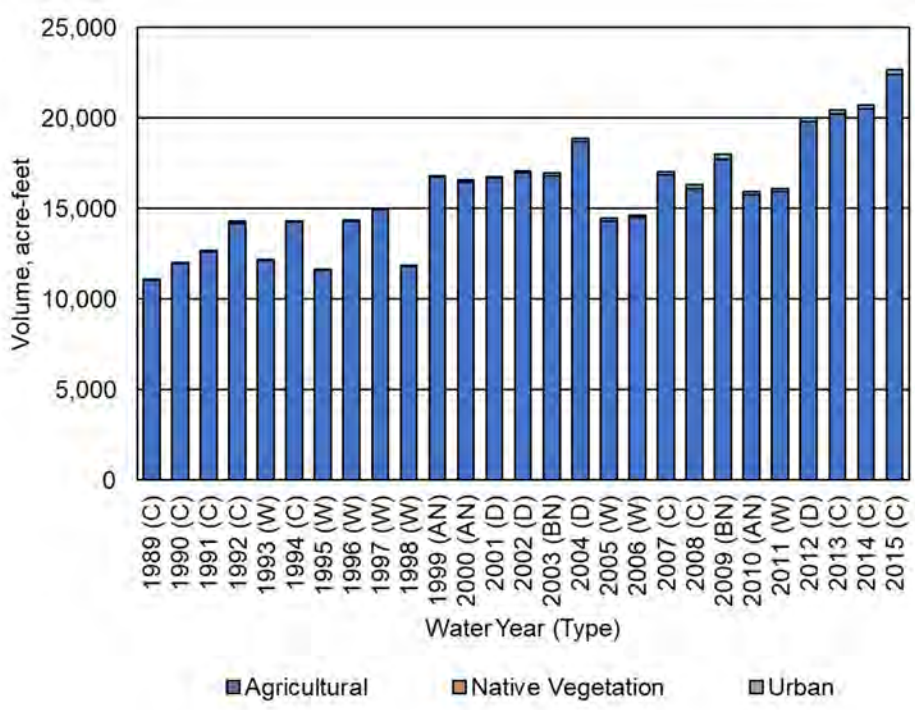

Figure A2.F.b-9. Madera County GSA – East Evapotranspiration of Applied Water by Water Use Sector.

Table A2.F.b- 7. Madera County GSA – East Evapotranspiration of Applied Water by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	11,050	0	50	11,100
1990 (C)	11,970	0	60	12,030
1991 (C)	12,650	0	50	12,700
1992 (C)	14,220	0	70	14,290
1993 (W)	12,150	0	60	12,210
1994 (C)	14,250	0	70	14,330
1995 (W)	11,610	0	50	11,660
1996 (W)	14,320	0	50	14,370
1997 (W)	14,940	0	70	15,030
1998 (W)	11,790	0	60	11,880
1999 (AN)	16,750	0	70	16,820
2000 (AN)	16,510	0	80	16,590
2001 (D)	16,690	0	80	16,770
2002 (D)	16,950	0	110	17,060
2003 (BN)	16,820	0	130	16,950
2004 (D)	18,710	0	170	18,880
2005 (W)	14,320	0	130	14,450
2006 (W)	14,520	0	130	14,650
2007 (C)	16,860	0	170	17,030
2008 (C)	16,110	0	220	16,330
2009 (BN)	17,740	0	240	17,980
2010 (AN)	15,760	0	160	15,920

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
2011 (W)	15,950	0	140	16,090
2012 (D)	19,810	0	190	20,000
2013 (C)	20,230	0	240	20,470
2014 (C)	20,510	0	240	20,750
2015 (C)	22,410	0	280	22,690
Average (1989-2014)	15,510	0	120	15,630
Average (1989-2014) W	13,700	0	90	13,800
Average (1989-2014) AN	16,340	0	100	16,440
Average (1989-2014) BN	17,280	0	180	17,460
Average (1989-2014) D	18,040	0	140	18,180
Average (1989-2014) C	15,320	0	130	15,450

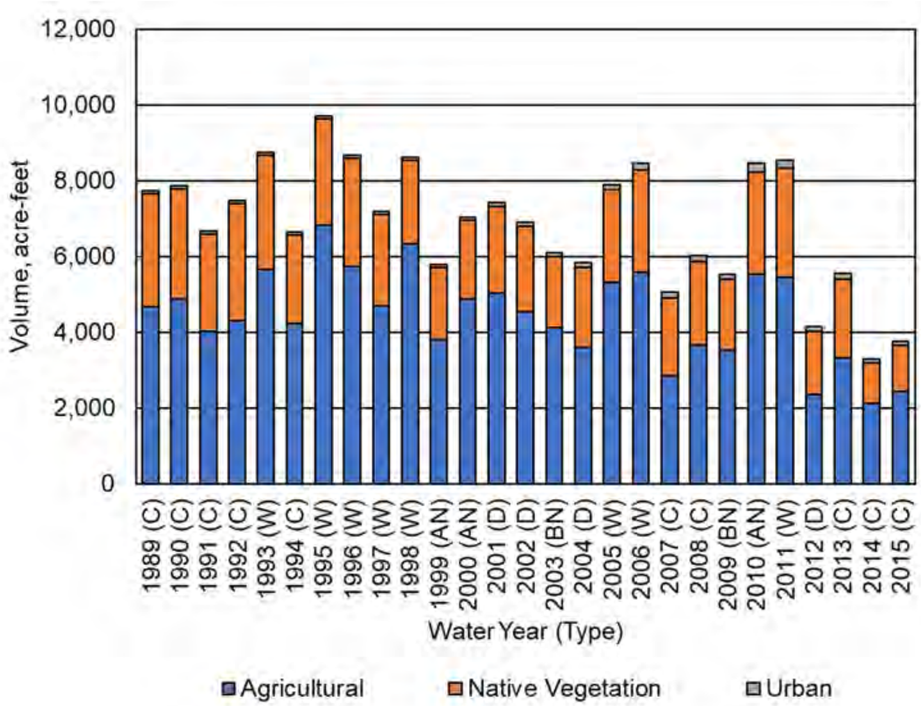

Figure A2.F.b-10. Madera County GSA – East Evapotranspiration of Precipitation by Water Use Sector.

Table A2.F.b-8. Madera County GSA – East Evapotranspiration of Precipitation by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	4,670	2,990	70	7,730
1990 (C)	4,870	2,920	70	7,860
1991 (C)	4,020	2,580	60	6,660
1992 (C)	4,310	3,090	80	7,480
1993 (W)	5,650	3,010	80	8,740
1994 (C)	4,220	2,350	70	6,640
1995 (W)	6,830	2,800	90	9,720
1996 (W)	5,730	2,850	100	8,680

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1997 (W)	4,710	2,400	90	7,200
1998 (W)	6,320	2,220	90	8,630
1999 (AN)	3,810	1,890	80	5,780
2000 (AN)	4,890	2,060	80	7,030
2001 (D)	5,030	2,300	100	7,430
2002 (D)	4,550	2,240	110	6,900
2003 (BN)	4,130	1,860	110	6,100
2004 (D)	3,610	2,100	120	5,830
2005 (W)	5,330	2,420	140	7,890
2006 (W)	5,590	2,690	170	8,450
2007 (C)	2,850	2,050	150	5,050
2008 (C)	3,650	2,210	160	6,020
2009 (BN)	3,520	1,870	150	5,540
2010 (AN)	5,540	2,700	210	8,450
2011 (W)	5,440	2,880	230	8,550
2012 (D)	2,360	1,650	150	4,160
2013 (C)	3,330	2,060	160	5,550
2014 (C)	2,140	1,050	100	3,290
2015 (C)	2,440	1,210	110	3,760
Average (1989-2014)	4,500	2,360	120	6,980
Average (1989-2014) W	5,700	2,660	120	8,480
Average (1989-2014) AN	4,740	2,220	120	7,080
Average (1989-2014) BN	3,820	1,870	130	5,820
Average (1989-2014) D	3,890	2,070	120	6,080
Average (1989-2014) C	3,780	2,370	100	6,250

Total ET varies between years, with the lowest observed in 1989, at approximately 19 taf, and greatest in 2015, at approximately 26 taf. Total ET generally increases over time, again following the trend of increasing orchard acreage, which has higher water demand than many other crops grown in the subbasin.

In addition to ET from land surfaces, estimates of evaporation from Madera Co GSA – East rivers and streams are reported in Figure A2.F.b-11 and Table A2.F.b-9. Evaporation from the Rivers and Streams System includes evaporation of both surface inflows and of precipitation runoff within local sloughs and depressions. Total evaporation from all sources averaged less than 0.1 taf per year between 1989 and 2014.

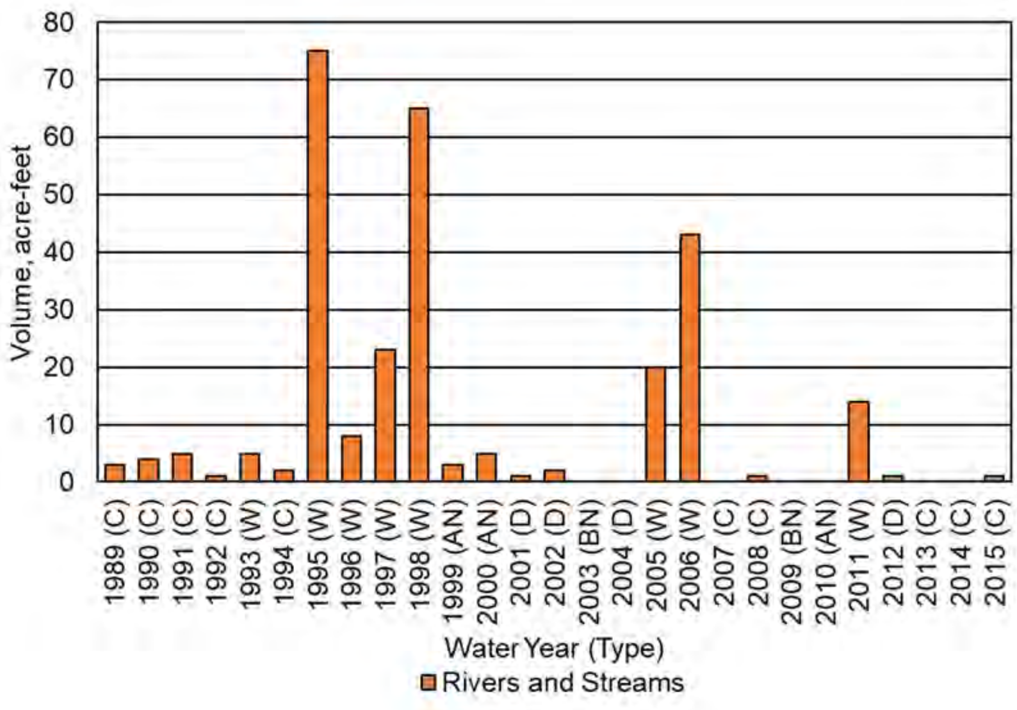

Figure A2.F.b-11. Madera County GSA – East Evaporation from the Surface Water System.

Table A2.F.b-9. Madera County GSA – East Evaporation from the Surface Water System (Acre-Feet).

Water Year (Type)	Rivers and Streams[1]
1989 (C)	0
1990 (C)	0
1991 (C)	10
1992 (C)	0
1993 (W)	10
1994 (C)	0
1995 (W)	80
1996 (W)	10
1997 (W)	20
1998 (W)	70
1999 (AN)	0
2000 (AN)	10
2001 (D)	0
2002 (D)	0
2003 (BN)	0
2004 (D)	0
2005 (W)	20
2006 (W)	40
2007 (C)	0
2008 (C)	0
2009 (BN)	0
2010 (AN)	0

Water Year (Type)	Rivers and Streams[1]
2011 (W)	10
2012 (D)	0
2013 (C)	0
2014 (C)	0
2015 (C)	0
Average (1989-2014)	10
Average (1989-2014) W	32
Average (1989-2014) AN	3
Average (1989-2014) BN	0
Average (1989-2014) D	1
Average (1989-2014) C	2

[1] Includes evaporation of surface inflows and of precipitation runoff.

3.2.2.2 Surface Water Outflow by Water Source Type

Surface water outflows by water source type are summarized in Figure A2.F.b-12 and Table A2.F.b-10. In Madera Co GSA – East, runoff of applied water is assumed negligible and runoff of precipitation is collected in waterways within Madera Co GSA – East, with most infiltrating to the groundwater system except following the largest storm events. Thus, surface outflows from the GSA – East are expected to be CVP supplies during flood releases from Buchanan Dam and Madera Canal. Between 1989 and 2014, these combined outflows averaged over 92 taf during wet years.

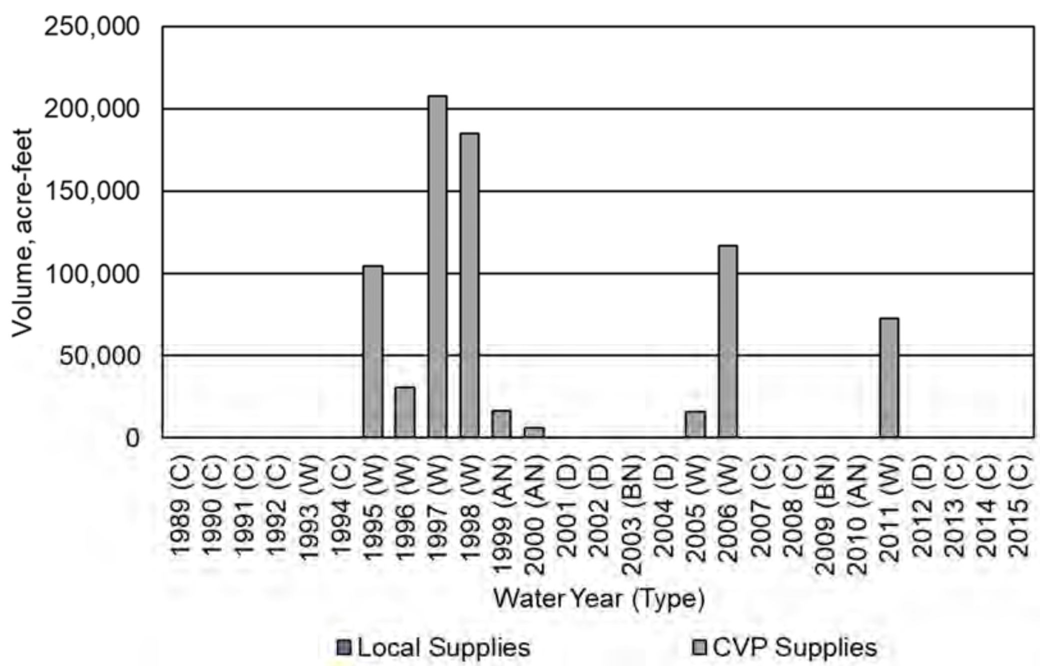

Figure A2.F.b-12. Madera County GSA – East Surface Outflows by Water Source Type.

Table A2.F.b-10. Madera County GSA – East Surface Outflows by Water Source Type (Acre-Feet).

Water Year (Type)	Local Supplies	CVP Supplies	Total
1989 (C)	0	0	0
1990 (C)	0	0	0
1991 (C)	0	0	0
1992 (C)	0	0	0
1993 (W)	0	0	0
1994 (C)	0	0	0
1995 (W)	0	104,543	104,543
1996 (W)	0	30,747	30,747
1997 (W)	0	207,633	207,633
1998 (W)	0	184,924	184,924
1999 (AN)	0	16,843	16,843
2000 (AN)	0	6,370	6,370
2001 (D)	0	0	0
2002 (D)	0	0	0
2003 (BN)	0	0	0
2004 (D)	0	0	0
2005 (W)	0	15,939	15,939
2006 (W)	0	116,785	116,785
2007 (C)	0	0	0
2008 (C)	0	0	0
2009 (BN)	0	0	0
2010 (AN)	0	0	0
2011 (W)	0	72,907	72,907
2012 (D)	0	0	0
2013 (C)	0	0	0
2014 (C)	0	0	0
2015 (C)	0	0	0
Average (1989-2014)	0	29,103	29,103
Average (1989-2014) W	0	91,685	91,685
Average (1989-2014) AN	0	7,738	7,738
Average (1989-2014) BN	0	0	0
Average (1989-2014) D	0	0	0
Average (1989-2014) C	0	0	0

3.2.2.3 Infiltration of Precipitation

Estimated infiltration of precipitation (deep percolation of precipitation) by water use sector is provided in Figure A2.F.b-13 and Table A2.F.b-11. Infiltration of precipitation to the groundwater system is highly variable from year to year due to variation in the timing and amount of precipitation, ranging from less than 1 taf annually during some critical and dry years to over 6 taf during 1995.

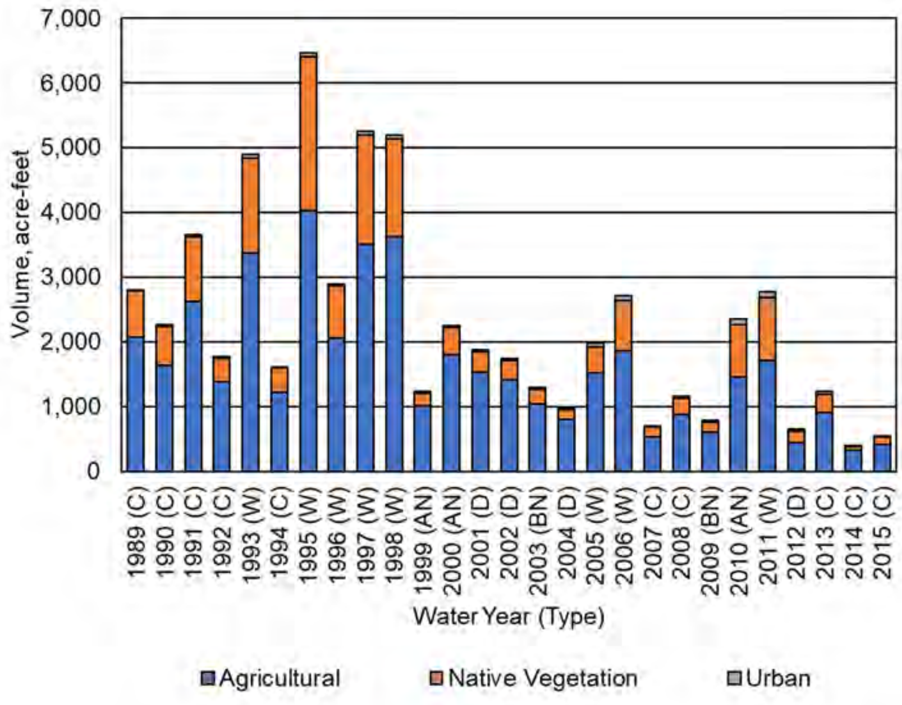

Figure A2.F.b-13. Madera County GSA – East Infiltration of Precipitation by Water Use Sector.

Table A2.F.b-11. Madera County GSA – East Infiltration of Precipitation by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	2,070	720	20	2,810
1990 (C)	1,640	600	20	2,260
1991 (C)	2,620	1,010	30	3,660
1992 (C)	1,380	370	20	1,770
1993 (W)	3,370	1,470	50	4,890
1994 (C)	1,220	370	20	1,610
1995 (W)	4,030	2,370	70	6,470
1996 (W)	2,060	810	30	2,900
1997 (W)	3,500	1,700	60	5,260
1998 (W)	3,630	1,500	60	5,190
1999 (AN)	1,010	200	20	1,230
2000 (AN)	1,800	420	30	2,250
2001 (D)	1,530	320	30	1,880
2002 (D)	1,410	300	30	1,740
2003 (BN)	1,040	230	20	1,290
2004 (D)	800	150	20	970
2005 (W)	1,520	410	50	1,980
2006 (W)	1,860	780	70	2,710
2007 (C)	530	150	20	700
2008 (C)	880	250	30	1,160
2009 (BN)	610	150	30	790

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
2010 (AN)	1,460	810	80	2,350
2011 (W)	1,710	980	90	2,780
2012 (D)	440	190	30	660
2013 (C)	910	280	40	1,230
2014 (C)	320	60	20	400
2015 (C)	410	120	20	550
Average (1989-2014)	1,670	640	40	2,350
Average (1989-2014) W	2,710	1,250	60	4,020
Average (1989-2014) AN	1,420	480	40	1,940
Average (1989-2014) BN	830	190	30	1,050
Average (1989-2014) D	1,050	240	30	1,320
Average (1989-2014) C	1,290	420	20	1,730

3.2.2.4 Infiltration of Surface Water

Estimated infiltration of surface water (seepage) by source is provided in Figure A2.F.b-14 and Table A2.F.b-12. Seepage from the Rivers and Streams System includes seepage of both surface inflows and of precipitation runoff into local sloughs and depressions. Seepage from rivers and streams follows the pattern of surface water inflows, averaging approximately 4.4 taf per wet year between 1989 and 2014.

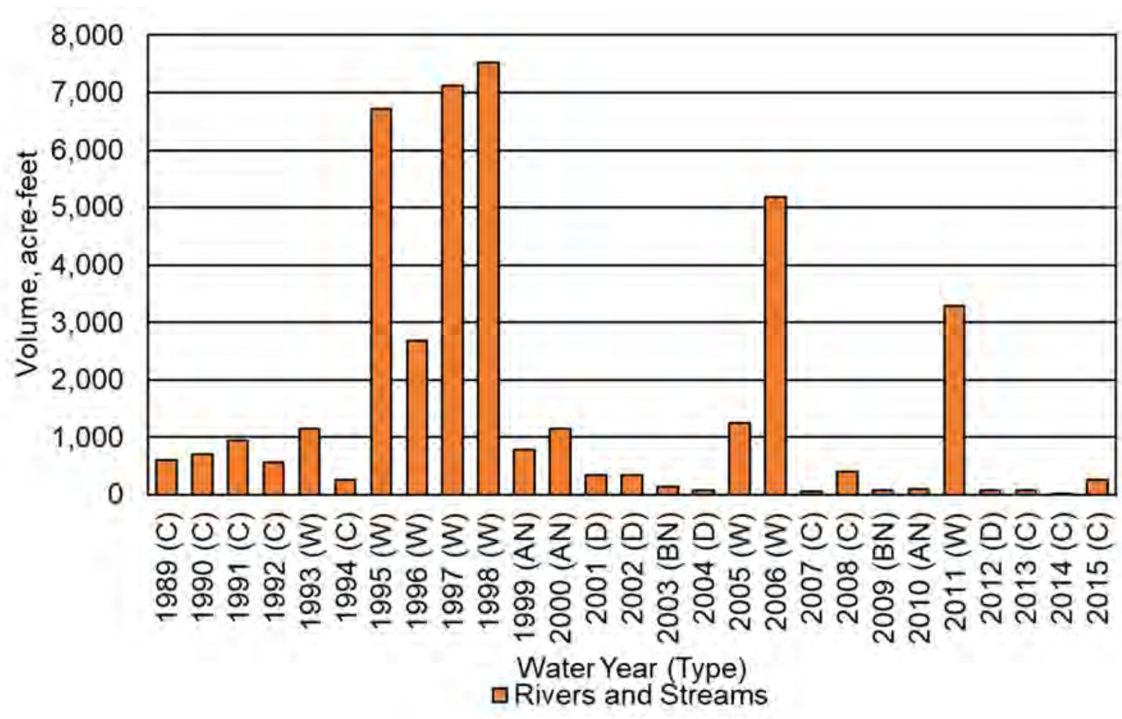

Figure A2.F.b-14. Madera County GSA – East Infiltration of Surface Water.

Table A2.F.b-12. Madera County GSA – East Infiltration of Surface Water (Acre-Feet).

Water Year (Type)	Rivers and Streams[1]
1989 (C)	600
1990 (C)	710
1991 (C)	950
1992 (C)	560
1993 (W)	1,150
1994 (C)	270
1995 (W)	6,720
1996 (W)	2,680
1997 (W)	7,120
1998 (W)	7,530
1999 (AN)	790
2000 (AN)	1,140
2001 (D)	340
2002 (D)	340
2003 (BN)	150
2004 (D)	90
2005 (W)	1,260
2006 (W)	5,180
2007 (C)	60
2008 (C)	410
2009 (BN)	90
2010 (AN)	110
2011 (W)	3,290
2012 (D)	90
2013 (C)	80
2014 (C)	10
2015 (C)	270
Average (1989-2014)	1,600
Average (1989-2014) W	4,370
Average (1989-2014) AN	680
Average (1989-2014) BN	120
Average (1989-2014) D	220
Average (1989-2014) C	410

[1] Includes infiltration of surface inflows and of precipitation runoff within the subregion. To calculate Net Recharge from SWS below, Rivers and Streams System seepage is summed across the subbasin and redistributed to each subregion in proportion to gross area.

3.2.2.5 Infiltration of Applied Water

Estimated infiltration of applied water (deep percolation of applied water) by water use sector is provided in Figure A2.F.b-15 and Table A2.F.b-13. Infiltration of applied water is dominated by agricultural irrigation and has slowly decreased over time, likely due to increase use of drip and micro-irrigation systems in place of flood irrigation.

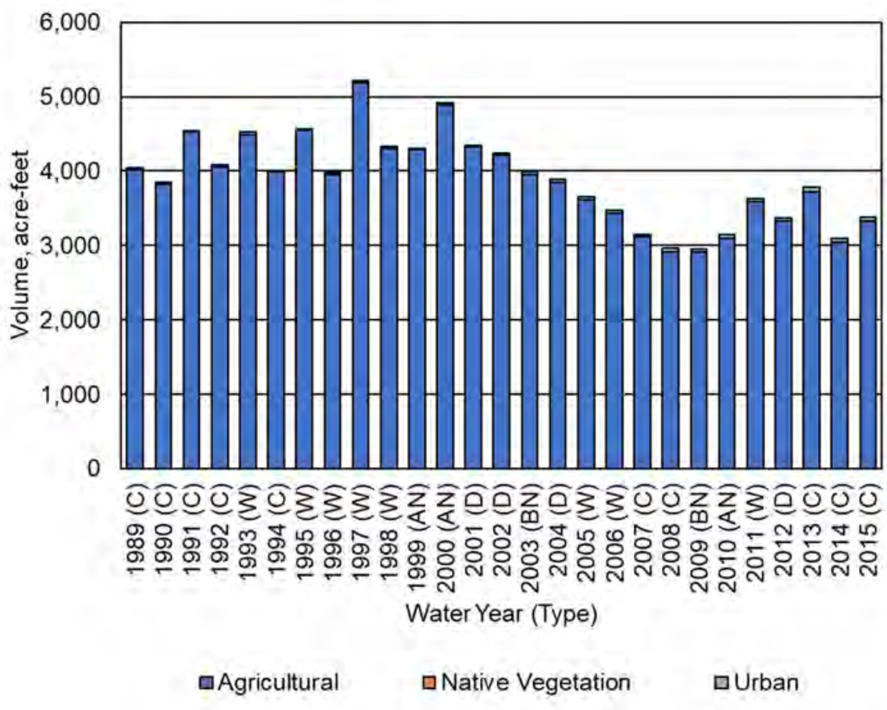

Figure A2.F.b-15. Madera County GSA – East Infiltration of Applied Water by Water Use Sector.

Table A2.F.b-13. Madera County GSA – East Infiltration of Applied Water by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	4,020	0	20	4,040
1990 (C)	3,830	0	20	3,850
1991 (C)	4,520	0	20	4,540
1992 (C)	4,060	0	20	4,080
1993 (W)	4,490	0	30	4,520
1994 (C)	3,990	0	20	4,010
1995 (W)	4,550	0	20	4,570
1996 (W)	3,960	0	20	3,980
1997 (W)	5,190	0	30	5,220
1998 (W)	4,300	0	30	4,330
1999 (AN)	4,290	0	10	4,300
2000 (AN)	4,890	0	20	4,910
2001 (D)	4,330	0	20	4,350
2002 (D)	4,210	0	30	4,240
2003 (BN)	3,960	0	30	3,990
2004 (D)	3,850	0	40	3,890
2005 (W)	3,620	0	40	3,660
2006 (W)	3,430	0	40	3,470
2007 (C)	3,120	0	30	3,150
2008 (C)	2,920	0	40	2,960
2009 (BN)	2,910	0	40	2,950
2010 (AN)	3,100	0	50	3,150

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
2011 (W)	3,590	0	40	3,630
2012 (D)	3,330	0	40	3,370
2013 (C)	3,720	0	60	3,780
2014 (C)	3,050	0	40	3,090
2015 (C)	3,330	0	50	3,380
Average (1989-2014)	3,890	0	30	3,920
Average (1989-2014) W	4,140	0	30	4,170
Average (1989-2014) AN	4,090	0	30	4,120
Average (1989-2014) BN	3,440	0	40	3,480
Average (1989-2014) D	3,930	0	30	3,960
Average (1989-2014) C	3,690	0	30	3,720

3.2.3 Change in Surface Water System Storage

Estimates of change in SWS storage are provided in Figure A2.F.b-16 and Table A2.F.b-14. Inter-annual changes in storage within the surface water system consist primarily of root zone soil moisture storage changes, are relatively small, and tend to average near zero over many years.

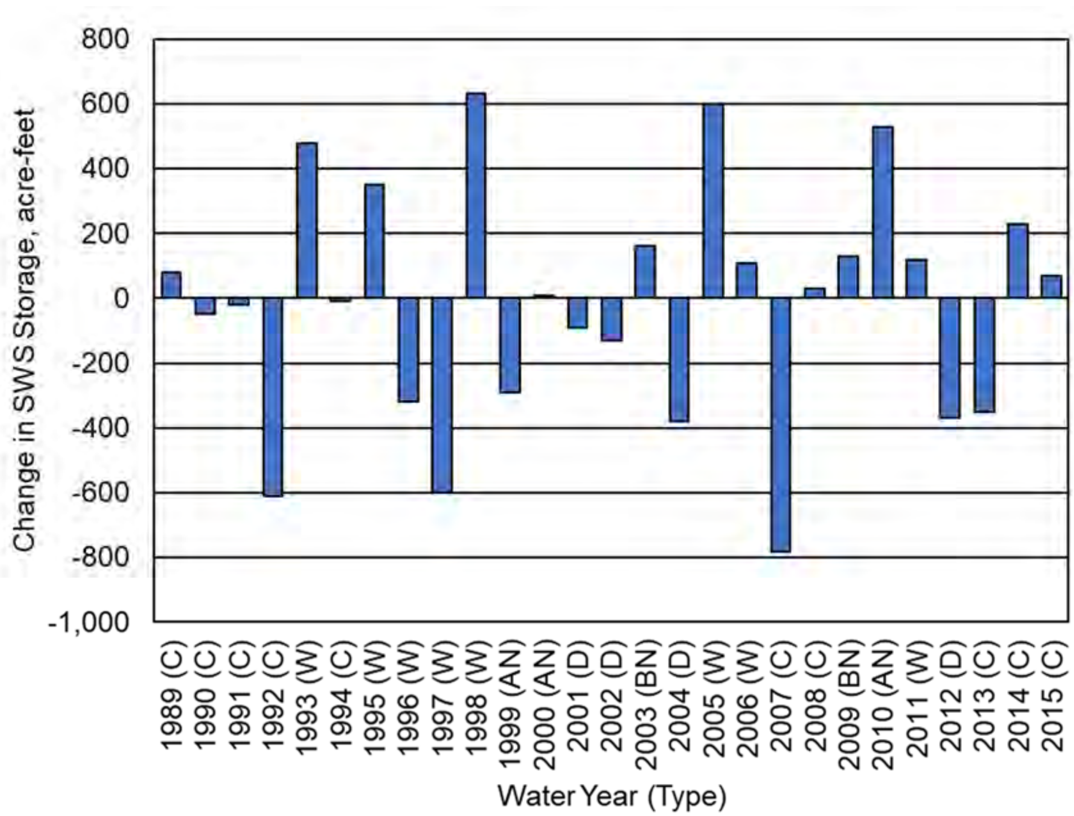

Figure A2.F.b-16. Madera County GSA – East Change in Surface Water System Storage.

Table A2.F.b-14. Madera County GSA – East Change in Surface Water System Storage (Acre-Feet).

Water Year (Type)	Change in SWS Storage
1989 (C)	80
1990 (C)	-50
1991 (C)	-20
1992 (C)	-610
1993 (W)	480
1994 (C)	-10
1995 (W)	350
1996 (W)	-320
1997 (W)	-600
1998 (W)	630
1999 (AN)	-290
2000 (AN)	10
2001 (D)	-90
2002 (D)	-130
2003 (BN)	160
2004 (D)	-380
2005 (W)	600
2006 (W)	110
2007 (C)	-780
2008 (C)	30
2009 (BN)	130
2010 (AN)	530
2011 (W)	120
2012 (D)	-370
2013 (C)	-350
2014 (C)	230
2015 (C)	70
Average (1989-2014)	-20
Average (1989-2014) W	170
Average (1989-2014) AN	80
Average (1989-2014) BN	150
Average (1989-2014) D	-240
Average (1989-2014) C	-160

3.3 Historical Water Budget Summary

Annual inflows, outflows, and change in SWS storage during the historical water budget period (1989-2014) are summarized in Figure A2.F.b-17 and Table A2.F.b-15. Inflows are shown as positive values, while outflows and change in SWS storage are shown as negative values. Review of the variability in component volumes across years provides insight into the impacts of hydrology on the surface water system water budget.

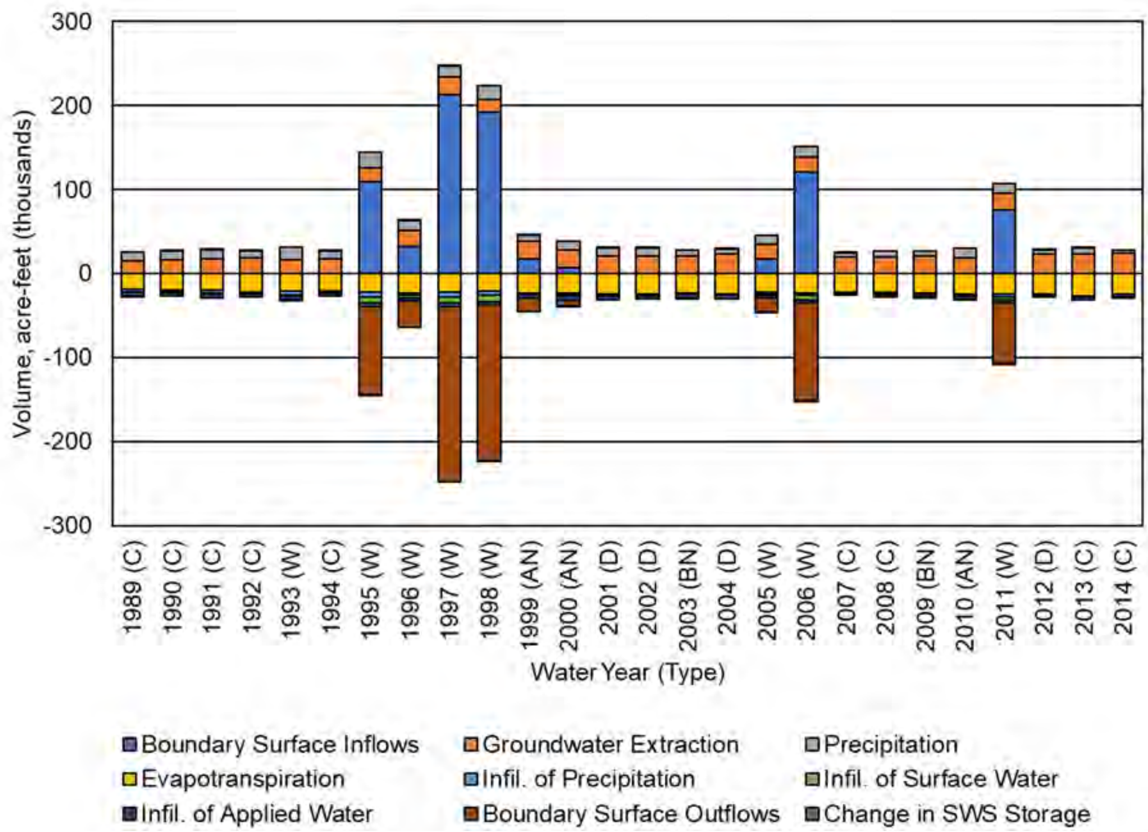

Figure A2.F.b-17. Madera County GSA – East Surface Water System Historical Water Budget, 1989-2014.

Table A2.F.b-15. Madera County GSA – East Surface Water System Historical Water Budget, 1989-2014 (Acre-Feet).

Water Year	Boundary Surface Inflows	Groundwater Extraction	Precipitation	Evapo-transpiration[1]	Infil. of Precipitation	Infil. of Surface Water[2]	Infil. of Applied Water	Boundary Surface Outflows	Change in SWS Storage
1989 (C)	0	15,080	11,270	-18,830	-2,810	-600	-4,040	0	-80
1990 (C)	0	16,130	10,520	-19,890	-2,260	-710	-3,850	0	50
1991 (C)	0	17,500	10,990	-19,360	-3,660	-950	-4,540	0	20
1992 (C)	0	18,570	8,980	-21,760	-1,760	-560	-4,080	0	610
1993 (W)	0	16,790	15,210	-20,960	-4,890	-1,150	-4,510	0	-480
1994 (C)	0	18,220	8,620	-20,970	-1,610	-270	-4,000	0	10
1995 (W)	109,760	15,820	18,520	-21,450	-6,470	-6,720	-4,570	-104,540	-350
1996 (W)	32,950	18,760	11,310	-23,050	-2,900	-2,680	-3,970	-30,750	320
1997 (W)	213,510	20,430	12,920	-22,230	-5,260	-7,120	-5,220	-207,630	600
1998 (W)	191,690	15,910	15,530	-20,540	-5,190	-7,530	-4,330	-184,920	-630
1999 (AN)	17,620	21,560	6,300	-22,600	-1,240	-790	-4,300	-16,840	290
2000 (AN)	6,850	21,170	10,270	-23,620	-2,250	-1,140	-4,910	-6,370	-10
2001 (D)	0	21,100	9,590	-24,200	-1,870	-340	-4,350	0	90
2002 (D)	530	20,910	8,700	-23,960	-1,730	-340	-4,240	0	130
2003 (BN)	280	20,710	7,650	-23,050	-1,290	-150	-3,990	0	-160
2004 (D)	360	22,560	6,350	-24,700	-970	-90	-3,890	0	380
2005 (W)	17,540	17,300	10,960	-22,360	-1,980	-1,260	-3,660	-15,940	-600
2006 (W)	121,690	17,620	12,080	-23,140	-2,710	-5,180	-3,470	-116,780	-110
2007 (C)	360	19,970	4,890	-22,080	-710	-60	-3,150	0	780
2008 (C)	260	19,220	7,430	-22,350	-1,160	-410	-2,960	0	-30
2009 (BN)	330	20,430	6,720	-23,520	-790	-90	-2,950	0	-130
2010 (AN)	410	18,550	11,550	-24,370	-2,350	-110	-3,140	0	-530
2011 (W)	76,050	19,230	12,090	-24,640	-2,770	-3,290	-3,640	-72,910	-120
2012 (D)	60	23,730	4,120	-24,160	-660	-90	-3,370	0	370
2013 (C)	110	23,680	6,960	-26,010	-1,230	-80	-3,770	0	350
2014 (C)	0	24,370	3,400	-24,040	-390	-10	-3,100	0	-230
Average (1989-2014)	30,400	19,430	9,730	-22,610	-2,340	-1,600	-3,920	-29,100	20
W	95,400	17,730	13,580	-22,300	-4,020	-4,370	-4,170	-91,680	-170
AN	8,290	20,430	9,370	-23,530	-1,940	-680	-4,120	-7,740	-80
BN	310	20,570	7,180	-23,280	-1,040	-120	-3,470	0	-140
D	240	22,080	7,190	-24,260	-1,310	-220	-3,960	0	240
C	80	19,190	8,120	-21,700	-1,730	-400	-3,720	0	170

[1]Includes ET of applied water, ET of precipitation, and evaporation from the Rivers and Streams System.

[2]Includes infiltration from the Rivers and Streams System within the subregion. To calculate Net Recharge from SWS below, Rivers and Streams System seepage is summed across the subbasin and redistributed to each subregion in proportion to gross area.

3.4 Current Water Budget Summary

The current water budget was developed following a similar process to the historical water budget using the 2015 land use in Table A2.F.b-1 and the same 1989-2014 average hydrologic conditions of the historical base period, including surface water flows, precipitation, and weather parameters. This allowed quantification of groundwater inflows and outflows for current consumptive use in the context of average water supply conditions.

Annual inflows, outflows, and change in SWS storage from the current water budget are summarized in Figure A2.F.b-18 and Table A2.F.b-16. Inflows are shown as positive values, while outflows and change in SWS storage are shown as negative values.

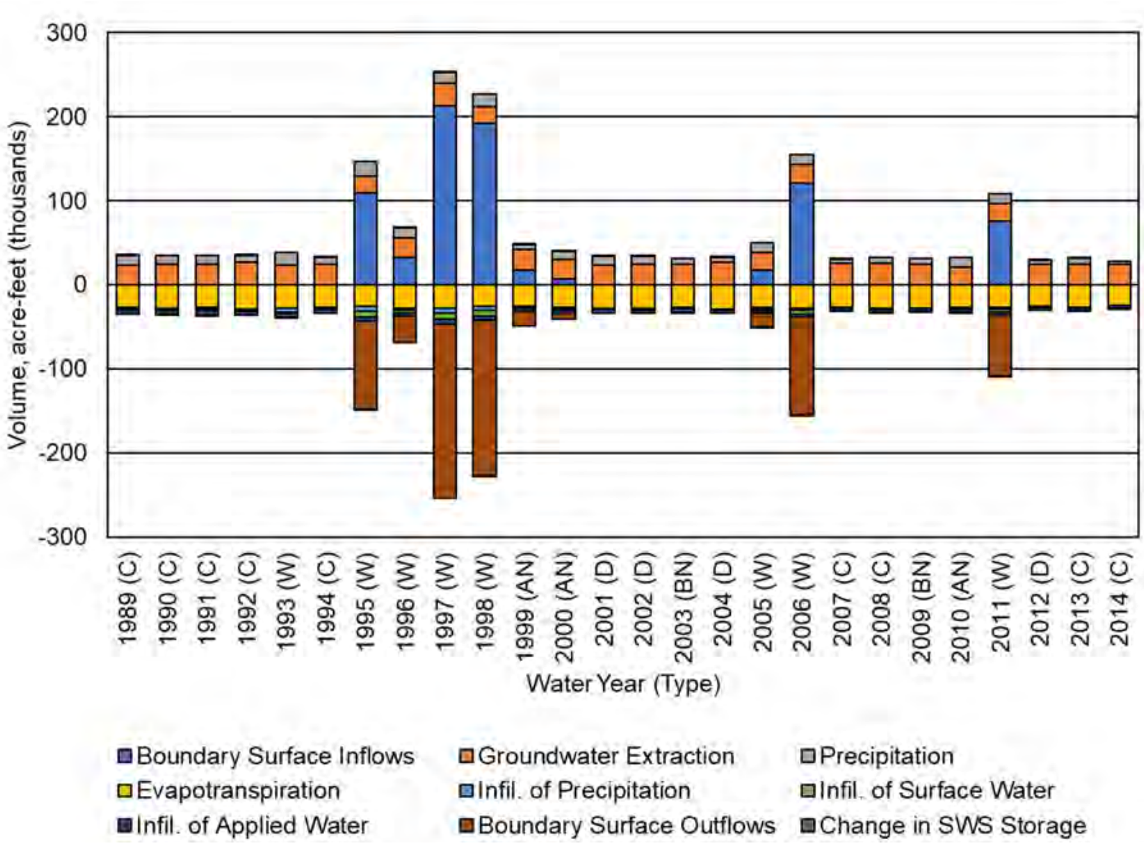

Figure A2.F.b-18. Madera County GSA – East Surface Water System Current Water Budget.

Table A2.F.b-16. Madera County GSA – East Surface Water System Current Water Budget (Acre-Feet).

Water Year	Boundary Surface Inflows	Groundwater Extraction	Precipitation	Evapo-transpiration[1]	Infil. of Precipitation	Infil. of Surface Water[2]	Infil. of Applied Water	Boundary Surface Outflows	Change in SWS Storage
1989 (C)	0	23,400	11,320	-26,580	-2,580	-360	-5,320	0	130
1990 (C)	0	24,210	10,550	-27,450	-2,040	-490	-4,740	0	-40
1991 (C)	0	24,420	11,020	-26,130	-3,350	-740	-5,170	0	-60
1992 (C)	0	26,450	9,010	-29,360	-1,550	-370	-4,620	0	450
1993 (W)	0	23,890	15,260	-27,840	-4,650	-800	-5,350	0	-520
1994 (C)	0	24,250	8,650	-27,130	-1,400	-160	-4,330	0	120
1995 (W)	109,760	19,080	18,560	-25,620	-6,070	-6,470	-4,570	-104,540	-130
1996 (W)	32,950	23,520	11,340	-27,850	-2,650	-2,560	-4,150	-30,750	130
1997 (W)	213,510	26,900	12,960	-28,160	-5,100	-6,810	-5,970	-207,630	290
1998 (W)	191,690	19,830	15,580	-24,860	-4,940	-7,250	-4,840	-184,920	-290
1999 (AN)	17,620	24,110	6,320	-25,620	-1,010	-790	-3,920	-16,840	130
2000 (AN)	6,850	23,070	10,300	-26,970	-1,930	-1,010	-4,080	-6,370	140
2001 (D)	0	23,770	9,610	-27,530	-1,620	-280	-4,000	0	50
2002 (D)	530	24,380	8,720	-27,770	-1,540	-260	-4,160	0	100
2003 (BN)	280	24,080	7,660	-26,780	-1,120	-80	-3,870	0	-170
2004 (D)	360	26,620	6,370	-29,130	-820	-40	-3,770	0	400
2005 (W)	17,540	21,610	10,980	-26,620	-1,820	-1,110	-3,940	-15,940	-690
2006 (W)	121,690	21,450	12,100	-27,220	-2,510	-4,960	-3,680	-116,780	-100
2007 (C)	360	24,890	4,900	-26,940	-630	-20	-3,450	0	900
2008 (C)	260	25,290	7,450	-27,880	-1,150	-260	-3,650	0	-50
2009 (BN)	330	24,770	6,730	-27,500	-780	-50	-3,370	0	-140
2010 (AN)	410	20,330	11,550	-26,110	-2,310	-120	-3,340	0	-410
2011 (W)	76,050	20,640	12,090	-26,110	-2,690	-3,250	-3,680	-72,910	-140
2012 (D)	60	25,030	4,120	-25,510	-630	-80	-3,340	0	340
2013 (C)	110	24,330	6,950	-26,530	-1,240	-80	-3,910	0	370
2014 (C)	0	24,360	3,400	-24,040	-400	-10	-3,090	0	-220
Average (1989-2014)	30,400	23,640	9,750	-26,890	-2,170	-1,480	-4,170	-29,100	20
W	95,400	22,110	13,610	-26,780	-3,800	-4,150	-4,520	-91,680	-180
AN	8,290	22,500	9,390	-26,230	-1,750	-640	-3,780	-7,740	-50
BN	310	24,420	7,200	-27,140	-950	-60	-3,620	0	-150
D	240	24,950	7,200	-27,490	-1,150	-160	-3,810	0	220
C	80	24,620	8,140	-26,890	-1,590	-280	-4,250	0	180

[1]Includes ET of applied water, ET of precipitation, and evaporation from the Rivers and Streams System.
[2]Includes infiltration from the Rivers and Streams System within the subregion. To calculate Net Recharge from SWS below, Rivers and Streams System seepage is summed across the subbasin and redistributed to each subregion in proportion to gross area.

3.5 Net Recharge from SWS

Overdraft is defined in DWR Bulletin 118 as "the condition of a groundwater basin or subbasin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years, during which the water supply conditions approximate average conditions" (DWR 2003). The Chowchilla Subbasin water budget indicates that overdraft conditions occurred during the 1989-2014 historical base period. Per 23 CCR Section 354.18(b)(5), the subbasin overdraft has been quantified for this base period. The evaluation of overdraft conditions includes estimates of recharge from subsurface flows. However, estimates of recharge from subsurface flows are less accurate when estimated for areas less that an entire subbasin. Thus, for estimates of GSA level contribution to overdraft, the term net recharge from the SWS is defined as groundwater recharge minus groundwater extraction. Net recharge from the SWS is useful for understanding and analyzing the combined effects of land surface processes on the underlying GWS.

When calculated from the historical water budget, average net recharge from the SWS represents the average recharge (when positive) or shortage of recharge (when negative) based on historical cropping, land use practices, and average hydrologic conditions. When calculated from the current land use water budget, average net recharge represents the average recharge or shortage (when negative) based on current cropping, land use practices, and average hydrologic conditions.

Average net recharge from the SWS is presented below for the Madera Co GSA – East portion of the Chowchilla Subbasin. Table A2.F.b-17 shows the average net recharge from the SWS for 1989-2014 based on the historical water budget, and Table A2.F.b-18 shows the same for the current water budget. Historically, the average net recharge in Madera Co GSA – East was approximately -11.5 taf per year between 1989 and 2014. Under current land use conditions, the average net recharge in Madera Co GSA – East is approximately -15.7 taf, indicating shortage conditions.

The Madera Co GSA - East recognizes that groundwater users within its boundaries want to understand potential future limitations on groundwater resources available to meet their beneficial uses. As shown in both Table A2.F.b-17 and Table A2.F.b-18, average values for infiltration of precipitation and infiltration of surface water are provided (columns "b" and "c"). The slight variation between the tables reflects the modified land use conditions. Together, these values represent the sustainable native groundwater for the Madera Co GSA – East, a value of about 4,000 acre-feet per year.

The Madera Co GSA – East has not determined whether an allocation approach, or other methods, will best allow the Madera Co GSA – East to achieve needed reductions in the consumptive use of groundwater (see GSP Chapter 4). However, the Madera Co GSA – East recognize the correlative nature of overlying groundwater rights, which, when coupled with appropriated groundwater use, provides that all the users share in the sustainable quantity of native groundwater. For purposes of analyzing the availability of sustainable quantities of native groundwater for all lands within the Madera Co GSA – East, the estimated total quantity of sustainable native groundwater – estimated at 4,000 acre-feet per year – can be calculated to be approximately 0.5 acre-feet per acre within the Madera Co GSA – East (based upon estimates of about 4,000 acre-feet of total sustainable native groundwater available for about 7,600 acres within the Madera Co GSA – East). The achievement of sustainability may or may not involve an equal allocation across the Madera Co GSA – East, and the Madera Co GSA – East will use its SGMA-granted authority to manage the basin so as to achieve this end. Furthermore, other GSAs within the Chowchilla Subbasin may choose to manage their proportion of the estimated sustainable native groundwater differently than the Madera Co GSA – East, but they are also subject to the overall subbasin sustainability requirements.

Table A2.F.b-17. Historical Water Budget: Average Net Recharge from SWS by Water Year Type, 1989-2014 (Acre-Feet).

Year Type	Number of Years	Infiltration of Applied Water (a)	Infiltration of Precipitation (b)	Infiltration of Surface Water[1] (c)	Groundwater Extraction (d)	Net Recharge from SWS (a+b+c-d)
W	8	4,170	4,020	4,340	17,730	-5,200
AN	3	4,120	1,940	990	20,430	-13,380
BN	2	3,470	1,040	130	20,570	-15,930
D	4	3,960	1,310	330	22,080	-16,480
C	9	3,720	1,730	510	19,190	-13,230
Annual Average (1989-2014)	26	3,920	2,340	1,690	19,430	-11,480

[1] Calculated from the total subbasin Rivers and Streams System seepage summed and redistributed to each subregion in proportion to gross area.

Table A2.F.b-18. Current Water Budget: Average Net Recharge from SWS by Water Year Type (Acre-Feet).

Year Type	Number of Years	Infiltration of Applied Water (a)	Infiltration of Precipitation (b)	Infiltration of Surface Water[1] (c)	Groundwater Extraction (d)	Net Recharge from SWS (a+b+c-d)
W	8	4,520	3,800	4,250	22,110	-9,540
AN	3	3,780	1,750	950	22,500	-16,020
BN	2	3,620	950	80	24,420	-19,770
D	4	3,810	1,150	290	24,950	-19,700
C	9	4,250	1,590	400	24,620	-18,380
Annual Average (1989-2014)	26	4,170	2,170	1,610	23,640	-15,690

[1][1] Calculated from the total subbasin Rivers and Streams System seepage summed and redistributed to each subregion in proportion to gross area.

3.6 Uncertainties in Water Budget Components

Uncertainties associated with each water budget component were estimated as a percentage representing approximately a 95% confidence interval following the procedure described by Clemmens and Burt (1997). Uncertainties for all independently measured or estimated water budget components were estimated based on the measurement accuracy, typical values reported in technical literature, typical values calculated in other water budgets, and professional judgement.

Table A2.F.b-19 provides a summary of typical uncertainty values associated with major SWS inflow and outflow components. These uncertainties provide a basis for evaluating confidence in water budget results and help to identify data needs that may be addressed during GSP implementation.

Table A2.F.b-19. Estimated Uncertainty of GSA Water Budget Components.

Flowpath Direction (SWS Boundary)	Water Budget Component	Data Source	Estimated Uncertainty (%)	Source
Inflows	Surface Water Inflows	Measurement	5%	Estimated streamflow measurement accuracy.
	Riparian Deliveries	Measurement	10%	Estimated measurement accuracy.
	Precipitation	Calculation	30%	Clemmens, A.J. and C.M. Burt, 1997.
	Groundwater Extraction	Closure	20%	Typical uncertainty calculated for Land Surface System water balance closure.
Outflows	Surface Water Outflows	Closure	20%	Typical uncertainty calculated for Rivers and Streams System water balance closure.
	Evaporation	Calculation	20%	Estimated accuracy of calculation based on CIMIS reference ET and free water surface evaporation coefficient.
	ET of Applied Water	Calculation	10%	Estimated accuracy of daily IDC root zone water budget component based on CIMIS reference ET, estimated crop coefficients from SEBAL energy balance, and annual land use.
	ET of Precipitation	Calculation	10%	Estimated accuracy of daily IDC root zone water budget component based on CIMIS reference ET, precipitation, estimated crop coefficients from SEBAL energy balance, and annual land use.
	Infiltration of Applied Water	Calculation	20%	Estimated accuracy of daily IDC root zone water budget component based on annual land use and NRCS soils characteristics.
	Infiltration of Precipitation	Calculation	20%	Estimated accuracy of daily IDC root zone water budget component based on annual land use, NRCS soils characteristics, and CIMIS precipitation.
	Infiltration of Surface Water	Calculation	15%	Estimated accuracy of daily seepage calculation using NRCS soils characteristics and calculated runoff of precipitation.
	Change in SWS Storage	Calculation	50%	Professional Judgment.
Net Recharge from SWS		Calculation	25%	Estimated water budget accuracy; typical value calculated for GSA-level net recharge from SWS.

APPENDIX 2.F. WATER BUDGET INFORMATION

2.F.c. Surface Water System Water Budget: Madera County GSA – West Subregion

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020

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1 INTRODUCTION

To ensure sustainable groundwater management throughout California's groundwater basins, the Sustainable Groundwater Management Act of 2014 (SGMA) requires Groundwater Sustainability Agencies (GSAs) to prepare and adopt Groundwater Sustainability Plans (GSPs) with strategies to achieve subbasin groundwater sustainability within 20 years of plan adoption. Integral to each GSP is a water budget used to quantify the subbasin's groundwater overdraft (if applicable) and sustainable yield.

In 2016, Madera County (Madera Co) GSA formed to manage approximately 45,100 acres of the Chowchilla Subbasin. Madera Co GSA includes noncontiguous areas on the eastern and western sides of the Chowchilla Subbasin. Portions of Madera Co GSA's eastern jurisdictional area also overlap with Sierra Vista Mutual Water Company (SVMWC). In the interests of separately accounting for inflows to each side of Madera County GSA and to SVMWC, two water budgets were prepared for Madera Co GSA: one for the western subregion, and one for the eastern subregion, excluding land in SVMWC.

This document presents results of the surface water system (SWS) water budgets developed for historical and current land use conditions in the Madera Co GSA – West Subregion. The Madera Co GSA – West water budgets were integrated with separate water budgets developed for four (4) other subregions covering the remainder of the Chowchilla Subbasin. Together, these water budgets provide the boundary water budget for the Chowchilla Subbasin SWS. Results of the subbasin boundary water budget are reported in the Chowchilla Subbasin GSP Section 2.2.3 and were integrated with a subbasin groundwater model (GSP Appendix 6.E) to estimate subbasin sustainable yield (GSP Section 2.2.3).

2 WATER BUDGET CONCEPTUAL MODEL

A water budget is defined as a complete accounting of all water flowing into and out of a defined volume (e.g., a subbasin or a GSA) over a specified period of time. The conceptual model (or structure) of the Madera Co GSA – West water budget developed for this investigation is consistent with the GSP Regulations defined under Title 23 of California Code of Regulations[1] (CCR) and adheres to sound water budget principles and practices defined by California Department of Water Resources (DWR) in the Water Budget Best Management Practice (BMP) guidelines (DWR, 2016).

The lateral extent of Madera Co GSA – West is defined by the boundaries indicated in Figure A2.F.c-1. The vertical extent of Madera Co GSA – West is the land surface (top) and the base of fresh water at the bottom of the basin (bottom), as described in the hydrogeologic conceptual model (HCM) developed in GSP Section 2.2.1. The vertical extent of Chowchilla Subbasin and its GSAs is subdivided into a surface water system (SWS) and the underlying groundwater system (GWS), with separate but related water budgets prepared for each that together represent the overall subbasin water budget.

[1] California Code of Regulations Title 23. Waters, Division 2. Department of Water Resources, Chapter 1.5. Groundwater Management, Subchapter 2. Groundwater Sustainability Plans.

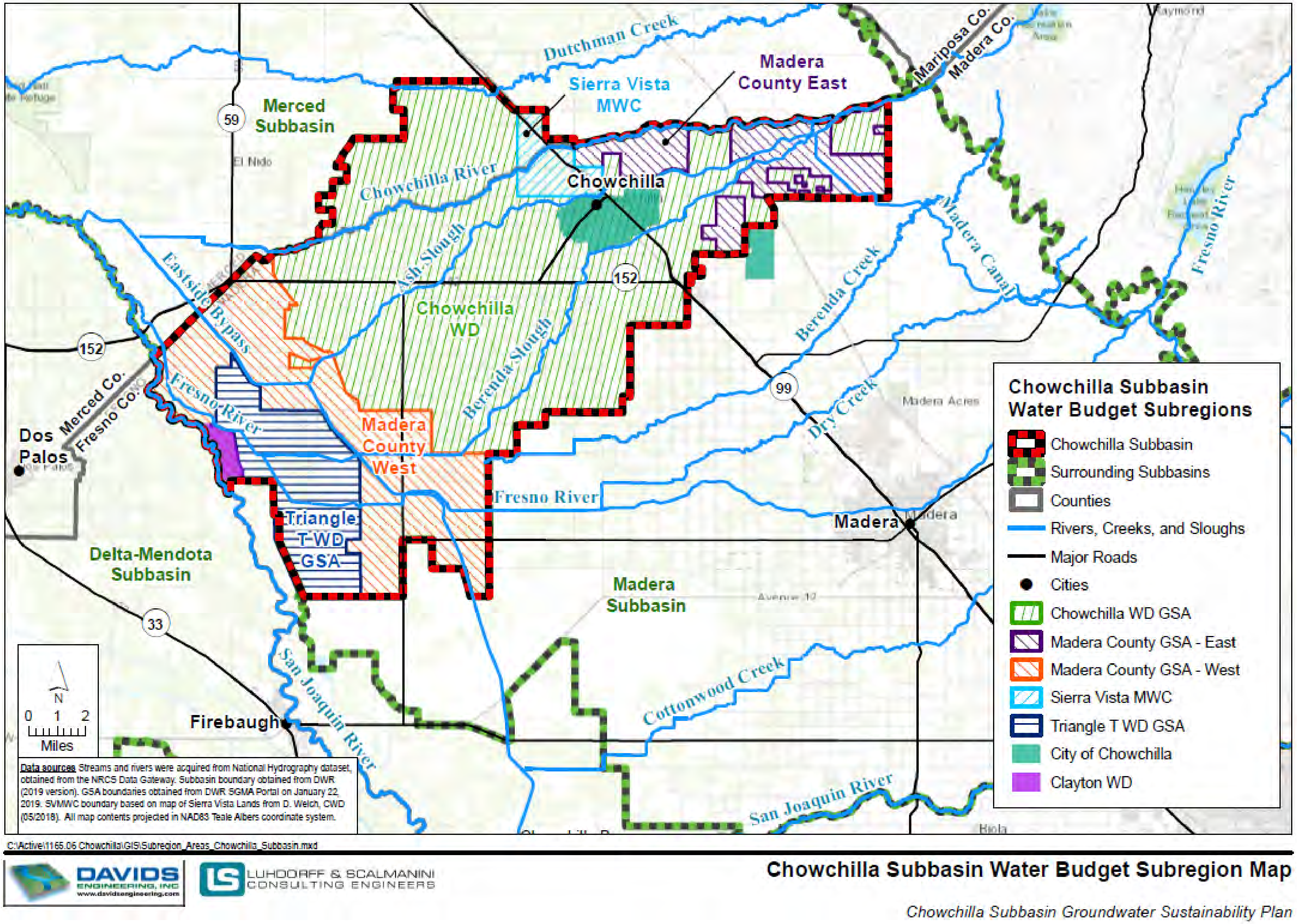

Figure A2.F.c-1. Chowchilla Subbasin Water Budget Subregion Map

A conceptual representation of the Madera Co GSA – West water budget is represented in Figure A2.F.c-2. This document details only the SWS portion of the Madera Co GSA – West water budget. The SWS is divided into two primary accounting centers: the Land Surface System and the Rivers and Streams System. The Land Surface System is further divided into three accounting centers representing the subregion water use sectors: Agricultural Land, Native Vegetation Land, and Urban Land (urban, industrial, and semi-agricultural).

Water budget components, or directional flow of water between accounting centers and across the SWS boundary, are indicated by arrows. Inflows and outflows were calculated using measurements and other historical data or were calculated as the water budget closure term – the difference between all other estimated or measured inflows and outflows from each accounting center or water use sector (bold arrows).

Inflows to the SWS include precipitation, surface water inflows (in various canals and streams), and groundwater extraction. Outflows from the SWS include evapotranspiration (ET), surface water outflows (in various canals and streams), and infiltration to the groundwater system (seepage and deep percolation). Also represented in Figure A2.F.c-2 are inflows and outflows from the GWS, which are discussed and quantified at the subbasin level in the GWS water budget in GSP Section 2.2.3. Subsurface GWS inflows and outflows are not quantified on the water budget subregion scale.

Inflows and outflows were quantified following the process described in GSP Section 2.2.3 on a monthly time step for water years in the historical water budget base period (1989-2014 hydrologic and land use conditions), the current water budget (2015 land use using 1989-2014 average hydrologic conditions), and projected water budget. Four projected water budgets were prepared for the years 2019 through 2090 based on 1965 through 2015 hydrologic conditions, projected water supplies, and 2017 land use adjusted for urban area projected growth from 2017-2070 (areas were held constant from 2071-2090):

1. Historical hydrologic conditions and water supply data, with adjustment for projected alteration of available Friant releases by the San Joaquin River Restoration Program (SJRRP)[2]
    a. Without projects and management actions, and
    b. With projects and management actions
2. Historical hydrologic conditions and water supply data, with adjustment for projected alteration of available Friant releases by the SJRRP and adjustment for anticipated climate change per DWR-provided 2030 climate change factors
    a. Without projects and management actions, and
    b. With projects and management actions.

Information regarding the data sources and adjustments used to prepare the historical, current, and projected water budgets are described in GSP Section 2.2.3.

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[2] Adjustments were based on the Friant Report ("Estimate of Future Friant Division Supplies for use in Groundwater Sustainability Plans, California," Friant Water Authority, 2018). Although the Friant Report accounts for climate change, it is considered the best available estimate of projected Friant releases under SJRRP. For comparison, projected Madera Canal deliveries under SJRRP were also estimated without account for climate change from the Kondolf Hydrographs (in “Effects to Water Supply and Friant Operations Resulting From Plaintiffs' Friant Release Requirements,” Steiner, 2005). These estimates were approximately equal to the Friant Report 2030 climate change adjusted deliveries. Thus, the Friant Report projections were used instead to maintain consistent assumptions in estimating Madera Canal deliveries across all projected simulations.

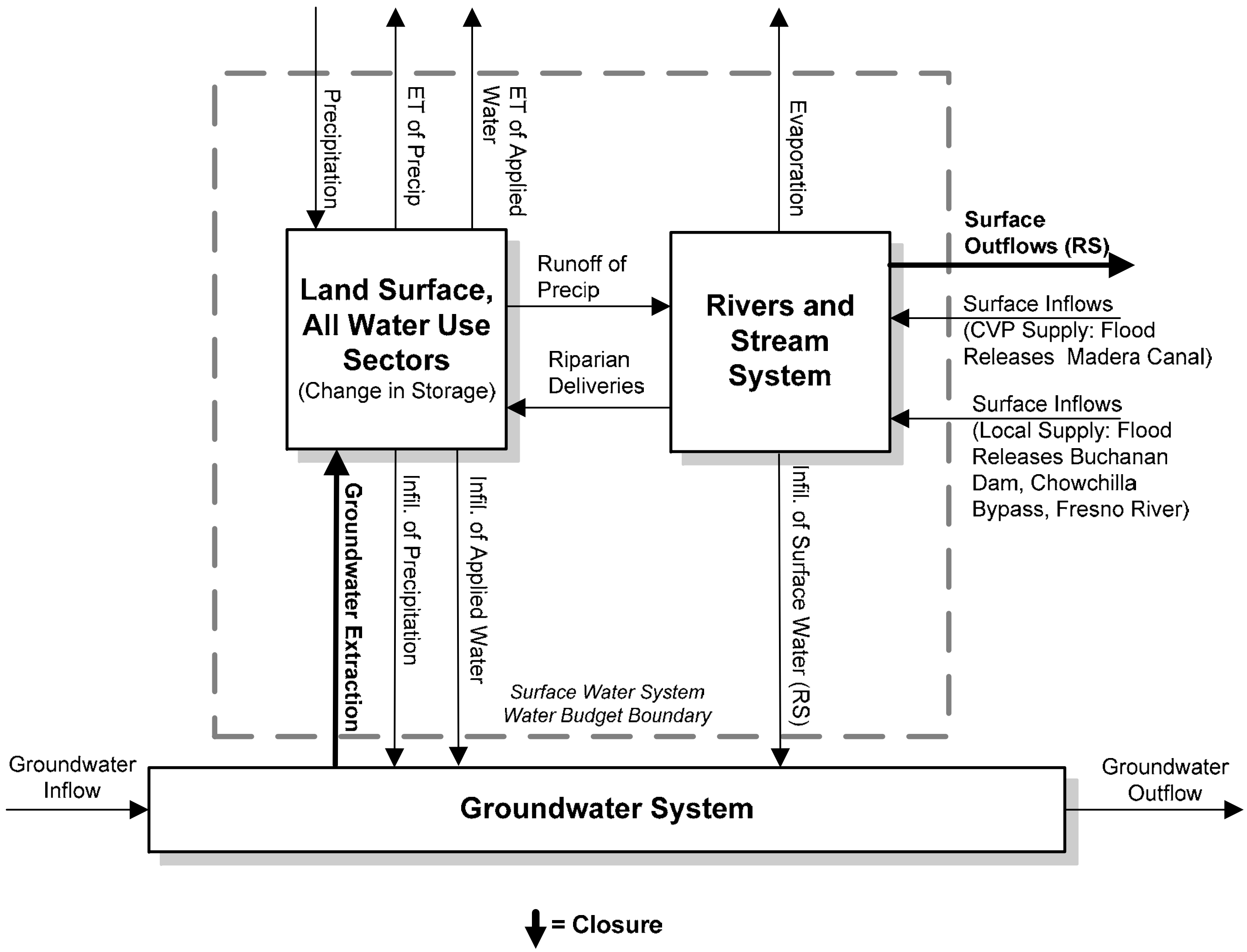

Figure A2.F.c-2. Madera County GSA – West Water Budget Structure

3 WATER BUDGET ANALYSIS

The historical water budget and current land use water budget for Madera Co GSA – West are presented below following a summary of land use data relevant to water budget development. Land use data is provided for the 1989-2014 historical water budget period and for 2015, the current land use water budget period.

3.1 Land Use

Land use estimates for 1989 through 2015 corresponding to water use sectors (as defined by the GSP Regulations) are summarized in Figure A2.F.c-3 and Table A2.F.c-1 for the Madera Co GSA – West subregion. According to GSP Regulations (23 CCR § 351(al)):

> *"Water use sector" refers to categories of water demand based on the general land uses to which the water is applied, including urban, industrial, agricultural, managed wetlands, managed recharge, and native vegetation*

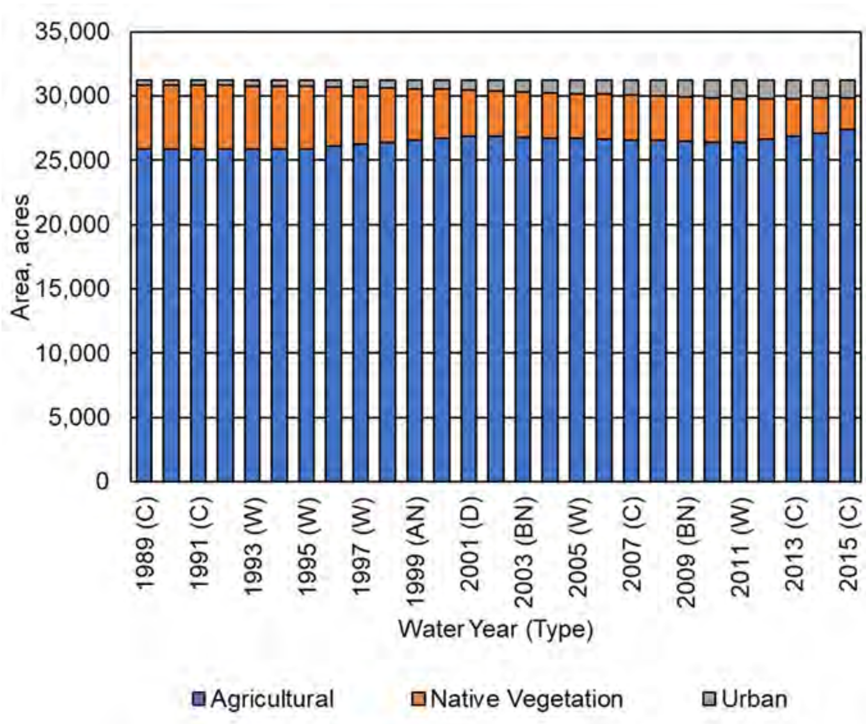

Figure A2.F.c-3. Madera County GSA – West Land Use Areas

Table A2.F.c-1. Madera County GSA – West Land Use Areas, acres

Water Year (Type)	Agricultural	Native Vegetation[1]	Urban[2]	Total
1989 (C)	25,911	4,939	363	31,213
1990 (C)	25,897	4,943	372	31,213
1991 (C)	25,903	4,928	382	31,213
1992 (C)	25,871	4,950	392	31,213
1993 (W)	25,885	4,926	401	31,213
1994 (C)	25,887	4,912	415	31,213
1995 (W)	25,905	4,876	432	31,213
1996 (W)	26,068	4,661	485	31,213
1997 (W)	26,231	4,445	537	31,213
1998 (W)	26,394	4,229	590	31,213
1999 (AN)	26,557	4,014	643	31,213
2000 (AN)	26,720	3,798	695	31,213
2001 (D)	26,883	3,582	748	31,213
2002 (D)	26,835	3,564	814	31,213
2003 (BN)	26,786	3,546	881	31,213
2004 (D)	26,738	3,528	948	31,213
2005 (W)	26,689	3,509	1,015	31,213
2006 (W)	26,641	3,491	1,081	31,213
2007 (C)	26,592	3,473	1,148	31,213
2008 (C)	26,544	3,455	1,214	31,213
2009 (BN)	26,496	3,436	1,281	31,213
2010 (AN)	26,447	3,418	1,348	31,213
2011 (W)	26,399	3,400	1,414	31,213
2012 (D)	26,636	3,170	1,407	31,213
2013 (C)	26,873	2,940	1,400	31,213
2014 (C)	27,110	2,710	1,393	31,213
2015 (C)	27,408	2,472	1,333	31,213
Average (1989-2014)	26,419	3,956	838	31,213

[1] Area includes land classified as native vegetation and water surfaces.
[2] Area includes land classified as urban, industrial, and semi-agricultural.

In Madera Co GSA – West, water use sectors include agricultural, native vegetation, and urban land use. The urban land use category includes urban and semi-agricultural[3] lands as well as industrial land, which covers only a small area in the subbasin.

[3] As defined in the DWR county land use surveys, semi-agricultural land use subclasses include farmsteads, livestock feed lot operations, dairies, poultry farms, and miscellaneous semi-agricultural land use incidental to agriculture (small roads, ditches, non-planted areas of cropped fields (DWR, 2009).

As indicated, the majority of land in Madera Co GSA – West is used for agriculture, covering an average of approximately 26,400 acres between 1989 and 2014. The remainder of the subregion is primarily native vegetation, averaging approximately 4,000 acres between 1989 and 2014.

Agricultural land uses are further detailed in Figure A2.F.c-4 and Table A2.F.c-2. In the 1990s, a majority of the agricultural area in Madera Co was used to cultivate alfalfa, mixed pasture, and miscellaneous field crops. In recent years, these crops have been increasingly replaced by corn and orchard crops, which have each more than tripled in area between 1989 and 2015.

3.2 Surface Water System Water Budget

This section presents surface water system water budget components within Madera Co GSA – West as per GSP regulations. These are followed by a summary of the water budget results by accounting center.

3.2.1 Inflows

3.2.1.1 Surface Water Inflow by Water Source Type

Surface water inflows include surface water flowing into Madera Co GSA – West across the subregion boundary. Per the Regulations, surface inflows must be reported by water source type. According to the Regulations:

> *"Water source type" represents the source from which water is derived to meet the applied beneficial uses, including groundwater, recycled water, reused water, and surface water sources identified as Central Valley Project, the State Water Project, the Colorado River Project, local supplies, and local imported supplies.*

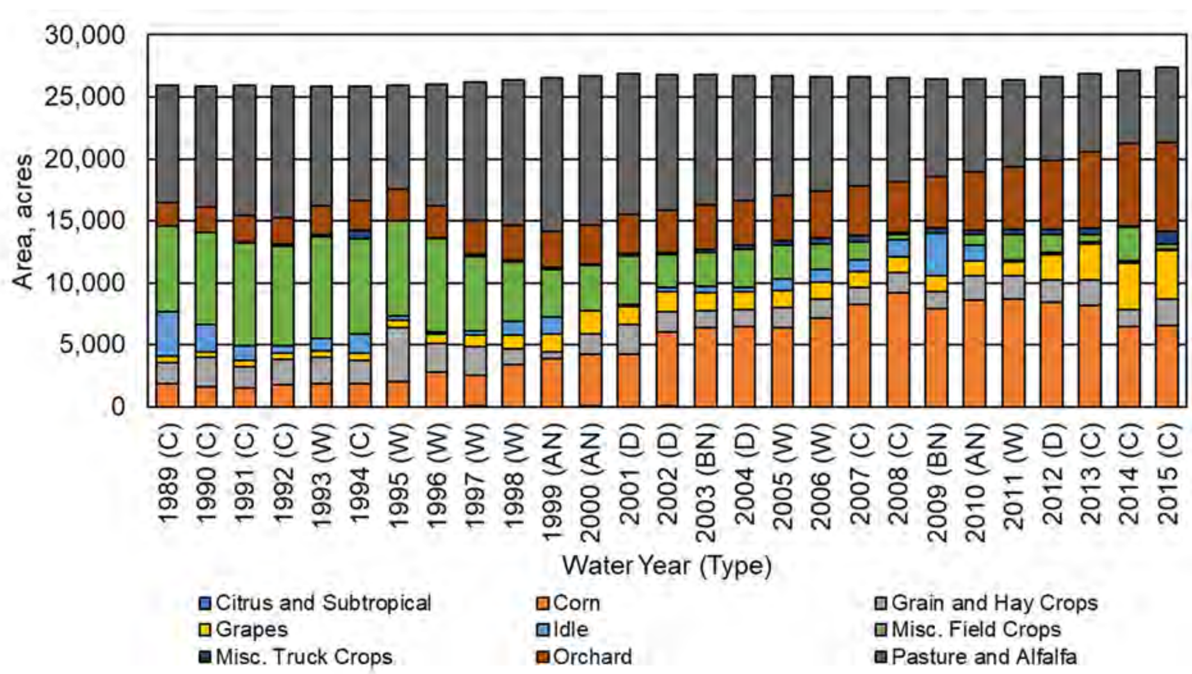

Figure A2.F.c-4. Madera County GSA – West Agricultural Land Use Areas

Table A2.F.c-2. Madera County GSA – West Agricultural Land Use Areas

Water Year (Type)	Citrus and Subtropical	Corn	Grain and Hay Crops	Grapes	Idle	Misc. Field Crops	Misc. Truck Crops	Orchard	Pasture and Alfalfa	Total
1989 (C)	0	1,820	1,772	467	3,575	6,938	40	1,854	9,444	25,911
1990 (C)	0	1,617	2,329	473	2,200	7,406	67	2,000	9,806	25,897
1991 (C)	0	1,531	1,703	489	1,224	8,266	71	2,133	10,486	25,903
1992 (C)	0	1,714	2,094	516	626	7,980	152	2,206	10,582	25,871
1993 (W)	0	1,853	2,094	531	1,060	8,144	244	2,302	9,656	25,885
1994 (C)	0	1,810	1,950	568	1,528	7,716	677	2,364	9,273	25,887
1995 (W)	0	1,988	4,383	576	404	7,611	34	2,602	8,307	25,905
1996 (W)	1	2,755	2,353	739	219	7,472	59	2,597	9,873	26,068
1997 (W)	20	2,491	2,293	1,000	322	5,980	176	2,712	11,238	26,231
1998 (W)	0	3,356	1,300	1,086	1,146	4,806	176	2,824	11,699	26,394
1999 (AN)	0	3,876	540	1,484	1,284	3,867	154	2,955	12,397	26,557
2000 (AN)	9	4,225	1,652	1,821	16	3,703	108	3,100	12,086	26,720
2001 (D)	0	4,197	2,453	1,432	158	3,959	124	3,159	11,400	26,883
2002 (D)	5	6,031	1,602	1,633	332	2,623	196	3,447	10,966	26,835
2003 (BN)	0	6,407	1,307	1,482	542	2,699	254	3,562	10,532	26,786
2004 (D)	0	6,472	1,345	1,425	417	3,075	325	3,580	10,097	26,738
2005 (W)	0	6,334	1,664	1,394	883	2,720	390	3,641	9,662	26,689
2006 (W)	0	7,145	1,560	1,324	1,043	2,037	486	3,818	9,228	26,641
2007 (C)	0	8,275	1,320	1,308	955	1,447	539	3,954	8,794	26,592
2008 (C)	0	9,196	1,595	1,293	1,385	398	199	4,118	8,360	26,544
2009 (BN)	0	7,895	1,393	1,253	3,399	57	367	4,207	7,925	26,496
2010 (AN)	0	8,628	1,889	1,206	1,349	783	405	4,697	7,491	26,447
2011 (W)	0	8,663	1,858	1,156	173	1,999	428	5,065	7,057	26,399
2012 (D)	0	8,384	1,841	2,014	195	1,440	467	5,558	6,736	26,636
2013 (C)	0	8,184	2,032	2,875	207	551	571	6,167	6,287	26,873
2014 (C)	0	6,427	1,392	3,733	191	2,761	58	6,701	5,847	27,110
2015 (C)	0	6,513	2,125	3,945	85	424	1,071	7,193	6,053	27,408
Average (1989-2014)	1	5,049	1,835	1,280	955	4,094	260	3,513	9,432	26,419

Additionally, runoff of precipitation from upgradient areas adjacent to the subregion represents a potential source of surface water inflow.

Local Supplies

Local supply inflows to Madera Co GSA – West include inflows along Fresno River and Chowchilla Bypass.

CVP Supplies

CVP supply inflows to Madera Co GSA – West include flood releases from Buchanan Dam and Millerton Reservoir that enter the subregion along Ash Slough and Berenda Slough.

Recycling and Reuse

Recycling and reuse are not a significant source of supply within Madera Co GSA – West.

Other Surface Inflows

For the water budgets presented herein, precipitation runoff from outside the subregion is considered relatively minimal and is expected to pass through the waterways accounted above following relatively large storm events. Precipitation runoff from lands inside the subregion is internal to the surface water system and is thus not considered as surface inflows to the subregion boundary.

Summary of Surface Inflows

The surface water inflows described above are summarized by water source type in Figure A2.F.c-5 and Table A2.F.c-3. During the study period, total surface water inflows vary by water year type, averaging 761 taf per wet year and less than 3 taf during below normal, dry, and critical years.

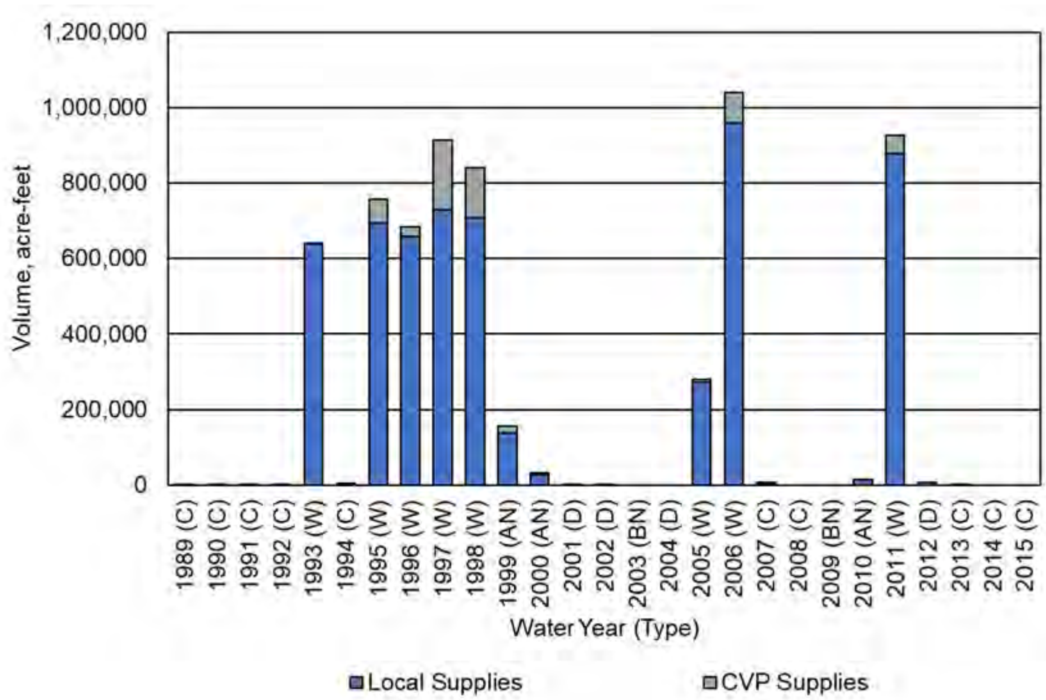

Figure A2.F.c-5. Madera County GSA – West Surface Water Inflows by Water Source Type.

Table A2.F.c-3. Madera County GSA – West Surface Water Inflows by Water Source Type (Acre-Feet).

Water Year (Type)	Local Supply	CVP Supply[1]	Total
1989 (C)	0	1,590	1,590
1990 (C)	0	960	960
1991 (C)	0	1,530	1,530
1992 (C)	0	1,520	1,520
1993 (W)	638,130	3,370	641,500
1994 (C)	170	3,040	3,210
1995 (W)	692,960	64,510	757,460
1996 (W)	658,970	24,440	683,410
1997 (W)	729,140	185,250	914,390
1998 (W)	709,340	130,890	840,230
1999 (AN)	139,110	17,680	156,790
2000 (AN)	26,250	6,550	32,800
2001 (D)	330	710	1,040
2002 (D)	0	0	0
2003 (BN)	0	0	0
2004 (D)	0	0	0
2005 (W)	271,760	9,140	280,900
2006 (W)	958,720	82,190	1,040,910
2007 (C)	4,640	120	4,760
2008 (C)	0	0	0
2009 (BN)	0	0	0
2010 (AN)	13,940	0	13,940
2011 (W)	877,900	49,190	927,090
2012 (D)	8,140	0	8,140
2013 (C)	1,700	0	1,700
2014 (C)	0	0	0
2015 (C)	0	0	0
Average (1989-2014)	220,430	22,410	242,840
Average (1989-2014) W	692,110	68,620	760,740
Average (1989-2014) AN	59,760	8,080	67,840
Average (1989-2014) BN	0	0	0
Average (1989-2014) D	2,120	180	2,300
Average (1989-2014) C	720	970	1,700

1. CVP Supply is considered as all water supply released from CVP storage facilities. The volume of CVP Supply includes CVP deliveries to CWD, and flood releases from CVP facilities that pass through the subbasin. In Madera County GSA - West, all CVP supply pass through the GSA.

3.2.1.2 Precipitation

Precipitation estimates for Madera Co GSA – West are provided in Figure A2.F.c-6 and Table A2.F.c-4. Precipitation estimates are reported by water use sector.

Total precipitation is highly variable between years in the study area, ranging from approximately 19 taf (7.6 inches) during average dry years to 36 taf (14.4 inches) during average wet years.

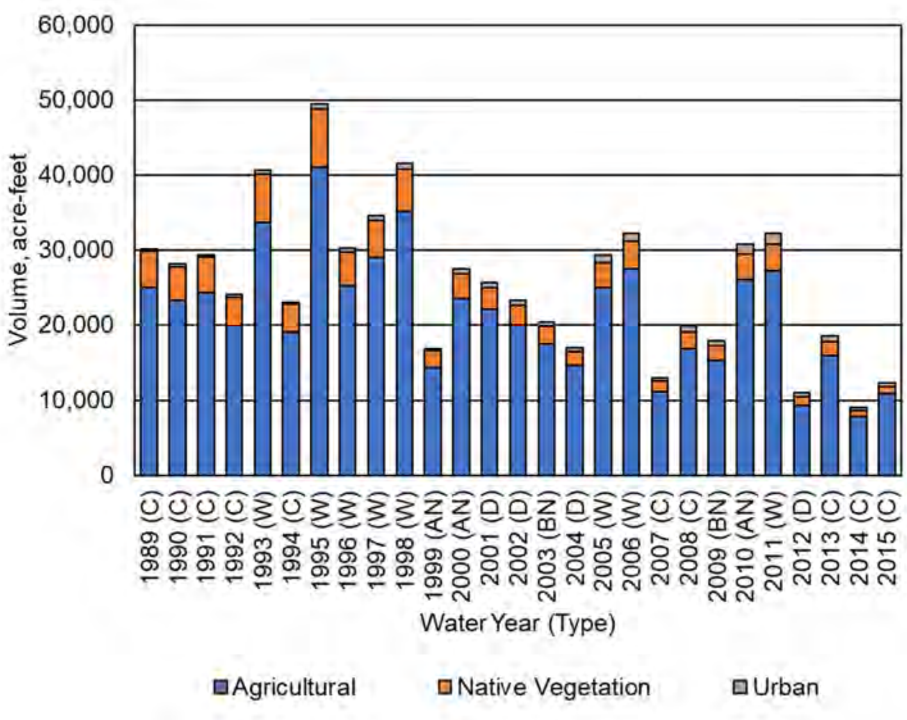

Figure A2.F.c-6. Madera County GSA – West Precipitation by Water Use Sector.

Table A2.F.c-4. Madera County GSA – West Precipitation by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	25,040	4,770	350	30,170
1990 (C)	23,330	4,460	340	28,130
1991 (C)	24,390	4,640	360	29,390
1992 (C)	19,900	3,810	300	24,010
1993 (W)	33,740	6,420	520	40,680
1994 (C)	19,120	3,630	310	23,060
1995 (W)	41,070	7,730	680	49,490
1996 (W)	25,260	4,520	470	30,240
1997 (W)	29,040	4,920	590	34,560
1998 (W)	35,130	5,630	790	41,540
1999 (AN)	14,340	2,170	350	16,850
2000 (AN)	23,510	3,340	610	27,470
2001 (D)	22,070	2,940	610	25,630
2002 (D)	19,990	2,660	610	23,260
2003 (BN)	17,530	2,320	580	20,430

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
2004 (D)	14,540	1,920	520	16,980
2005 (W)	25,040	3,290	950	29,290
2006 (W)	27,530	3,610	1,120	32,260
2007 (C)	11,130	1,450	480	13,060
2008 (C)	16,880	2,200	770	19,850
2009 (BN)	15,220	1,980	740	17,930
2010 (AN)	26,090	3,370	1,330	30,800
2011 (W)	27,270	3,510	1,460	32,240
2012 (D)	9,360	1,110	490	10,970
2013 (C)	15,960	1,750	830	18,540
2014 (C)	7,870	790	400	9,050
2015 (C)	10,850	980	530	12,360
Average (1989-2014)	21,940	3,420	640	25,990
Average (1989-2014) W	30,510	4,950	820	36,290
Average (1989-2014) AN	21,310	2,960	760	25,040
Average (1989-2014) BN	16,380	2,150	660	19,180
Average (1989-2014) D	16,490	2,160	560	19,210
Average (1989-2014) C	18,180	3,050	460	21,700

3.2.1.3 Groundwater Extraction by Water Use Sector

Estimates of groundwater extraction by water use sector are provided in Figure A2.F.c-7 and Table A2.F.c-5. For agricultural and urban (urban, semi-agricultural, industrial) lands, groundwater extraction represents pumping, while for native lands, groundwater extraction by riparian vegetation was considered to be negligible. In all water use sector water budgets, groundwater extraction served as the water budget closure term. Groundwater extraction is dominated by irrigated agriculture and increases over time, following the trend of increasing orchard acreage in the subregion. The consumptive water use of orchards is higher than most other crops grown in the subbasin, and groundwater serves as a major source of supply for the pressurized irrigation systems typical of orchards.

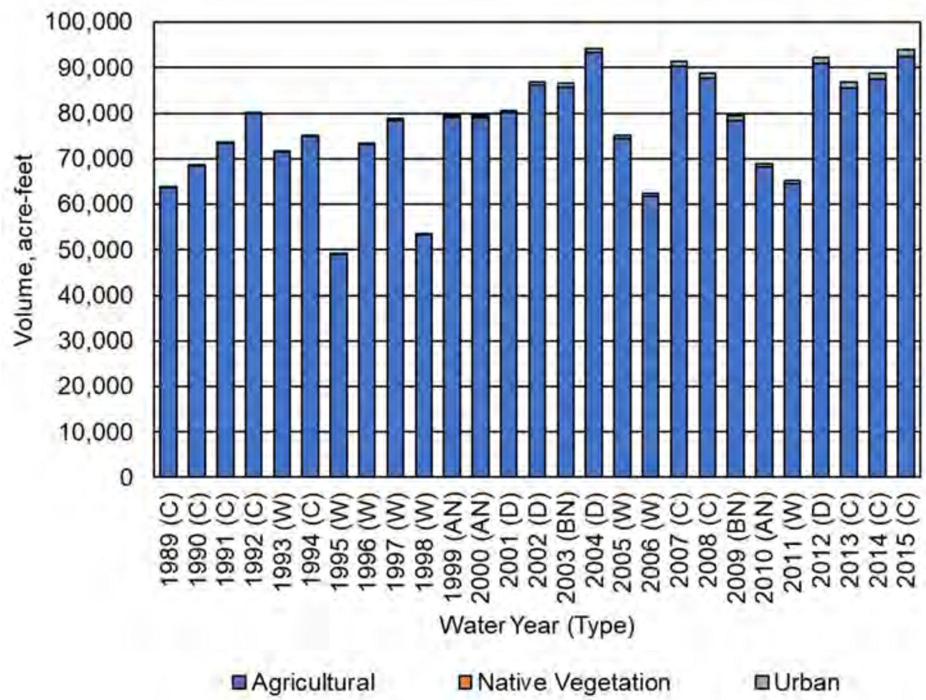

Figure A2.F.c-7. Madera County GSA – West Groundwater Extraction by Water Use Sector.

Table A2.F.c-5. Madera County GSA – West Groundwater Extraction by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	63,760	0	230	63,990
1990 (C)	68,380	0	250	68,630
1991 (C)	73,380	0	250	73,640
1992 (C)	79,830	0	320	80,160
1993 (W)	71,390	0	260	71,640
1994 (C)	74,930	0	330	75,260
1995 (W)	48,930	0	170	49,100
1996 (W)	73,170	0	300	73,470
1997 (W)	78,320	0	520	78,840
1998 (W)	53,270	0	290	53,570
1999 (AN)	79,080	0	500	79,580
2000 (AN)	79,100	0	460	79,560
2001 (D)	80,060	0	490	80,550
2002 (D)	86,220	0	670	86,900
2003 (BN)	85,840	0	690	86,530
2004 (D)	93,320	0	940	94,260
2005 (W)	74,470	0	600	75,070
2006 (W)	61,830	0	620	62,450
2007 (C)	90,260	0	1,060	91,320
2008 (C)	87,660	0	1,090	88,750
2009 (BN)	78,450	0	1,120	79,560
2010 (AN)	68,170	0	650	68,820

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
2011 (W)	64,510	0	730	65,250
2012 (D)	90,890	0	1,270	92,160
2013 (C)	85,560	0	1,280	86,830
2014 (C)	87,450	0	1,250	88,700
2015 (C)	92,550	0	1,360	93,910
Average (1989-2014)	76,090	0	630	76,710
Average (1989-2014) W	65,740	0	440	66,170
Average (1989-2014) AN	75,450	0	540	75,990
Average (1989-2014) BN	82,150	0	900	83,050
Average (1989-2014) D	87,620	0	840	88,470
Average (1989-2014) C	79,020	0	670	79,700

3.2.1.4 Groundwater Discharge to Surface Water Sources

The depth to groundwater is greater than 100-200 ft across much of the Chowchilla Subbasin. Given the depth to the water table in the Chowchilla Subbasin, groundwater discharge to surface water sources is negligible.

3.2.2 Outflows

3.2.2.1 Evapotranspiration by Water Use Sector

Evapotranspiration (ET) by water use sector is reported in Figures A2.F.c-8 to A2.F.c-10 and Tables A2.F.c-6 to A2.F.c-8. First, total ET is reported, followed by ET from applied water and ET from precipitation.

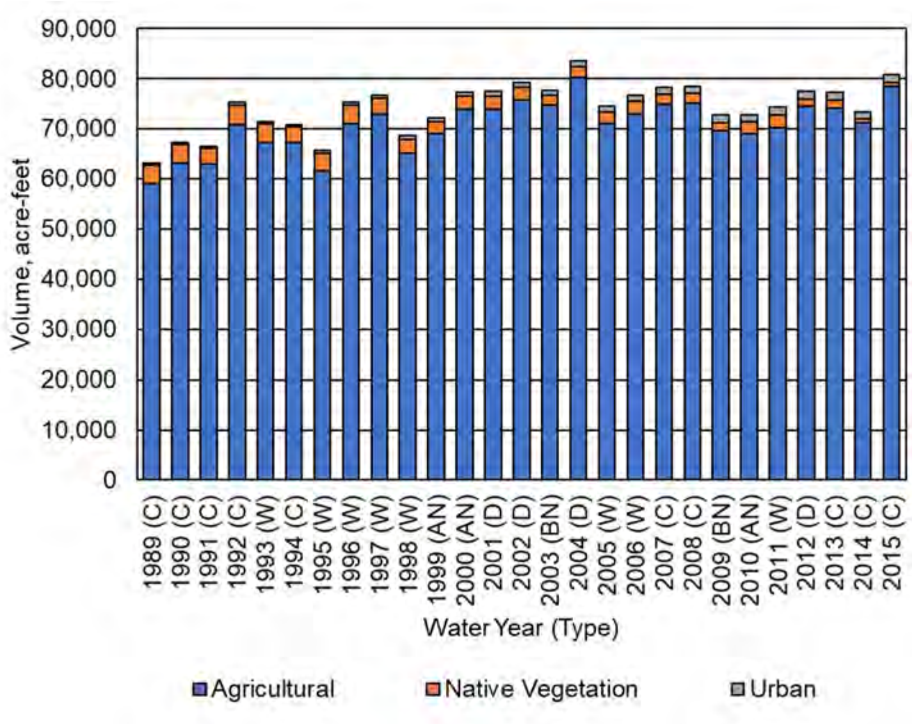

Figure A2.F.c-8. Madera County GSA – West Evapotranspiration by Water Use Sector.

Table A2.F.c-6. Madera County GSA – West Evapotranspiration by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	59,100	3,680	410	63,190
1990 (C)	63,250	3,670	430	67,350
1991 (C)	62,910	3,270	390	66,570
1992 (C)	70,740	4,020	490	75,250
1993 (W)	67,200	3,820	480	71,500
1994 (C)	67,240	3,170	490	70,900
1995 (W)	61,540	3,650	460	65,650
1996 (W)	70,950	3,740	560	75,250
1997 (W)	72,880	3,200	660	76,740
1998 (W)	65,130	2,800	630	68,560
1999 (AN)	69,000	2,450	690	72,140
2000 (AN)	73,880	2,560	790	77,230
2001 (D)	73,960	2,620	840	77,420
2002 (D)	75,780	2,470	970	79,220
2003 (BN)	74,670	1,970	1,030	77,670
2004 (D)	80,270	2,130	1,210	83,610
2005 (W)	71,060	2,380	1,140	74,580
2006 (W)	72,960	2,600	1,230	76,790
2007 (C)	74,980	1,920	1,300	78,200
2008 (C)	75,080	1,980	1,490	78,550
2009 (BN)	69,630	1,640	1,530	72,800
2010 (AN)	68,980	2,340	1,440	72,760
2011 (W)	70,220	2,530	1,520	74,270
2012 (D)	74,620	1,380	1,430	77,430
2013 (C)	74,150	1,580	1,660	77,390
2014 (C)	71,160	790	1,390	73,340
2015 (C)	78,520	820	1,530	80,870
Average (1989-2014)	70,440	2,630	940	74,010
Average (1989-2014) W	69,000	3,090	830	72,920
Average (1989-2014) AN	70,620	2,450	970	74,040
Average (1989-2014) BN	72,140	1,810	1,270	75,220
Average (1989-2014) D	76,150	2,150	1,120	79,420
Average (1989-2014) C	68,730	2,680	890	72,300

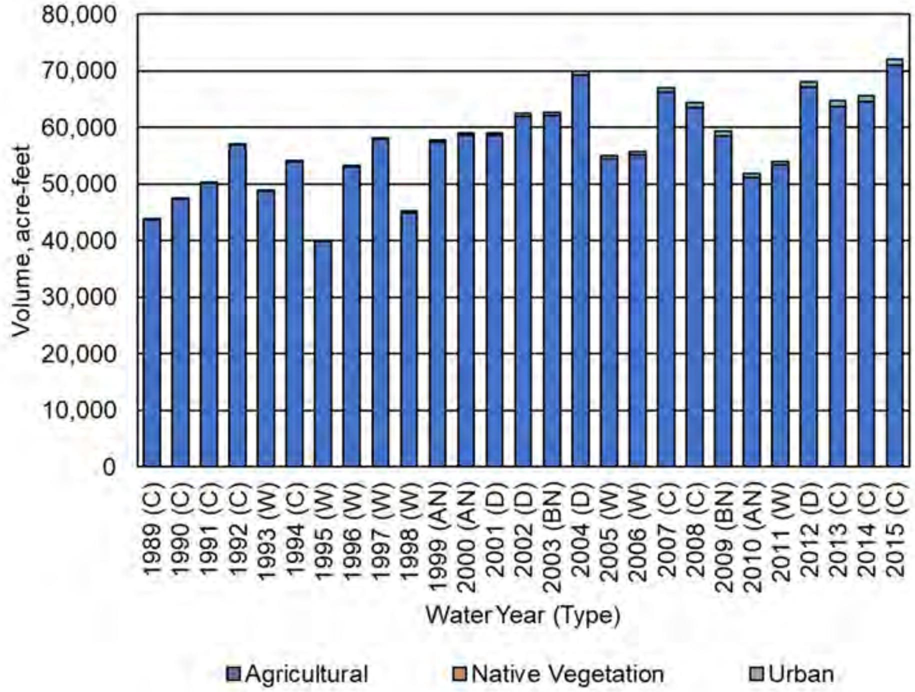

Figure A2.F.c-9. Madera County GSA – West Evapotranspiration of Applied Water by Water Use Sector.

Table A2.F.c-7. Madera County GSA – West Evapotranspiration of Applied Water by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	43,740	0	180	43,920
1990 (C)	47,340	0	180	47,520
1991 (C)	50,060	0	180	50,240
1992 (C)	56,930	0	230	57,160
1993 (W)	48,670	0	200	48,870
1994 (C)	53,970	0	250	54,220
1995 (W)	39,810	0	150	39,960
1996 (W)	53,160	0	190	53,350
1997 (W)	57,900	0	300	58,200
1998 (W)	44,980	0	260	45,240
1999 (AN)	57,500	0	330	57,830
2000 (AN)	58,610	0	390	59,000
2001 (D)	58,670	0	370	59,040
2002 (D)	62,030	0	490	62,520
2003 (BN)	62,160	0	570	62,730
2004 (D)	69,340	0	710	70,050
2005 (W)	54,510	0	540	55,050
2006 (W)	55,120	0	530	55,650
2007 (C)	66,250	0	720	66,970
2008 (C)	63,610	0	870	64,480
2009 (BN)	58,490	0	940	59,430
2010 (AN)	51,200	0	630	51,830

2011 (W)	53,420	0	570	53,990
2012 (D)	67,220	0	830	68,050
2013 (C)	63,760	0	1,010	64,770
2014 (C)	64,580	0	990	65,570
2015 (C)	70,970	0	1,120	72,090
Average (1989-2014)	56,270	0	480	56,750
Average (1989-2014) W	50,950	0	340	51,290
Average (1989-2014) AN	55,770	0	450	56,220
Average (1989-2014) BN	60,320	0	750	61,070
Average (1989-2014) D	64,310	0	600	64,910
Average (1989-2014) C	56,690	0	510	57,200

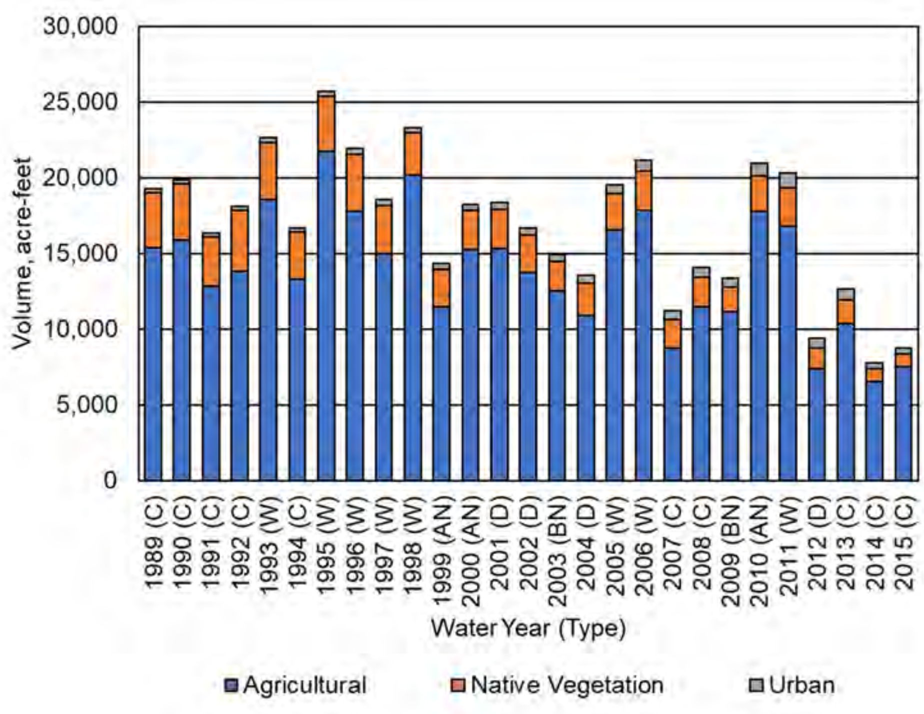

Figure A2.F.c-10. Madera County GSA – West Evapotranspiration of Precipitation by Water Use Sector.

Table A2.F.c-8. Madera County GSA – West Evapotranspiration of Precipitation by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	15,360	3,680	230	19,270
1990 (C)	15,910	3,670	250	19,830
1991 (C)	12,850	3,270	210	16,330
1992 (C)	13,810	4,020	260	18,090
1993 (W)	18,530	3,820	280	22,630
1994 (C)	13,270	3,170	240	16,680
1995 (W)	21,730	3,650	310	25,690
1996 (W)	17,790	3,740	370	21,900
1997 (W)	14,980	3,200	360	18,540

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1998 (W)	20,150	2,800	370	23,320
1999 (AN)	11,500	2,450	360	14,310
2000 (AN)	15,270	2,560	400	18,230
2001 (D)	15,290	2,620	470	18,380
2002 (D)	13,750	2,470	480	16,700
2003 (BN)	12,510	1,970	460	14,940
2004 (D)	10,930	2,130	500	13,560
2005 (W)	16,550	2,380	600	19,530
2006 (W)	17,840	2,600	700	21,140
2007 (C)	8,730	1,920	580	11,230
2008 (C)	11,470	1,980	620	14,070
2009 (BN)	11,140	1,640	590	13,370
2010 (AN)	17,780	2,340	810	20,930
2011 (W)	16,800	2,530	950	20,280
2012 (D)	7,400	1,380	600	9,380
2013 (C)	10,390	1,580	650	12,620
2014 (C)	6,580	790	400	7,770
2015 (C)	7,550	820	410	8,780
Average (1989-2014)	14,170	2,630	460	17,260
Average (1989-2014) W	18,050	3,090	490	21,630
Average (1989-2014) AN	14,850	2,450	520	17,820
Average (1989-2014) BN	11,820	1,810	520	14,150
Average (1989-2014) D	11,840	2,150	520	14,510
Average (1989-2014) C	12,040	2,680	380	15,100

Total ET varies between years, with the lowest observed in 1989, at approximately 63 taf, and greatest in 2004, at approximately 84 taf. Total ET generally increases over time, again following the trend of increasing orchard acreage.

In addition to ET from land surfaces, estimates of evaporation from Madera Co GSA – West rivers and streams are reported in Figure A2.F.c-11 and Table A2.F.c-9. Evaporation from the Rivers and Streams System includes evaporation of both surface inflows and of precipitation runoff within local sloughs and depressions. Total evaporation from all sources averaged less than 1 taf per year between 1989 and 2014.

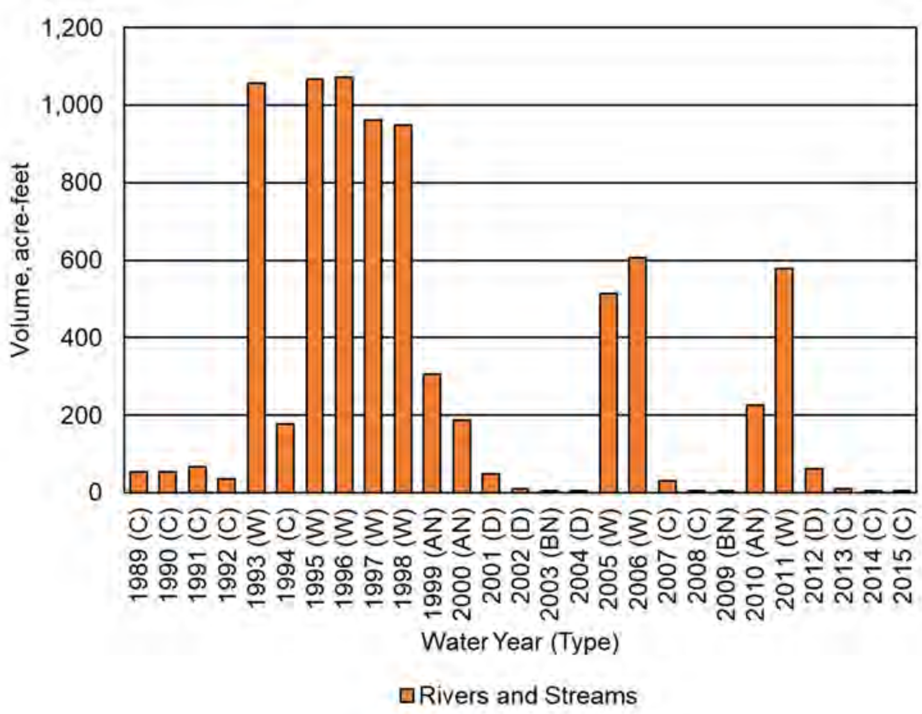

Figure A2.F.c-11. Madera County GSA – West Evaporation from the Surface Water System.

Table A2.F.c-9. Madera County GSA – West Evaporation from the Surface Water System (Acre-Feet).

Water Year (Type)	Rivers and Streams[1]
1989 (C)	60
1990 (C)	50
1991 (C)	70
1992 (C)	40
1993 (W)	1,060
1994 (C)	180
1995 (W)	1,070
1996 (W)	1,070
1997 (W)	960
1998 (W)	950
1999 (AN)	310
2000 (AN)	190
2001 (D)	50
2002 (D)	10
2003 (BN)	10
2004 (D)	10
2005 (W)	520
2006 (W)	610
2007 (C)	30
2008 (C)	10
2009 (BN)	10
2010 (AN)	230

2011 (W)	580
2012 (D)	60
2013 (C)	10
2014 (C)	10
2015 (C)	10
Average (1989-2014)	310
Average (1989-2014) W	850
Average (1989-2014) AN	240
Average (1989-2014) BN	10
Average (1989-2014) D	30
Average (1989-2014) C	50

[1] Includes evaporation of surface inflows and of precipitation runoff.

3.2.2.2 Surface Water Outflow by Water Source Type

Surface water outflows by water source type are summarized in Figure A2.F.c-12 and Table A2.F.c-10. In Madera Co GSA – West, runoff of applied water is assumed negligible and runoff of precipitation is collected in waterways within Madera Co GSA – West, with most infiltrating to the groundwater system except following the largest storm events. Thus, surface outflows from the GSA – West are expected to be a mixture of local supplies and CVP supplies along Eastside Bypass. Between 1989 and 2014, these combined outflows averaged approximately 735 taf during wet years.

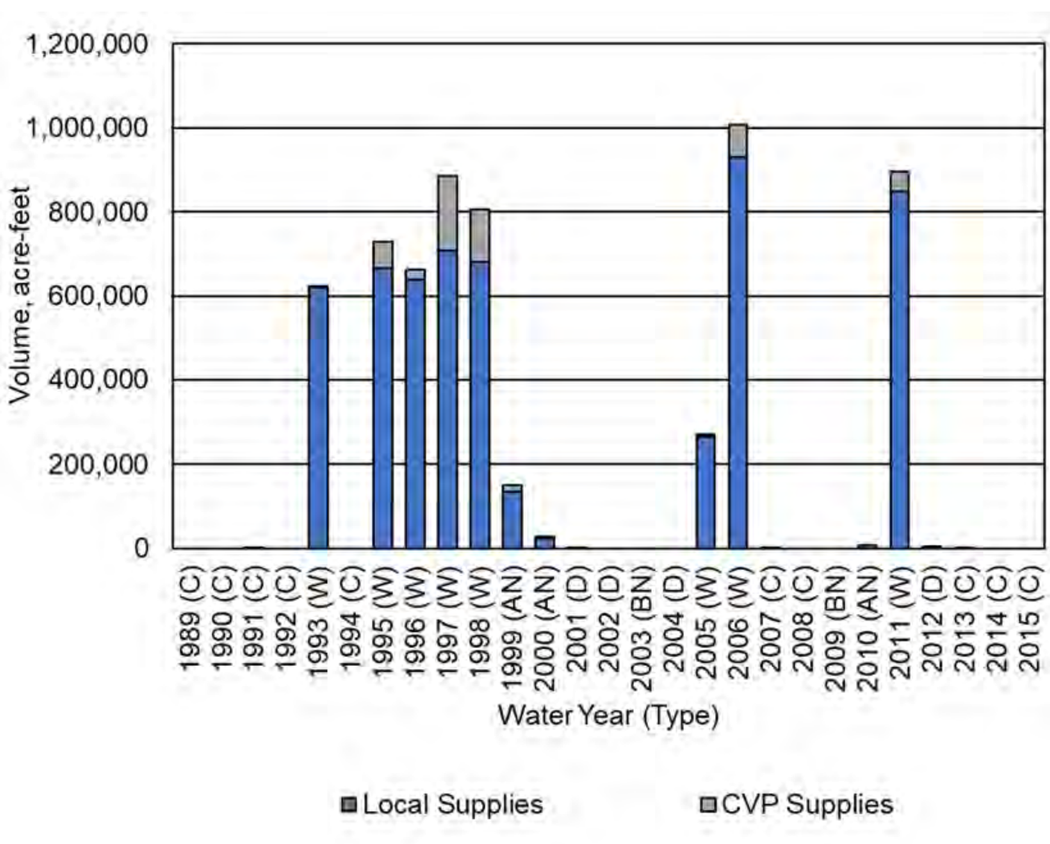

Figure A2.F.c-12. Madera County GSA – West Surface Outflows by Water Source Type.

Table A2.F.c-10. Madera County GSA – West Surface Outflows by Water Source Type (Acre-Feet).

Water Year (Type)	Local Supplies	CVP Supplies	Total
1989 (C)	0	0	0
1990 (C)	0	0	0
1991 (C)	240	0	240
1992 (C)	0	0	0
1993 (W)	619,400	3,270	622,670
1994 (C)	0	0	0
1995 (W)	666,290	61,860	728,150
1996 (W)	638,500	22,940	661,440
1997 (W)	708,150	177,050	885,200
1998 (W)	682,020	124,100	806,120
1999 (AN)	135,870	15,150	151,020
2000 (AN)	22,330	5,640	27,970
2001 (D)	0	110	110
2002 (D)	0	0	0
2003 (BN)	0	0	0
2004 (D)	0	0	0
2005 (W)	263,610	6,470	270,080
2006 (W)	929,750	77,470	1,007,220
2007 (C)	1,900	0	1,900
2008 (C)	0	0	0
2009 (BN)	0	0	0
2010 (AN)	7,470	0	7,470
2011 (W)	847,610	47,930	895,540
2012 (D)	4,310	0	4,310
2013 (C)	350	0	350
2014 (C)	0	0	0
2015 (C)	0	0	0
Average (1989-2014)	212,610	20,850	233,450
Average (1989-2014) W	669,420	65,140	734,550
Average (1989-2014) AN	55,220	6,930	62,150
Average (1989-2014) BN	0	0	0
Average (1989-2014) D	1,080	30	1,110
Average (1989-2014) C	280	0	280

3.2.2.3 Infiltration of Precipitation

Estimated infiltration of precipitation (deep percolation of precipitation) by water use sector is provided in Figure A2.F.c-13 and Table A2.F.c-11. Infiltration of precipitation to the groundwater system is highly variable from year to year due to variation in the timing and amount of precipitation, ranging from less than 4 taf annually during some critical and dry years to over 17 taf during 1995.

3.2.2.4 Infiltration of Surface Water

Estimated infiltration of surface water (seepage) by source is provided in Figure A2.F.c-14 and Table A2.F.c-12. Seepage from the Rivers and Streams System includes seepage of both surface inflows and of precipitation runoff into local sloughs and depressions. Seepage from rivers and streams follows the pattern of surface water inflows, averaging approximately 21 taf per wet year between 1989 and 2014. While flows in the San Joaquin River were not accounted directly as water budget components[4], boundary seepage from the San Joaquin River contributes an additional 11 taf per wet year to net recharge in Madera County GSA – West.

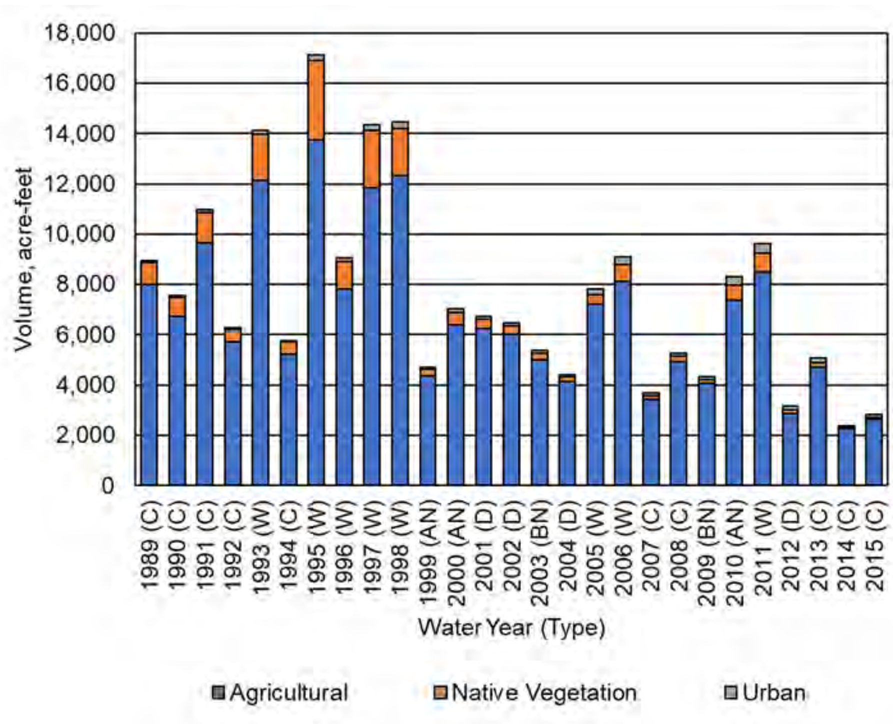

Figure A2.F.c-13. Madera County GSA – West Infiltration of Precipitation by Water Use Sector.

Table A2.F.c-11. Madera County GSA – West Infiltration of Precipitation by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	7,990	860	90	8,940
1990 (C)	6,740	730	70	7,540
1991 (C)	9,650	1,210	110	10,970
1992 (C)	5,730	480	60	6,270
1993 (W)	12,120	1,840	160	14,120
1994 (C)	5,220	490	60	5,770
1995 (W)	13,750	3,140	230	17,120
1996 (W)	7,820	1,100	130	9,050
1997 (W)	11,840	2,270	250	14,360
1998 (W)	12,310	1,880	270	14,460

[4] The San Joaquin River does not cross the lateral boundaries of the Chowchilla Subbasin, as defined above. Thus, San Joaquin River flows are not considered surface water inflows within this water budget. A portion of infiltration of surface water from the San Joaquin River is considered to cross the subbasin boundaries into the groundwater system and is included in the calculation of the subbasin estimates of overdraft and net recharge from SWS.

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1999 (AN)	4,350	290	80	4,720
2000 (AN)	6,400	490	130	7,020
2001 (D)	6,240	370	120	6,730
2002 (D)	6,010	330	130	6,470
2003 (BN)	5,020	250	110	5,380
2004 (D)	4,150	160	90	4,400
2005 (W)	7,210	400	200	7,810
2006 (W)	8,130	680	280	9,090
2007 (C)	3,430	150	100	3,680
2008 (C)	4,920	230	130	5,280
2009 (BN)	4,080	150	110	4,340
2010 (AN)	7,370	610	320	8,300
2011 (W)	8,480	750	370	9,600
2012 (D)	2,880	150	120	3,150
2013 (C)	4,690	210	170	5,070
2014 (C)	2,250	50	70	2,370
2015 (C)	2,650	80	80	2,810
Average (1989-2014)	6,880	740	150	7,770
Average (1989-2014) W	10,210	1,510	240	11,960
Average (1989-2014) AN	6,040	460	180	6,680
Average (1989-2014) BN	4,550	200	110	4,860
Average (1989-2014) D	4,820	250	120	5,190
Average (1989-2014) C	5,620	490	100	6,210

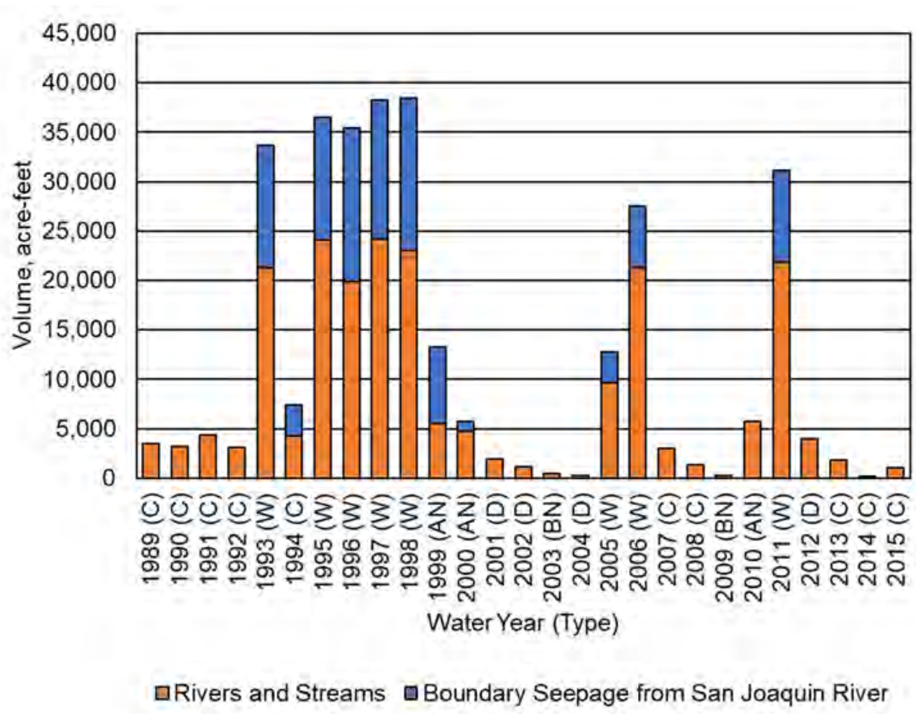

Figure A2.F.c-14. Madera County GSA – West Infiltration of Surface Water.

Table A2.F.c-12. Madera County GSA – West Infiltration of Surface Water (Acre-Feet).

Water Year (Type)	Rivers and Streams[1]	Boundary Seepage from San Joaquin River	Total
1989 (C)	3,530	0	3,530
1990 (C)	3,230	0	3,230
1991 (C)	4,380	0	4,380
1992 (C)	3,080	0	3,080
1993 (W)	21,220	12,450	33,670
1994 (C)	4,270	3,100	7,370
1995 (W)	24,090	12,450	36,540
1996 (W)	19,890	15,540	35,430
1997 (W)	24,220	14,020	38,240
1998 (W)	22,980	15,450	38,430
1999 (AN)	5,560	7,670	13,230
2000 (AN)	4,800	910	5,710
2001 (D)	1,950	0	1,950
2002 (D)	1,110	0	1,110
2003 (BN)	460	0	460
2004 (D)	290	0	290
2005 (W)	9,680	3,100	12,780
2006 (W)	21,270	6,200	27,470
2007 (C)	3,040	0	3,040
2008 (C)	1,340	0	1,340
2009 (BN)	310	0	310
2010 (AN)	5,770	0	5,770
2011 (W)	21,800	9,350	31,150
2012 (D)	3,930	0	3,930
2013 (C)	1,850	0	1,850
2014 (C)	140	0	140
2015 (C)	1,070	0	1,070
Average (1989-2014)	8,240	3,860	12,100
Average (1989-2014) W	20,640	11,070	31,710
Average (1989-2014) AN	5,380	2,860	8,240
Average (1989-2014) BN	390	0	390
Average (1989-2014) D	1,820	0	1,820
Average (1989-2014) C	2,760	340	3,100

[1] Includes infiltration of surface inflows and of precipitation runoff within the subregion. To calculate Net Recharge from SWS below, Rivers and Streams System seepage is summed across the subbasin and redistributed to each subregion in proportion to gross area.

3.2.2.5 Infiltration of Applied Water

Estimated infiltration of applied water (deep percolation of applied water) by water use sector is provided in Figure A2.F.c-15 and Table A2.F.c-13. Infiltration of applied water is dominated by agricultural irrigation and has slowly decreased over time, likely due to increase use of drip and micro-irrigation systems in place of flood irrigation.

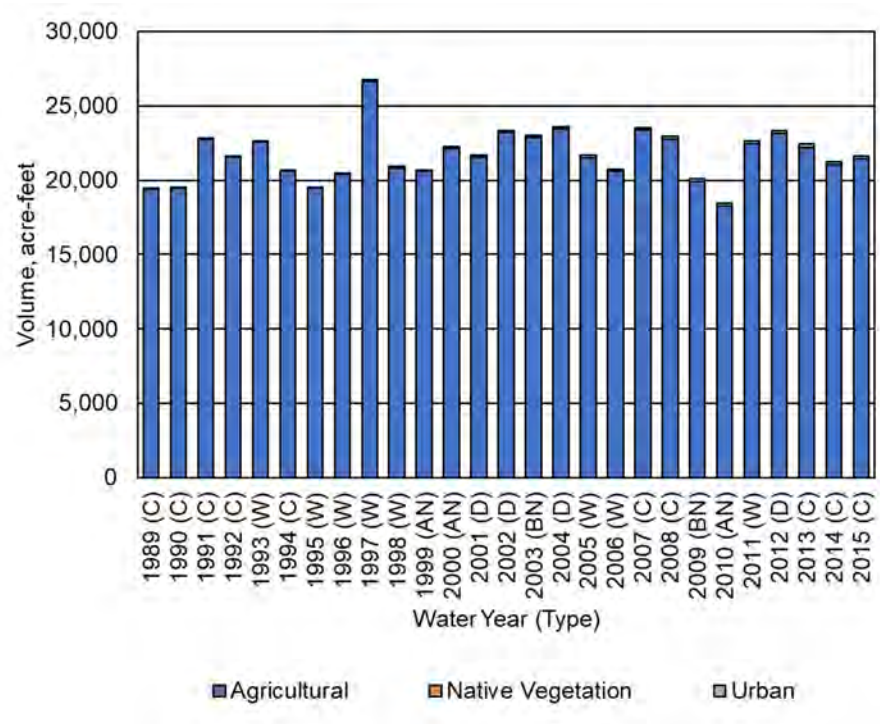

Figure A2.F.c-15. Madera County GSA – West Infiltration of Applied Water by Water Use Sector.

Table A2.F.c-13. Madera County GSA – West Infiltration of Applied Water by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	19,430	0	60	19,490
1990 (C)	19,490	0	60	19,550
1991 (C)	22,770	0	60	22,830
1992 (C)	21,580	0	60	21,640
1993 (W)	22,570	0	90	22,660
1994 (C)	20,600	0	70	20,670
1995 (W)	19,470	0	80	19,550
1996 (W)	20,390	0	50	20,440
1997 (W)	26,640	0	140	26,780
1998 (W)	20,820	0	130	20,950
1999 (AN)	20,610	0	80	20,690
2000 (AN)	22,140	0	100	22,240
2001 (D)	21,570	0	100	21,670
2002 (D)	23,220	0	130	23,350
2003 (BN)	22,870	0	130	23,000
2004 (D)	23,440	0	140	23,580
2005 (W)	21,490	0	180	21,670
2006 (W)	20,620	0	150	20,770
2007 (C)	23,380	0	150	23,530
2008 (C)	22,760	0	200	22,960
2009 (BN)	19,890	0	190	20,080

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
2010 (AN)	18,250	0	190	18,440
2011 (W)	22,440	0	190	22,630
2012 (D)	23,120	0	190	23,310
2013 (C)	22,210	0	260	22,470
2014 (C)	21,080	0	190	21,270
2015 (C)	21,420	0	220	21,640
Average (1989-2014)	21,650	0	130	21,780
Average (1989-2014) W	21,810	0	130	21,940
Average (1989-2014) AN	20,330	0	120	20,450
Average (1989-2014) BN	21,380	0	160	21,540
Average (1989-2014) D	22,840	0	140	22,980
Average (1989-2014) C	21,480	0	120	21,600

3.2.3 Change in Surface Water System Storage

Estimates of change in SWS storage are provided in Figure A2.F.c-16 and Table A2.F.c-14. Inter-annual changes in storage within the surface water system consist primarily of root zone soil moisture storage changes, are relatively small, and tend to average near zero over many years.

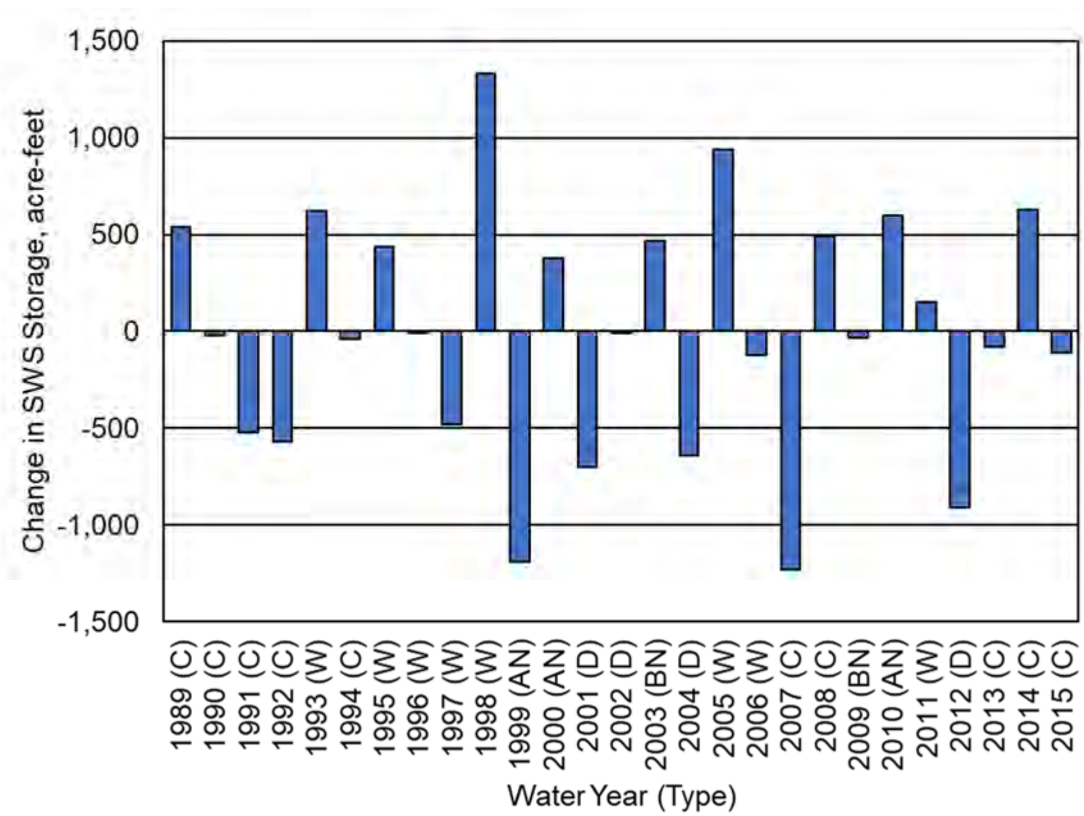

Figure A2.F.c-16. Madera County GSA – West Change in Surface Water System Storage.

Table A2.F.c-14. Madera County GSA – West Change in Surface Water System Storage (Acre-Feet).

Water Year (Type)	Change in SWS Storage
1989 (C)	540
1990 (C)	-20
1991 (C)	-520
1992 (C)	-570
1993 (W)	620
1994 (C)	-40
1995 (W)	440
1996 (W)	-10
1997 (W)	-480
1998 (W)	1,330
1999 (AN)	-1,190
2000 (AN)	380
2001 (D)	-700
2002 (D)	-10
2003 (BN)	470
2004 (D)	-640
2005 (W)	940
2006 (W)	-120
2007 (C)	-1,230
2008 (C)	490
2009 (BN)	-30
2010 (AN)	600
2011 (W)	150
2012 (D)	-910
2013 (C)	-80
2014 (C)	630
2015 (C)	-110
Average (1989-2014)	0
Average (1989-2014) W	360
Average (1989-2014) AN	-70
Average (1989-2014) BN	220
Average (1989-2014) D	-570
Average (1989-2014) C	-90

3.3 Historical Water Budget Summary

Annual inflows, outflows, and change in SWS storage during the historical water budget period (1989-2014) are summarized in Figure A2.F.c-17 and Table A2.F.c-15. Inflows are shown as positive values, while outflows and change in SWS storage are shown as negative values. During wet years, boundary surface inflow and outflow volumes are substantially higher than other components. Figure A2.F.c-17 thus only shows the difference between the surface inflows and surface outflows after seepage and evaporation are accounted within Madera Co GSA – West. Review of the variability in component volumes across years provides insight into the impacts of hydrology on the surface water system water budget.

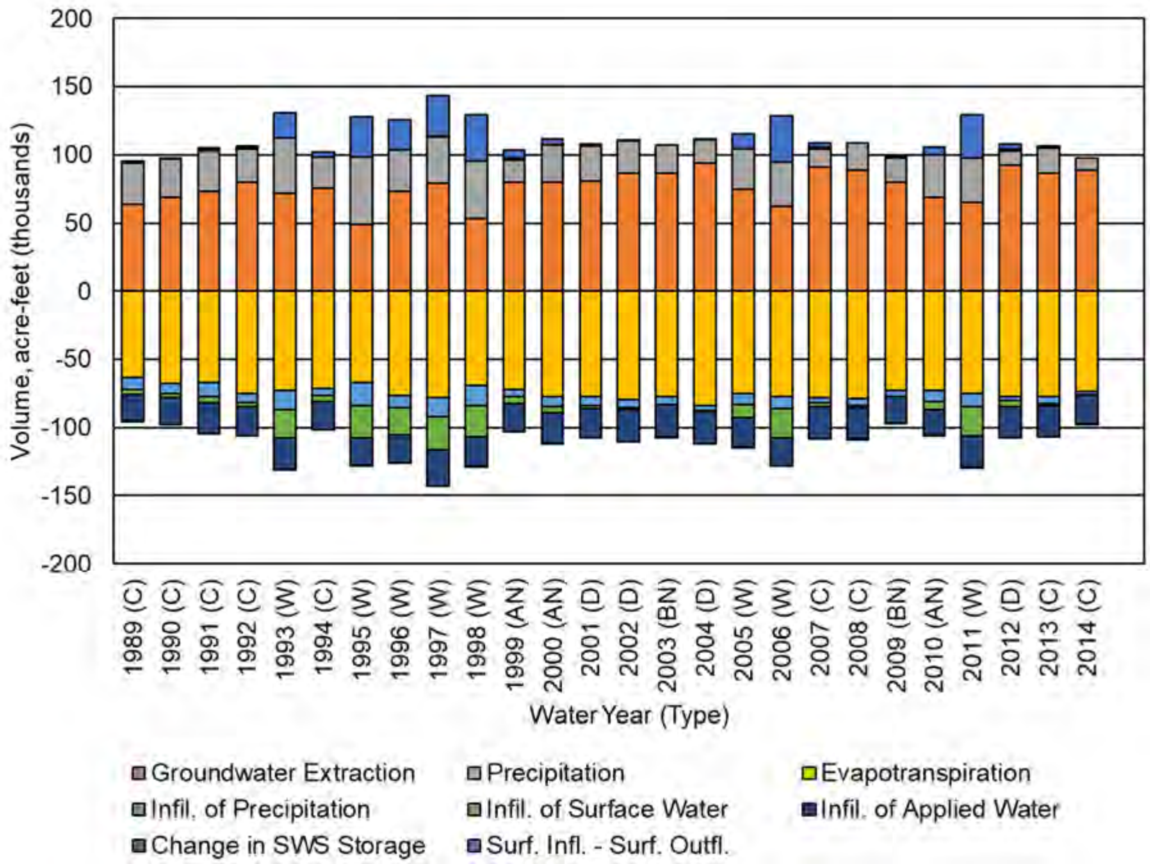

Figure A2.F.c-17. Madera County GSA – West Surface Water System Historical Water Budget, 1989-2014.

Table A2.F.c-15. Madera County GSA – West Surface Water System Historical Water Budget, 1989-2014 (Acre-Feet).

Water Year	Boundary Surface Inflows	Groundwater Extraction	Precipitation	Evapo-transpiration[1]	Infil. of Precipitation	Infil. of Surface Water[2]	Infil. of Applied Water	Boundary Surface Outflows	Change in SWS Storage
1989 (C)	1,590	63,990	30,170	-63,250	-8,940	-3,530	-19,490	0	-540
1990 (C)	960	68,630	28,130	-67,410	-7,550	-3,230	-19,540	0	20
1991 (C)	1,530	73,640	29,390	-66,650	-10,970	-4,380	-22,840	-240	520
1992 (C)	1,520	80,160	24,010	-75,280	-6,260	-3,080	-21,640	0	570
1993 (W)	641,500	71,650	40,680	-72,550	-14,120	-21,220	-22,660	-622,670	-620
1994 (C)	3,210	75,260	23,060	-71,070	-5,780	-4,270	-20,670	0	260
1995 (W)	757,460	49,100	49,490	-66,720	-17,110	-24,090	-19,540	-728,150	-440
1996 (W)	683,410	73,470	30,240	-76,320	-9,040	-19,890	-20,440	-661,440	10
1997 (W)	914,390	78,840	34,560	-77,700	-14,350	-24,220	-26,780	-885,200	480
1998 (W)	840,230	53,570	41,540	-69,500	-14,460	-22,980	-20,950	-806,120	-1,330
1999 (AN)	156,790	79,580	16,850	-72,430	-4,720	-5,560	-20,680	-151,020	1,190
2000 (AN)	32,800	79,560	27,470	-77,420	-7,020	-4,800	-22,240	-27,970	-380
2001 (D)	1,040	80,550	25,630	-77,460	-6,730	-1,950	-21,670	-110	700
2002 (D)	0	86,900	23,260	-79,240	-6,470	-1,110	-23,350	0	10
2003 (BN)	0	86,530	20,430	-77,660	-5,380	-460	-23,000	0	-470
2004 (D)	0	94,260	16,980	-83,610	-4,400	-290	-23,580	0	640
2005 (W)	280,900	75,080	29,290	-75,090	-7,800	-9,680	-21,670	-270,080	-940
2006 (W)	1,040,910	62,450	32,260	-77,390	-9,090	-21,270	-20,770	-1,007,220	120
2007 (C)	4,760	91,320	13,060	-78,230	-3,670	-3,040	-23,530	-1,900	1,230
2008 (C)	0	88,750	19,850	-78,550	-5,270	-1,340	-22,950	0	-490
2009 (BN)	0	79,560	17,930	-72,800	-4,340	-310	-20,080	0	30
2010 (AN)	13,940	68,820	30,800	-72,980	-8,290	-5,770	-18,440	-7,470	-600
2011 (W)	927,090	65,250	32,240	-74,850	-9,600	-21,800	-22,630	-895,540	-150
2012 (D)	8,140	92,160	10,970	-77,480	-3,150	-3,930	-23,310	-4,310	910
2013 (C)	1,700	86,830	18,540	-77,400	-5,070	-1,850	-22,470	-350	80
2014 (C)	0	88,700	9,050	-73,330	-2,380	-140	-21,270	0	-630
Average (1989-2014)	242,840	76,710	25,990	-74,320	-7,770	-8,240	-21,780	-233,450	10
W	760,740	66,170	36,290	-73,770	-11,950	-20,640	-21,930	-734,550	-360
AN	67,840	75,990	25,040	-74,280	-6,680	-5,380	-20,450	-62,150	70
BN	0	83,050	19,180	-75,230	-4,860	-390	-21,540	0	-220
D	2,300	88,470	19,210	-79,450	-5,190	-1,820	-22,980	-1,110	570
C	1,700	79,700	21,700	-72,350	-6,210	-2,760	-21,600	-280	110

[1]Includes ET of applied water, ET of precipitation, and evaporation from the Rivers and Streams System.
[2]Includes infiltration from the Rivers and Streams System within the subregion. To calculate Net Recharge from SWS below, Rivers and Streams System seepage is summed across the subbasin and redistributed to each subregion in proportion to gross area.

3.4 Current Water Budget Summary

The current water budget was developed following a similar process to the historical water budget using the 2015 land use in Table A2.F.c-1 and the same 1989-2014 average hydrologic conditions of the historical base period, including surface water flows, precipitation, and weather parameters. This allowed quantification of groundwater inflows and outflows for current consumptive use in the context of average water supply conditions.

Annual inflows, outflows, and change in SWS storage from the current water budget are summarized in Figure A2.F.c-18 and Table A2.F.c-16. Inflows are shown as positive values, while outflows and change in SWS storage are shown as negative values. Similar to Figure A2.F.c-17, Figure A2.F.c-18 only shows the difference between the surface inflows and surface outflows after seepage and evaporation are accounted within Madera Co GSA – West.

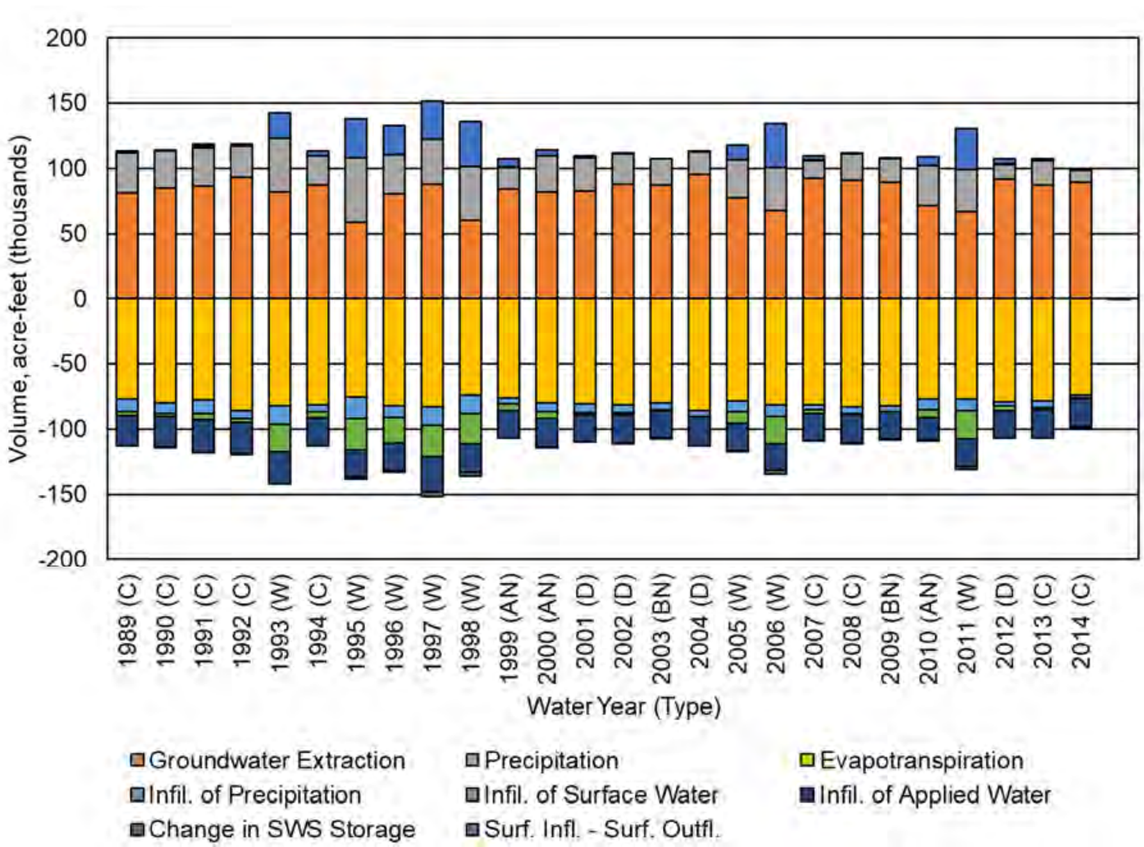

Figure A2.F.c-18. Madera County GSA – West Surface Water System Current Water Budget.

Table A2.F.c-16. Madera County GSA – West Surface Water System Current Water Budget (Acre-Feet).

Water Year	Boundary Surface Inflows	Groundwater Extraction	Precipitation	Evapo-transpiration[1]	Infil. of Precipitation	Infil. of Surface Water[2]	Infil. of Applied Water	Boundary Surface Outflows	Change in SWS Storage
1989 (C)	1,590	81,420	30,170	-77,260	-9,030	-2,980	-23,910	0	10
1990 (C)	960	84,930	28,120	-80,210	-7,610	-2,840	-22,770	0	-580
1991 (C)	1,530	86,450	29,380	-77,320	-10,670	-4,370	-25,870	-10	870
1992 (C)	1,520	93,220	24,010	-85,600	-6,390	-2,960	-23,630	0	-170
1993 (W)	641,500	82,110	40,680	-82,170	-14,200	-21,190	-24,730	-622,090	90
1994 (C)	3,210	86,830	23,050	-81,100	-5,770	-3,900	-22,350	0	30
1995 (W)	757,460	58,680	49,490	-75,190	-16,430	-24,070	-20,770	-727,690	-1,480
1996 (W)	683,410	80,360	30,240	-81,960	-8,880	-19,890	-20,720	-661,090	-1,480
1997 (W)	914,390	87,820	34,560	-82,820	-14,130	-24,220	-26,860	-885,000	-3,730
1998 (W)	840,230	59,840	41,540	-73,900	-14,340	-22,980	-21,700	-805,830	-2,860
1999 (AN)	156,790	83,750	16,850	-75,810	-4,710	-5,550	-21,160	-150,990	830
2000 (AN)	32,800	81,760	27,470	-79,790	-7,000	-4,790	-22,100	-27,820	-530
2001 (D)	1,040	82,420	25,630	-80,610	-6,500	-1,790	-20,800	-70	680
2002 (D)	10	87,760	23,260	-81,460	-6,300	-1,030	-21,980	0	-250
2003 (BN)	0	86,730	20,430	-80,070	-5,140	-370	-21,560	0	-20
2004 (D)	0	95,220	16,980	-86,260	-4,220	-240	-21,830	0	350
2005 (W)	280,900	77,310	29,280	-78,770	-7,550	-9,610	-21,010	-269,830	-730
2006 (W)	1,040,910	67,970	32,260	-81,490	-8,780	-21,270	-20,100	-1,006,640	-2,860
2007 (C)	4,760	92,590	13,070	-81,490	-3,390	-3,000	-21,560	-1,860	880
2008 (C)	0	91,180	19,850	-83,100	-4,970	-1,080	-21,390	0	-490
2009 (BN)	0	89,130	17,930	-82,240	-4,090	-110	-20,830	0	200
2010 (AN)	13,940	71,460	30,800	-77,200	-7,940	-5,660	-17,770	-7,160	-460
2011 (W)	927,090	66,630	32,240	-76,990	-9,200	-21,660	-20,700	-895,140	-2,270
2012 (D)	8,140	91,500	10,970	-78,950	-2,990	-3,750	-21,410	-4,340	820
2013 (C)	1,700	87,070	18,540	-78,780	-4,930	-1,810	-21,560	-270	40
2014 (C)	0	89,130	9,060	-74,150	-2,350	-130	-21,030	0	-530
Average (1989-2014)	242,840	82,430	25,990	-79,800	-7,600	-8,120	-21,930	-233,300	-520
W	760,740	72,590	36,290	-79,160	-11,690	-20,610	-22,070	-734,160	-1,920
AN	67,840	78,990	25,040	-77,600	-6,550	-5,330	-20,340	-61,990	-50
BN	0	87,930	19,180	-81,160	-4,610	-240	-21,190	0	90
D	2,300	89,220	19,210	-81,820	-5,000	-1,700	-21,510	-1,100	400
C	1,700	88,090	21,690	-79,890	-6,120	-2,560	-22,680	-240	10

[1]Includes ET of applied water, ET of precipitation, and evaporation from the Rivers and Streams System.
[2]Includes infiltration from the Rivers and Streams System within the subregion. To calculate Net Recharge from SWS below, Rivers and Streams System seepage is summed across the subbasin and redistributed to each subregion in proportion to gross area.

3.5 Net Recharge from SWS

Overdraft is defined in DWR Bulletin 118 as "the condition of a groundwater basin or subbasin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years, during which the water supply conditions approximate average conditions" (DWR 2003). The Chowchilla Subbasin water budget indicates that overdraft conditions occurred during the 1989-2014 historical base period. Per 23 CCR Section 354.18(b)(5), the subbasin overdraft has been quantified for this base period. The evaluation of overdraft conditions includes estimates of recharge from subsurface flows. However, estimates of recharge from subsurface flows are less accurate when estimated for areas less that an entire subbasin. Thus, for estimates of GSA level contribution to overdraft, the term net recharge from the SWS is defined as groundwater recharge minus groundwater extraction. Net recharge from the SWS is useful for understanding and analyzing the combined effects of land surface processes on the underlying GWS.

When calculated from the historical water budget, average net recharge from the SWS represents the average recharge (when positive) or shortage of recharge (when negative) based on historical cropping, land use practices, and average hydrologic conditions. When calculated from the current land use water budget, average net recharge represents the average recharge or shortage (when negative) based on current cropping, land use practices, and average hydrologic conditions.

Average net recharge from the SWS is presented below for the Madera Co GSA – West portion of the Chowchilla Subbasin. Table A2.F.c-17 shows the average net recharge from the SWS for 1989-2014 based on the historical water budget, and Table A2.F.c-18 shows the same for the current water budget. Historically, the average net recharge in Madera Co GSA – West was approximately -38 taf per year between 1989 and 2014. Under current land use conditions, the average net recharge in Madera Co GSA – West is approximately -44 taf, indicating shortage conditions.

The Madera Co GSA - West recognizes that groundwater users within its boundaries want to understand potential future limitations on groundwater resources available to meet their beneficial uses. As shown in both Table A2.F.c-17 and Table A2.F.c-18, average values for infiltration of precipitation and infiltration of surface water are provided (columns "b" and "c"). The slight variation between the tables reflects the modified land use conditions. Together, these values represent the sustainable native groundwater for the Madera Co GSA – West, a value of about 17,300 acre-feet per year.

The Madera Co GSA – West has not determined whether an allocation approach, or other methods, will best allow the Madera Co GSA – West to achieve needed reductions in the consumptive use of groundwater (see GSP Chapter 4). However, the Madera Co GSA – West recognize the correlative nature of overlying groundwater rights, which, when coupled with appropriated groundwater use, provides that all the users share in the sustainable quantity of native groundwater. For purposes of analyzing the availability of sustainable quantities of native groundwater for all lands within the Madera Co GSA – West, the estimated total quantity of sustainable native groundwater – estimated at 17,300 acre-feet per year – can be calculated to be approximately 0.5 acre-feet per acre within the Madera Co GSA – West (based upon estimates of about 17,300 acre-feet of total sustainable native groundwater available for about 31,200 acres within the Madera Co GSA – West). The achievement of sustainability may or may not involve an equal allocation across the Madera Co GSA – West, and the Madera Co GSA – West will use its SGMA-granted authority to manage the basin so as to achieve this end. Furthermore, other GSAs within the Chowchilla Subbasin may choose to manage their proportion of the estimated sustainable native groundwater differently than the Madera Co GSA – West, but they are also subject to the overall subbasin sustainability requirements.

Table A2.F.c-17. Historical Water Budget: Average Net Recharge from SWS by Water Year Type, 1989-2014 (Acre-Feet).

Year Type	Number of Years	Infiltration of Applied Water (a)	Infiltration of Precipitation (b)	Infiltration of Surface Water[1] (c)	Groundwater Extraction (d)	Net Recharge from SWS (a+b+c-d)
W	8	21,930	11,950	25,160	66,170	-7,130
AN	3	20,450	6,680	6,980	75,990	-41,880
BN	2	21,540	4,860	360	83,050	-56,290
D	4	22,980	5,190	1,080	88,470	-59,220
C	9	21,600	6,210	2,160	79,700	-49,730
Annual Average (1989-2014)	26	21,780	7,770	9,490	76,710	-37,670

[1] Includes seepage from the Rivers and Streams System and boundary seepage from San Joaquin River. Rivers and Streams System seepage is calculated from the total subbasin Rivers and Streams System seepage redistributed to each subregion in proportion to gross area.

Table A2.F.c-18. Current Water Budget: Average Net Recharge from SWS by Water Year Type (Acre-Feet).

Year Type	Number of Years	Infiltration of Applied Water (a)	Infiltration of Precipitation (b)	Infiltration of Surface Water[1] (c)	Groundwater Extraction (d)	Net Recharge from SWS (a+b+c-d)
W	8	22,070	11,690	24,910	72,590	-13,920
AN	3	20,340	6,550	6,880	78,990	-45,220
BN	2	21,190	4,610	220	87,930	-61,910
D	4	21,510	5,000	970	89,220	-61,740
C	9	22,680	6,120	1,850	88,090	-57,440
Annual Average (1989-2014)	26	21,930	7,600	9,270	82,430	-43,630

[1] Includes seepage from the Rivers and Streams System and boundary seepage from San Joaquin River. Rivers and Streams System seepage is calculated from the total subbasin Rivers and Streams System seepage redistributed to each subregion in proportion to gross area.

3.6 Uncertainties in Water Budget Components

Uncertainties associated with each water budget component were estimated as a percentage representing approximately a 95% confidence interval following the procedure described by Clemmens and Burt (1997). Uncertainties for all independently measured or estimated water budget components were estimated based on the measurement accuracy, typical values reported in technical literature, typical values calculated in other water budgets, and professional judgement.

Table A2.F.c-19 provides a summary of typical uncertainty values associated with major SWS inflow and outflow components. These uncertainties provide a basis for evaluating confidence in water budget results and help to identify data needs that may be addressed during GSP implementation.

Table A2.F.c-19. Estimated Uncertainty of GSA Water Budget Components.

Flowpath Direction (SWS Boundary)	Water Budget Component	Data Source	Estimated Uncertainty (%)	Source
Inflows	Surface Water Inflows	Measurement	20%	Estimated streamflow measurement accuracy and adjustment for losses.
	Riparian Deliveries	Measurement	10%	Estimated measurement accuracy.
	Precipitation	Calculation	30%	Clemmens, A.J. and C.M. Burt, 1997.
	Groundwater Extraction	Closure	20%	Typical uncertainty calculated for Land Surface System water balance closure.
Outflows	Surface Water Outflows	Closure	20%	Typical uncertainty calculated for Rivers and Streams System water balance closure.
	Evaporation	Calculation	20%	Estimated accuracy of calculation based on CIMIS reference ET and free water surface evaporation coefficient.
	ET of Applied Water	Calculation	10%	Estimated accuracy of daily IDC root zone water budget component based on CIMIS reference ET, estimated crop coefficients from SEBAL energy balance, and annual land use.
	ET of Precipitation	Calculation	10%	Estimated accuracy of daily IDC root zone water budget component based on CIMIS reference ET, precipitation, estimated crop coefficients from SEBAL energy balance, and annual land use.
	Infiltration of Applied Water	Calculation	20%	Estimated accuracy of daily IDC root zone water budget component based on annual land use and NRCS soils characteristics.
	Infiltration of Precipitation	Calculation	20%	Estimated accuracy of daily IDC root zone water budget component based on annual land use, NRCS soils characteristics, and CIMIS precipitation.
	Infiltration of Surface Water	Calculation	15%	Estimated accuracy of daily seepage calculation using NRCS soils characteristics and calculated runoff of precipitation.
	Change in SWS Storage	Calculation	50%	Professional Judgment.
Net Recharge from SWS		Calculation	25%	Estimated water budget accuracy; typical value calculated for GSA-level net recharge from SWS.

APPENDIX 2.F. WATER BUDGET INFORMATION

2.F.d. Surface Water System Water Budget: Sierra Vista Mutual Water Company

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020

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1 INTRODUCTION

To ensure sustainable groundwater management throughout California's groundwater basins, the Sustainable Groundwater Management Act of 2014 (SGMA) requires Groundwater Sustainability Agencies (GSAs) to prepare and adopt Groundwater Sustainability Plans (GSPs) with strategies to achieve subbasin groundwater sustainability within 20 years of plan adoption. Integral to each GSP is a water budget used to quantify the subbasin's groundwater overdraft (if applicable) and sustainable yield.

In 2017, Merced County (Merced Co) GSA and Madera County (Madera Co) GSA each formed to separately manage approximately 1,300 acres and 45,100 acres of the Chowchilla Subbasin, respectively. The jurisdictional areas of both GSAs overlap with Sierra Vista Mutual Water Company (SVMWC). In the interests of separately accounting for inflows to SVMWC, a water budget was prepared encompassing the total area within SVMWC, including the entirety of Merced Co GSA in the Chowchilla Subbasin and a portion of Madera Co GSA.

This document presents results of the surface water system (SWS) water budgets developed for historical and current land use conditions in SVMWC. The SVMWC water budgets were integrated with separate water budgets developed for four (4) other subregions covering the remainder of the Chowchilla Subbasin. Together, these water budgets provide the boundary water budget for the Chowchilla Subbasin SWS. Results of the subbasin boundary water budget are reported in the Chowchilla Subbasin GSP Section 2.2.3 and were integrated with a subbasin groundwater model (GSP Appendix 6.E) to estimate subbasin sustainable yield (GSP Section 2.2.3).

2 WATER BUDGET CONCEPTUAL MODEL

A water budget is defined as a complete accounting of all water flowing into and out of a defined volume (e.g., a subbasin or a GSA) over a specified period of time. The conceptual model (or structure) of the SVMWC water budget developed for this investigation is consistent with the GSP Regulations defined under Title 23 of California Code of Regulations[1] (CCR) and adheres to sound water budget principles and practices defined by California Department of Water Resources (DWR) in the Water Budget Best Management Practice (BMP) guidelines (DWR, 2016).

The lateral extent of SVMWC is defined by the boundaries indicated in Figure A2.F.d-1. The vertical extent of SVMWC is the land surface (top) and the base of fresh water at the bottom of the basin (bottom), as described in the hydrogeologic conceptual model (HCM) developed in GSP Section 2.2.1. The vertical extent of Chowchilla Subbasin and its GSAs is subdivided into a surface water system (SWS) and the underlying groundwater system (GWS), with separate but related water budgets prepared for each that together represent the overall subbasin water budget.

[1] California Code of Regulations Title 23. Waters, Division 2. Department of Water Resources, Chapter 1.5. Groundwater Management, Subchapter 2. Groundwater Sustainability Plans.

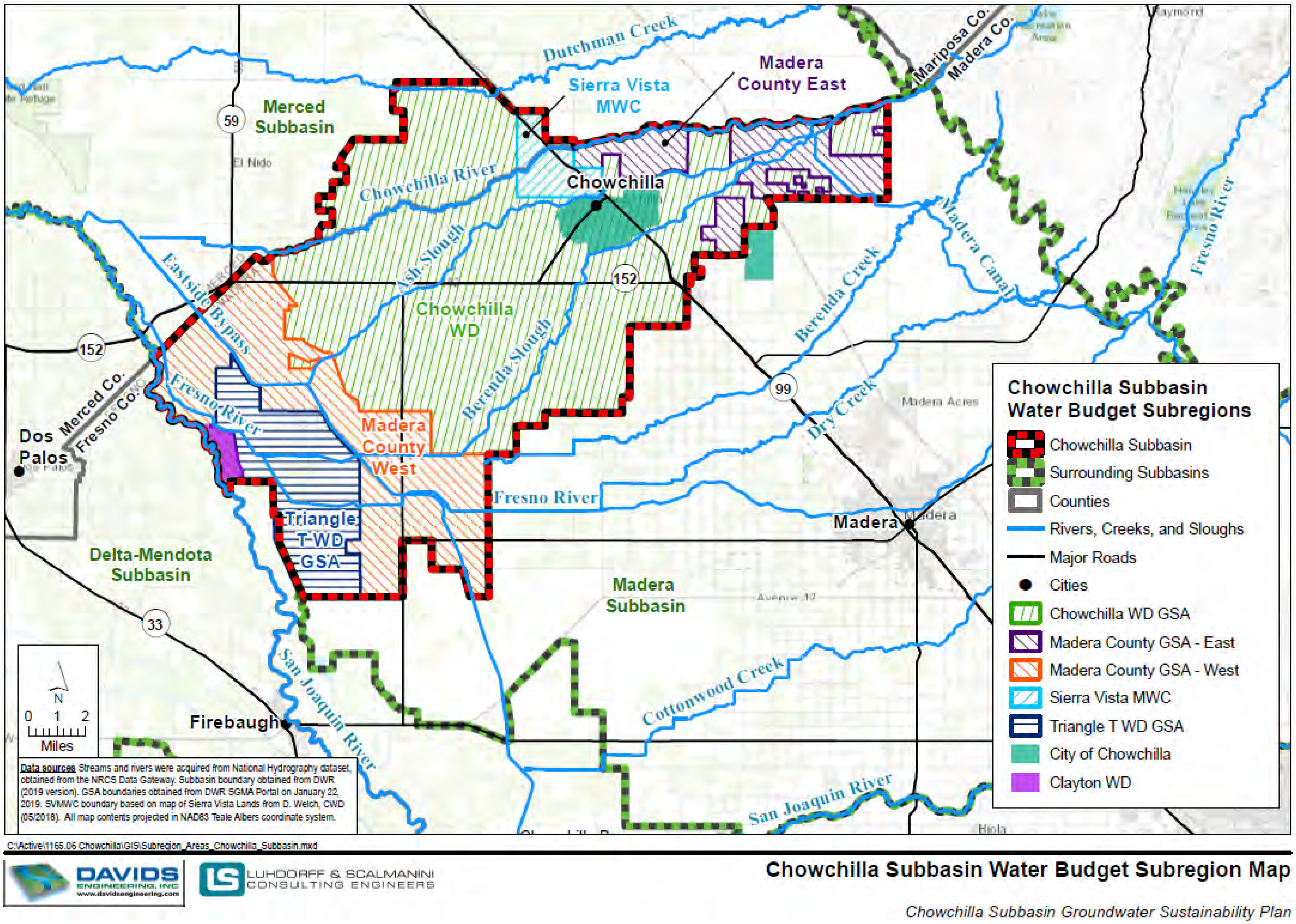

Figure A2.F.d-1. Chowchilla Subbasin Water Budget Subregion Map

A conceptual representation of the SVMWC water budget is represented in Figure A2.F.d-2. This document details only the SWS portion of the SVMWC water budget. The SWS is divided into two primary accounting centers: the Land Surface System and the Rivers and Streams System[2]. The Land Surface System is further divided into three accounting centers representing the subregion water use sectors: Agricultural Land, Native Vegetation Land, and Urban Land (urban, industrial, and semi-agricultural).

Water budget components, or directional flow of water between accounting centers and across the SWS boundary, are indicated by arrows. Inflows and outflows were calculated using measurements and other historical data or were calculated as the water budget closure term – the difference between all other estimated or measured inflows and outflows from each accounting center or water use sector (bold arrows).

Inflows to the SWS include precipitation, surface water inflows (in various rivers and streams), and groundwater extraction. Outflows from the SWS include evapotranspiration (ET), surface water outflows (in various canals and streams), and infiltration to the groundwater system (seepage and deep percolation). Also represented in Figure A2.F.d-2 are inflows and outflows from the GWS, which are discussed and quantified at the subbasin level in the GWS water budget in GSP Section 2.2.3. Subsurface GWS inflows and outflows are not quantified on the water budget subregion scale.

Inflows and outflows were quantified following the process described in GSP Section 2.2.3 on a monthly time step for water years in the historical water budget base period (1989-2014 hydrologic and land use conditions), the current water budget (2015 land use using 1989-2014 average hydrologic conditions), and projected water budget. Four projected water budgets were prepared for the years 2019 through 2090 based on 1965 through 2015 hydrologic conditions, projected water supplies, and 2017 land use adjusted for urban area projected growth from 2017-2070 (areas were held constant from 2071-2090):

1. Historical hydrologic conditions and water supply data, with adjustment for projected alteration of available Friant releases by the San Joaquin River Restoration Program (SJRRP)[3]
    a. Without projects and management actions, and
    b. With projects and management actions
2. Historical hydrologic conditions and water supply data, with adjustment for projected alteration of available Friant releases by the SJRRP and adjustment for anticipated climate change per DWR-provided 2030 climate change factors
    a. Without projects and management actions, and
    b. With projects and management actions.

Information regarding the data sources and adjustments used to prepare the historical, current, and projected water budgets are described in GSP Section 2.2.3.

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[2] The Chowchilla River is used for conveyance of pre-1914, riparian, and prescriptive water rights deliveries to growers in SVMWC. These inflows, deliveries, and associated seepage are summarized within the Rivers and Streams System in SVMWC.

[3] Adjustments were based on the Friant Report ("Estimate of Future Friant Division Supplies for use in Groundwater Sustainability Plans, California," Friant Water Authority, 2018). Although the Friant Report accounts for climate change, it is considered the best available estimate of projected Friant releases under SJRRP. For comparison, projected Madera Canal deliveries under SJRRP were also estimated without account for climate change from the Kondolf Hydrographs (in "Effects to Water Supply and Friant Operations Resulting From Plaintiffs' Friant Release Requirements," Steiner, 2005). These estimates were approximately equal to the Friant Report 2030 climate change adjusted deliveries. Thus, the Friant Report projections were used instead to maintain consistent assumptions in estimating Madera Canal deliveries across all projected simulations.

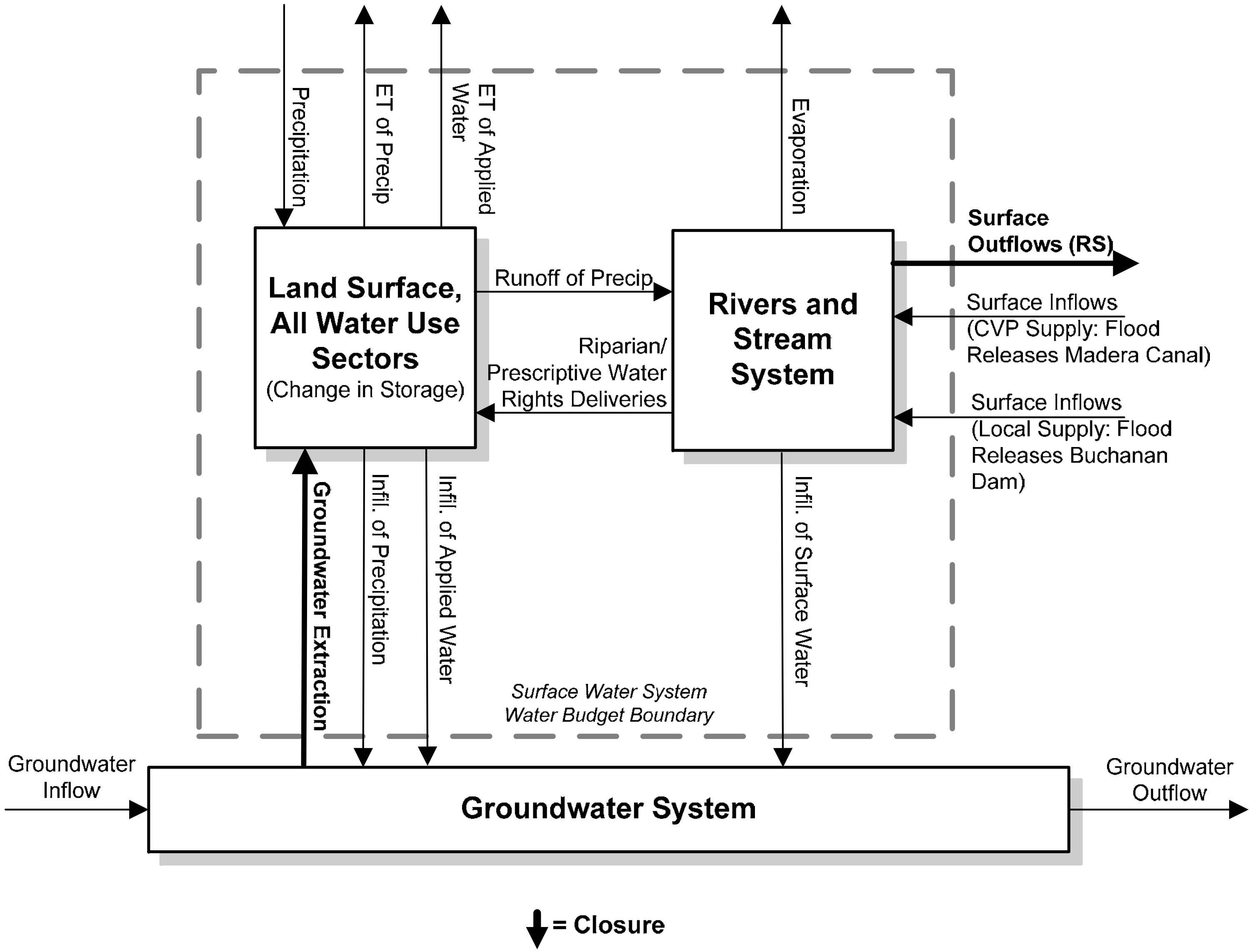

Figure A2.F.d-2. Sierra Vista Mutual Water Company Water Budget Structure

3 WATER BUDGET ANALYSIS

The historical water budget and current land use water budget for SVMWC are presented below following a summary of land use data relevant to water budget development. Land use data is provided for the 1989-2014 historical water budget period and for 2015, the current land use water budget period.

3.1 Land Use

Land use estimates for 1989 through 2015 corresponding to water use sectors (as defined by the GSP Regulations) are summarized in Figure A2.F.d-3 and Table A2.F.d-1 for SVMWC. According to GSP Regulations (23 CCR § 351(al)):

> *"Water use sector" refers to categories of water demand based on the general land uses to which the water is applied, including urban, industrial, agricultural, managed wetlands, managed recharge, and native vegetation.*

In SVMWC, water use sectors include agricultural, native vegetation, and urban land use. The urban land use category includes urban and semi-agricultural[4] lands as well as industrial land, which covers only a small area in the subbasin.

As indicated, the majority of land in SVMWC is currently used for agriculture, covering an average of 3,400 acres between 1989 and 2015. Urban land has slightly expanded since the mid-2000s, but still covers a relatively small area in the subregion.

Agricultural land uses are further detailed in Figure A2.F.d-4 and Table A2.F.d-2. In the 1990s, a majority of agricultural land in SVMWC was used to cultivate alfalfa, mixed pasture, and miscellaneous field crops. In recent years, alfalfa and mixed pasture acreage has continued to expand while the remaining agricultural land is used in cultivating mostly corn and orchard crops.

[4] As defined in the DWR county land use surveys, semi-agricultural land use subclasses include farmsteads, livestock feed lot operations, dairies, poultry farms, and miscellaneous semi-agricultural land use incidental to agriculture (small roads, ditches, non-planted areas of cropped fields (DWR, 2009).

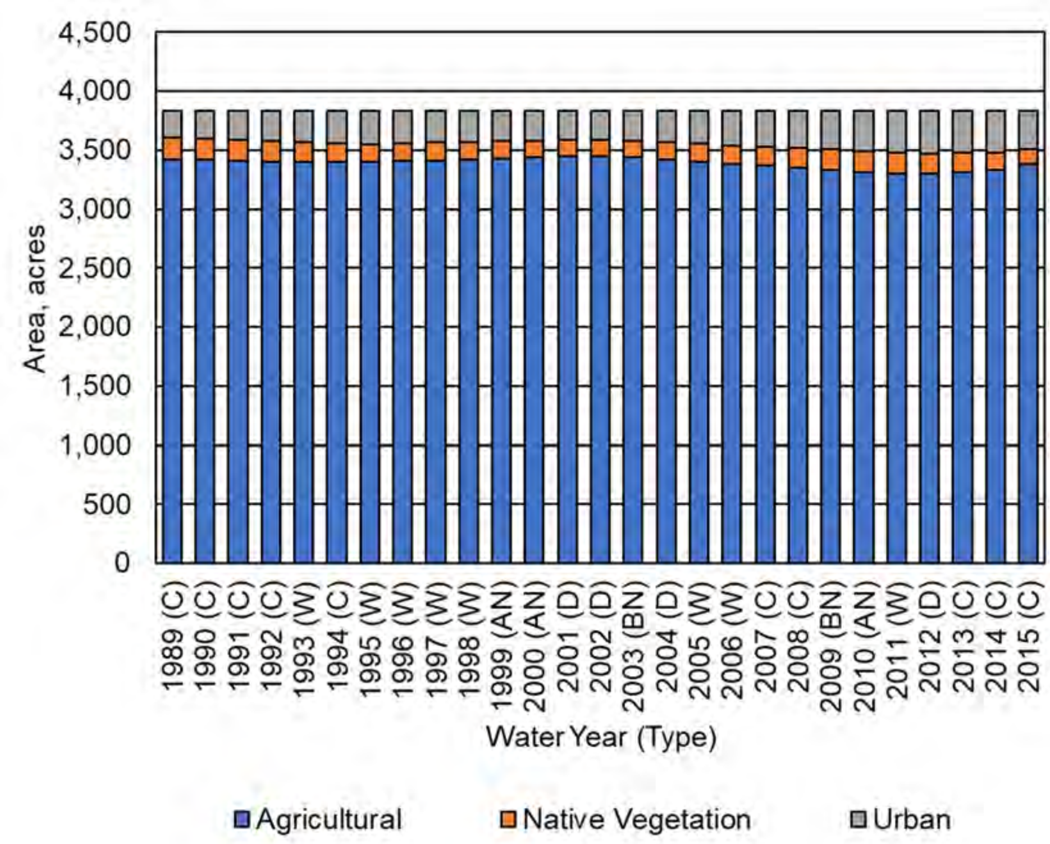

Figure A2.F.d-3. Sierra Vista Mutual Water Company Land Use Areas

Table A2.F.d-1. Sierra Vista Mutual Water Company Land Use Areas, acres

Water Year (Type)	Agricultural	Native Vegetation[1]	Urban[2]	Total
1989 (C)	3,419	184	227	3,830
1990 (C)	3,418	176	236	3,830
1991 (C)	3,410	175	246	3,830
1992 (C)	3,404	172	254	3,830
1993 (W)	3,401	166	262	3,830
1994 (C)	3,404	156	271	3,830
1995 (W)	3,397	155	279	3,830
1996 (W)	3,405	152	273	3,830
1997 (W)	3,414	150	266	3,830
1998 (W)	3,423	147	260	3,830
1999 (AN)	3,431	145	254	3,830
2000 (AN)	3,440	142	248	3,830
2001 (D)	3,448	140	242	3,830
2002 (D)	3,453	137	241	3,830
2003 (BN)	3,436	142	253	3,830

Water Year (Type)	Agricultural	Native Vegetation[1]	Urban[2]	Total
2004 (D)	3,418	147	265	3,830
2005 (W)	3,401	152	277	3,830
2006 (W)	3,384	157	290	3,830
2007 (C)	3,367	162	302	3,830
2008 (C)	3,349	167	314	3,830
2009 (BN)	3,332	172	326	3,830
2010 (AN)	3,315	177	338	3,830
2011 (W)	3,297	182	351	3,830
2012 (D)	3,300	173	357	3,830
2013 (C)	3,313	162	355	3,830
2014 (C)	3,326	151	353	3,830
2015 (C)	3,378	128	325	3,830
Average (1989-2014)	3,389	159	282	3,830

[1] Area includes land classified as native vegetation and water surfaces.
[2] Area includes land classified as urban, industrial, and semi-agricultural.

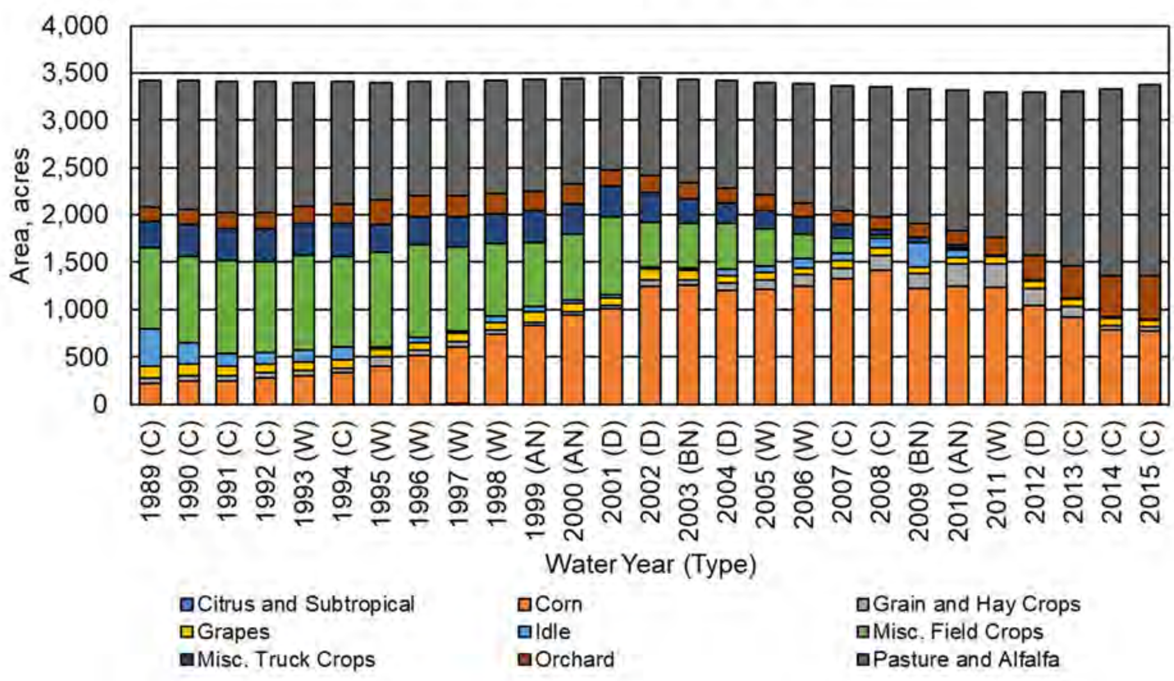

Figure A2.F.d-4. Sierra Vista Mutual Water Company Agricultural Land Use Areas

Table A2.F.d-2. Sierra Vista Mutual Water Company Agricultural Land Use Areas

Water Year (Type)	Citrus and Subtropical	Corn	Grain and Hay Crops	Grapes	Idle	Misc. Field Crops	Misc. Truck Crops	Orchard	Pasture and Alfalfa	Total
1989 (C)	0	225	49	131	391	856	281	148	1,337	3,419
1990 (C)	0	241	64	121	222	909	343	162	1,357	3,418
1991 (C)	0	248	47	104	139	983	331	174	1,383	3,410
1992 (C)	0	276	57	92	122	963	341	174	1,380	3,404
1993 (W)	0	304	53	88	127	996	342	186	1,305	3,401
1994 (C)	0	335	48	86	131	957	355	201	1,291	3,404
1995 (W)	0	400	101	84	18	1,006	287	262	1,239	3,397
1996 (W)	0	513	56	83	52	977	301	225	1,198	3,405
1997 (W)	2	598	54	100	18	890	311	227	1,214	3,414
1998 (W)	0	742	39	81	73	764	316	207	1,201	3,423
1999 (AN)	0	830	31	119	55	677	337	198	1,184	3,431
2000 (AN)	0	941	37	85	36	695	317	215	1,114	3,440
2001 (D)	0	1,008	33	77	39	817	330	171	974	3,448
2002 (D)	0	1,241	77	103	21	484	305	183	1,038	3,453
2003 (BN)	0	1,252	64	102	25	467	256	172	1,098	3,436
2004 (D)	0	1,198	77	86	60	493	210	163	1,132	3,418
2005 (W)	0	1,209	106	76	71	396	189	166	1,187	3,401
2006 (W)	0	1,250	119	74	97	264	170	148	1,262	3,384
2007 (C)	0	1,324	118	74	82	160	141	149	1,318	3,367
2008 (C)	0	1,411	161	77	107	36	52	135	1,371	3,349
2009 (BN)	0	1,218	160	74	251	4	58	141	1,426	3,332
2010 (AN)	0	1,245	235	74	74	27	29	148	1,482	3,315
2011 (W)	0	1,230	257	72	13	0	0	188	1,537	3,297
2012 (D)	0	1,047	180	74	11	0	0	261	1,726	3,300
2013 (C)	0	914	120	76	9	0	0	344	1,848	3,313
2014 (C)	0	783	49	79	8	0	0	436	1,971	3,326
2015 (C)	0	768	46	77	3	0	0	460	2,024	3,378
Average (1989-2014)	0	846	92	88	87	532	215	199	1,330	3,389

3.2 Surface Water System Water Budget

This section presents surface water system water budget components within SVMWC as per GSP regulations. These are followed by a summary of the water budget results by accounting center.

3.2.1 Inflows

3.2.1.1 Surface Water Inflow by Water Source Type

Surface water inflows include surface water flowing into SVMWC across the subregion boundary. Per the Regulations, surface inflows must be reported by water source type. According to the Regulations:

> *"Water source type" represents the source from which water is derived to meet the applied beneficial uses, including groundwater, recycled water, reused water, and surface water sources identified as Central Valley Project, the State Water Project, the Colorado River Project, local supplies, and local imported supplies.*

Additionally, runoff of precipitation from upgradient areas adjacent to the subregion represents a potential source of surface water inflow.

Local Supplies

Local supplies to SVMWC include pre-1914, riparian, and prescriptive water rights deliveries received by growers along Chowchilla River.

CVP Supplies

SVMWC does not receive CVP supplies for irrigation purposes. However, some CVP supplies flow into SVMWC along Chowchilla River in the form of releases from Buchanan Dam and Millerton Reservoir. Much of this water passes through and exits SVMWC as surface water outflows.

Recycling and Reuse

Recycling and reuse are not a significant source of supply within SVMWC.

Other Surface Inflows

For the water budgets presented herein, precipitation runoff from outside the subregion is considered relatively minimal and is expected to pass through the waterways accounted above following relatively large storm events. Precipitation runoff from lands inside the subregion is internal to the surface water system and is thus not considered as surface inflows to the subregion boundary.

Summary of Surface Inflows

The surface water inflows described above are summarized by water source type in Figure A2.F.d-5 and Table A2.F.d-3. During the study period, total surface water inflows vary by water year type, averaging 4.5 taf per year.

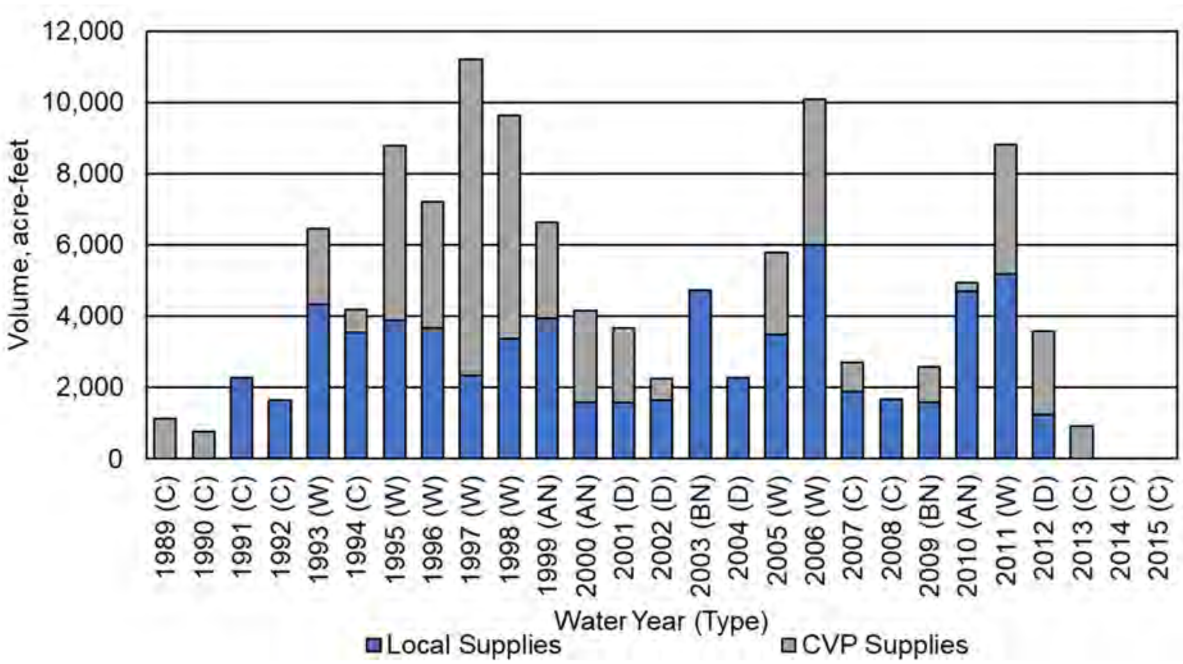

Figure A2.F.d-5. Sierra Vista Mutual Water Company Surface Water Inflows by Water Source Type.

Table A2.F.d-3. Sierra Vista Mutual Water Company Surface Water Inflows by Water Source Type (Acre-Feet).

Water Year (Type)	Local Supply	CVP Supply[1]	Total
1989 (C)	0	1,140	1,140
1990 (C)	0	750	750
1991 (C)	2,270	0	2,270
1992 (C)	1,650	0	1,650
1993 (W)	4,320	2,140	6,450
1994 (C)	3,550	650	4,200
1995 (W)	3,890	4,900	8,790
1996 (W)	3,680	3,530	7,220
1997 (W)	2,330	8,870	11,200
1998 (W)	3,360	6,260	9,620
1999 (AN)	3,930	2,690	6,630
2000 (AN)	1,580	2,570	4,150
2001 (D)	1,580	2,080	3,660
2002 (D)	1,640	600	2,240
2003 (BN)	4,710	0	4,710
2004 (D)	2,280	0	2,280
2005 (W)	3,500	2,300	5,800
2006 (W)	6,000	4,070	10,070
2007 (C)	1,890	810	2,690
2008 (C)	1,680	0	1,680

Water Year (Type)	Local Supply	CVP Supply[1]	Total
2009 (BN)	1,590	980	2,570
2010 (AN)	4,690	260	4,950
2011 (W)	5,190	3,620	8,810
2012 (D)	1,240	2,330	3,560
2013 (C)	0	910	910
2014 (C)	0	0	0
2015 (C)	0	0	0
Average (1989-2014)	2,560	1,980	4,540
Average (1989-2014) W	4,030	4,460	8,490
Average (1989-2014) AN	3,400	1,840	5,240
Average (1989-2014) BN	3,150	490	3,640
Average (1989-2014) D	1,680	1,250	2,940
Average (1989-2014) C	1,230	470	1,700

1. CVP Supply is considered as all water supply released from CVP storage facilities. The volume of CVP Supply includes CVP deliveries to CWD, and flood releases from CVP facilities that pass through the subbasin.

3.2.1.2 Precipitation

Precipitation estimates for SVMWC are provided in Figure A2.F.d-6 and Table A2.F.d-4. Precipitation estimates are reported by water use sector.

Total precipitation is highly variable between years in the study area, ranging from approximately 2.4 taf (7.6 inches) during average dry years to 4.6 taf (14.4 inches) during average wet years.

3.2.1.3 Groundwater Extraction by Water Use Sector

Estimates of groundwater extraction by water use sector are provided in Figure A2.F.d-7 and Table A2.F.d-5. For agricultural and urban (urban, semi-agricultural, industrial) lands, groundwater extraction represents pumping, while for native lands, groundwater extraction by riparian vegetation was considered to be negligible. In all water use sector water budgets, groundwater extraction served as the water budget closure term. Groundwater extraction is dominated by irrigated agriculture and increases over time, following the trend of increasing alfalfa, pasture, and orchard acreage. During some wet years, the groundwater extraction closure term is reduced in months when surface water is available to water rights users.

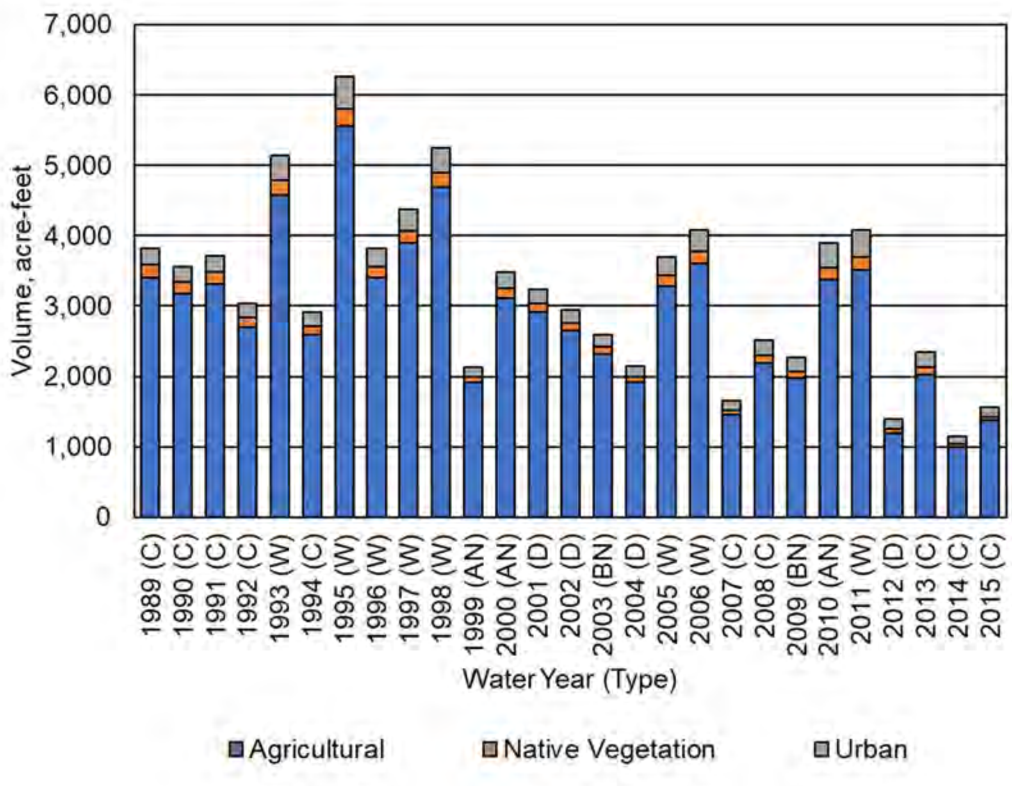

Figure A2.F.d-6. Sierra Vista Mutual Water Company Precipitation by Water Use Sector.

Table A2.F.d-4. Sierra Vista Mutual Water Company Precipitation by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	3,410	180	230	3,820
1990 (C)	3,180	160	220	3,560
1991 (C)	3,310	170	240	3,720
1992 (C)	2,700	140	200	3,040
1993 (W)	4,570	220	350	5,150
1994 (C)	2,590	120	210	2,920
1995 (W)	5,550	250	460	6,260
1996 (W)	3,400	150	270	3,830
1997 (W)	3,900	170	310	4,370
1998 (W)	4,700	200	360	5,260
1999 (AN)	1,910	80	140	2,130
2000 (AN)	3,120	130	230	3,480
2001 (D)	2,920	120	210	3,240
2002 (D)	2,650	110	190	2,940
2003 (BN)	2,320	100	170	2,590
2004 (D)	1,920	80	150	2,150
2005 (W)	3,290	150	270	3,710
2006 (W)	3,610	170	310	4,080
2007 (C)	1,450	70	130	1,650

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
2008 (C)	2,200	110	210	2,510
2009 (BN)	1,970	100	190	2,270
2010 (AN)	3,370	180	340	3,900
2011 (W)	3,510	190	370	4,080
2012 (D)	1,200	60	130	1,390
2013 (C)	2,030	100	220	2,350
2014 (C)	1,000	40	110	1,150
2015 (C)	1,380	50	130	1,560
Average (1989-2014)	2,910	140	240	3,290
Average (1989-2014) W	4,070	190	340	4,590
Average (1989-2014) AN	2,800	130	240	3,170
Average (1989-2014) BN	2,150	100	180	2,430
Average (1989-2014) D	2,170	90	170	2,430
Average (1989-2014) C	2,430	120	190	2,750

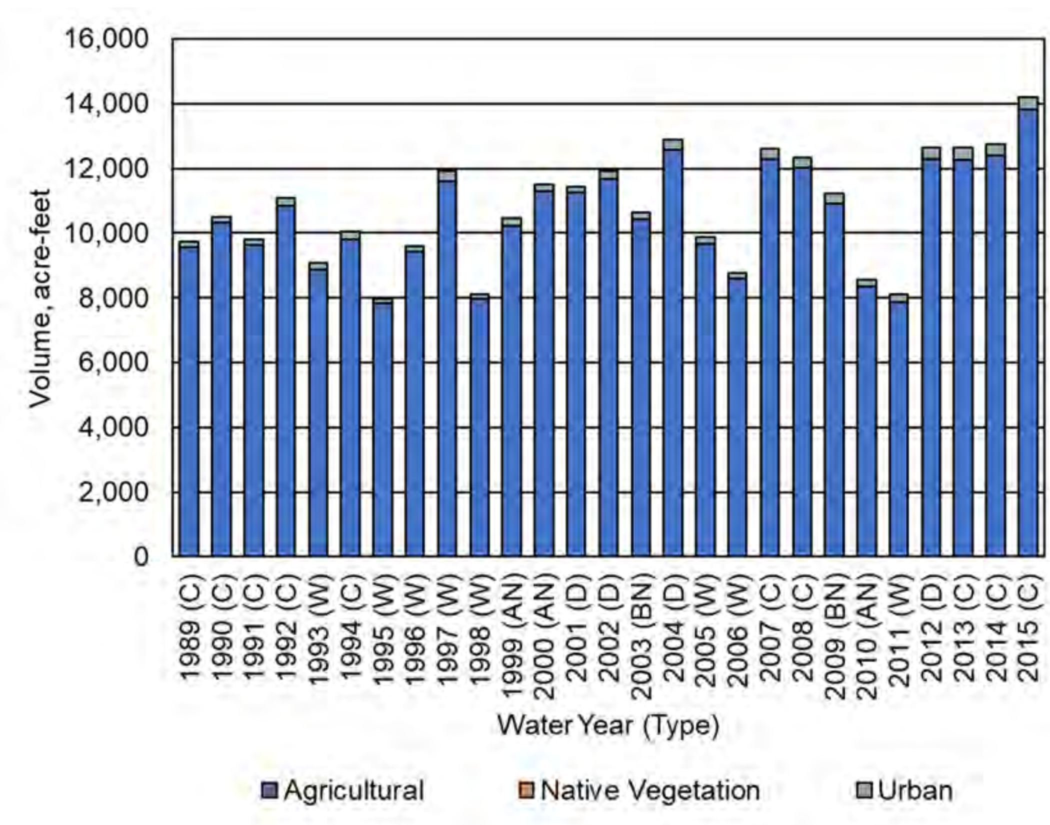

Figure A2.F.d-7. Sierra Vista Mutual Water Company Groundwater Extraction by Water Use Sector.

Table A2.F.d-5. Sierra Vista Mutual Water Company Groundwater Extraction by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	9,580	0	170	9,750
1990 (C)	10,320	0	190	10,510
1991 (C)	9,620	0	190	9,810
1992 (C)	10,850	0	240	11,080
1993 (W)	8,890	0	200	9,090
1994 (C)	9,820	0	240	10,060
1995 (W)	7,820	0	140	7,960
1996 (W)	9,420	0	190	9,610
1997 (W)	11,620	0	290	11,910
1998 (W)	7,970	0	160	8,120
1999 (AN)	10,230	0	230	10,450
2000 (AN)	11,310	0	190	11,500
2001 (D)	11,270	0	180	11,450
2002 (D)	11,690	0	230	11,920
2003 (BN)	10,440	0	220	10,660
2004 (D)	12,590	0	300	12,890
2005 (W)	9,680	0	200	9,880
2006 (W)	8,590	0	200	8,780
2007 (C)	12,300	0	310	12,610
2008 (C)	12,020	0	320	12,340
2009 (BN)	10,920	0	320	11,230
2010 (AN)	8,370	0	200	8,560
2011 (W)	7,890	0	220	8,110
2012 (D)	12,290	0	350	12,640
2013 (C)	12,270	0	370	12,640
2014 (C)	12,420	0	350	12,770
2015 (C)	13,840	0	360	14,200
Average (1989-2014)	10,390	0	240	10,630
Average (1989-2014) W	8,980	0	200	9,180
Average (1989-2014) AN	9,970	0	200	10,170
Average (1989-2014) BN	10,680	0	270	10,950
Average (1989-2014) D	11,960	0	260	12,220
Average (1989-2014) C	11,020	0	260	11,290

3.2.1.4 Groundwater Discharge to Surface Water Sources

The depth to groundwater is greater than 100-200 ft across much of the Chowchilla Subbasin. Given the depth to the water table in the Chowchilla Subbasin, groundwater discharge to surface water sources is negligible.

3.2.2 Outflows

3.2.2.1 Evapotranspiration by Water Use Sector

Evapotranspiration (ET) by water use sector is reported in Figures A2.F.d-8 to A2.F.d-10 and Tables A2.F.d-6 to A2.F.d-8. First, total ET is reported, followed by ET from applied water and ET from precipitation.

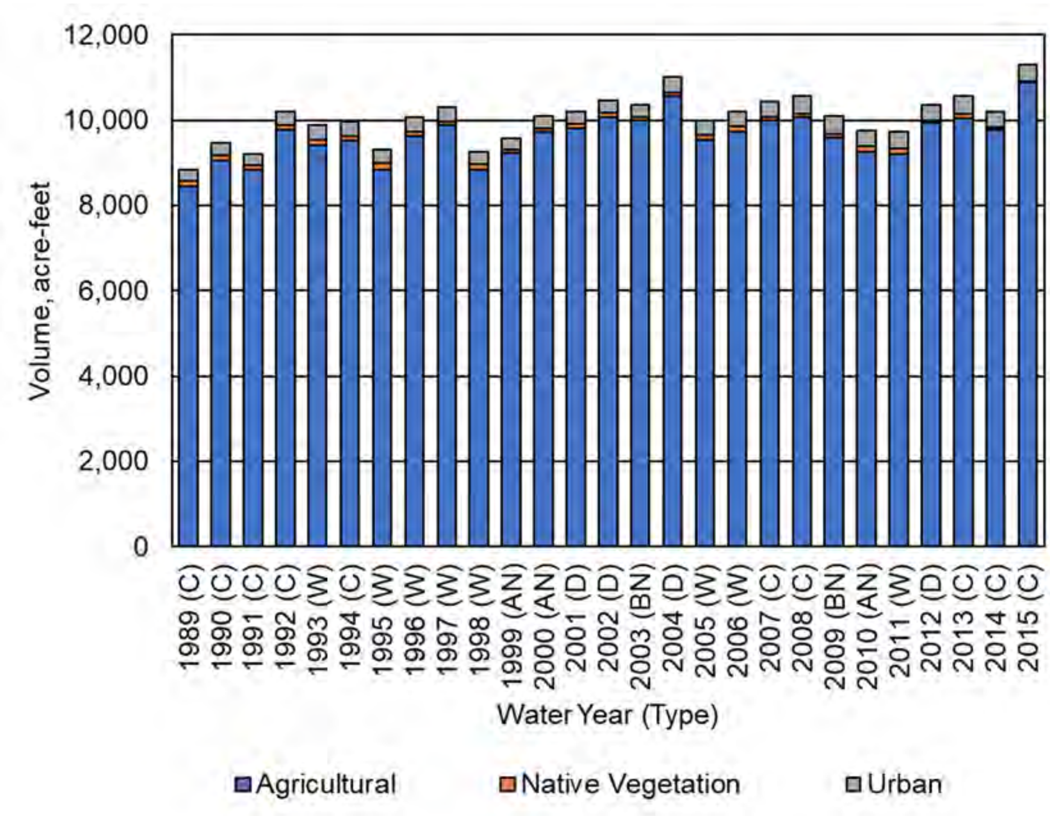

Figure A2.F.d-8. Sierra Vista Mutual Water Company Evapotranspiration by Water Use Sector.

Table A2.F.d-6. Sierra Vista Mutual Water Company Evapotranspiration by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	8,440	140	270	8,850
1990 (C)	9,040	130	290	9,460
1991 (C)	8,840	110	260	9,210
1992 (C)	9,770	120	320	10,210
1993 (W)	9,410	140	330	9,880
1994 (C)	9,530	100	330	9,960
1995 (W)	8,850	150	310	9,310
1996 (W)	9,620	120	320	10,060
1997 (W)	9,880	90	340	10,310
1998 (W)	8,840	120	290	9,250
1999 (AN)	9,220	80	280	9,580
2000 (AN)	9,720	100	290	10,110
2001 (D)	9,810	100	280	10,190
2002 (D)	10,080	90	300	10,470
2003 (BN)	9,990	80	300	10,370
2004 (D)	10,580	80	360	11,020
2005 (W)	9,540	110	330	9,980
2006 (W)	9,730	120	340	10,190
2007 (C)	9,990	80	360	10,430
2008 (C)	10,070	90	400	10,560
2009 (BN)	9,600	80	410	10,090
2010 (AN)	9,260	120	380	9,760
2011 (W)	9,200	140	390	9,730
2012 (D)	9,930	70	370	10,370
2013 (C)	10,050	90	430	10,570
2014 (C)	9,790	40	370	10,200
2015 (C)	10,880	40	380	11,300
Average (1989-2014)	9,570	100	330	10,000
Average (1989-2014) W	9,380	120	330	9,830
Average (1989-2014) AN	9,400	100	310	9,810
Average (1989-2014) BN	9,790	80	350	10,220
Average (1989-2014) D	10,100	90	320	10,510
Average (1989-2014) C	9,500	100	340	9,940

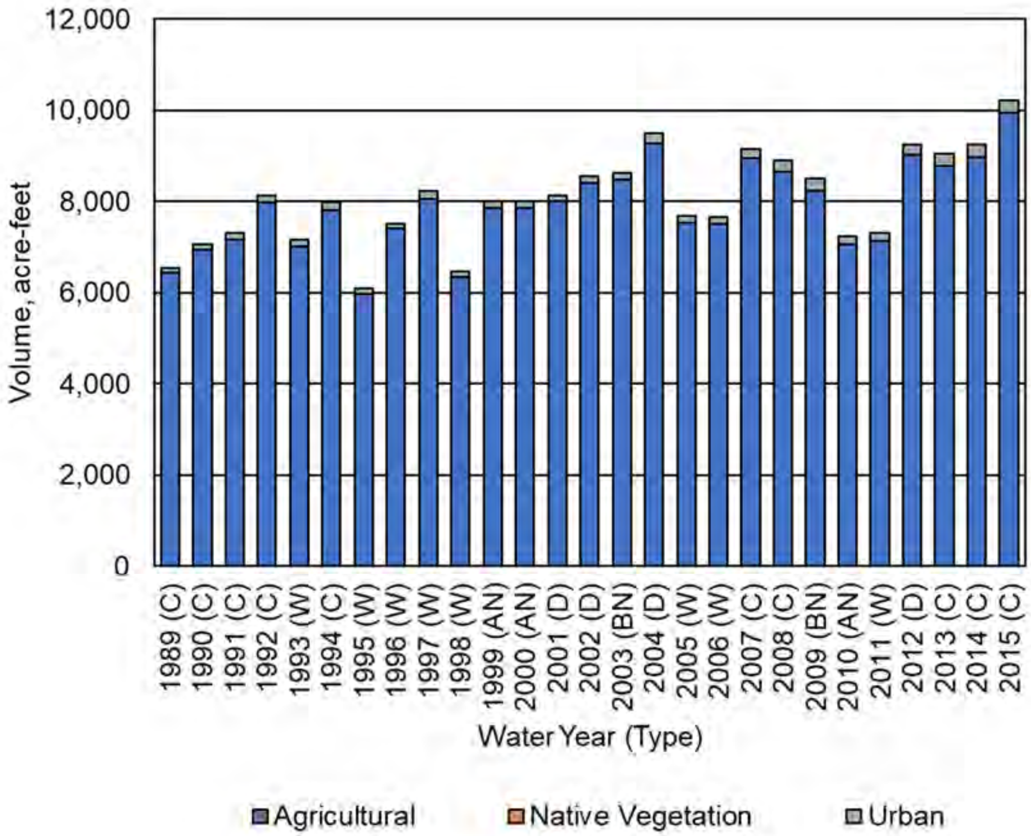

Figure A2.F.d-9. Sierra Vista Mutual Water Company Evapotranspiration of Applied Water by Water Use Sector.

Table A2.F.d-7. Sierra Vista Mutual Water Company Evapotranspiration of Applied Water by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	6,430	0	120	6,550
1990 (C)	6,930	0	130	7,060
1991 (C)	7,170	0	130	7,300
1992 (C)	7,980	0	160	8,140
1993 (W)	7,020	0	140	7,160
1994 (C)	7,800	0	180	7,980
1995 (W)	5,980	0	110	6,090
1996 (W)	7,400	0	120	7,520
1997 (W)	8,060	0	170	8,230
1998 (W)	6,350	0	120	6,470
1999 (AN)	7,850	0	150	8,000
2000 (AN)	7,860	0	150	8,010
2001 (D)	8,010	0	130	8,140
2002 (D)	8,400	0	160	8,560
2003 (BN)	8,470	0	170	8,640
2004 (D)	9,270	0	220	9,490
2005 (W)	7,530	0	160	7,690

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
2006 (W)	7,500	0	150	7,650
2007 (C)	8,940	0	210	9,150
2008 (C)	8,660	0	240	8,900
2009 (BN)	8,240	0	260	8,500
2010 (AN)	7,070	0	170	7,240
2011 (W)	7,140	0	160	7,300
2012 (D)	9,030	0	230	9,260
2013 (C)	8,790	0	270	9,060
2014 (C)	8,980	0	270	9,250
2015 (C)	9,940	0	280	10,220
Average (1989-2014)	7,800	0	170	7,970
Average (1989-2014) W	7,120	0	140	7,260
Average (1989-2014) AN	7,590	0	150	7,740
Average (1989-2014) BN	8,350	0	210	8,560
Average (1989-2014) D	8,680	0	180	8,860
Average (1989-2014) C	7,960	0	190	8,150

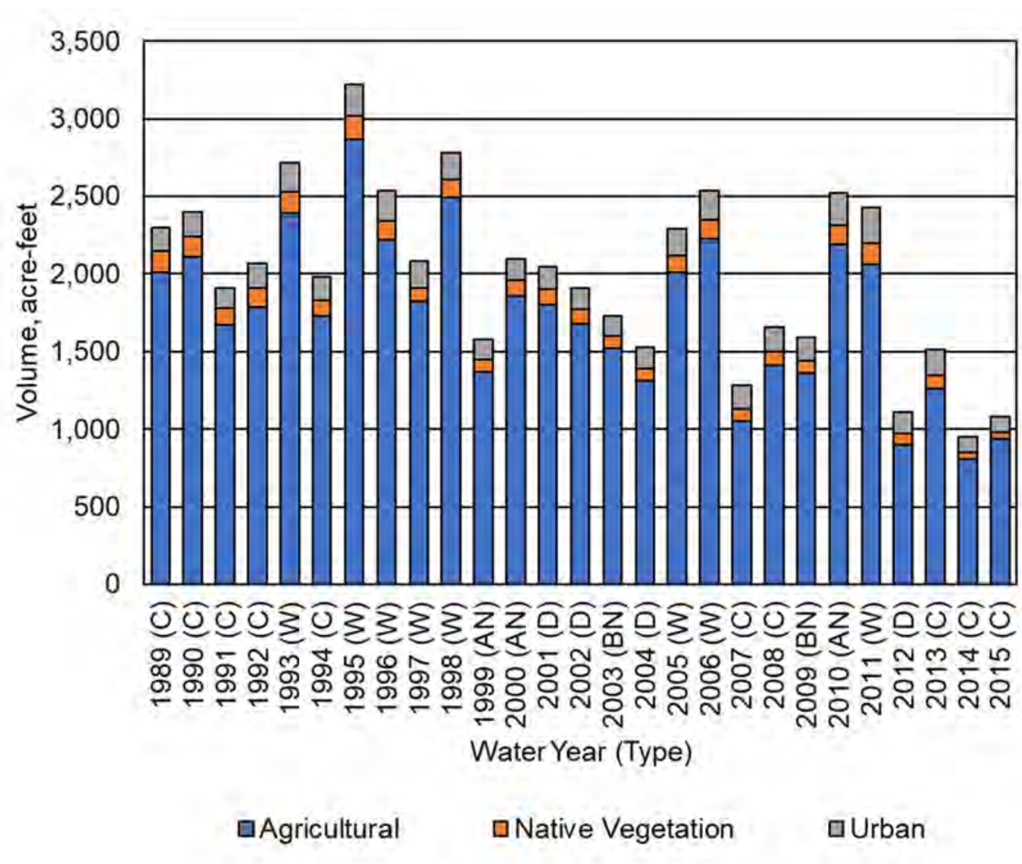

Figure A2.F.d-10. Sierra Vista Mutual Water Company Evapotranspiration of Precipitation by Water Use Sector.

Table A2.F.d-8. Sierra Vista Mutual Water Company Evapotranspiration of Precipitation by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	2,010	140	150	2,300
1990 (C)	2,110	130	160	2,400
1991 (C)	1,670	110	130	1,910
1992 (C)	1,790	120	160	2,070
1993 (W)	2,390	140	190	2,720
1994 (C)	1,730	100	150	1,980
1995 (W)	2,870	150	200	3,220
1996 (W)	2,220	120	200	2,540
1997 (W)	1,820	90	170	2,080
1998 (W)	2,490	120	170	2,780
1999 (AN)	1,370	80	130	1,580
2000 (AN)	1,860	100	140	2,100
2001 (D)	1,800	100	150	2,050
2002 (D)	1,680	90	140	1,910
2003 (BN)	1,520	80	130	1,730
2004 (D)	1,310	80	140	1,530
2005 (W)	2,010	110	170	2,290
2006 (W)	2,230	120	190	2,540
2007 (C)	1,050	80	150	1,280
2008 (C)	1,410	90	160	1,660
2009 (BN)	1,360	80	150	1,590
2010 (AN)	2,190	120	210	2,520
2011 (W)	2,060	140	230	2,430
2012 (D)	900	70	140	1,110
2013 (C)	1,260	90	160	1,510
2014 (C)	810	40	100	950
2015 (C)	940	40	100	1,080
Average (1989-2014)	1,770	100	160	2,030
Average (1989-2014) W	2,260	120	190	2,570
Average (1989-2014) AN	1,810	100	160	2,070
Average (1989-2014) BN	1,440	80	140	1,660
Average (1989-2014) D	1,420	90	140	1,650
Average (1989-2014) C	1,540	100	150	1,790

Total ET varies between years, with the lowest observed in 1989, at approximately 8.9 taf, and greatest in 2015, at approximately 11.3 taf. Total ET generally increases over time, again following the trend of increasing alfalfa, pasture, and orchard acreage.

In addition to ET from land surfaces, estimates of evaporation from SVMWC rivers and streams are reported in Figure A2.F.d-11 and Table A2.F.d-9. Evaporation from the Rivers and Streams System includes evaporation of flood inflows and of precipitation runoff within local sloughs and depressions. Total evaporation from all sources averaged less than 0.1 taf per year between 1989 and 2014.

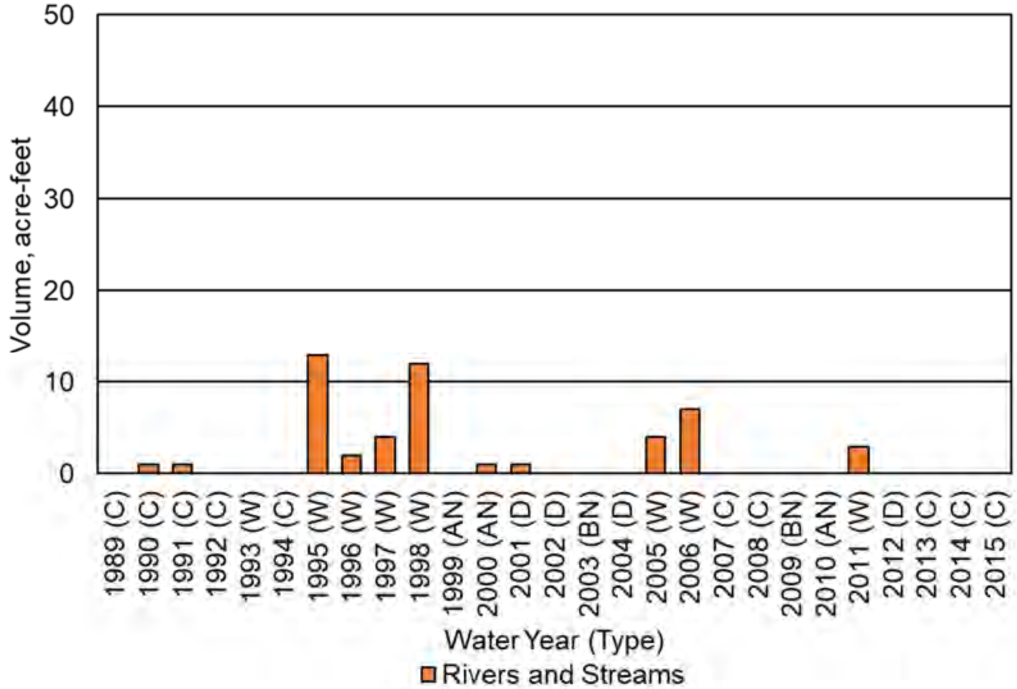

Figure A2.F.d-11. Sierra Vista Mutual Water Company Evaporation from the Surface Water System.

Table A2.F.d-9. Sierra Vista Mutual Water Company Evaporation from the Surface Water System (Acre-Feet).

Water Year (Type)	Rivers and Streams
1989 (C)	0
1990 (C)	1
1991 (C)	1
1992 (C)	0
1993 (W)	0
1994 (C)	0
1995 (W)	13
1996 (W)	2
1997 (W)	4
1998 (W)	12
1999 (AN)	0
2000 (AN)	1
2001 (D)	1
2002 (D)	0
2003 (BN)	0
2004 (D)	0
2005 (W)	4
2006 (W)	7
2007 (C)	0
2008 (C)	0
2009 (BN)	0
2010 (AN)	0

Water Year (Type)	Rivers and Streams
2011 (W)	3
2012 (D)	0
2013 (C)	0
2014 (C)	0
2015 (C)	0
Average (1989-2014)	1.9
Average (1989-2014) W	5.6
Average (1989-2014) AN	0.3
Average (1989-2014) BN	0.0
Average (1989-2014) D	0.3
Average (1989-2014) C	0.2

3.2.2.2 Surface Water Outflow by Water Source Type

Surface water outflows by water source type are summarized in Figure A2.F.d-12 and Table A2.F.d-10. In SVMWC, runoff of applied water is assumed negligible and runoff of precipitation is collected in waterways within SVMWC, with most infiltrating to the groundwater system except following the largest storm events. Thus, surface outflows from SVMWC are expected to be a mixture of flood releases from Buchanan Dam and Millerton Reservoir along Chowchilla River. Between 1989 and 2014, these combined outflows averaged approximately 2.1 taf during wet years.

3.2.2.3 Infiltration of Precipitation

Estimated infiltration of precipitation (deep percolation of precipitation) by water use sector is provided in Figure A2.F.d-13 and Table A2.F.d-11. Infiltration of precipitation to the groundwater system is highly variable from year to year due to variation in the timing and amount of precipitation, ranging from less than 0.5 taf annually during some critical and dry years to over 2.4 taf during 1995.

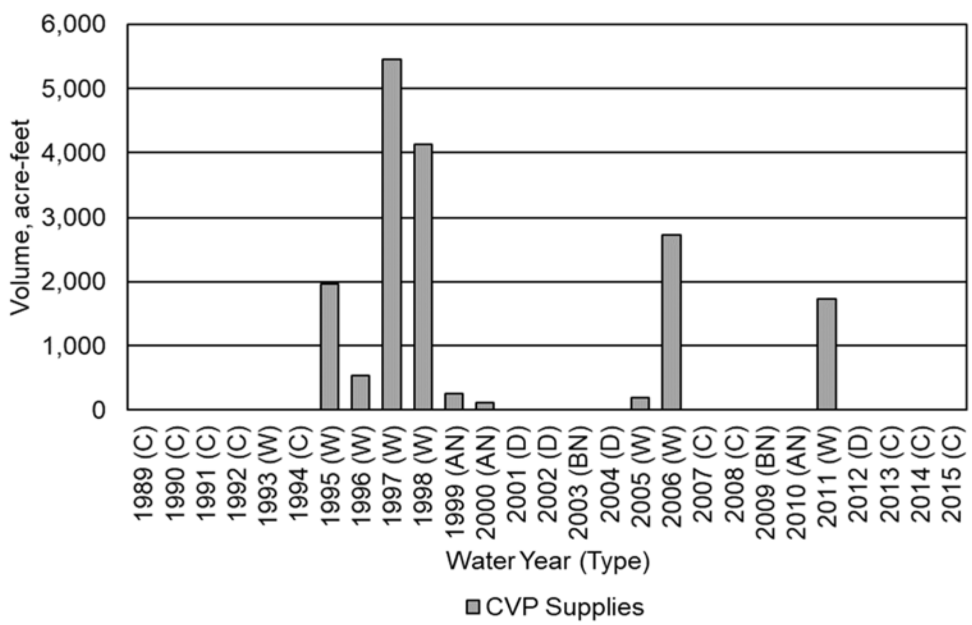

Figure A2.F.d-12. Sierra Vista Mutual Water Company Surface Outflows by Water Source Type.

Table A2.F.d-10. Sierra Vista Mutual Water Company Surface Outflows by Water Source Type (Acre-Feet).

Water Year (Type)	Local Supplies	CVP Supplies	Total
1989 (C)	0	0	0
1990 (C)	0	0	0
1991 (C)	0	0	0
1992 (C)	0	0	0
1993 (W)	0	0	0
1994 (C)	0	0	0
1995 (W)	0	1,970	1,970
1996 (W)	0	540	540
1997 (W)	0	5,450	5,450
1998 (W)	0	4,130	4,130
1999 (AN)	0	260	260
2000 (AN)	0	110	110
2001 (D)	0	0	0
2002 (D)	0	0	0
2003 (BN)	0	0	0
2004 (D)	0	0	0
2005 (W)	0	190	190
2006 (W)	0	2,730	2,730
2007 (C)	0	0	0
2008 (C)	0	0	0
2009 (BN)	0	0	0
2010 (AN)	0	0	0
2011 (W)	0	1,730	1,730
2012 (D)	0	0	0
2013 (C)	0	0	0
2014 (C)	0	0	0
2015 (C)	0	0	0
Average (1989-2014)	0	660	660
Average (1989-2014) W	0	2,090	2,090
Average (1989-2014) AN	0	120	120
Average (1989-2014) BN	0	0	0
Average (1989-2014) D	0	0	0
Average (1989-2014) C	0	0	0

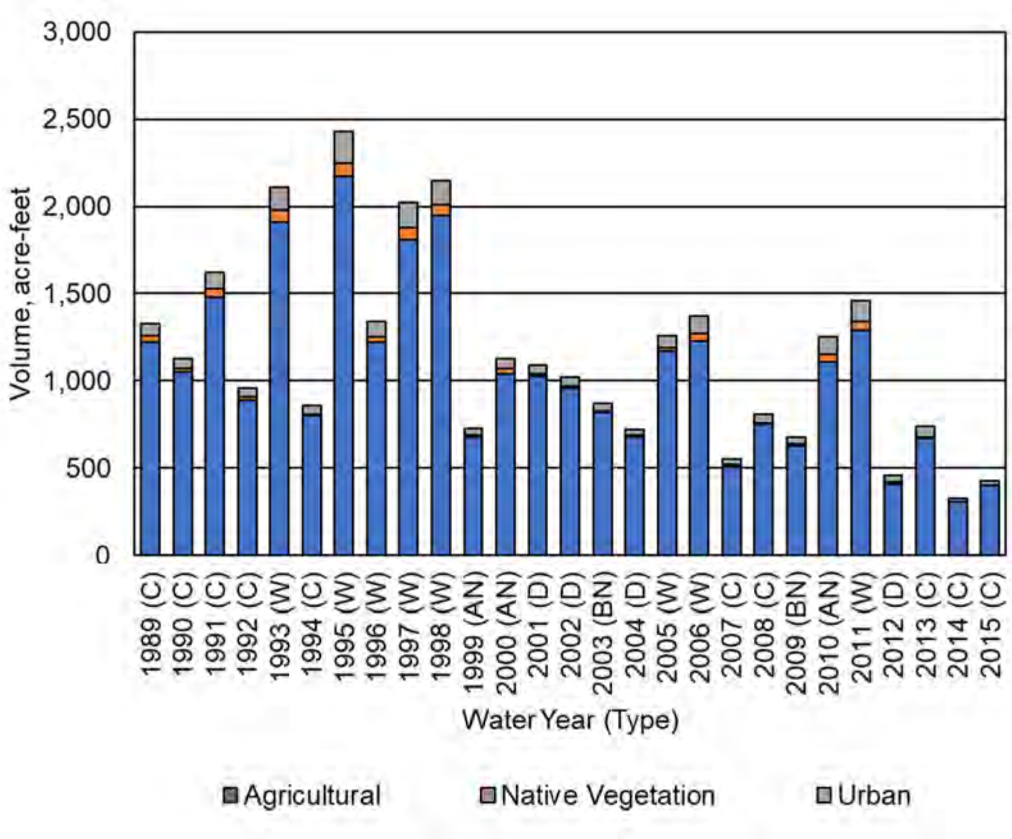

Figure A2.F.d-13. Sierra Vista Mutual Water Company Infiltration of Precipitation by Water Use Sector.

Table A2.F.d-11. Sierra Vista Mutual Water Company Infiltration of Precipitation by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	1,220	40	70	1,330
1990 (C)	1,050	20	60	1,130
1991 (C)	1,480	50	90	1,620
1992 (C)	890	20	50	960
1993 (W)	1,910	70	130	2,110
1994 (C)	800	10	50	860
1995 (W)	2,170	80	180	2,430
1996 (W)	1,220	30	90	1,340
1997 (W)	1,810	70	140	2,020
1998 (W)	1,950	60	140	2,150
1999 (AN)	680	10	40	730
2000 (AN)	1,040	30	60	1,130
2001 (D)	1,030	10	50	1,090
2002 (D)	960	10	50	1,020
2003 (BN)	820	10	40	870
2004 (D)	680	10	30	720
2005 (W)	1,170	20	70	1,260
2006 (W)	1,230	40	100	1,370
2007 (C)	510	10	30	550

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
2008 (C)	750	10	50	810
2009 (BN)	630	10	40	680
2010 (AN)	1,110	40	100	1,250
2011 (W)	1,290	50	120	1,460
2012 (D)	410	10	40	460
2013 (C)	670	10	60	740
2014 (C)	310	0	20	330
2015 (C)	400	0	30	430
Average (1989-2014)	1,070	30	70	1,170
Average (1989-2014) W	1,590	50	120	1,760
Average (1989-2014) AN	940	30	70	1,040
Average (1989-2014) BN	730	10	40	780
Average (1989-2014) D	770	10	40	820
Average (1989-2014) C	850	20	50	920

3.2.2.4 Infiltration of Surface Water

Estimated infiltration of surface water (seepage) by source is provided in Figure A2.F.d-14 and Table A2.F.d-12. Seepage from the Rivers and Streams System includes seepage of surface inflows along Chowchilla River and of precipitation runoff into local sloughs and depressions. Seepage from rivers and streams follows the pattern of surface water inflows, averaging approximately 2.9 taf per year between 1989 and 2014. During non-flood releases, seepage is also allocated to SVMWC along reach C-2 of the Chowchilla River upstream of SVMWC. Per an agreement between SVMWC and CWD, 70% of non-flood seepage along reach C-2 is allocated to SVMWC, and 30% is allocated to CWD.

3.2.2.5 Infiltration of Applied Water

Estimated infiltration of applied water (deep percolation of applied water) by water use sector is provided in Figure A2.F.d-15 and Table A2.F.d-13. Infiltration of applied water is dominated by agricultural irrigation and has slightly increased in recent years with shifts in agricultural land use.

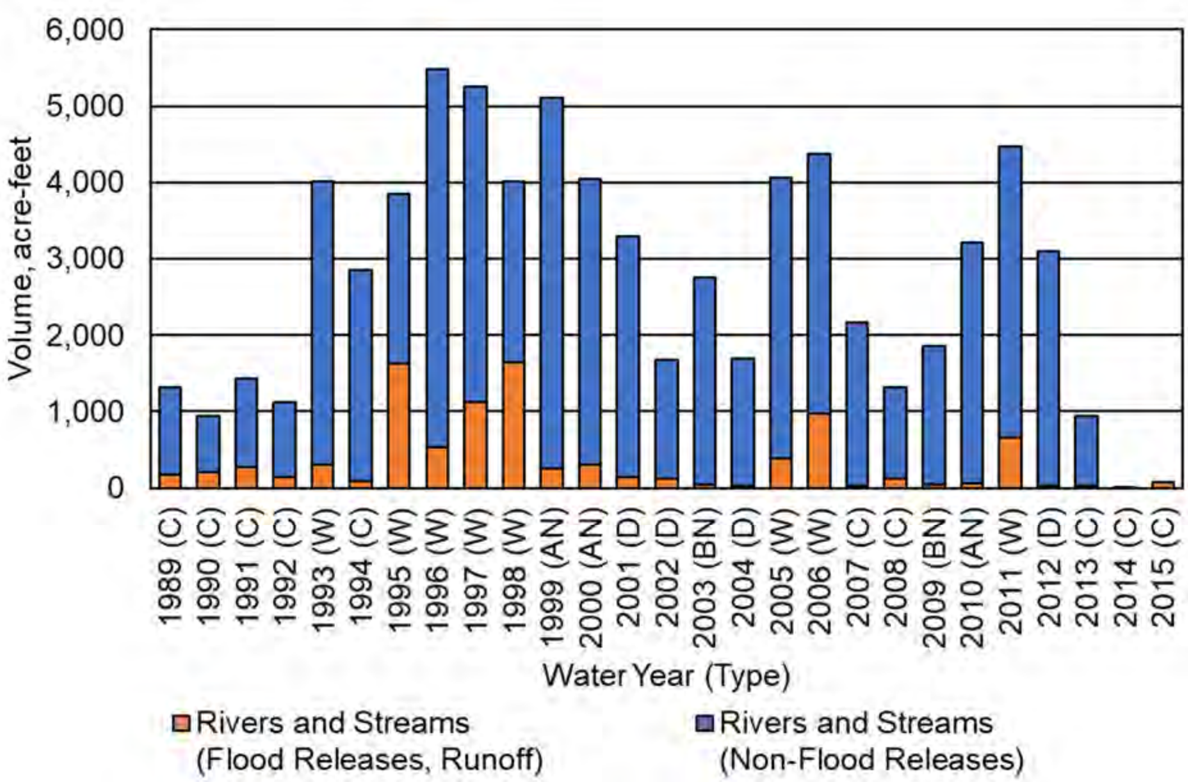

Figure A2.F.d-14. Sierra Vista Mutual Water Company Infiltration of Surface Water.

Table* A2.F.d-*12. Sierra Vista Mutual Water Company Infiltration of Surface Water (Acre-Feet).

Water Year (Type)	Rivers and Streams (Flood Releases, Runoff)[1]	Rivers and Streams (Non-Flood Releases)[2]	Total
1989 (C)	170	1,140	1,310
1990 (C)	200	750	950
1991 (C)	280	1,160	1,440
1992 (C)	150	980	1,130
1993 (W)	310	3,710	4,020
1994 (C)	90	2,770	2,860
1995 (W)	1,630	2,220	3,850
1996 (W)	540	4,940	5,480
1997 (W)	1,120	4,130	5,250
1998 (W)	1,640	2,380	4,020
1999 (AN)	250	4,850	5,100
2000 (AN)	310	3,730	4,040
2001 (D)	150	3,150	3,300
2002 (D)	120	1,560	1,680
2003 (BN)	50	2,700	2,750
2004 (D)	30	1,660	1,690
2005 (W)	390	3,680	4,070
2006 (W)	970	3,400	4,370
2007 (C)	20	2,140	2,160

Water Year (Type)	Rivers and Streams (Flood Releases, Runoff)[1]	Rivers and Streams (Non-Flood Releases)[2]	Total
2008 (C)	120	1,190	1,310
2009 (BN)	40	1,820	1,860
2010 (AN)	60	3,150	3,210
2011 (W)	660	3,810	4,470
2012 (D)	20	3,080	3,100
2013 (C)	30	910	940
2014 (C)	10	0	10
2015 (C)	80	0	80
Average (1989-2014)	360	2,500	2,860
Average (1989-2014) W	910	3,530	4,440
Average (1989-2014) AN	210	3,910	4,120
Average (1989-2014) BN	50	2,260	2,310
Average (1989-2014) D	80	2,360	2,440
Average (1989-2014) C	120	1,230	1,350

[1] Includes infiltration of flood releases and of precipitation runoff within the subregion. To calculate Net Recharge from SWS below, Rivers and Streams System seepage is summed across the subbasin and redistributed to each subregion in proportion to gross area.
[2] Includes infiltration of non-flood releases along Chowchilla River upstream of SVMWC.

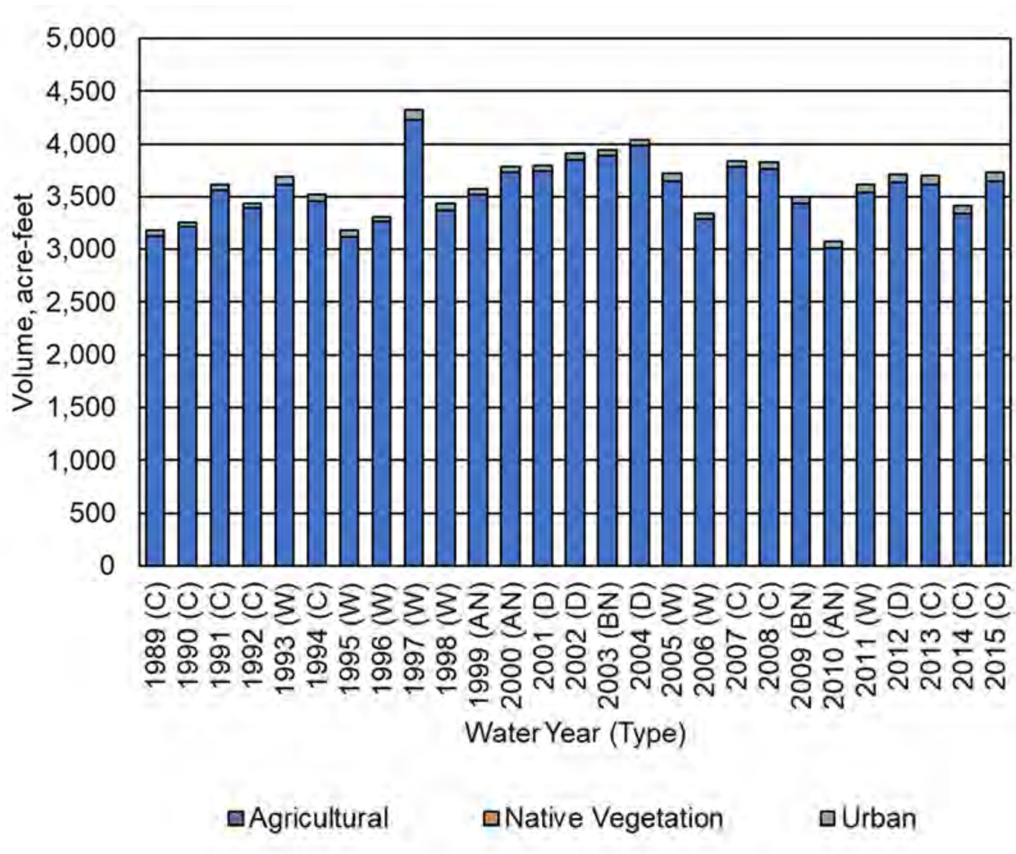

Figure A2.F.d-15. Sierra Vista Mutual Water Company Infiltration of Applied Water by Water Use Sector.

Table A2.F.d-13. Sierra Vista Mutual Water Company Infiltration of Applied Water by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	3,130	0	50	3,180
1990 (C)	3,210	0	50	3,260
1991 (C)	3,560	0	50	3,610
1992 (C)	3,390	0	50	3,440
1993 (W)	3,610	0	80	3,690
1994 (C)	3,460	0	60	3,520
1995 (W)	3,120	0	60	3,180
1996 (W)	3,270	0	40	3,310
1997 (W)	4,230	0	90	4,320
1998 (W)	3,370	0	70	3,440
1999 (AN)	3,520	0	50	3,570
2000 (AN)	3,730	0	50	3,780
2001 (D)	3,740	0	50	3,790
2002 (D)	3,850	0	60	3,910
2003 (BN)	3,890	0	50	3,940
2004 (D)	3,980	0	60	4,040
2005 (W)	3,650	0	70	3,720
2006 (W)	3,290	0	50	3,340
2007 (C)	3,780	0	60	3,840
2008 (C)	3,760	0	70	3,830
2009 (BN)	3,430	0	70	3,500
2010 (AN)	3,010	0	70	3,080
2011 (W)	3,540	0	70	3,610
2012 (D)	3,640	0	70	3,710
2013 (C)	3,610	0	90	3,700
2014 (C)	3,340	0	70	3,410
2015 (C)	3,650	0	80	3,730
Average (1989-2014)	3,540	0	60	3,600
Average (1989-2014) W	3,510	0	70	3,580
Average (1989-2014) AN	3,420	0	60	3,480
Average (1989-2014) BN	3,660	0	60	3,720
Average (1989-2014) D	3,800	0	60	3,860
Average (1989-2014) C	3,470	0	60	3,530

3.2.3 Change in Surface Water System Storage

Estimates of change in SWS storage are provided in Figure A2.F.d-16 and Table A2.F.d-14. Inter-annual changes in storage within the surface water system consist primarily of root zone soil moisture storage changes, are relatively small, and tend to average near zero over many years. During some wet years, change in SWS storage is estimated as higher during months when prescriptive water rights deliveries satisfy much of the crop water demand, substantially reducing groundwater pumping closure estimates.

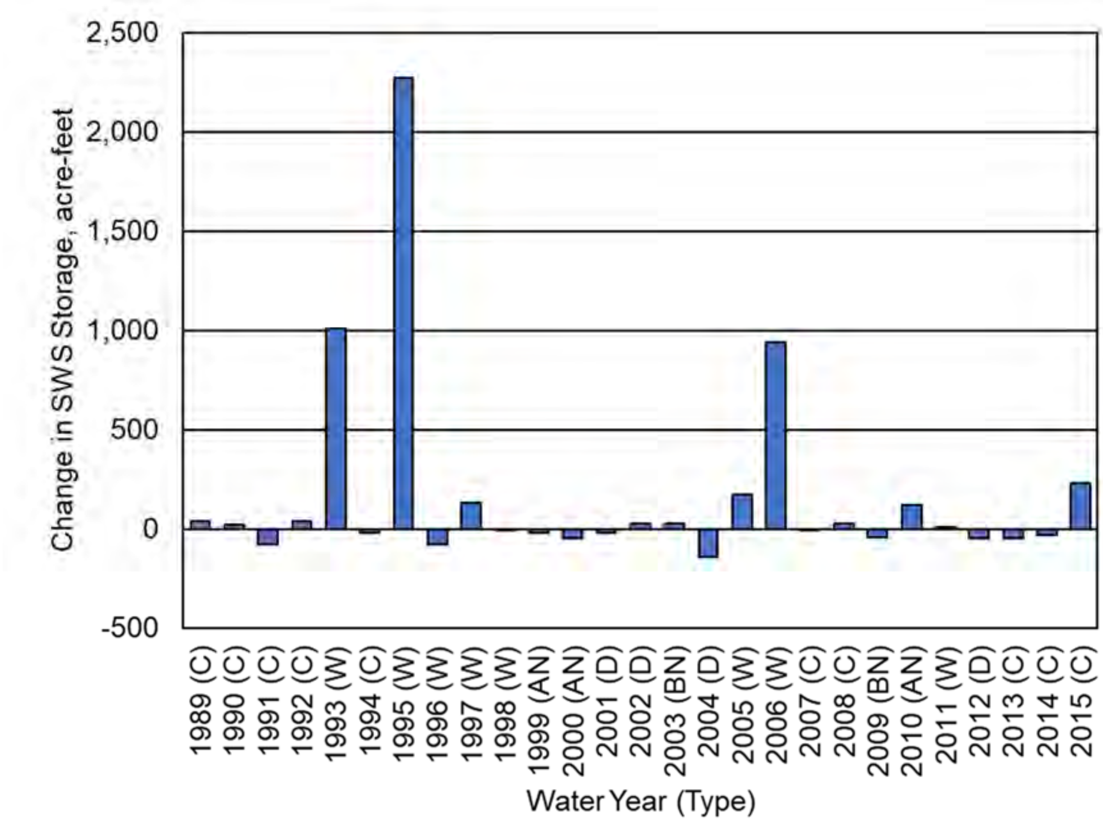

Figure A2.F.d-16. Sierra Vista Mutual Water Company Change in Surface Water System Storage.

Table A2.F.d-14. Sierra Vista Mutual Water Company Change in Surface Water System Storage (Acre-Feet).

Water Year (Type)	Change in SWS Storage
1989 (C)	40
1990 (C)	20
1991 (C)	-80
1992 (C)	40
1993 (W)	1,010
1994 (C)	-20
1995 (W)	2,270
1996 (W)	-80
1997 (W)	130
1998 (W)	-10
1999 (AN)	-20
2000 (AN)	-50
2001 (D)	-20
2002 (D)	30
2003 (BN)	30
2004 (D)	-140
2005 (W)	170
2006 (W)	940

Water Year (Type)	Change in SWS Storage
2007 (C)	-10
2008 (C)	30
2009 (BN)	-40
2010 (AN)	120
2011 (W)	10
2012 (D)	-50
2013 (C)	-50
2014 (C)	-30
2015 (C)	230
Average (1989-2014)	160
Average (1989-2014) W	560
Average (1989-2014) AN	20
Average (1989-2014) BN	-10
Average (1989-2014) D	-50
Average (1989-2014) C	-10

3.3 Historical Water Budget Summary

Annual inflows, outflows, and change in SWS storage during the historical water budget period (1989-2014) are summarized in Figure A2.F.d-17 and Table A2.F.d-15. Inflows are shown as positive values, while outflows and change in SWS storage are shown as negative values. Review of the variability in component volumes across years provides insight into the impacts of hydrology on the surface water system water budget.

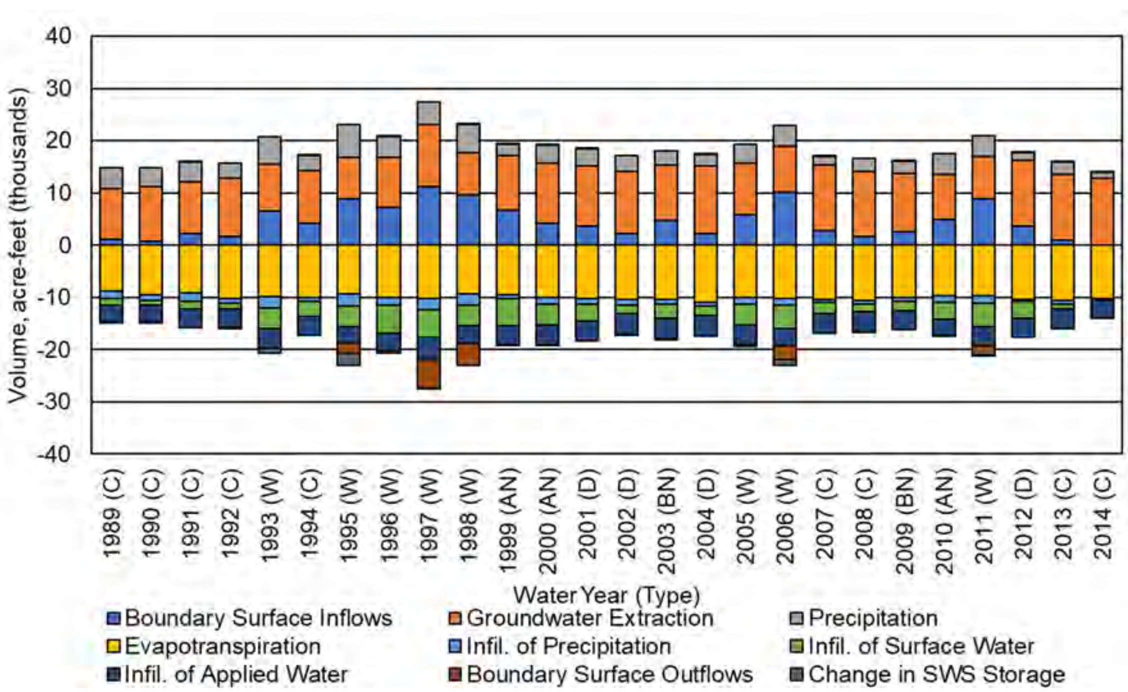

Figure A2.F.d-17. Sierra Vista Mutual Water Company Surface Water System Historical Water Budget, 1989-2014.

Table A2.F.d-15. Sierra Vista Mutual Water Company Surface Water System Historical Water Budget, 1989-2014 (Acre-Feet).

Water Year	Boundary Surface Inflows	Groundwater Extraction	Precipitation	Evapo-transpiration[1]	Infil. of Precipitation	Infil. of Surface Water[2]	Infil. of Applied Water	Boundary Surface Outflows	Change in SWS Storage
1989 (C)	1,140	9,750	3,820	-8,850	-1,330	-1,300	-3,180	0	-40
1990 (C)	750	10,510	3,560	-9,460	-1,130	-950	-3,260	0	-20
1991 (C)	2,270	9,810	3,720	-9,210	-1,630	-1,440	-3,610	0	80
1992 (C)	1,650	11,080	3,040	-10,220	-950	-1,130	-3,440	0	-40
1993 (W)	6,450	9,090	5,150	-9,870	-2,110	-4,020	-3,690	0	-1,010
1994 (C)	4,200	10,060	2,920	-9,960	-870	-2,850	-3,520	0	20
1995 (W)	8,790	7,960	6,260	-9,320	-2,430	-3,850	-3,180	-1,970	-2,270
1996 (W)	7,220	9,610	3,830	-10,070	-1,340	-5,480	-3,310	-540	80
1997 (W)	11,200	11,910	4,370	-10,310	-2,020	-5,250	-4,320	-5,450	-130
1998 (W)	9,620	8,120	5,260	-9,260	-2,150	-4,020	-3,440	-4,130	10
1999 (AN)	6,630	10,450	2,130	-9,580	-720	-5,100	-3,570	-260	20
2000 (AN)	4,150	11,500	3,480	-10,110	-1,130	-4,040	-3,780	-110	50
2001 (D)	3,660	11,450	3,240	-10,190	-1,100	-3,300	-3,780	0	20
2002 (D)	2,240	11,920	2,940	-10,470	-1,020	-1,680	-3,910	0	-30
2003 (BN)	4,710	10,660	2,590	-10,370	-870	-2,750	-3,940	0	-30
2004 (D)	2,280	12,890	2,150	-11,010	-710	-1,700	-4,030	0	140
2005 (W)	5,800	9,880	3,710	-9,980	-1,260	-4,070	-3,710	-190	-170
2006 (W)	10,070	8,780	4,080	-10,190	-1,360	-4,370	-3,350	-2,730	-940
2007 (C)	2,690	12,610	1,650	-10,420	-550	-2,150	-3,840	0	10
2008 (C)	1,680	12,340	2,510	-10,560	-810	-1,310	-3,830	0	-30
2009 (BN)	2,570	11,230	2,270	-10,090	-670	-1,860	-3,500	0	40
2010 (AN)	4,950	8,560	3,900	-9,760	-1,240	-3,210	-3,080	0	-120
2011 (W)	8,810	8,110	4,080	-9,730	-1,460	-4,460	-3,610	-1,730	-10
2012 (D)	3,560	12,640	1,390	-10,370	-450	-3,100	-3,710	0	50
2013 (C)	910	12,640	2,350	-10,570	-740	-940	-3,700	0	50
2014 (C)	0	12,770	1,150	-10,190	-340	-10	-3,400	0	30
Average (1989-2014)	4,540	10,630	3,290	-10,000	-1,170	-2,860	-3,600	-660	-160
W	8,490	9,180	4,590	-9,840	-1,770	-4,440	-3,580	-2,090	-550
AN	5,240	10,170	3,170	-9,820	-1,030	-4,120	-3,480	-120	-20
BN	3,640	10,950	2,430	-10,230	-770	-2,300	-3,720	0	0
D	2,940	12,220	2,430	-10,510	-820	-2,440	-3,860	0	40
C	1,700	11,290	2,750	-9,940	-930	-1,340	-3,530	0	10

[1]Includes ET of applied water, ET of precipitation, and evaporation from the Rivers and Streams system.

[2]Includes infiltration from flood releases along Chowchilla River and runoff of precipitation in SVMWC, and 70% of non-flood releases along Chowchilla River reach C-2. To calculate Net Recharge from SWS below, Rivers and Streams System seepage from flood releases and runoff of precipitation is summed across the subbasin and redistributed to each subregion in proportion to gross area

3.4 Current Water Budget Summary

The current water budget was developed following a similar process to the historical water budget using the 2015 land use in Table A2.F.d-1 and the same 1989-2014 average hydrologic conditions of the historical base period, including surface water flows, precipitation, and weather parameters. This allowed quantification of groundwater inflows and outflows for current consumptive use in the context of average water supply conditions.

Annual inflows, outflows, and change in SWS storage from the current water budget are summarized in Figure A2.F.d-18 and Table A2.F.d-16. Inflows are shown as positive values, while outflows and change in SWS storage are shown as negative values.

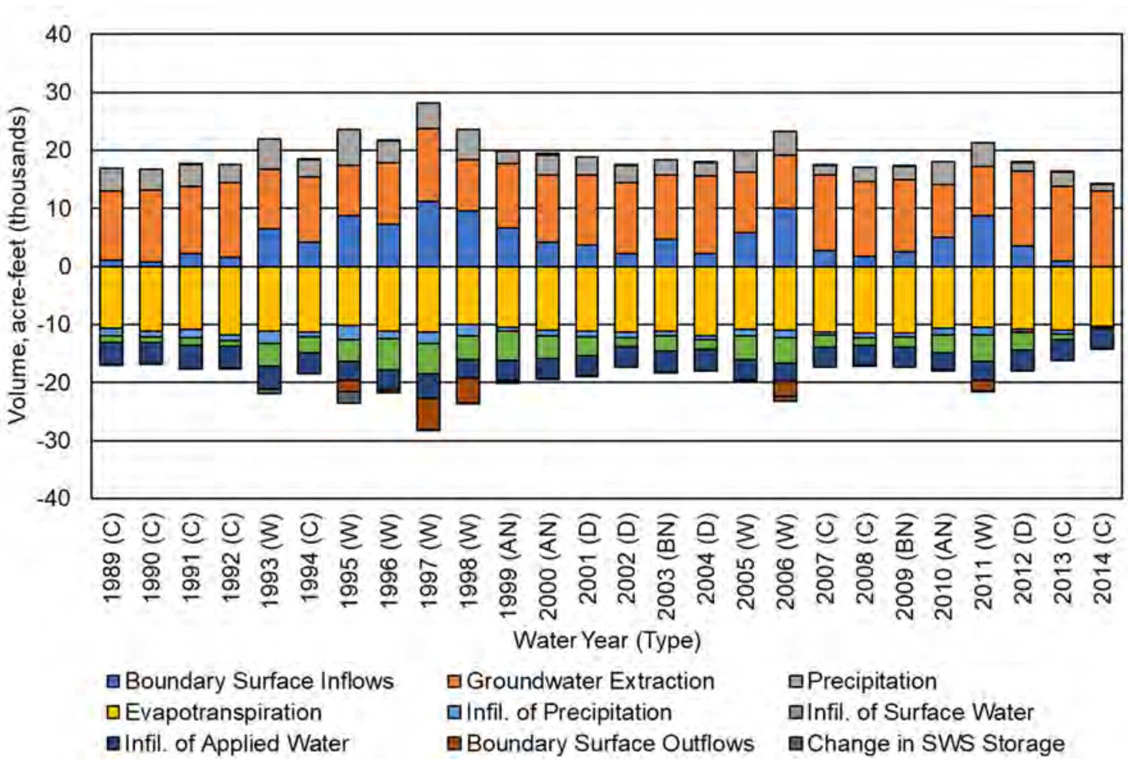

Figure A2.F.d-18. Sierra Vista Mutual Water Company Surface Water System Current Water Budget.

Table A2.F.d-16. Sierra Vista Mutual Water Company Surface Water System Current Water Budget (Acre-Feet).

Water Year	Boundary Surface Inflows	Groundwater Extraction	Precipitation	Evapo-transpiration[1]	Infil. of Precipitation	Infil. of Surface Water[2]	Infil. of Applied Water	Boundary Surface Outflows	Change in SWS Storage
1989 (C)	1,140	11,920	3,820	-10,660	-1,270	-1,230	-3,690	0	-20
1990 (C)	750	12,430	3,560	-11,100	-1,090	-880	-3,590	0	-80
1991 (C)	2,270	11,550	3,720	-10,740	-1,550	-1,350	-3,990	0	80
1992 (C)	1,650	12,840	3,040	-11,830	-920	-1,080	-3,670	0	-30
1993 (W)	6,450	10,280	5,150	-11,170	-2,030	-3,910	-3,920	0	-850
1994 (C)	4,200	11,310	2,920	-11,240	-830	-2,820	-3,640	0	100
1995 (W)	8,790	8,540	6,260	-10,230	-2,300	-3,810	-3,260	-1,890	-2,100
1996 (W)	7,220	10,640	3,830	-11,170	-1,260	-5,460	-3,370	-510	80
1997 (W)	11,200	12,600	4,370	-11,350	-1,990	-5,190	-4,230	-5,380	-20
1998 (W)	9,620	8,690	5,260	-10,040	-1,980	-3,960	-3,380	-4,090	-110
1999 (AN)	6,630	11,120	2,130	-10,450	-670	-5,100	-3,400	-260	-10
2000 (AN)	4,150	11,640	3,480	-10,950	-1,010	-3,960	-3,430	-90	190
2001 (D)	3,660	12,020	3,240	-11,140	-980	-3,220	-3,520	0	-70
2002 (D)	2,240	12,160	2,940	-11,280	-920	-1,620	-3,580	0	70
2003 (BN)	4,710	11,000	2,590	-11,110	-770	-2,720	-3,620	0	-80
2004 (D)	2,280	13,370	2,150	-12,000	-610	-1,680	-3,670	0	170
2005 (W)	5,800	10,440	3,710	-10,820	-1,130	-4,030	-3,520	-180	-260
2006 (W)	10,070	9,050	4,080	-11,050	-1,240	-4,330	-3,120	-2,690	-770
2007 (C)	2,690	13,000	1,650	-11,280	-470	-2,140	-3,500	0	40
2008 (C)	1,680	12,870	2,510	-11,530	-720	-1,260	-3,510	0	-40
2009 (BN)	2,570	12,380	2,270	-11,450	-590	-1,840	-3,420	0	90
2010 (AN)	4,950	9,200	3,900	-10,640	-1,140	-3,190	-2,920	0	-170
2011 (W)	8,810	8,490	4,080	-10,510	-1,350	-4,440	-3,340	-1,710	-30
2012 (D)	3,560	12,900	1,390	-10,890	-430	-3,100	-3,510	0	80
2013 (C)	910	12,960	2,350	-10,940	-720	-940	-3,670	0	50
2014 (C)	0	12,950	1,150	-10,340	-340	-10	-3,440	0	30
Average (1989-2014)	4,540	11,400	3,290	-11,000	-1,090	-2,820	-3,540	-650	-140
W	8,490	9,840	4,590	-10,790	-1,660	-4,390	-3,520	-2,060	-510
AN	5,240	10,650	3,170	-10,680	-940	-4,080	-3,250	-120	0
BN	3,640	11,690	2,430	-11,280	-680	-2,280	-3,520	0	0
D	2,940	12,610	2,430	-11,330	-740	-2,410	-3,570	0	60
C	1,700	12,430	2,750	-11,070	-880	-1,300	-3,630	0	10

[1]Includes ET of applied water, ET of precipitation, and evaporation from the Rivers and Streams System.
[2]Includes infiltration from flood releases along Chowchilla River and runoff of precipitation in SVMWC, and 70% of non-flood releases along Chowchilla River reach C-2. To calculate Net Recharge from SWS below, Rivers and Streams System seepage from flood releases and runoff of precipitation is summed across the subbasin and redistributed to each subregion in proportion to gross area.

3.5 Net Recharge from SWS

Overdraft is defined in DWR Bulletin 118 as “the condition of a groundwater basin or subbasin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years, during which the water supply conditions approximate average conditions” (DWR 2003). The Chowchilla Subbasin water budget indicates that overdraft conditions occurred during the 1989-2014 historical base period. Per 23 CCR Section 354.18(b)(5), the subbasin overdraft has been quantified for this base period. The evaluation of overdraft conditions includes estimates of recharge from subsurface flows. However, estimates of recharge from subsurface flows are less accurate when estimated for areas less that an entire subbasin. Thus, for estimates of GSA level contribution to overdraft, the term net recharge from the SWS is defined as groundwater recharge minus groundwater extraction. Net recharge from the SWS is useful for understanding and analyzing the combined effects of land surface processes on the underlying GWS.

When calculated from the historical water budget, average net recharge from the SWS represents the average recharge (when positive) or shortage of recharge (when negative) based on historical cropping, land use practices, and average hydrologic conditions. When calculated from the current land use water budget, average net recharge represents the average recharge or shortage (when negative) based on current cropping, land use practices, and average hydrologic conditions.

Average net recharge from the SWS is presented below for the SVMWC portion of the Chowchilla Subbasin. Table A2.F.d-17 shows the average net recharge from the SWS for 1989-2014 based on the historical water budget, and Table A2.F.d-18 shows the same for the current water budget. Historically, the average net recharge in SVMWC was approximately -2.8 taf per year between 1989 and 2014. Under current land use conditions, the average net recharge in SVMWC is approximately -3.7 taf, indicating shortage conditions.

Table A2.F.d-17. Historical Water Budget: Average Net Recharge from SWS by Water Year Type, 1989-2014 (Acre-Feet).

Year Type	Number of Years	Infiltration of Applied Water (a)	Infiltration of Precipitation (b)	Infiltration of Surface Water[1] (c)	Groundwater Extraction (d)	Net Recharge from SWS (a+b+c-d)
W	8	3,580	1,770	5,000	9,180	1,170
AN	3	3,480	1,030	4,240	10,170	-1,420
BN	2	3,720	770	2,300	10,950	-4,160
D	4	3,860	820	2,470	12,220	-5,070
C	9	3,530	930	1,400	11,290	-5,430
Annual Average (1989-2014)	26	3,600	1,170	3,070	10,630	-2,790

[1] Includes infiltration from flood releases along Chowchilla River and runoff of precipitation in SVMWC, and 70% of non-flood releases along Chowchilla River reach C-2. To calculate Net Recharge from SWS below, Rivers and Streams System seepage from flood releases and runoff of precipitation is summed across the subbasin and redistributed to each subregion in proportion to gross area

Table A2.F.d-18. Current Water Budget: Average Net Recharge from SWS by Water Year Type (Acre-Feet).

Year Type	Number of Years	Infiltration of Applied Water (a)	Infiltration of Precipitation (b)	Infiltration of Surface Water[1] (c)	Groundwater Extraction (d)	Net Recharge from SWS (a+b+c-d)
W	8	3,520	1,660	4,970	9,840	310
AN	3	3,250	940	4,230	10,650	-2,230
BN	2	3,520	680	2,290	11,690	-5,200
D	4	3,570	740	2,460	12,610	-5,840
C	9	3,630	880	1,360	12,430	-6,560
Annual Average (1989-2014)	26	3,540	1,090	3,040	11,400	-3,730

[1] Includes infiltration from flood releases along Chowchilla River and runoff of precipitation in SVMWC, and 70% of non-flood releases along Chowchilla River reach C-2. To calculate Net Recharge from SWS below, Rivers and Streams System seepage from flood releases and runoff of precipitation is summed across the subbasin and redistributed to each subregion in proportion to gross area.

3.6 Uncertainties in Water Budget Components

Uncertainties associated with each water budget component were estimated as a percentage representing approximately a 95% confidence interval following the procedure described by Clemmens and Burt (1997). Uncertainties for all independently measured or estimated water budget components were estimated based on the measurement accuracy, typical values reported in technical literature, typical values calculated in other water budgets, and professional judgement.

Table A2.F.d-19 provides a summary of typical uncertainty values associated with major SWS inflow and outflow components. These uncertainties provide a basis for evaluating confidence in water budget results and help to identify data needs that may be addressed during GSP implementation.

Table A2.F.d-19. Estimated Uncertainty of Subregion Water Budget Components.

Flowpath Direction (SWS Boundary)	Water Budget Component	Data Source	Estimated Uncertainty (%)	Source
Inflows	Surface Water Inflows	Measurement	20%	Estimated streamflow measurement accuracy and adjustment for losses.
	Precipitation	Calculation	30%	Clemmens, A.J. and C.M. Burt, 1997.
	Groundwater Extraction	Closure	20%	Typical uncertainty calculated for Land Surface System water balance closure.
Outflows	Surface Water Outflows	Closure	20%	Typical uncertainty calculated for Rivers and Streams System water balance closure.
	Evaporation	Calculation	20%	Estimated accuracy of calculation based on CIMIS reference ET and free water surface evaporation coefficient.
	ET of Applied Water	Calculation	10%	Estimated accuracy of daily IDC root zone water budget component based on CIMIS reference ET, estimated crop coefficients from SEBAL energy balance, and annual land use.
	ET of Precipitation	Calculation	10%	Estimated accuracy of daily IDC root zone water budget component based on CIMIS reference ET, precipitation, estimated crop coefficients from SEBAL energy balance, and annual land use.
	Infiltration of Applied Water	Calculation	20%	Estimated accuracy of daily IDC root zone water budget component based on annual land use and NRCS soils characteristics.
	Infiltration of Precipitation	Calculation	20%	Estimated accuracy of daily IDC root zone water budget component based on annual land use, NRCS soils characteristics, and CIMIS precipitation.
	Infiltration of Surface Water	Calculation	15%	Estimated accuracy of daily seepage calculation using NRCS soils characteristics and calculated runoff of precipitation.
	Change in SWS Storage	Calculation	50%	Professional Judgment.
Net Recharge from SWS		Calculation	25%	Estimated water budget accuracy; typical value calculated for subregion-level net recharge from SWS.

APPENDIX 2.F. WATER BUDGET INFORMATION

2.F.e. Surface Water System Water Budget: Triangle T Water District GSA

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020

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1 INTRODUCTION

To ensure sustainable groundwater management throughout California's groundwater basins, the Sustainable Groundwater Management Act of 2014 (SGMA) requires Groundwater Sustainability Agencies (GSAs) to prepare and adopt Groundwater Sustainability Plans (GSPs) with strategies to achieve subbasin groundwater sustainability within 20 years of plan adoption. Integral to each GSP is a water budget used to quantify the subbasin's groundwater overdraft (if applicable) and sustainable yield.

In 2017, Triangle T Water District (TTWD) GSA formed to manage approximately 14,700 acres of the Chowchilla Subbasin. This document presents results of the surface water system (SWS) water budgets developed for historical and current land use conditions in TTWD GSA. The TTWD GSA water budgets were integrated with separate water budgets developed for four (4) other subregions covering the remainder of the Chowchilla Subbasin. Together, these water budgets provide the boundary water budget for the Chowchilla Subbasin SWS. Results of the subbasin boundary water budget are reported in the Chowchilla Subbasin GSP Section 2.2.3 and were integrated with a subbasin groundwater model (GSP Appendix 6.E) to estimate subbasin sustainable yield (GSP Section 2.2.3).

2 WATER BUDGET CONCEPTUAL MODEL

A water budget is defined as a complete accounting of all water flowing into and out of a defined volume (e.g., a subbasin or a GSA) over a specified period of time. The conceptual model (or structure) of the TTWD GSA water budget developed for this investigation is consistent with the GSP Regulations defined under Title 23 of California Code of Regulations[1] (CCR) and adheres to sound water budget principles and practices defined by California Department of Water Resources (DWR) in the Water Budget Best Management Practice (BMP) guidelines (DWR, 2016).

The lateral extent of TTWD GSA is defined by the boundaries indicated in Figure A2.F.e-1. The vertical extent of TTWD GSA is the land surface (top) and the base of fresh water at the bottom of the basin (bottom), as described in the hydrogeologic conceptual model (HCM) developed in GSP Section 2.2.1. The vertical extent of Chowchilla Subbasin and its GSAs is subdivided into a surface water system (SWS) and the underlying groundwater system (GWS), with separate but related water budgets prepared for each that together represent the overall subbasin water budget.

A conceptual representation of the TTWD GSA water budget is represented in Figure A2.F.e-2. This document details only the SWS portion of the TTWD GSA water budget. The SWS is divided into two primary accounting centers: the Land Surface System and the Rivers and Streams System. The Land Surface System is further divided into three accounting centers representing the subregion water use sectors: Agricultural Land, Native Vegetation Land, and Urban Land (urban, industrial, and semi-agricultural).

[1] California Code of Regulations Title 23. Waters, Division 2. Department of Water Resources, Chapter 1.5. Groundwater Management, Subchapter 2. Groundwater Sustainability Plans.

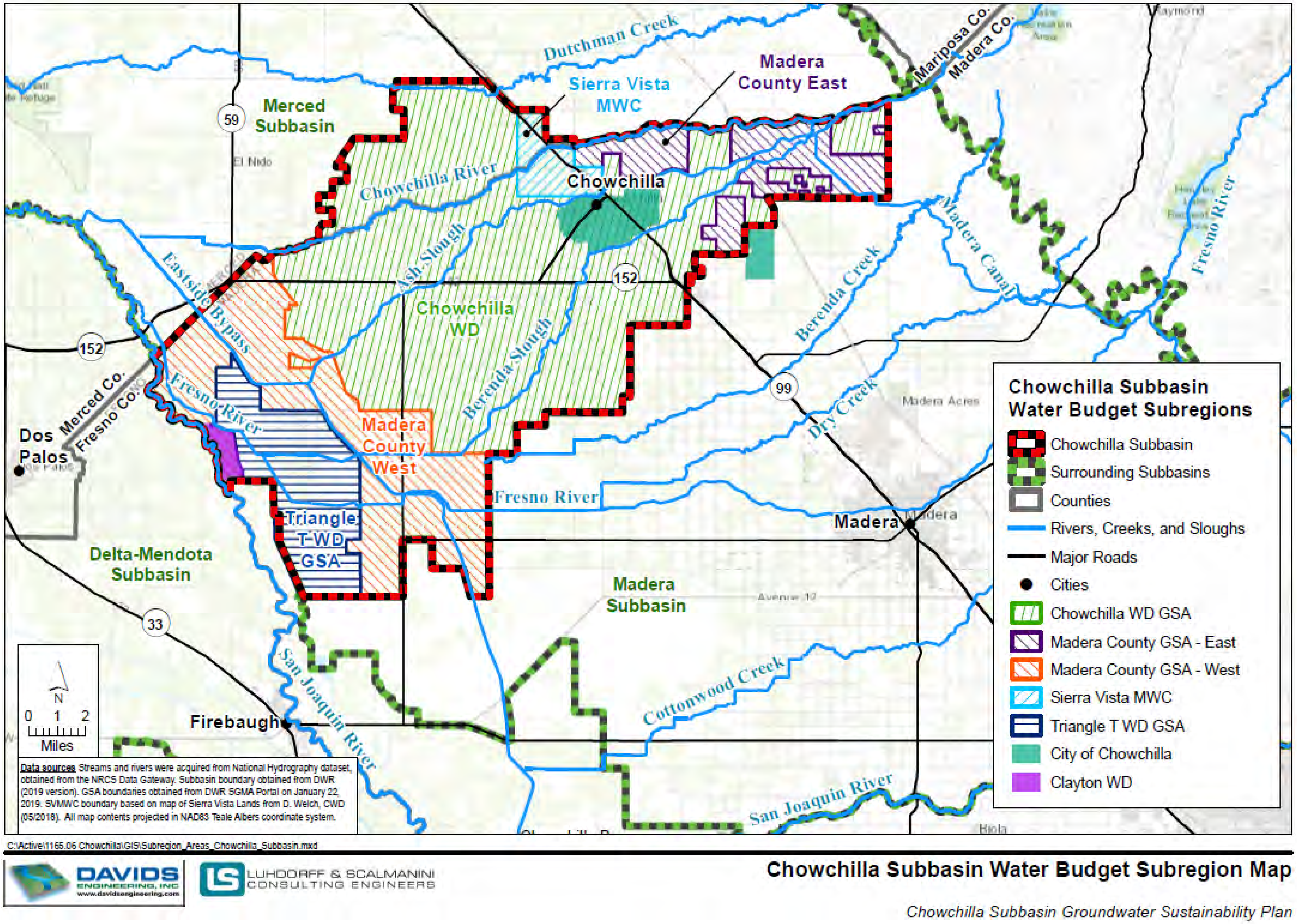

Figure A2.F.e-1. Chowchilla Subbasin Water Budget Subregion Map

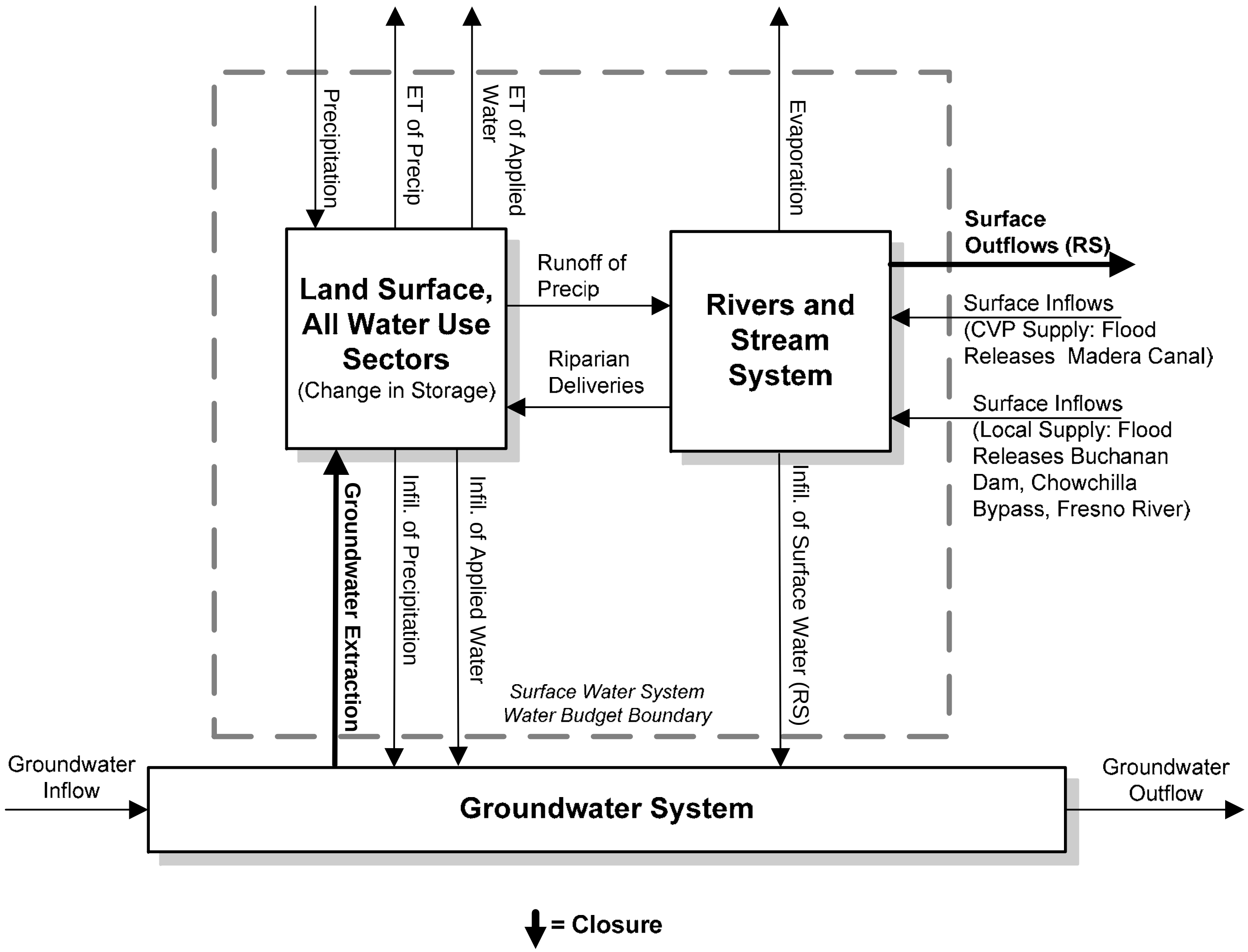

Figure A2.F.e-2. Triangle T Water District GSA Water Budget Structure

Water budget components, or directional flow of water between accounting centers and across the SWS boundary, are indicated by arrows. Inflows and outflows were calculated using measurements and other historical data or were calculated as the water budget closure term – the difference between all other estimated or measured inflows and outflows from each accounting center or water use sector (bold arrows).

Inflows to the SWS include precipitation, surface water inflows (in various canals and streams), and groundwater extraction. Outflows from the SWS include evapotranspiration (ET), surface water outflows (in various canals and streams), and infiltration to the groundwater system (seepage and deep percolation). Also represented in Figure A2.F.e-2 are inflows and outflows from the GWS, which are discussed and quantified at the subbasin level in the GWS water budget in GSP Section 2.2.3. Subsurface GWS inflows and outflows are not quantified on the water budget subregion scale.

Inflows and outflows were quantified following the process described in GSP Section 2.2.3 on a monthly time step for water years in the historical water budget base period (1989-2014 hydrologic and land use conditions), the current water budget (2015 land use using 1989-2014 average hydrologic conditions), and projected water budget. Four projected water budgets were prepared for the years 2019 through 2090 based on 1965 through 2015 hydrologic conditions, projected water supplies, and 2017 land use adjusted for urban area projected growth from 2017-2070 (areas were held constant from 2071-2090):

1. Historical hydrologic conditions and water supply data, with adjustment for projected alteration of available Friant releases by the San Joaquin River Restoration Program (SJRRP)[2]
    a. Without projects and management actions, and
    b. With projects and management actions
2. Historical hydrologic conditions and water supply data, with adjustment for projected alteration of available Friant releases by the SJRRP and adjustment for anticipated climate change per DWR-provided 2030 climate change factors
    a. Without projects and management actions, and
    b. With projects and management actions.

Information regarding the data sources and adjustments used to prepare the historical, current, and projected water budgets are described in GSP Section 2.2.3.

3 WATER BUDGET ANALYSIS

The historical water budget and current land use water budget for TTWD GSA are presented below following a summary of land use data relevant to water budget development. Land use data is provided for the 1989-2014 historical water budget period and for 2015, the current land use water budget period.

[2] Adjustments were based on the Friant Report ("Estimate of Future Friant Division Supplies for use in Groundwater Sustainability Plans, California," Friant Water Authority, 2018). Although the Friant Report accounts for climate change, it is considered the best available estimate of projected Friant releases under SJRRP. For comparison, projected Madera Canal deliveries under SJRRP were also estimated without account for climate change from the Kondolf Hydrographs (in "Effects to Water Supply and Friant Operations Resulting From Plaintiffs' Friant Release Requirements," Steiner, 2005). These estimates were approximately equal to the Friant Report 2030 climate change adjusted deliveries. Thus, the Friant Report projections were used instead to maintain consistent assumptions in estimating Madera Canal deliveries across all projected simulations.

3.1 Land Use

Land use estimates for 1989 through 2015 corresponding to water use sectors (as defined by the GSP Regulations) are summarized in Figure A2.F.e-3 and Table A2.F.e-1 for the TTWD GSA. According to GSP Regulations (23 CCR § 351(al)):

> *"Water use sector" refers to categories of water demand based on the general land uses to which the water is applied, including urban, industrial, agricultural, managed wetlands, managed recharge, and native vegetation.*

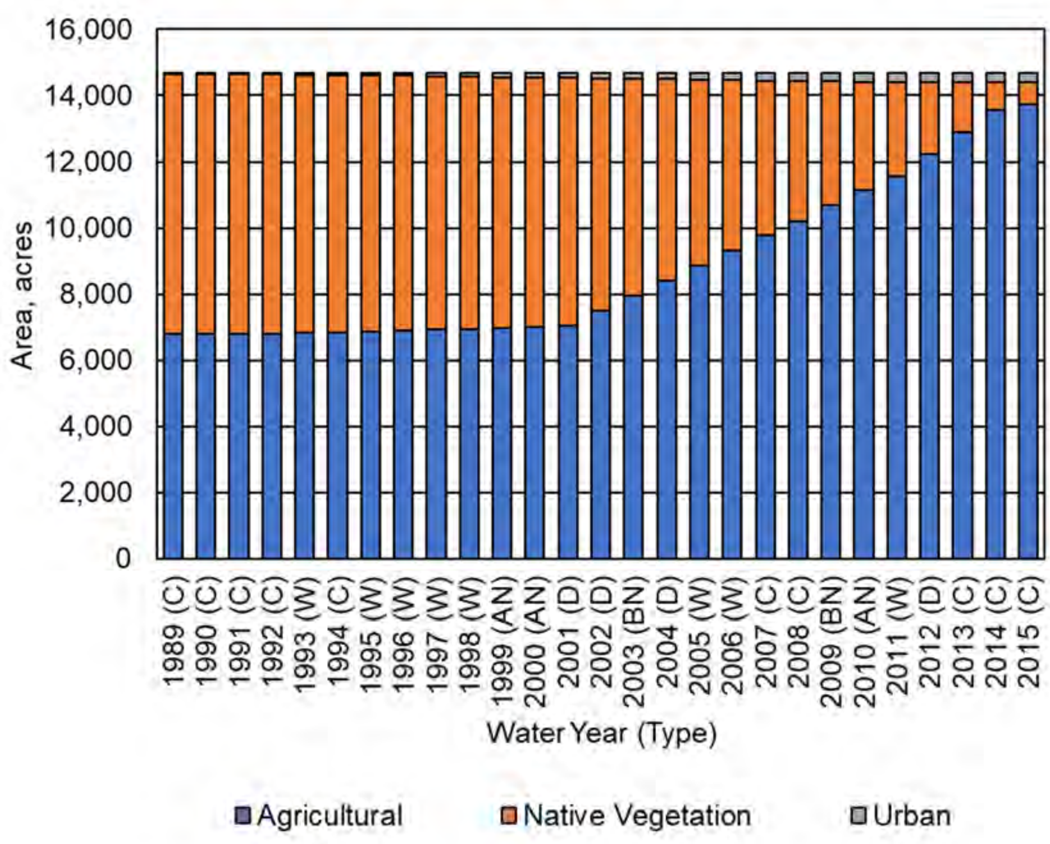

Figure A2.F.e-3. Triangle T Water District GSA Land Use Areas

Table A2.F.e-1. Triangle T Water District GSA Land Use Areas, acres

Water Year (Type)	Agricultural	Native Vegetation[1]	Urban[2]	Total
1989 (C)	6,792	7,844	55	14,691
1990 (C)	6,809	7,825	56	14,691
1991 (C)	6,813	7,819	58	14,691
1992 (C)	6,815	7,814	61	14,691
1993 (W)	6,825	7,801	64	14,691
1994 (C)	6,842	7,780	69	14,691
1995 (W)	6,872	7,745	74	14,691

Water Year (Type)	Agricultural	Native Vegetation[1]	Urban[2]	Total
1996 (W)	6,898	7,704	89	14,691
1997 (W)	6,924	7,663	104	14,691
1998 (W)	6,950	7,622	119	14,691
1999 (AN)	6,976	7,580	134	14,691
2000 (AN)	7,002	7,539	149	14,691
2001 (D)	7,029	7,498	164	14,691
2002 (D)	7,484	7,030	177	14,691
2003 (BN)	7,938	6,563	190	14,691
2004 (D)	8,393	6,095	202	14,691
2005 (W)	8,849	5,626	215	14,691
2006 (W)	9,304	5,159	228	14,691
2007 (C)	9,759	4,691	241	14,691
2008 (C)	10,214	4,223	253	14,691
2009 (BN)	10,670	3,754	266	14,691
2010 (AN)	11,125	3,287	279	14,691
2011 (W)	11,580	2,819	292	14,691
2012 (D)	12,243	2,159	288	14,691
2013 (C)	12,908	1,498	285	14,691
2014 (C)	13,571	838	281	14,691
2015 (C)	13,746	671	273	14,691
Average (1989-2014)	8,600	5,922	169	14,691

[1] Area includes land classified as native vegetation and water surfaces.
[2] Area includes land classified as urban, industrial, and semi-agricultural.

In TTWD GSA, water use sectors include agricultural, native vegetation, and urban land use. The urban land use category includes urban and semi-agricultural[3] lands as well as industrial land, which covers only a small area in the subbasin.

As indicated, the majority of land in TTWD GSA is currently used for agriculture, covering approximately 13,700 acres in 2015. Much of this land has gone into agricultural production since the early 2000s, largely replacing native vegetation in the GSA.

Agricultural land uses are further detailed in Figure A2.F.e-4 and Table A2.F.e-2. In the 1990s, a majority of the agricultural area in TTWD GSA was used to cultivate alfalfa, mixed pasture, and miscellaneous field crops. In recent years, these crops have been increasingly replaced by orchard crops, which expanded from less than 100 acres in 1989 to over 11,000 acres in 2015.

[3] As defined in the DWR county land use surveys, semi-agricultural land use subclasses include farmsteads, livestock feed lot operations, dairies, poultry farms, and miscellaneous semi-agricultural land use incidental to agriculture (small roads, ditches, non-planted areas of cropped fields (DWR, 2009).

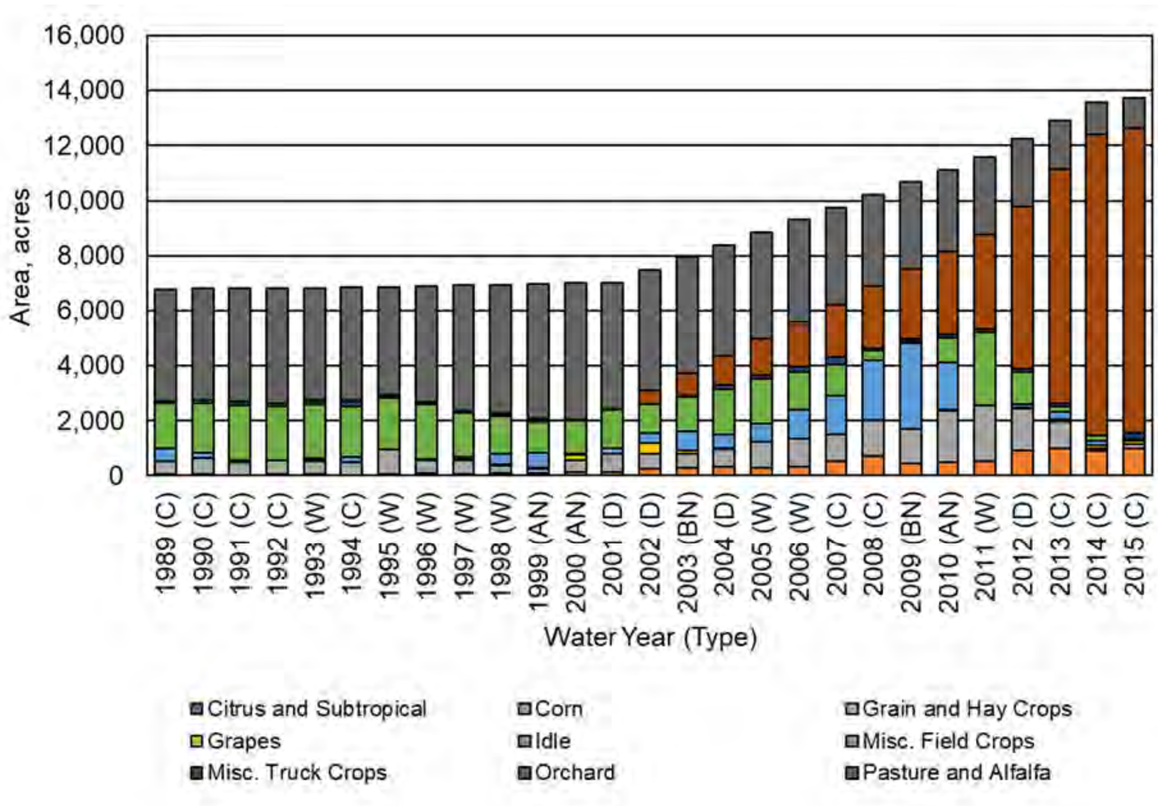

Figure A2.F.e-4. Triangle T Water District GSA Agricultural Land Use Areas

Table A2.F.e-2. Triangle T Water District GSA Agricultural Land Use Areas

Water Year (Type)	Citrus and Subtropical	Corn	Grain and Hay Crops	Grapes	Idle	Misc. Field Crops	Misc. Truck Crops	Orchard	Pasture and Alfalfa	Total
1989 (C)	0	45	463	5	473	1,643	65	16	4,083	6,792
1990 (C)	0	38	593	5	220	1,767	124	17	4,044	6,809
1991 (C)	0	35	439	5	96	1,989	116	21	4,111	6,813
1992 (C)	0	38	514	6	24	1,925	129	16	4,162	6,815
1993 (W)	0	40	500	6	89	1,964	127	16	4,082	6,825
1994 (C)	0	37	456	6	166	1,872	183	16	4,105	6,842
1995 (W)	0	38	905	7	12	1,886	72	16	3,935	6,872
1996 (W)	0	77	502	7	26	1,976	64	20	4,225	6,898
1997 (W)	5	59	509	16	75	1,616	78	24	4,543	6,924
1998 (W)	0	86	301	7	396	1,369	82	28	4,682	6,950
1999 (AN)	0	104	131	75	509	1,172	66	32	4,888	6,976
2000 (AN)	4	127	426	214	14	1,207	12	44	4,954	7,002
2001 (D)	0	118	677	7	201	1,410	1	39	4,576	7,029
2002 (D)	9	247	545	397	325	1,069	18	477	4,398	7,484
2003 (BN)	0	278	532	124	683	1,253	53	795	4,220	7,938
2004 (D)	0	313	643	37	508	1,623	183	1,043	4,043	8,393
2005 (W)	0	295	920	13	661	1,631	139	1,326	3,865	8,849
2006 (W)	0	350	985	3	1,052	1,386	206	1,635	3,687	9,304
2007 (C)	0	545	943	3	1,421	1,117	287	1,932	3,510	9,759
2008 (C)	0	730	1,279	12	2,194	349	54	2,263	3,332	10,214
2009 (BN)	0	452	1,248	2	3,125	57	104	2,528	3,155	10,670
2010 (AN)	0	499	1,879	11	1,746	898	121	2,994	2,977	11,125
2011 (W)	0	532	2,043	0	1	2,643	130	3,431	2,799	11,580
2012 (D)	0	921	1,505	36	137	1,167	128	5,888	2,461	12,243
2013 (C)	0	993	979	72	271	221	115	8,490	1,767	12,908
2014 (C)	0	900	108	108	155	189	11	10,925	1,174	13,571
2015 (C)	0	1,004	136	126	70	3	232	11,051	1,126	13,746
Average (1989-2014)	1	304	770	46	561	1,362	103	1,694	3,761	8,600

3.2 Surface Water System Water Budget

This section presents surface water system water budget components within TTWD GSA as per GSP regulations. These are followed by a summary of the water budget results by accounting center.

3.2.1 Inflows

3.2.1.1 Surface Water Inflow by Water Source Type

Surface water inflows include surface water flowing into TTWD GSA across the subregion boundary. Per the Regulations, surface inflows must be reported by water source type. According to the Regulations:

> *"Water source type" represents the source from which water is derived to meet the applied beneficial uses, including groundwater, recycled water, reused water, and surface water sources identified as Central Valley Project, the State Water Project, the Colorado River Project, local supplies, and local imported supplies.*

Additionally, runoff of precipitation from upgradient areas adjacent to the subregion represents a potential source of surface water inflow.

Local Supplies

Local supply inflows to TTWD GSA include inflows along Fresno River and Chowchilla Bypass.

CVP Supplies

CVP supply inflows to TTWD GSA include flood releases from Buchanan Dam and Millerton Reservoir that enter the subregion along Berenda Slough.

Recycling and Reuse

Recycling and reuse are not a significant source of supply within TTWD GSA.

Other Surface Inflows

For the water budgets presented herein, precipitation runoff from outside the subregion is considered relatively minimal and is expected to pass through the waterways accounted above following relatively large storm events. Precipitation runoff from lands inside the subregion is internal to the surface water system and is thus not considered as surface inflows to the subregion boundary.

Summary of Surface Inflows

The surface water inflows described above are summarized by water source type in Figure A2.F.e-5 and Table A2.F.e-3. During the study period, total surface water inflows vary by water year type, averaging 747 thousand acre-feet (taf) per wet year.

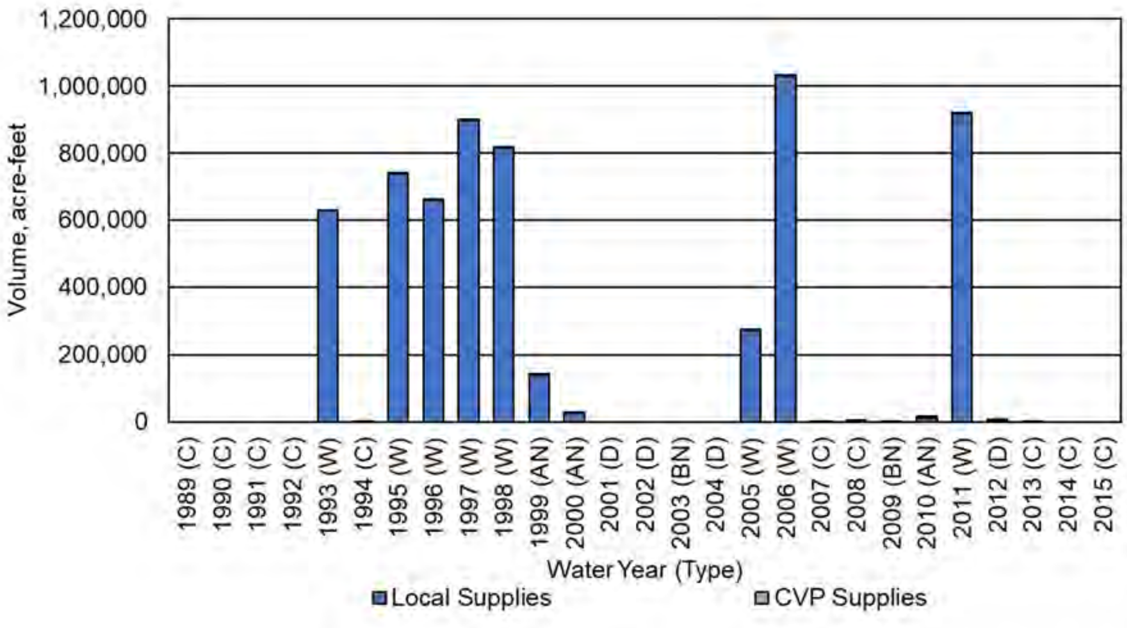

Figure A2.F.e-5. Triangle T Water District GSA Surface Water Inflows by Water Source Type.

Table A2.F.e-3. Triangle T Water District GSA Surface Water Inflows by Water Source Type (Acre-Feet).

Water Year (Type)	Local Supply	CVP Supply[1]	Total
1989 (C)	0	0	0
1990 (C)	0	0	0
1991 (C)	0	0	0
1992 (C)	0	0	0
1993 (W)	630,140	0	630,140
1994 (C)	0	870	870
1995 (W)	739,540	1,320	740,860
1996 (W)	660,590	900	661,490
1997 (W)	897,730	1,920	899,650
1998 (W)	815,570	2,820	818,390
1999 (AN)	141,120	660	141,780
2000 (AN)	27,460	270	27,730
2001 (D)	0	0	0
2002 (D)	0	0	0
2003 (BN)	0	0	0
2004 (D)	0	0	0
2005 (W)	274,160	360	274,520
2006 (W)	1,030,340	1,320	1,031,660
2007 (C)	3,380	0	3,380
2008 (C)	2,320	20	2,330
2009 (BN)	620	500	1,120

Water Year (Type)	Local Supply	CVP Supply[1]	Total
2010 (AN)	10,710	6,160	16,870
2011 (W)	916,970	2,620	919,590
2012 (D)	5,960	850	6,810
2013 (C)	1,040	510	1,550
2014 (C)	0	0	0
2015 (C)	0	0	0
Average (1989-2014)	236,830	810	237,640
Average (1989-2014) W	745,630	1,410	747,040
Average (1989-2014) AN	59,760	2,360	62,130
Average (1989-2014) BN	310	250	560
Average (1989-2014) D	1,490	210	1,700
Average (1989-2014) C	750	150	900

1. CVP Supply is considered as all water supply released from CVP storage facilities. The volume of CVP Supply includes CVP deliveries to CWD, and flood releases from CVP facilities that pass through the subbasin. In Triangle T Water District GSA, all CVP supply pass through the GSA.

3.2.1.2 Precipitation

Precipitation estimates for TTWD GSA are provided in Figure A2.F.e-6 and Table A2.F.e- 4. Precipitation estimates are reported by water use sector.

Total precipitation is highly variable between years in the study area, ranging from approximately 9 taf (7 inches) during average dry years to 17 taf (14 inches) during average wet years.

3.2.1.3 Groundwater Extraction by Water Use Sector

Estimates of groundwater extraction by water use sector are provided in Figure A2.F.e-7 and Table A2.F.e-5. For agricultural and urban (urban, semi-agricultural, industrial) lands, groundwater extraction represents pumping, while for native lands, groundwater extraction by riparian vegetation was considered to be negligible. In all water use sector water budgets, groundwater extraction served as the water budget closure term. Groundwater extraction is dominated by irrigated agriculture and increases over time, following the trend of increasing orchard acreage in the subregion. The consumptive water use of orchards is higher than most other crops grown in the subbasin, and groundwater serves as a major source of supply for the pressurized irrigation systems typical of orchards. During wet years, groundwater extraction is reduced in months when surface water is available to water rights users.

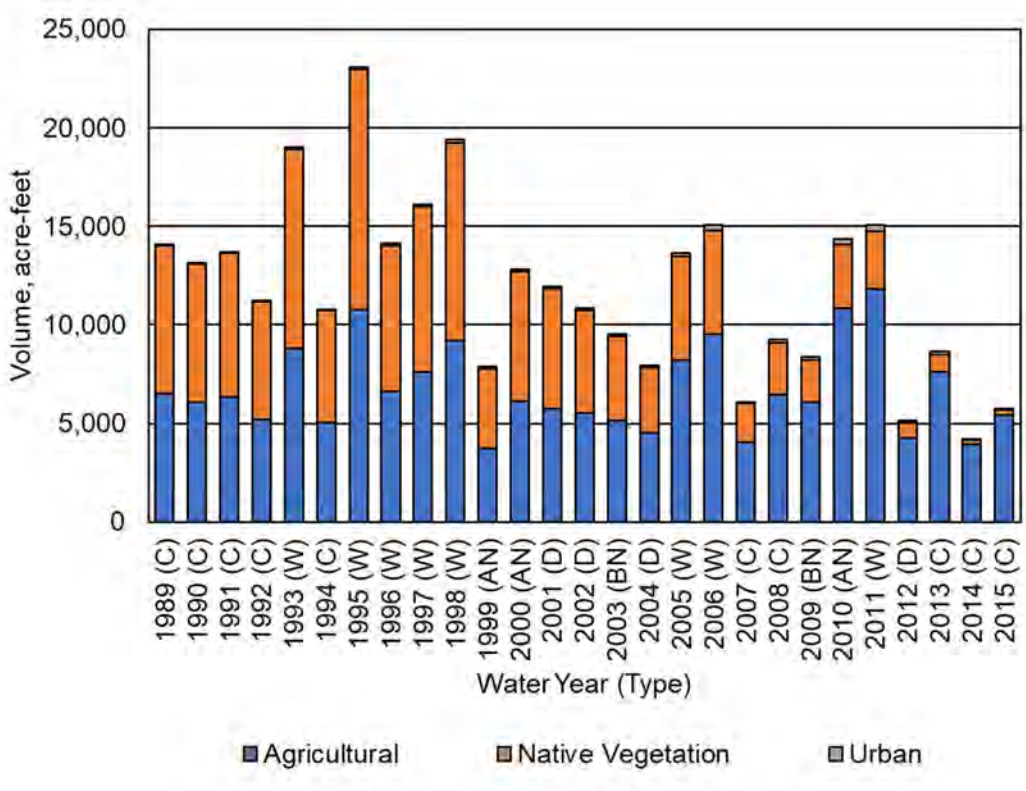

Figure A2.F.e-6. Triangle T Water District GSA Precipitation by Water Use Sector.

Table A2.F.e-4. Triangle T Water District GSA Precipitation by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	6,510	7,530	50	14,090
1990 (C)	6,090	7,000	50	13,140
1991 (C)	6,370	7,310	60	13,730
1992 (C)	5,200	5,970	50	11,210
1993 (W)	8,830	10,100	80	19,010
1994 (C)	5,010	5,710	50	10,770
1995 (W)	10,810	12,190	120	23,110
1996 (W)	6,630	7,410	90	14,130
1997 (W)	7,610	8,420	110	16,140
1998 (W)	9,180	10,070	160	19,410
1999 (AN)	3,740	4,060	70	7,870
2000 (AN)	6,110	6,590	130	12,830
2001 (D)	5,730	6,110	130	11,970
2002 (D)	5,530	5,200	130	10,860
2003 (BN)	5,150	4,260	120	9,540
2004 (D)	4,530	3,290	110	7,930
2005 (W)	8,230	5,240	200	13,670
2006 (W)	9,530	5,290	230	15,060
2007 (C)	4,050	1,950	100	6,100
2008 (C)	6,440	2,670	160	9,260

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
2009 (BN)	6,070	2,140	150	8,360
2010 (AN)	10,880	3,220	270	14,370
2011 (W)	11,860	2,890	300	15,050
2012 (D)	4,270	750	100	5,120
2013 (C)	7,610	880	170	8,660
2014 (C)	3,910	240	80	4,230
2015 (C)	5,400	260	110	5,770
Average (1989-2014)	6,760	5,250	130	12,140
Average (1989-2014) W	9,080	7,700	160	16,950
Average (1989-2014) AN	6,910	4,620	160	11,690
Average (1989-2014) BN	5,610	3,200	140	8,950
Average (1989-2014) D	5,010	3,840	120	8,970
Average (1989-2014) C	5,690	4,360	80	10,130

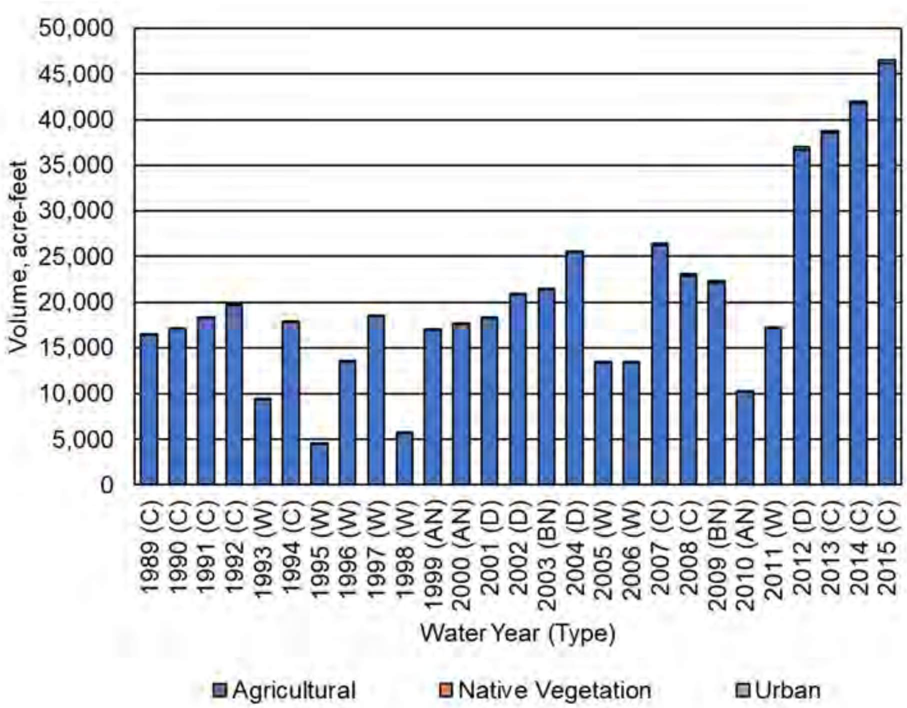

Figure A2.F.e-7. Triangle T Water District GSA Groundwater Extraction by Water Use Sector.

Table A2.F.e-5. Triangle T Water District GSA Groundwater Extraction by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	16,394	0	31	16,425
1990 (C)	17,065	0	33	17,098
1991 (C)	18,175	0	39	18,214
1992 (C)	19,632	0	47	19,679
1993 (W)	9,383	0	36	9,419
1994 (C)	17,755	0	48	17,803
1995 (W)	4,526	0	24	4,550
1996 (W)	13,425	0	50	13,475
1997 (W)	18,475	0	92	18,567
1998 (W)	5,703	0	50	5,753
1999 (AN)	16,940	0	97	17,037
2000 (AN)	17,613	0	91	17,704
2001 (D)	18,213	0	98	18,311
2002 (D)	20,786	0	135	20,921
2003 (BN)	21,344	0	137	21,481
2004 (D)	25,414	0	190	25,604
2005 (W)	13,324	0	119	13,443
2006 (W)	13,319	0	120	13,439
2007 (C)	26,217	0	212	26,429
2008 (C)	22,910	0	211	23,121
2009 (BN)	22,076	0	215	22,291
2010 (AN)	10,222	0	120	10,342
2011 (W)	17,120	0	134	17,254
2012 (D)	36,765	0	252	37,017
2013 (C)	38,526	0	243	38,769
2014 (C)	41,814	0	239	42,053
2015 (C)	46,248	0	264	46,512
Average (1989-2014)	19,351	0	118	19,469
Average (1989-2014) W	11,909	0	78	11,988
Average (1989-2014) AN	14,925	0	103	15,027
Average (1989-2014) BN	21,710	0	176	21,886
Average (1989-2014) D	25,295	0	169	25,463
Average (1989-2014) C	24,276	0	123	24,399

3.2.1.4 Groundwater Discharge to Surface Water Sources

The depth to groundwater is greater than 100-200 ft across much of the Chowchilla Subbasin. Given the depth to the water table in the Chowchilla Subbasin, groundwater discharge to surface water sources is negligible.

3.2.2 Outflows

3.2.2.1 Evapotranspiration by Water Use Sector

Evapotranspiration (ET) by water use sector is reported in Figures A2.F.e-8 to A2.F.e-10 and Tables A2.F.e-6 to A2.F.e-8. First, total ET is reported, followed by ET from applied water and ET from precipitation.

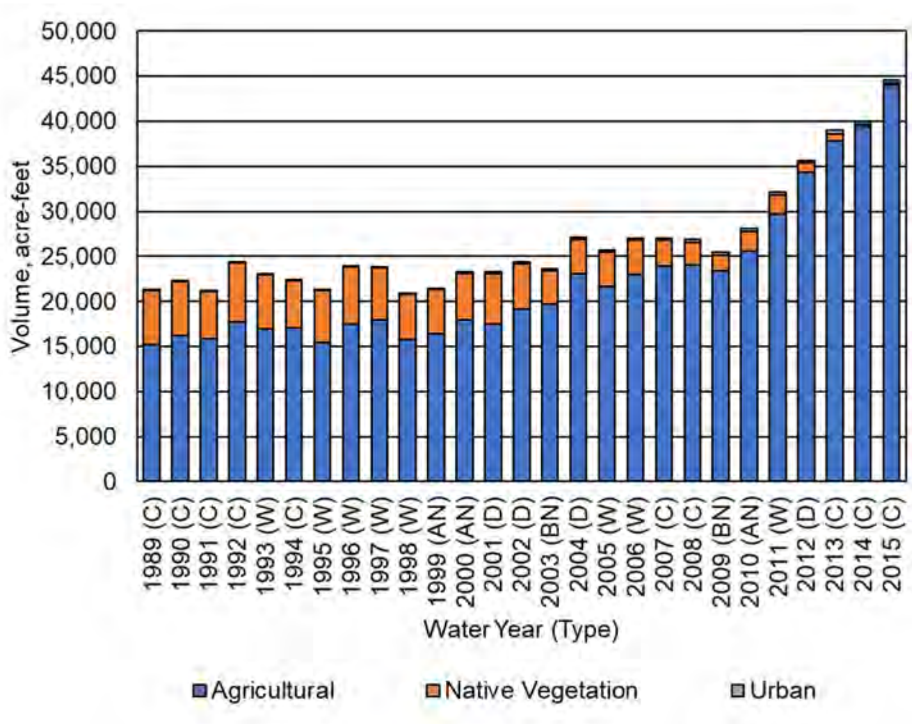

Figure A2.F.e-8. Triangle T Water District GSA Evapotranspiration by Water Use Sector.

Table A2.F.e-6. Triangle T Water District GSA Evapotranspiration by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	15,240	5,940	70	21,250
1990 (C)	16,200	5,980	70	22,250
1991 (C)	15,850	5,320	70	21,240
1992 (C)	17,770	6,560	80	24,410
1993 (W)	16,930	6,090	80	23,100
1994 (C)	17,050	5,240	80	22,370
1995 (W)	15,480	5,790	80	21,350
1996 (W)	17,510	6,320	100	23,930
1997 (W)	17,970	5,720	120	23,810
1998 (W)	15,720	5,030	120	20,870
1999 (AN)	16,460	4,850	140	21,450
2000 (AN)	17,950	5,180	170	23,300
2001 (D)	17,480	5,590	190	23,260
2002 (D)	19,130	5,010	210	24,350

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
2003 (BN)	19,700	3,710	220	23,630
2004 (D)	23,050	3,800	260	27,110
2005 (W)	21,690	3,790	240	25,720
2006 (W)	22,940	3,850	260	27,050
2007 (C)	23,960	2,810	270	27,040
2008 (C)	24,070	2,480	310	26,860
2009 (BN)	23,360	1,800	310	25,470
2010 (AN)	25,550	2,210	300	28,060
2011 (W)	29,700	2,110	310	32,120
2012 (D)	34,350	1,020	290	35,660
2013 (C)	37,800	830	340	38,970
2014 (C)	39,430	250	280	39,960
2015 (C)	44,010	230	310	44,550
Average (1989-2014)	21,630	4,130	190	25,950
Average (1989-2014) W	19,740	4,840	170	24,750
Average (1989-2014) AN	19,990	4,080	200	24,270
Average (1989-2014) BN	21,540	2,750	270	24,560
Average (1989-2014) D	23,500	3,850	230	27,580
Average (1989-2014) C	23,040	3,930	180	27,150

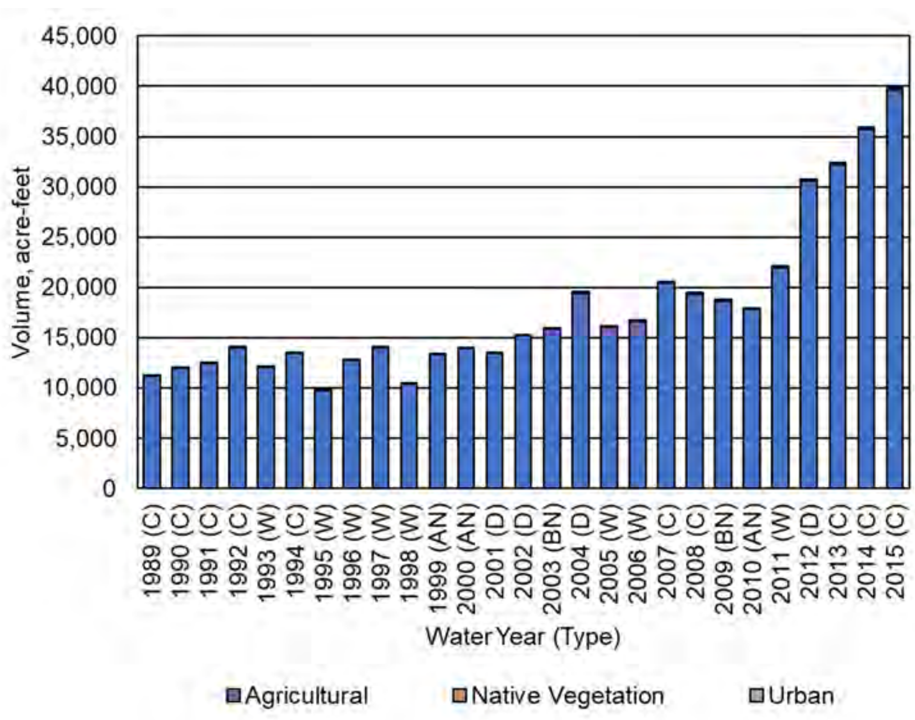

Figure A2.F.e-9. Triangle T Water District GSA Evapotranspiration of Applied Water by Water Use Sector.

Table A2.F.e-7. Triangle T Water District GSA Evapotranspiration of Applied Water by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	11,200	0	30	11,230
1990 (C)	11,960	0	30	11,990
1991 (C)	12,450	0	30	12,480
1992 (C)	14,060	0	40	14,100
1993 (W)	12,050	0	30	12,080
1994 (C)	13,470	0	40	13,510
1995 (W)	9,690	0	20	9,710
1996 (W)	12,730	0	30	12,760
1997 (W)	14,020	0	50	14,070
1998 (W)	10,400	0	50	10,450
1999 (AN)	13,360	0	60	13,420
2000 (AN)	13,900	0	80	13,980
2001 (D)	13,390	0	80	13,470
2002 (D)	15,180	0	100	15,280
2003 (BN)	15,850	0	120	15,970
2004 (D)	19,440	0	150	19,590
2005 (W)	16,040	0	110	16,150
2006 (W)	16,610	0	110	16,720
2007 (C)	20,470	0	140	20,610
2008 (C)	19,350	0	180	19,530
2009 (BN)	18,580	0	190	18,770
2010 (AN)	17,830	0	130	17,960
2011 (W)	21,990	0	110	22,100
2012 (D)	30,550	0	160	30,710
2013 (C)	32,260	0	200	32,460
2014 (C)	35,700	0	200	35,900
2015 (C)	39,670	0	220	39,890
Average (1989-2014)	17,020	0	90	17,110
Average (1989-2014) W	14,190	0	70	14,260
Average (1989-2014) AN	15,030	0	90	15,120
Average (1989-2014) BN	17,220	0	160	17,380
Average (1989-2014) D	19,640	0	120	19,760
Average (1989-2014) C	18,990	0	100	19,090

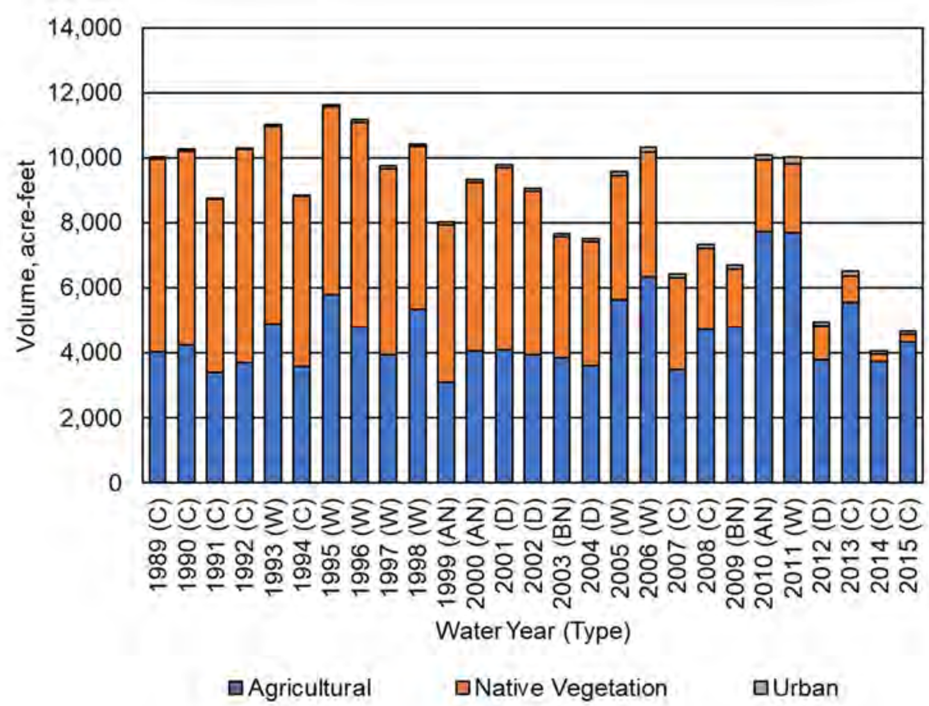

Figure A2.F.e-10. Triangle T Water District GSA Evapotranspiration of Precipitation by Water Use Sector.

Table A2.F.e-8. Triangle T Water District GSA Evapotranspiration of Precipitation by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	4,040	5,940	40	10,020
1990 (C)	4,240	5,980	40	10,260
1991 (C)	3,400	5,320	40	8,760
1992 (C)	3,710	6,560	40	10,310
1993 (W)	4,880	6,090	50	11,020
1994 (C)	3,580	5,240	40	8,860
1995 (W)	5,790	5,790	60	11,640
1996 (W)	4,780	6,320	70	11,170
1997 (W)	3,950	5,720	70	9,740
1998 (W)	5,320	5,030	70	10,420
1999 (AN)	3,100	4,850	80	8,030
2000 (AN)	4,050	5,180	90	9,320
2001 (D)	4,090	5,590	110	9,790
2002 (D)	3,950	5,010	110	9,070
2003 (BN)	3,850	3,710	100	7,660
2004 (D)	3,610	3,800	110	7,520
2005 (W)	5,650	3,790	130	9,570
2006 (W)	6,330	3,850	150	10,330
2007 (C)	3,490	2,810	130	6,430
2008 (C)	4,720	2,480	130	7,330
2009 (BN)	4,780	1,800	120	6,700
2010 (AN)	7,720	2,210	170	10,100

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
2011 (W)	7,710	2,110	200	10,020
2012 (D)	3,800	1,020	130	4,950
2013 (C)	5,540	830	140	6,510
2014 (C)	3,730	250	80	4,060
2015 (C)	4,340	230	90	4,660
Average (1989-2014)	4,610	4,130	100	8,840
Average (1989-2014) W	5,550	4,840	100	10,490
Average (1989-2014) AN	4,960	4,080	110	9,150
Average (1989-2014) BN	4,320	2,750	110	7,180
Average (1989-2014) D	3,860	3,850	110	7,820
Average (1989-2014) C	4,050	3,930	80	8,060

Total ET varies between years, with the lowest observed in 1998, at less than 21 taf, and greatest in 2015, at approximately 45 taf. Total ET generally increases over time, again following the trend of increasing orchard acreage.

In addition to ET from land surfaces, estimates of evaporation from TTWD GSA rivers and streams are reported in Figure A2.F.e-11 and Table A2.F.e-9. Evaporation from the Rivers and Streams System includes evaporation of both surface inflows and of precipitation runoff within local sloughs and depressions. Total evaporation from all sources averaged less than 1 taf per year between 1989 and 2014.

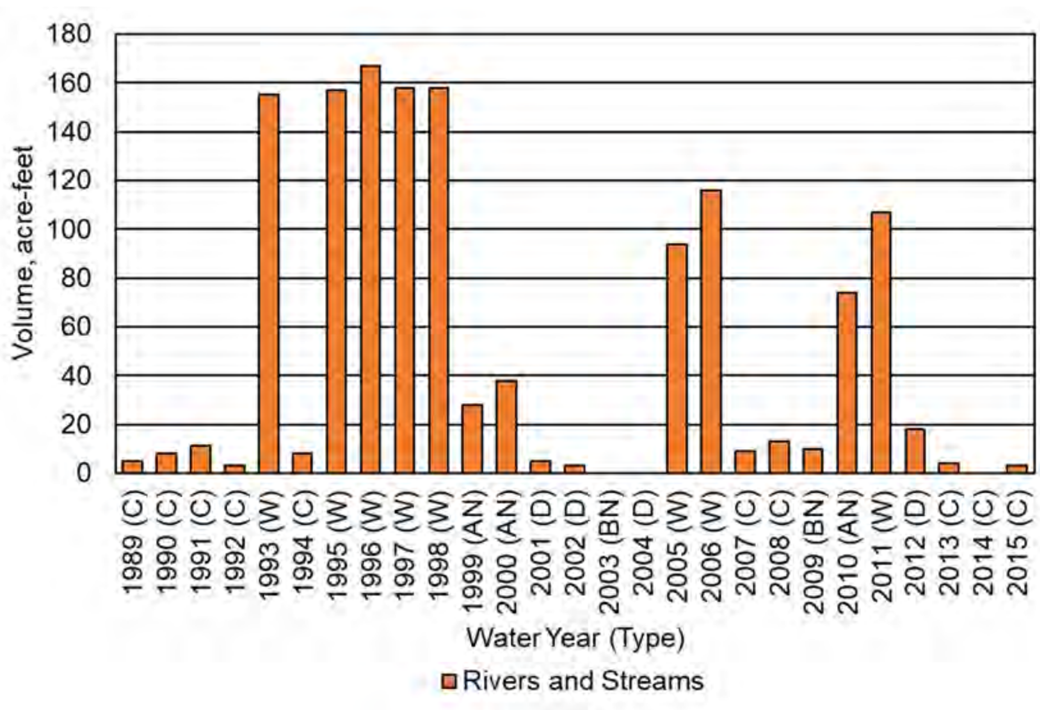

Figure A2.F.e-11. Triangle T Water District GSA Evaporation from the Surface Water System.

Table A2.F.e-9. Triangle T Water District GSA Evaporation from the Surface Water System (Acre-Feet).

Water Year (Type)	Rivers and Streams[1]
1989 (C)	10
1990 (C)	10
1991 (C)	10
1992 (C)	0
1993 (W)	160
1994 (C)	10
1995 (W)	160
1996 (W)	170
1997 (W)	160
1998 (W)	160
1999 (AN)	30
2000 (AN)	40
2001 (D)	10
2002 (D)	0
2003 (BN)	0
2004 (D)	0
2005 (W)	90
2006 (W)	120
2007 (C)	10
2008 (C)	10
2009 (BN)	10
2010 (AN)	70
2011 (W)	110
2012 (D)	20
2013 (C)	0
2014 (C)	0
2015 (C)	0
Average (1989-2014)	50
Average (1989-2014) W	140
Average (1989-2014) AN	50
Average (1989-2014) BN	10
Average (1989-2014) D	10
Average (1989-2014) C	10

[1] Includes evaporation of surface inflows and of precipitation runoff.

3.2.2.2 Surface Water Outflow by Water Source Type

Surface water outflows by water source type are summarized in Figure A2.F.e-12 and Table A2.F.e-10. In TTWD GSA, runoff of applied water is assumed negligible and runoff of precipitation is collected in waterways within TTWD GSA, with most infiltrating to the groundwater system except following the largest storm events. Thus, surface outflows from the GSA are expected to be a mixture of local supplies and CVP supplies along Eastside Bypass and Fresno River. Between 1989 and 2014, these combined outflows averaged approximately 726 taf during wet years.

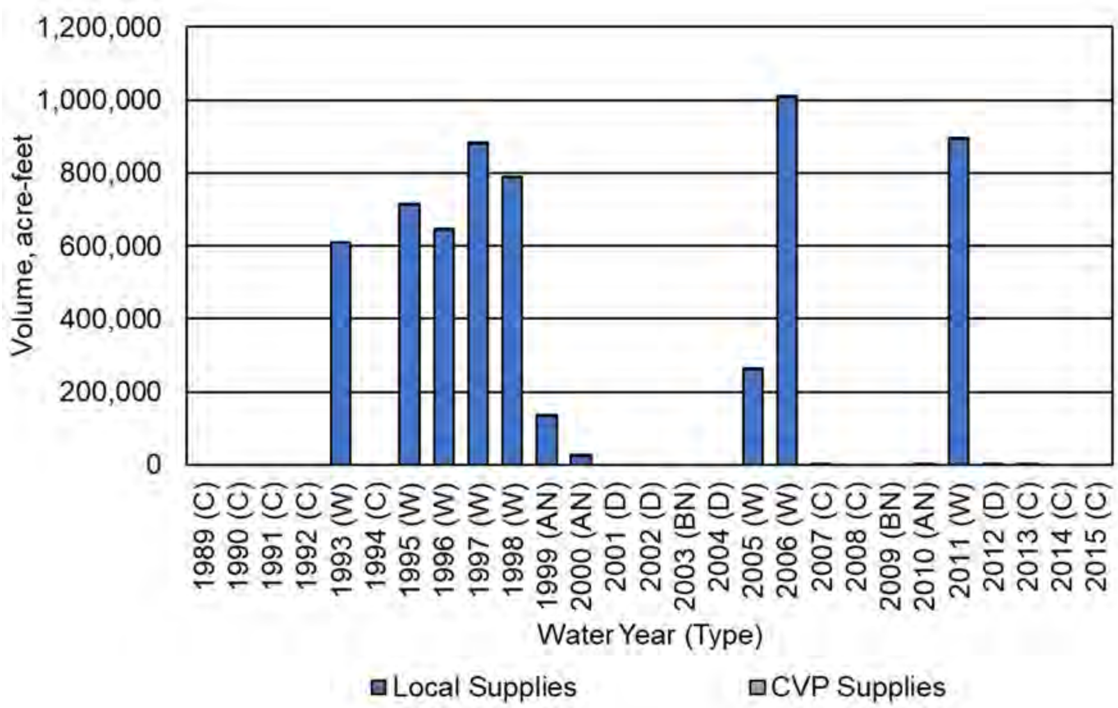

Figure A2.F.e-12. Triangle T Water District GSA Surface Outflows by Water Source Type.

Table A2.F.e-10. Triangle T Water District GSA Surface Outflows by Water Source Type (Acre-Feet).

Water Year (Type)	Local Supplies	CVP Supplies	Total
1989 (C)	0	0	0
1990 (C)	0	0	0
1991 (C)	0	0	0
1992 (C)	0	0	0
1993 (W)	609,400	0	609,400
1994 (C)	0	0	0
1995 (W)	712,830	1,280	714,110
1996 (W)	642,890	840	643,730
1997 (W)	882,030	1,870	883,900
1998 (W)	786,740	2,690	789,430
1999 (AN)	134,560	640	135,200
2000 (AN)	23,670	250	23,920
2001 (D)	0	0	0
2002 (D)	0	0	0
2003 (BN)	0	0	0
2004 (D)	0	0	0
2005 (W)	260,810	350	261,160
2006 (W)	1,009,250	1,260	1,010,510
2007 (C)	1,740	0	1,740
2008 (C)	0	0	0
2009 (BN)	0	0	0
2010 (AN)	370	0	370

Water Year (Type)	Local Supplies	CVP Supplies	Total
2011 (W)	892,570	740	893,310
2012 (D)	3,900	0	3,900
2013 (C)	270	0	270
2014 (C)	0	0	0
2015 (C)	0	0	0
Average (1989-2014)	229,270	380	229,650
Average (1989-2014) W	724,570	1,130	725,690
Average (1989-2014) AN	52,870	300	53,160
Average (1989-2014) BN	0	0	0
Average (1989-2014) D	980	0	980
Average (1989-2014) C	220	0	220

3.2.2.3 Infiltration of Precipitation

Estimated infiltration of precipitation (deep percolation of precipitation) by water use sector is provided in Figure A2.F.e-13 and Table A2.F.e-11. Infiltration of precipitation to the groundwater system is highly variable from year to year due to variation in the timing and amount of precipitation, ranging from less than 2 taf annually during some critical and dry years to over 8 taf during 1995.

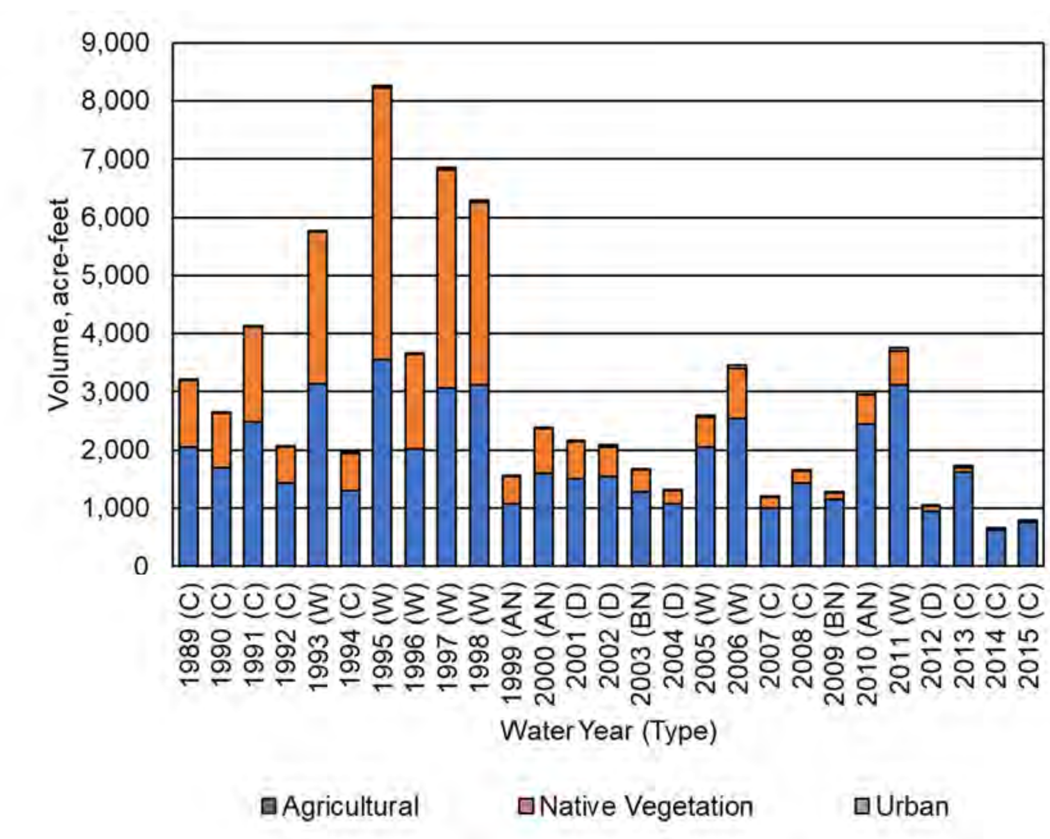

Figure A2.F.e-13. Triangle T Water District GSA Infiltration of Precipitation by Water Use Sector.

Table A2.F.e-11. Triangle T Water District GSA Infiltration of Precipitation by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	2,050	1,150	10	3,210
1990 (C)	1,690	940	10	2,640
1991 (C)	2,490	1,630	20	4,140
1992 (C)	1,430	620	10	2,060
1993 (W)	3,130	2,610	20	5,760
1994 (C)	1,310	630	10	1,950
1995 (W)	3,560	4,660	40	8,260
1996 (W)	2,010	1,640	20	3,670
1997 (W)	3,070	3,750	40	6,860
1998 (W)	3,120	3,130	50	6,300
1999 (AN)	1,080	460	10	1,550
2000 (AN)	1,600	770	20	2,390
2001 (D)	1,510	630	20	2,160
2002 (D)	1,540	520	20	2,080
2003 (BN)	1,280	370	20	1,670
2004 (D)	1,080	220	20	1,320
2005 (W)	2,050	510	30	2,590
2006 (W)	2,530	870	50	3,450
2007 (C)	1,010	180	20	1,210
2008 (C)	1,430	210	20	1,660
2009 (BN)	1,150	120	20	1,290
2010 (AN)	2,450	500	60	3,010
2011 (W)	3,120	580	60	3,760
2012 (D)	940	90	20	1,050
2013 (C)	1,620	80	30	1,730
2014 (C)	630	10	10	650
2015 (C)	760	20	10	790
Average (1989-2014)	1,880	1,030	30	2,940
Average (1989-2014) W	2,820	2,220	40	5,080
Average (1989-2014) AN	1,710	580	30	2,320
Average (1989-2014) BN	1,220	250	20	1,490
Average (1989-2014) D	1,270	370	20	1,660
Average (1989-2014) C	1,520	610	20	2,150

3.2.2.4 Infiltration of Surface Water

Estimated infiltration of surface water (seepage) by source is provided in Figure A2.F.e-14 and Table A2.F.e-12. Seepage from the Rivers and Streams System includes seepage of both surface inflows and of precipitation runoff into local sloughs and depressions. Seepage from rivers and streams follows the pattern of surface water inflows, averaging approximately 10 taf per wet year between 1989 and 2014.

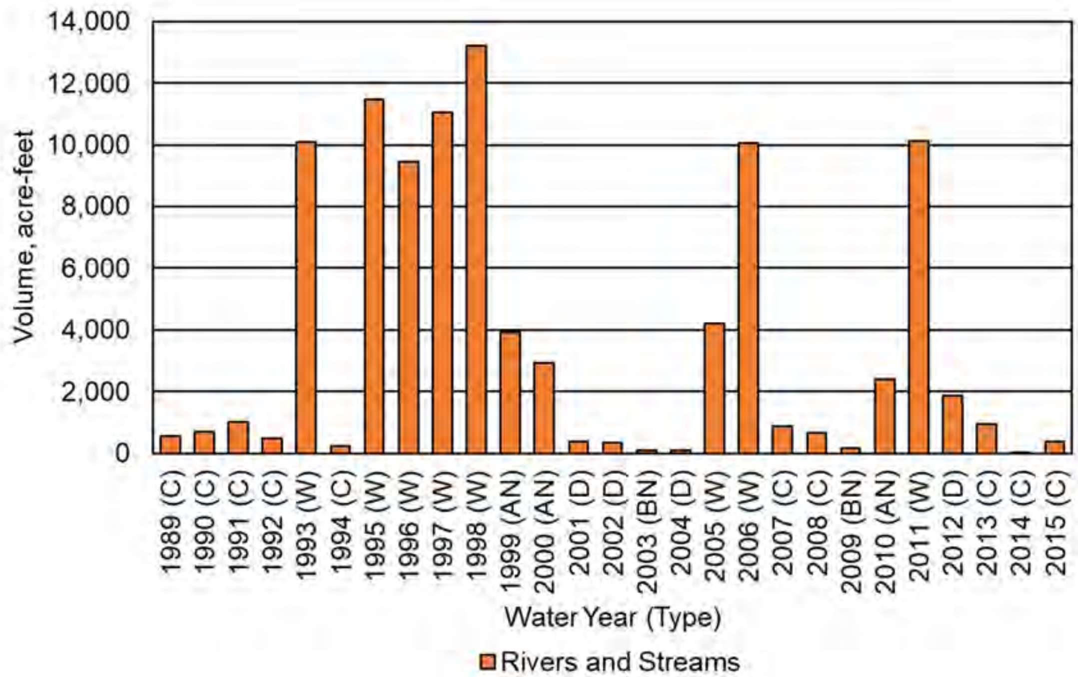

Figure A2.F.e-14. Triangle T Water District GSA Infiltration of Surface Water.

Table A2.F.e-12. Triangle T Water District GSA Infiltration of Surface Water (Acre-Feet).

Water Year (Type)	Rivers and Streams[1]
1989 (C)	540
1990 (C)	690
1991 (C)	1,010
1992 (C)	480
1993 (W)	10,110
1994 (C)	240
1995 (W)	11,470
1996 (W)	9,440
1997 (W)	11,040
1998 (W)	13,210
1999 (AN)	3,910
2000 (AN)	2,920
2001 (D)	370
2002 (D)	330
2003 (BN)	100
2004 (D)	80
2005 (W)	4,210
2006 (W)	10,070
2007 (C)	890
2008 (C)	660
2009 (BN)	150
2010 (AN)	2,390
2011 (W)	10,140

Water Year (Type)	Rivers and Streams[1]
2012 (D)	1,880
2013 (C)	940
2014 (C)	30
2015 (C)	390
Average (1989-2014)	3,740
Average (1989-2014) W	9,960
Average (1989-2014) AN	3,070
Average (1989-2014) BN	130
Average (1989-2014) D	670
Average (1989-2014) C	610

[1] Includes infiltration of surface inflows and of precipitation runoff within the subregion. To calculate Net Recharge from SWS below, Rivers and Streams System seepage is summed across the subbasin and redistributed to each subregion in proportion to gross area.

3.2.2.5 Infiltration of Applied Water

Estimated infiltration of applied water (deep percolation of applied water) by water use sector is provided in Figure A2.F.e-15 and Table A2.F.e-13. Infiltration of applied water is dominated by agricultural irrigation and has increased over time due to the expansion of agriculture land in the GSA.

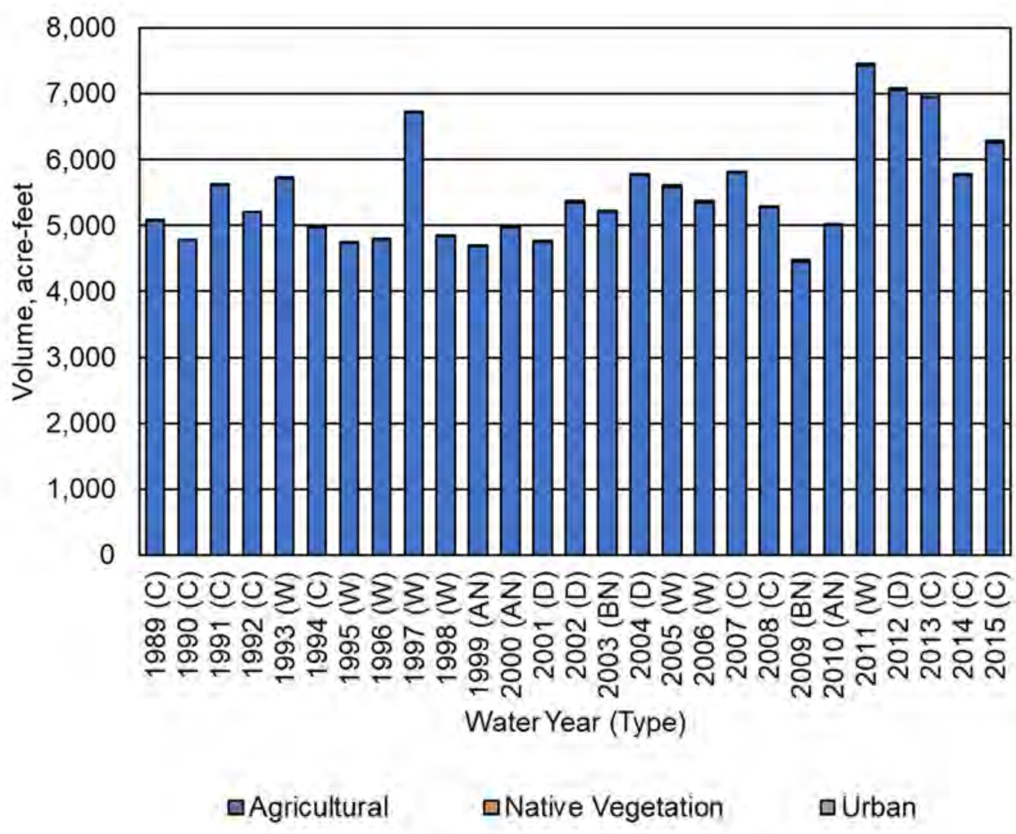

Figure A2.F.e-15. Triangle T Water District GSA Infiltration of Applied Water by Water Use Sector.

Table A2.F.e-13. Triangle T Water District GSA Infiltration of Applied Water by Water Use Sector (Acre-Feet).

Water Year (Type)	Agricultural	Native Vegetation	Urban	Total
1989 (C)	5,080	0	10	5,090
1990 (C)	4,790	0	0	4,790
1991 (C)	5,620	0	10	5,630
1992 (C)	5,210	0	0	5,210
1993 (W)	5,710	0	10	5,720
1994 (C)	4,980	0	10	4,990
1995 (W)	4,730	0	10	4,740
1996 (W)	4,790	0	10	4,800
1997 (W)	6,720	0	20	6,740
1998 (W)	4,830	0	20	4,850
1999 (AN)	4,690	0	10	4,700
2000 (AN)	4,970	0	20	4,990
2001 (D)	4,750	0	20	4,770
2002 (D)	5,350	0	20	5,370
2003 (BN)	5,210	0	20	5,230
2004 (D)	5,760	0	20	5,780
2005 (W)	5,580	0	30	5,610
2006 (W)	5,350	0	30	5,380
2007 (C)	5,800	0	20	5,820
2008 (C)	5,270	0	30	5,300
2009 (BN)	4,450	0	30	4,480
2010 (AN)	5,000	0	30	5,030
2011 (W)	7,430	0	30	7,460
2012 (D)	7,050	0	30	7,080
2013 (C)	6,960	0	40	7,000
2014 (C)	5,760	0	30	5,790
2015 (C)	6,260	0	30	6,290
Average (1989-2014)	5,460	0	20	5,480
Average (1989-2014) W	5,640	0	20	5,660
Average (1989-2014) AN	4,890	0	20	4,910
Average (1989-2014) BN	4,830	0	30	4,860
Average (1989-2014) D	5,730	0	20	5,750
Average (1989-2014) C	5,500	0	20	5,520

3.2.3 Change in Surface Water System Storage

Estimates of change in SWS storage are provided in Figure A2.F.e-16 and Table A2.F.e-14. Inter-annual changes in storage within the surface water system consist primarily of root zone soil moisture storage changes, are relatively small, and tend to average near zero over many years. During wet years, change in SWS storage is estimated as higher during some months when estimated riparian deliveries satisfy much of the crop water demand, substantially reducing groundwater pumping estimates.

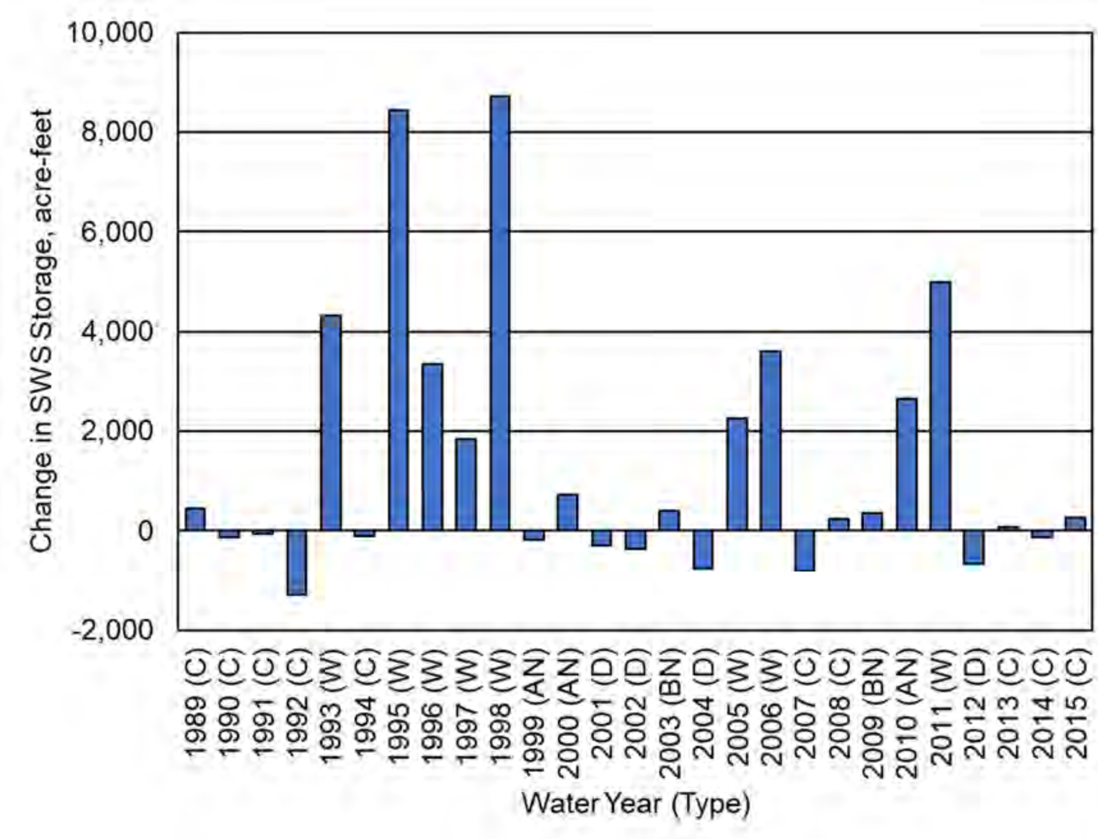

Figure A2.F.e-16. Triangle T Water District GSA Change in Surface Water System Storage.

Table A2.F.e-14. Triangle T Water District GSA Change in Surface Water System Storage (Acre-Feet).

Water Year (Type)	Change in SWS Storage
1989 (C)	440
1990 (C)	-140
1991 (C)	-60
1992 (C)	-1,280
1993 (W)	4,320
1994 (C)	-100
1995 (W)	8,440
1996 (W)	3,350
1997 (W)	1,840
1998 (W)	8,730
1999 (AN)	-170
2000 (AN)	720
2001 (D)	-280
2002 (D)	-350
2003 (BN)	410
2004 (D)	-760
2005 (W)	2,250
2006 (W)	3,590

Water Year (Type)	Change in SWS Storage
2007 (C)	-790
2008 (C)	250
2009 (BN)	360
2010 (AN)	2,650
2011 (W)	5,000
2012 (D)	-650
2013 (C)	70
2014 (C)	-140
2015 (C)	270
Average (1989-2014)	1,450
Average (1989-2014) W	4,690
Average (1989-2014) AN	1,070
Average (1989-2014) BN	390
Average (1989-2014) D	-510
Average (1989-2014) C	-190

3.3 Historical Water Budget Summary

Annual inflows, outflows, and change in SWS storage during the historical water budget period (1989-2014) are summarized in Figure A2.F.e-17 and Table A2.F.e-15. Inflows are shown as positive values, while outflows and change in SWS storage are shown as negative values. During wet years, boundary surface inflow and outflow volumes are substantially higher than other components. Figure A2.F.e-17 thus only shows the difference between the surface inflows and surface outflows after seepage and evaporation are accounted within TTWD GSA. Review of the variability in component volumes across years provides insight into the impacts of hydrology on the surface water system water budget.

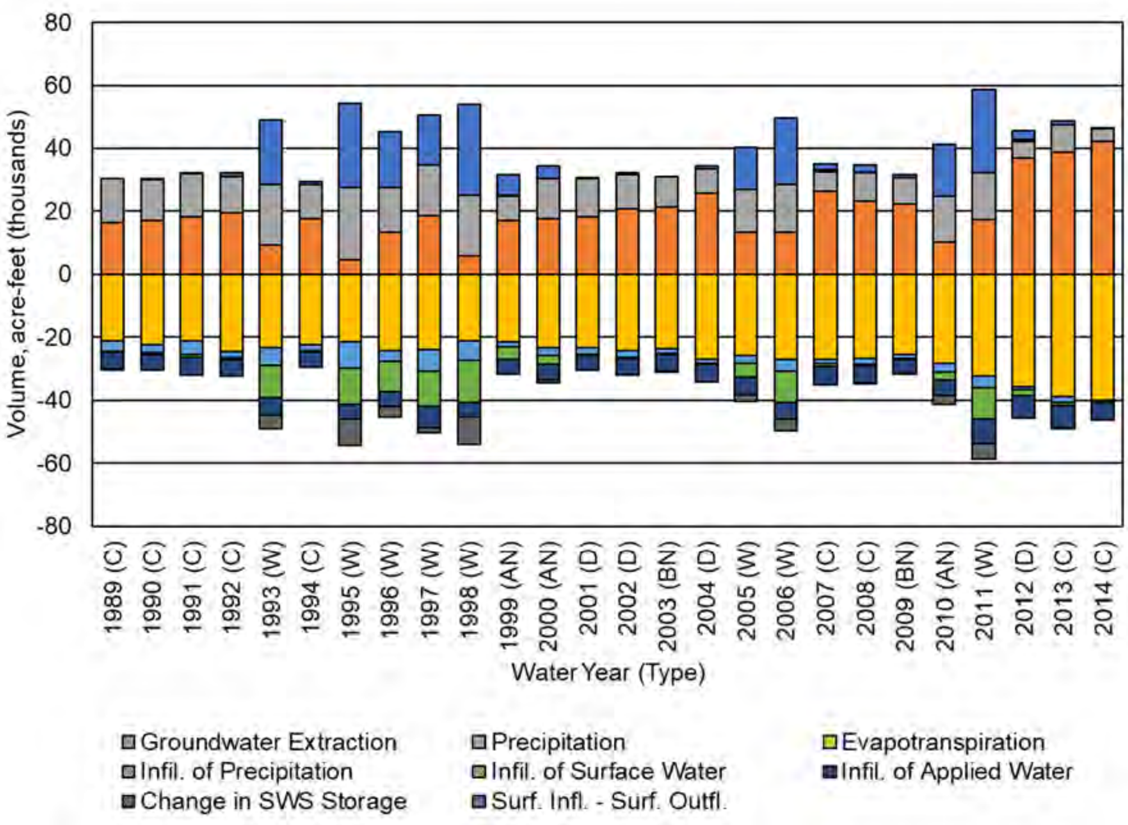

Figure A2.F.e-17. Triangle T Water District GSA Surface Water System Historical Water Budget, 1989-2014.

Table A2.F.e-15. Triangle T Water District GSA Surface Water System Historical Water Budget, 1989-2014 (Acre-Feet).

Water Year	Boundary Surface Inflows	Groundwater Extraction	Precipitation	Evapo-transpiration[1]	Infil. of Precipitation	Infil. of Surface Water[2]	Infil. of Applied Water	Boundary Surface Outflows	Change in SWS Storage
1989 (C)	0	16,430	14,090	-21,240	-3,210	-540	-5,090	0	-440
1990 (C)	0	17,100	13,140	-22,250	-2,640	-690	-4,790	0	140
1991 (C)	0	18,210	13,730	-21,230	-4,140	-1,010	-5,620	0	60
1992 (C)	0	19,680	11,210	-24,420	-2,060	-480	-5,210	0	1,280
1993 (W)	630,140	9,420	19,010	-23,260	-5,760	-10,110	-5,720	-609,400	-4,320
1994 (C)	870	17,800	10,770	-22,370	-1,940	-240	-4,990	0	100
1995 (W)	740,860	4,550	23,110	-21,510	-8,260	-11,470	-4,740	-714,110	-8,440
1996 (W)	661,490	13,480	14,130	-24,100	-3,670	-9,440	-4,800	-643,730	-3,350
1997 (W)	899,650	18,570	16,140	-23,970	-6,860	-11,040	-6,740	-883,900	-1,840
1998 (W)	818,390	5,750	19,410	-21,030	-6,300	-13,210	-4,850	-789,430	-8,730
1999 (AN)	141,780	17,040	7,870	-21,480	-1,560	-3,910	-4,710	-135,200	170
2000 (AN)	27,730	17,700	12,830	-23,340	-2,390	-2,920	-4,980	-23,920	-720
2001 (D)	0	18,310	11,970	-23,270	-2,160	-370	-4,760	0	280
2002 (D)	0	20,920	10,860	-24,350	-2,080	-330	-5,370	0	350
2003 (BN)	0	21,480	9,540	-23,630	-1,670	-100	-5,230	0	-410
2004 (D)	0	25,600	7,930	-27,100	-1,320	-80	-5,790	0	760
2005 (W)	274,520	13,440	13,670	-25,810	-2,590	-4,210	-5,620	-261,160	-2,250
2006 (W)	1,031,670	13,440	15,060	-27,170	-3,450	-10,070	-5,370	-1,010,510	-3,590
2007 (C)	3,380	26,430	6,100	-27,060	-1,200	-890	-5,820	-1,740	790
2008 (C)	2,330	23,120	9,260	-26,860	-1,660	-660	-5,290	0	-250
2009 (BN)	1,120	22,290	8,360	-25,490	-1,290	-150	-4,480	0	-360
2010 (AN)	16,870	10,340	14,370	-28,130	-3,000	-2,390	-5,030	-370	-2,650
2011 (W)	919,590	17,250	15,050	-32,230	-3,760	-10,140	-7,460	-893,310	-5,000
2012 (D)	6,810	37,020	5,120	-35,680	-1,060	-1,880	-7,080	-3,900	650
2013 (C)	1,560	38,770	8,660	-38,970	-1,730	-940	-7,010	-270	-70
2014 (C)	0	42,050	4,230	-39,950	-650	-30	-5,800	0	140
Average (1989-2014)	237,640	19,470	12,140	-26,000	-2,940	-3,740	-5,470	-229,650	-1,450
W	747,040	11,990	16,950	-24,890	-5,080	-9,960	-5,660	-725,690	-4,690
AN	62,130	15,030	11,690	-24,320	-2,320	-3,070	-4,910	-53,160	-1,070
BN	560	21,890	8,950	-24,560	-1,480	-120	-4,850	0	-390
D	1,700	25,460	8,970	-27,600	-1,650	-670	-5,750	-980	510
C	900	24,400	10,130	-27,150	-2,140	-610	-5,510	-220	190

[1]Includes ET of applied water, ET of precipitation, and evaporation from the Rivers and Streams System.
[2]Includes infiltration from the Rivers and Streams System within the subregion. To calculate Net Recharge from SWS below, Rivers and Streams System seepage is summed across the subbasin and redistributed to each subregion in proportion to gross area.

3.4 Current Water Budget Summary

The current water budget was developed following a similar process to the historical water budget using the 2015 land use in Table A2.F.e-1 and the same 1989-2014 average hydrologic conditions of the historical base period, including surface water flows, precipitation, and weather parameters. This allowed quantification of groundwater inflows and outflows for current consumptive use in the context of average water supply conditions.

Annual inflows, outflows, and change in SWS storage from the current water budget are summarized in Figure A2.F.e-18 and Table A2.F.e-16. Inflows are shown as positive values, while outflows and change in SWS storage are shown as negative values. Similar to Figure A2.F.e-17, Figure A2.F.e-18 only shows the difference between the surface inflows and surface outflows after seepage and evaporation are accounted within TTWD GSA.

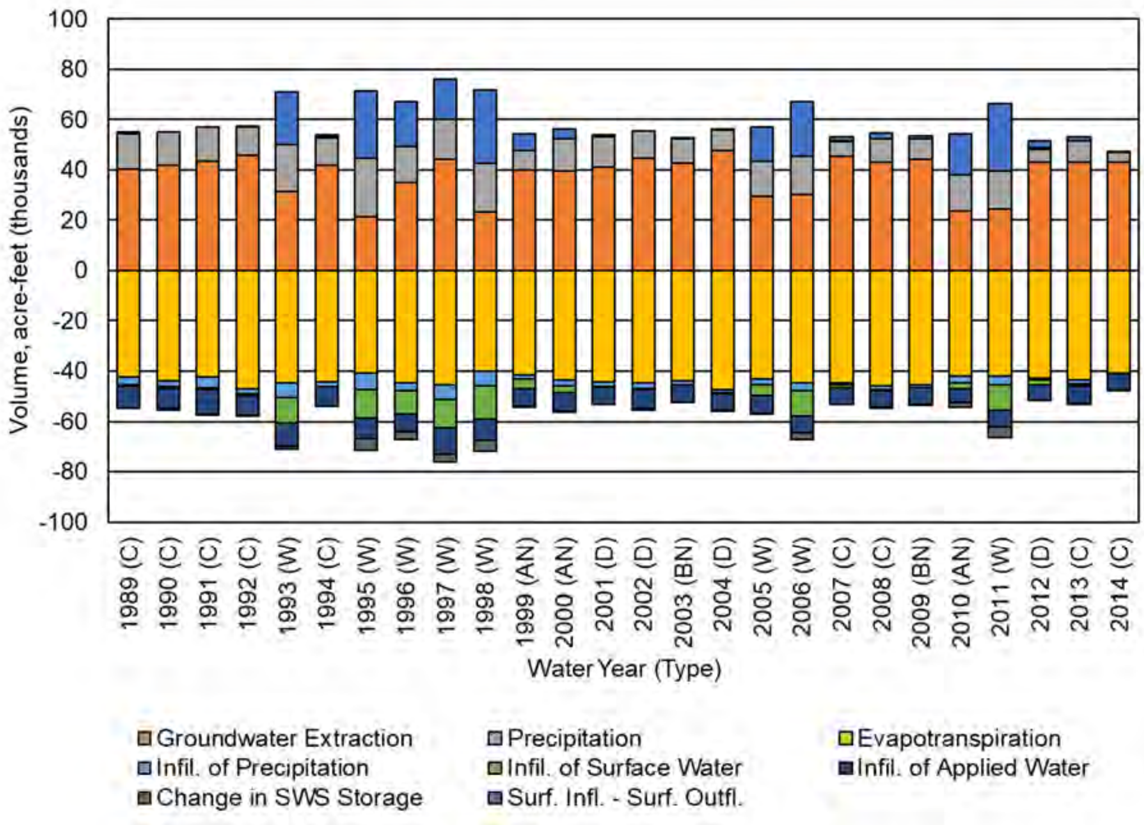

Figure A2.F.e-18. Triangle T Water District GSA Surface Water System Current Water Budget.

Table A2.F.e-16. Triangle T Water District GSA Surface Water System Current Water Budget (Acre-Feet).

Water Year	Boundary Surface Inflows	Groundwater Extraction	Precipitation	Evapo-transpiration[1]	Infil. of Precipitation	Infil. of Surface Water[2]	Infil. of Applied Water	Boundary Surface Outflows	Change in SWS Storage
1989 (C)	0	40,210	14,090	-42,260	-3,270	-480	-8,800	0	510
1990 (C)	0	42,010	13,140	-43,690	-2,590	-670	-7,850	-20	-330
1991 (C)	0	43,380	13,730	-42,260	-4,260	-1,010	-9,380	-90	-110
1992 (C)	0	45,860	11,220	-46,960	-2,110	-480	-7,860	-10	340
1993 (W)	630,140	31,210	19,010	-44,760	-5,660	-10,110	-9,460	-609,200	-1,160
1994 (C)	870	41,960	10,770	-44,300	-1,860	-220	-7,560	0	350
1995 (W)	740,860	21,320	23,120	-40,770	-6,520	-11,470	-8,130	-713,860	-4,550
1996 (W)	661,490	34,970	14,130	-44,620	-3,120	-9,440	-7,010	-643,460	-2,940
1997 (W)	899,650	44,110	16,140	-45,440	-5,840	-11,040	-10,680	-883,760	-3,140
1998 (W)	818,390	23,240	19,410	-40,070	-5,690	-13,210	-8,410	-789,240	-4,420
1999 (AN)	141,780	39,890	7,870	-41,670	-1,490	-3,900	-7,000	-135,160	-330
2000 (AN)	27,730	39,590	12,830	-43,370	-2,410	-2,920	-7,030	-24,010	-420
2001 (D)	0	41,010	11,970	-44,310	-2,040	-350	-6,670	0	390
2002 (D)	0	44,440	10,860	-44,770	-2,190	-320	-7,560	-20	-430
2003 (BN)	0	42,730	9,550	-43,880	-1,610	-40	-7,000	0	260
2004 (D)	0	47,750	7,930	-47,470	-1,240	-30	-6,770	0	-160
2005 (W)	274,520	29,650	13,680	-42,980	-2,500	-4,160	-7,100	-260,950	-140
2006 (W)	1,031,660	30,290	15,070	-44,490	-3,120	-10,070	-6,880	-1,010,030	-2,430
2007 (C)	3,380	45,210	6,100	-44,660	-970	-860	-6,590	-1,700	70
2008 (C)	2,330	43,160	9,270	-45,630	-1,600	-370	-6,660	-10	-500
2009 (BN)	1,120	44,030	8,380	-45,560	-1,230	30	-6,420	-10	-350
2010 (AN)	16,870	23,540	14,390	-42,020	-2,680	-2,120	-5,680	-310	-1,990
2011 (W)	919,590	24,580	15,060	-42,090	-3,170	-10,130	-6,760	-892,750	-4,330
2012 (D)	6,810	43,090	5,130	-42,830	-830	-1,830	-6,140	-3,900	500
2013 (C)	1,560	43,020	8,660	-43,300	-1,660	-910	-6,930	-260	-170
2014 (C)	0	42,860	4,230	-40,660	-660	-30	-5,940	0	190
Average (1989-2014)	237,640	38,200	12,140	-43,650	-2,710	-3,700	-7,400	-229,570	-970
W	747,040	29,920	16,950	-43,150	-4,450	-9,950	-8,060	-725,410	-2,890
AN	62,130	34,340	11,700	-42,350	-2,190	-2,980	-6,570	-53,160	-910
BN	560	43,380	8,960	-44,720	-1,420	0	-6,710	0	-40
D	1,700	44,070	8,970	-44,850	-1,580	-630	-6,790	-980	70
C	900	43,070	10,140	-43,750	-2,110	-560	-7,510	-230	40

[1]Includes ET of applied water, ET of precipitation, and evaporation from the Rivers and Streams System.
[2]Includes infiltration from the Rivers and Streams System within the subregion. To calculate Net Recharge from SWS below, Rivers and Streams System seepage is summed across the subbasin and redistributed to each subregion in proportion to gross area.

3.5 Net Recharge from SWS

Overdraft is defined in DWR Bulletin 118 as "the condition of a groundwater basin or subbasin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years, during which the water supply conditions approximate average conditions" (DWR 2003). The Chowchilla Subbasin water budget indicates that overdraft conditions occurred during the 1989-2014 historical base period. Per 23 CCR Section 354.18(b)(5), the subbasin overdraft has been quantified for this base period. The evaluation of overdraft conditions includes estimates of recharge from subsurface flows. However, estimates of recharge from subsurface flows are less accurate when estimated for areas less that an entire subbasin. Thus, for estimates of GSA level contribution to overdraft, the term net recharge from the SWS is defined as groundwater recharge minus groundwater extraction. Net recharge from the SWS is useful for understanding and analyzing the combined effects of land surface processes on the underlying GWS.

When calculated from the historical water budget, average net recharge from the SWS represents the average recharge (when positive) or shortage of recharge (when negative) based on historical cropping, land use practices, and average hydrologic conditions. When calculated from the current land use water budget, average net recharge represents the average recharge based on current cropping, land use practices, and average hydrologic conditions.

Average net recharge from the SWS is presented below for the TTWD GSA portion of the Chowchilla Subbasin. Table A2.F.e-17 shows the average net recharge from the SWS for 1989-2014 based on the historical water budget, and Table A2.F.e-18 shows the same for the current water budget. Historically, the average net recharge in TTWD GSA was approximately -8.9 taf per year between 1989 and 2014. Under current land use conditions, the average net recharge in TTWD GSA is approximately -26 taf, indicating shortage conditions.

Table A2.F.e-17. Historical Water Budget: Average Net Recharge from SWS by Water Year Type, 1989-2014 (Acre-Feet).

Year Type	Number of Years	Infiltration of Applied Water (a)	Infiltration of Precipitation (b)	Infiltration of Surface Water[1] (c)	Groundwater Extraction (d)	Net Recharge from SWS (a+b+c-d)
W	8	5,660	5,080	5,610	11,990	4,360
AN	3	4,910	2,320	1,280	15,030	-6,520
BN	2	4,850	1,480	170	21,890	-15,390
D	4	5,750	1,650	430	25,460	-17,630
C	9	5,510	2,140	660	24,400	-16,090
Annual Average (1989-2014)	26	5,470	2,940	2,180	19,470	-8,880

[1] Calculated from the total subbasin Rivers and Streams System seepage summed and redistributed to each subregion in proportion to gross area.

Table A2.F.e-18. Current Water Budget: Average Net Recharge from SWS by Water Year Type (Acre-Feet).

Year Type	Number of Years	Infiltration of Applied Water (a)	Infiltration of Precipitation (b)	Infiltration of Surface Water[1] (c)	Groundwater Extraction (d)	Net Recharge from SWS (a+b+c-d)
W	8	8,060	4,450	5,490	29,920	-11,920
AN	3	6,570	2,190	1,230	34,340	-24,350
BN	2	6,710	1,420	110	43,380	-35,140
D	4	6,790	1,580	380	44,070	-35,320
C	9	7,510	2,110	510	43,070	-32,940
Annual Average (1989-2014)	26	7,400	2,710	2,080	38,200	-26,010

[1] Calculated from the total subbasin Rivers and Streams System seepage summed and redistributed to each subregion in proportion to gross area.

3.6 Uncertainties in Water Budget Components

Uncertainties associated with each water budget component were estimated as a percentage representing approximately a 95% confidence interval following the procedure described by Clemmens and Burt (1997). Uncertainties for all independently measured or estimated water budget components were estimated based on the measurement accuracy, typical values reported in technical literature, typical values calculated in other water budgets, and professional judgement.

Table A2.F.e-19 provides a summary of typical uncertainty values associated with major SWS inflow and outflow components. These uncertainties provide a basis for evaluating confidence in water budget results and help to identify data needs that may be addressed during GSP implementation.

Table A2.F.e-19. Estimated Uncertainty of GSA Water Budget Components.

Flowpath Direction (SWS Boundary)	Water Budget Component	Data Source	Estimated Uncertainty (%)	Source
Inflows	Surface Water Inflows	Measurement	20%	Estimated streamflow measurement accuracy and adjustment for losses.
	Riparian Deliveries	Measurement	10%	Estimated measurement accuracy.
	Precipitation	Calculation	30%	Clemmens, A.J. and C.M. Burt, 1997.
	Groundwater Extraction	Closure	20%	Typical uncertainty calculated for Land Surface System water balance closure.
Outflows	Surface Water Outflows	Closure	20%	Typical uncertainty calculated for Rivers and Streams System water balance closure.
	Evaporation	Calculation	20%	Estimated accuracy of calculation based on CIMIS reference ET and free water surface evaporation coefficient.
	ET of Applied Water	Calculation	10%	Estimated accuracy of daily IDC root zone water budget component based on CIMIS reference ET, estimated crop coefficients from SEBAL energy balance, and annual land use.
	ET of Precipitation	Calculation	10%	Estimated accuracy of daily IDC root zone water budget component based on CIMIS reference ET, precipitation, estimated crop coefficients from SEBAL energy balance, and annual land use.
	Infiltration of Applied Water	Calculation	20%	Estimated accuracy of daily IDC root zone water budget component based on annual land use and NRCS soils characteristics.
	Infiltration of Precipitation	Calculation	20%	Estimated accuracy of daily IDC root zone water budget component based on annual land use, NRCS soils characteristics, and CIMIS precipitation.
	Infiltration of Surface Water	Calculation	15%	Estimated accuracy of daily seepage calculation using NRCS soils characteristics and calculated runoff of precipitation.
	Change in SWS Storage	Calculation	50%	Professional Judgment.
Net Recharge from SWS		Calculation	25%	Estimated water budget accuracy; typical value calculated for GSA-level net recharge from SWS.

APPENDIX 2.F. WATER BUDGET INFORMATION

2.F.f. Daily Reference Evapotranspiration and Precipitation Quality Control

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020

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1 PURPOSE

The purpose of this report is to describe the development of daily reference evapotranspiration (ET_{ref}) and precipitation values for water years 1989 through 2015 for use to determine consumptive use of irrigation water. The Study Area is the Chowchilla Subbasin.

This report describes the methodology for developing ET_{ref} and precipitation records, the results and the findings.

2 METHODOLOGY

Scientifically sound and widely accepted methods for determining consumptive use of irrigation water utilize daily ET_{ref} determined using the standardized Penman-Monteith (PM) method as described by the ASCE Task Committee Report on the Standardized Reference Evapotranspiration Equation (ASCE-EWRI, 2005). The PM method requires measurements of incoming solar radiation (R_s), air temperature (T_a), relative humidity (RH) and wind speed (W_s) at hourly or daily time steps. The task committee report standardizes the ASCE PM method for application to a full-cover alfalfa reference (ET_r) and to a clipped cool season grass reference (ET_o). The clipped cool season grass reference is widely used throughout the western United States and was selected for this application. Additionally, the Task Committee Report provides recommended methods for estimating required inputs to the standardized equation when measured data are unavailable. The remainder of this section describes an inventory of weather stations and available data, weather data quality control (QC), and the methods used to estimate ET_o.

2.1 Weather Data Inventory

Weather data from irrigated areas are needed to develop estimates of consumptive use of irrigation water. Automatic Weather Stations (AWS) provide measurements of R_s, T_a, RH and W_s over hourly or shorter periods used to compute ET_o. AWS data are often available from state extension services and weather station networks. Prior to the advent of the AWS, National Oceanic and Atmospheric Administration (NOAA) stations recorded daily minimum and maximum air temperatures and daily precipitation. Data from these NOAA stations are available from the National Centers for Environmental Information (NCEI) formerly National Climatic Data Center (NCDC).

In recent years, several gridded climate data sets have become available for public use. Daymet and PRISM (Parameter-elevation Relationships on Independent Slopes Model) are two of the more well-known data sets. The gridded estimates are developed by a collection of algorithms that interpolate and extrapolate from daily meteorological observations at available weather stations. Generally, the gridded estimates do not include all necessary parameters to calculate ET_o. PRISM[1] provides estimates for precipitation, daily maximum air temperature, daily minimum air temperature and daily average dewpoint temperature by interpolating between weather stations based on the physiographic similarity of the station to the grid cell.

For developing ET_o values to use in determining crop water depletions, the weather data used must represent irrigated agriculture. This is because ET from irrigated areas in arid regions is generally lower than that from surrounding not irrigated areas. The evaporation process tends to both cool and humidify the near-surface boundary layer over irrigated fields. This cooling and humidifying effect tends to reduce ET rates, including the reference ET estimate, and should be considered when calculating reference ET.

[1] http://www.prism.oregonstate.edu/ accessed on May 18, 2014.

Weather stations used to develop the gridded data are from both irrigated and not irrigated areas. For this reason, AWS inside the irrigated area are the preferred source for weather data to calculate ET_o for use in determining consumptive use of irrigation water.

A complete inventory of weather stations both inside and near irrigated areas was conducted to select the most appropriate weather station, or stations, for the historical crop water consumptive use analysis.

2.2 Weather Data Quality Control

Accurate estimation of consumptive use of irrigation water requires accurate and representative weather data. Weather data from each station were reviewed and corrected when necessary, following accepted, scientific procedures (Allen, et al 1996, Allen, et al, 1998, ASCE-EWRI, 2005 and ASCE, 2016). Daily data obtained for the AWS stations were quality checked using spreadsheets and graphs of weather data parameters for analysis and application of quality control methods according to the guidelines specified in Appendix-D of the ASCE Task Committee Report on the Standardized Reference Evapotranspiration Equation (ASCE-EWRI, 2005). Quality control procedures applied to R_s, T_a, RH and W_s are briefly described in the following sections.

2.2.1 Solar Radiation

Solar radiation data were quality controlled by plotting measured R_s and computed clear sky envelopes of solar radiation on cloudless days (R_{so}) for hourly or daily time steps (Allen, et al 1996, Allen, et al, 1998, ASCE-EWRI, 2005 and ASCE, 2016). Recommended equations for R_{so} that include the influence of sun angle, turbidity, atmospheric thickness, and precipitable water were used. The measured R_s should reach the clear sky envelope on cloud-free days. On cloudy or hazy days, the measured R_s will not reach the clear sky envelope. Measured R_s values that consistently fall above or below the curve indicate improper calibration or other problems, such as the presence of dust, bird droppings or something else on the sensor. Values for R_s that were found to be consistently above or below R_{so} on clear days were adjusted by dividing R_s by the average value of R_s/R_{so} on clear days at intervals of 60-day groupings for daily data and 30-day periods for hourly data. The values resulting from these adjustments were carefully reviewed for reasonableness of the adjustments.

2.2.2 Air Temperature

Air temperature is the simplest weather parameter to measure and the parameter most likely to be of high quality (Allen, et al 1996, Allen, et al, 1998, ASCE-EWRI, 2005 and ASCE, 2016). Nevertheless, daily maximum and minimum air temperatures were plotted together vs. time, and the extreme values were compared against historical extremes. Temperatures that consistently exceed the recorded extremes for a region may indicate a problem with the sensor or environment and may need to be adjusted based on air temperatures collected at a nearby station.

2.2.3 Relative Humidity

Daily maximum and minimum relative humidity values were plotted and examined for values chronically lower than five to ten percent and values that were consistently over 100 percent (Allen, et al 1996, Allen, et al, 1998, ASCE-EWRI, 2005 and ASCE, 2016). Additionally, relative humidity was checked on days having recorded rainfall to confirm that the measured maximum RH values approached 90 to 100 percent. Where necessary, reasonable adjustments such as setting all values above 100 percent equal to 100 percent were made.

2.2.4 Wind Speed

Wind speed records were plotted and visually inspected for consistently low wind speed values (Allen, et al 1996, Allen, et al, 1998, ASCE-EWRI, 2005 and ASCE, 2016). Low wind speeds can indicate dirty or worn anemometer bearings that lead to failure of the anemometer. Any period of more than thirty days with wind speeds below 1.0 meters per second was compared to available nearby stations and, if the wind speed at the nearby station did not indicate a period of unusually low wind speeds, adjusted based on the nearby station.

3 RESULTS

This section describes the results of an inventory of weather stations and available data, weather data quality control, and ET_o estimates.

3.1 Weather Station Inventory

Table A2.F.f-1 lists the stations and time periods used for the Chowchilla Subbasin weather data.

Table A2.F.f-1. Chowchilla Subbasin Weather Data Time Series Summary for the period 1989 – 2015.

Weather Station	Start Date	End Date	Comment
Fresno State (#80)	Oct. 2, 1988	May 12, 1998	AWS. Before Madera was installed.
Madera (#145)	May 13, 1998	Apr. 2, 2013	AWS. Moved East 2 miles and renamed “Madera II”
Madera II (#188)	Apr. 3, 2013	Dec. 31, 2015	AWS.

3.2 Weather Data Quality Control

Hourly checks and necessary adjustments performed on AWS station data and daily checks are described in the following sections. However, the following sections only include examples of common data adjustments observed in the quality-controlling process. A complete list of adjustments can be found in Attachment A2.F.f-A.

3.2.1 Solar Radiation

CIMIS AWS solar radiation data were generally of good quality, but it was apparent that some records required adjustment to fall within reasonable bounds. Two different types of quality control were performed on the solar radiation data. First, there are time periods in certain years where there is an obvious drop or rise in solar radiation values which cause them to fall significantly above or below the expected values. One instance of an unreasonable, sudden drop in solar radiation occurred in 1996 at the Madera CIMIS station. This is displayed in Figure A2.F.f-1 below. This data was then adjusted up by a factor of 1.08, and the calibrated data is displayed in Figure A2.F.f-2 below.

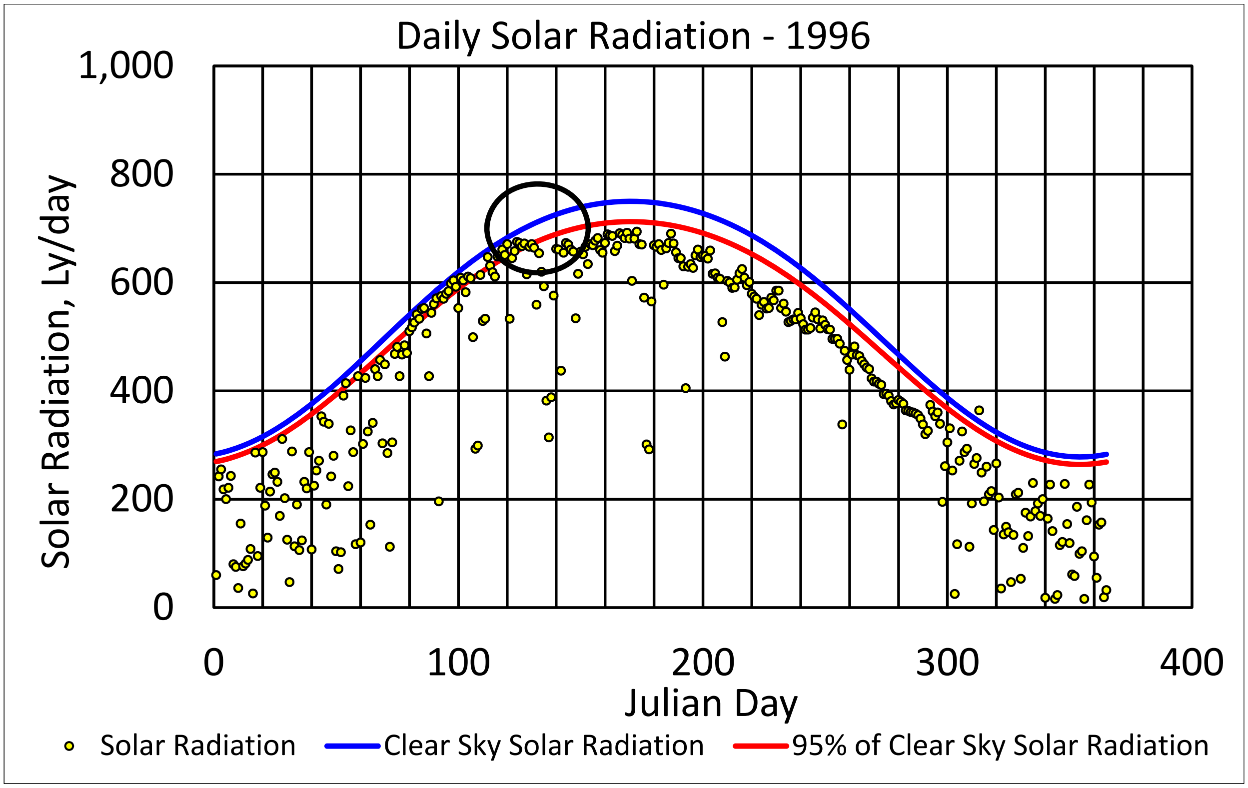

Figure A2.F.f-1. Daily Solar Radiation (Ly/day) for Madera CIMIS station (#145) for 1996 before QC.

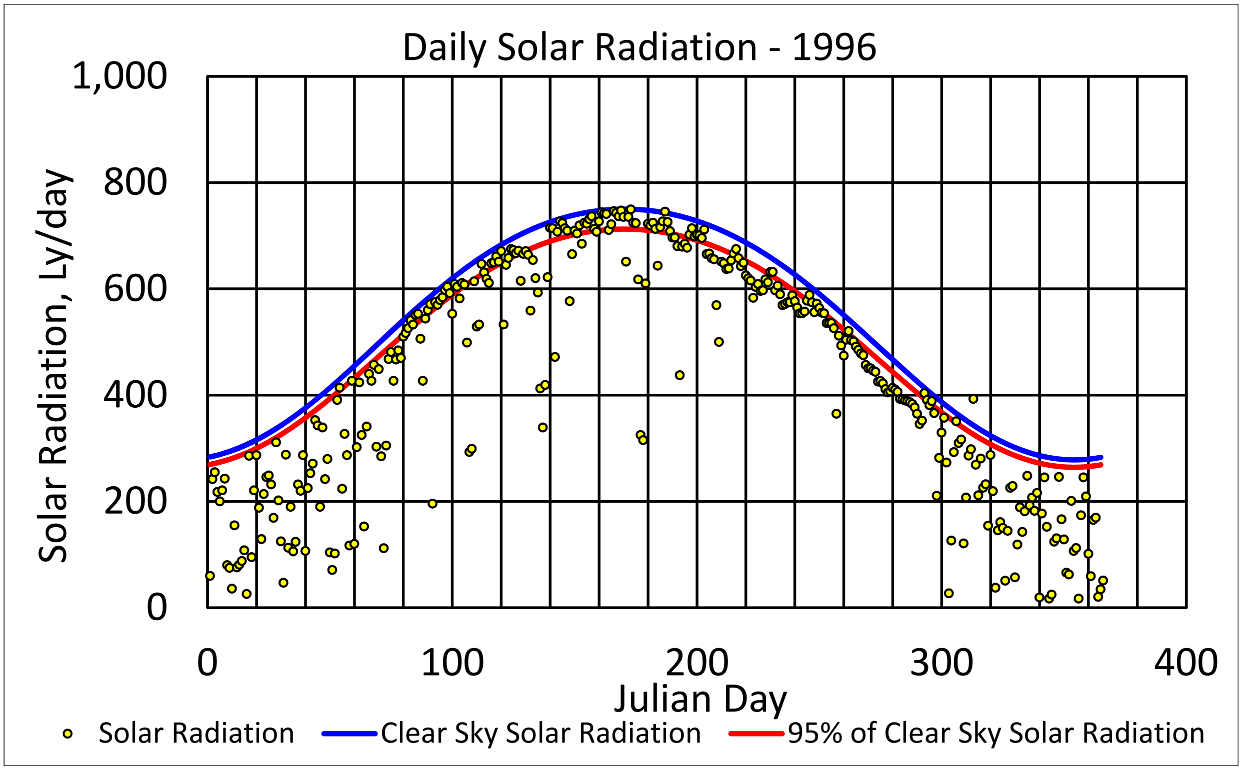

Figure A2.F.f-2. Daily Solar Radiation (Ly/day) for Madera CIMIS station (#145) for 1996 after QC.

3.2.2 Air Temperature

For the most part, CIMIS AWS air temperature data were consistent and followed expected values and behavior. However, adjustments were applied to some data points to more closely reflect the expected temperatures within the seasons for each year. There were two common problems observed within this parameter: missing data points and minimum temperatures automatically being assigned a value of 32 degrees Fahrenheit. The latter is made obvious by the season in which the data points reside, and the difference between this point and those immediately before and after. Examples of both issues are displayed in Figure A2.F.f-3. Missing data points were filled in with a value of the corresponding parameter from a nearby CIMIS station. The same process was applied to the points that were automatically set to 32 degrees Fahrenheit. The adjusted data can be observed in Figure A2.F.f-4.

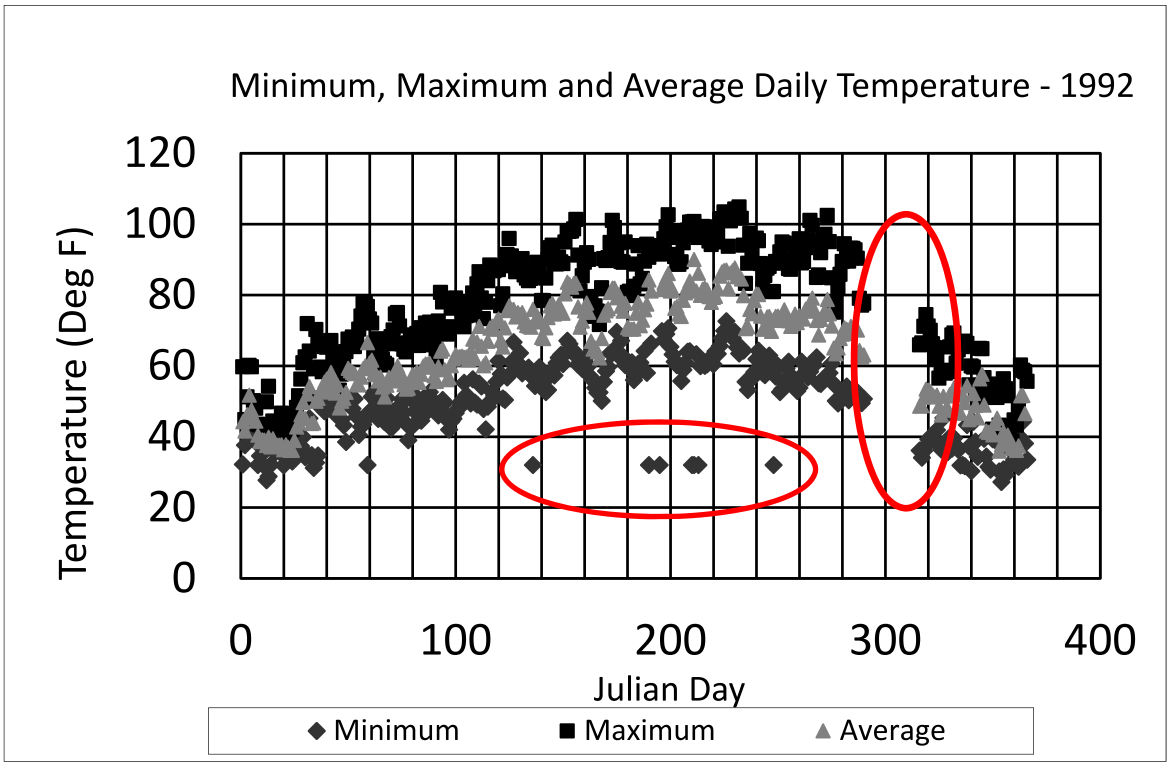

Figure A2.F.f-3. Average, Maximum, and Minimum Daily Temperatures (DegF) for Fresno State CIMIS station (#80) for 1992 before QC.

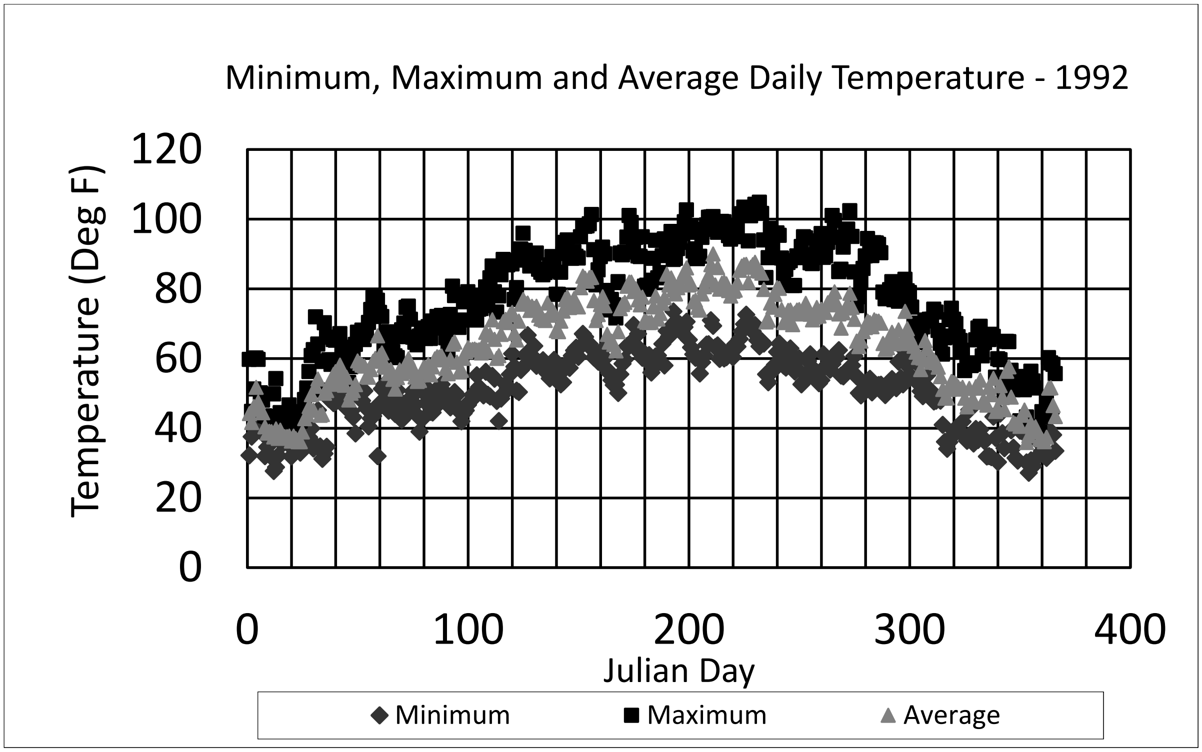

Figure A2.F.f-4. Average, Maximum, and Minimum Daily Temperatures (DegF) for Fresno State CIMIS station (#80) for 1992 after QC.

3.2.3 Relative Humidity

CIMIS AWS Relative Humidity (RH) data was analyzed for all of the time period and station combinations listed in Table A2.F.f-1 above and the necessary adjustments were made. Maximum RH at night commonly approaches 60% during the summer period and 100% during the winter period. When values fall significantly below this expected range of values (Figure A2.F.f-5), it can be concluded that the RH sensor is in need of calibration or to be replaced and the data need to be adjusted. In years when this trend was observed, such as for the Madera station in 2005, the data was adjusted (Figure A2.F.f-6).

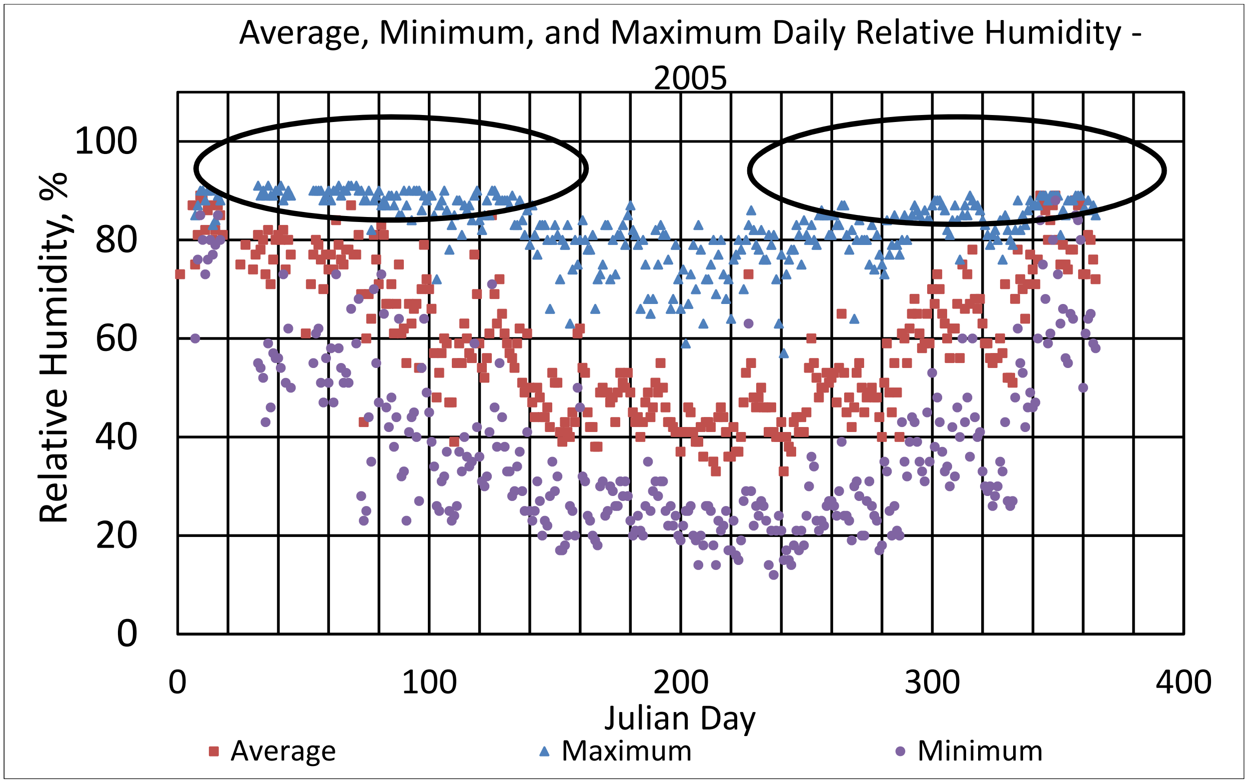

Figure A2.F.f-5. Average, Maximum, and Minimum Daily Temperature (DegF) for Madera CIMIS station (#145) for 2005 before QC.

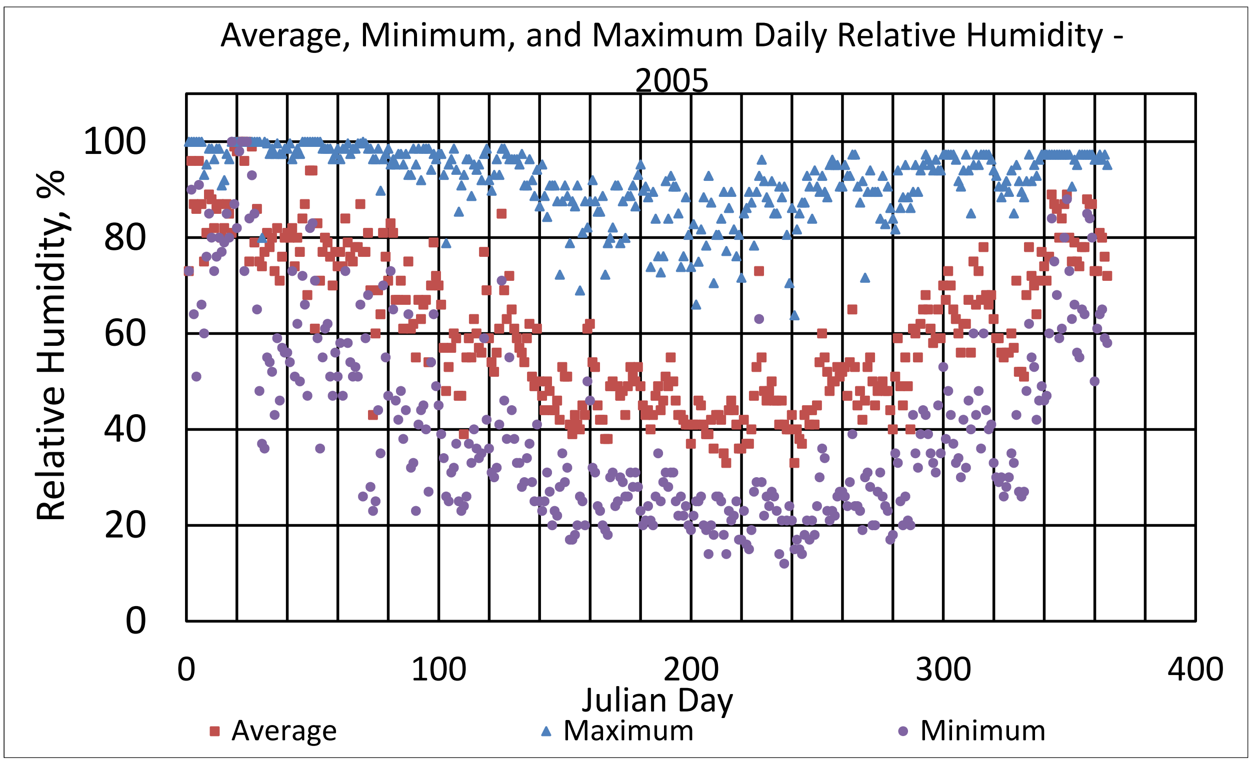

Figure A2.F.f-6. Average, Maximum, and Minimum Daily Temperature (DegF) for Madera CIMIS station (#145) for 2005 after QC.

3.2.4 Wind Speed

CIMIS AWS wind speed data were generally reasonable and usually followed expected ranges and patterns, with lower values during nighttime and higher values during the day. To calculate ET_o, all hourly wind speed values less than 0.5 m/s were set to 0.5 m/s, following the recommendation in ASCE-EWRI (2005), Appendix E, to represent a floor on wind movement and equilibrium boundary layer stability effects in the Penman-Monteith equation. A graphical example of this quality-control as it is applied to Madera windspeed data in the year 2000, can be observed in Figures A2.F.f-7 (unadjusted data) and 8 (adjusted data).

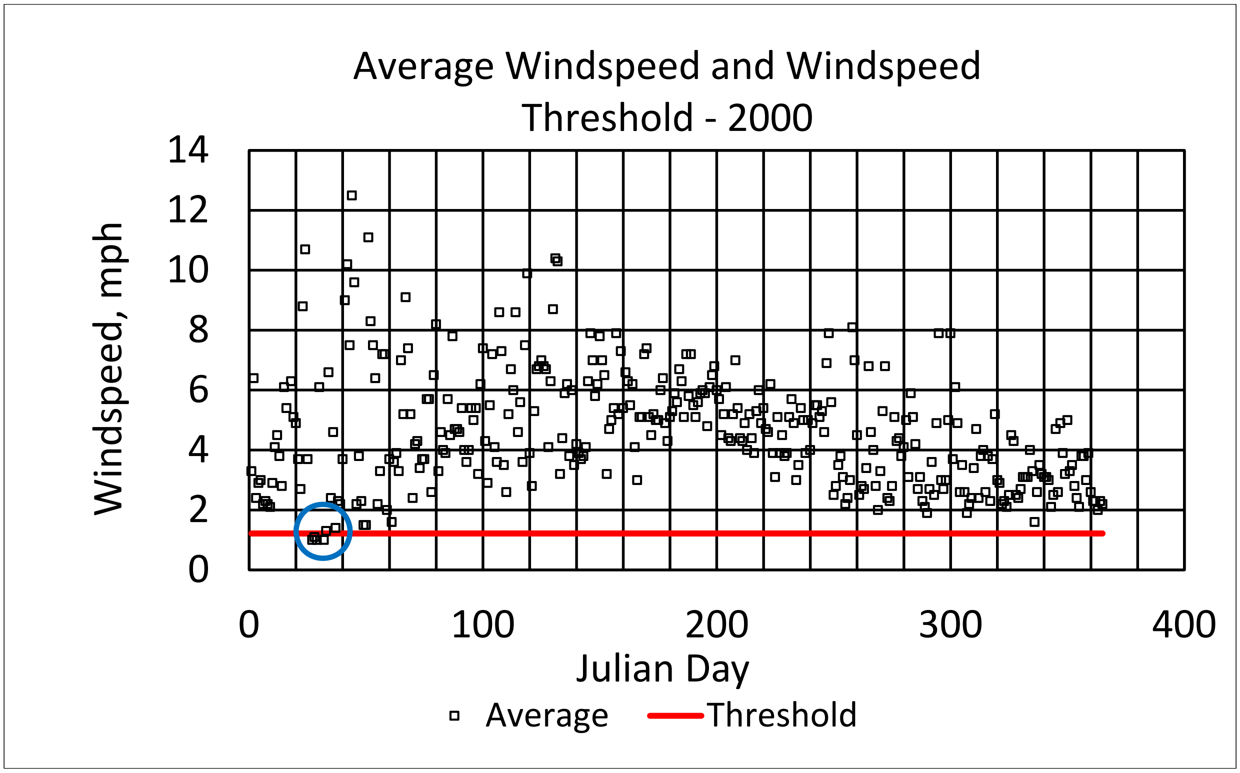

Figure A2.F.f-7. Average Windspeed (mph) for Madera CIMIS station (#145) for 2000 before quality-controlling.

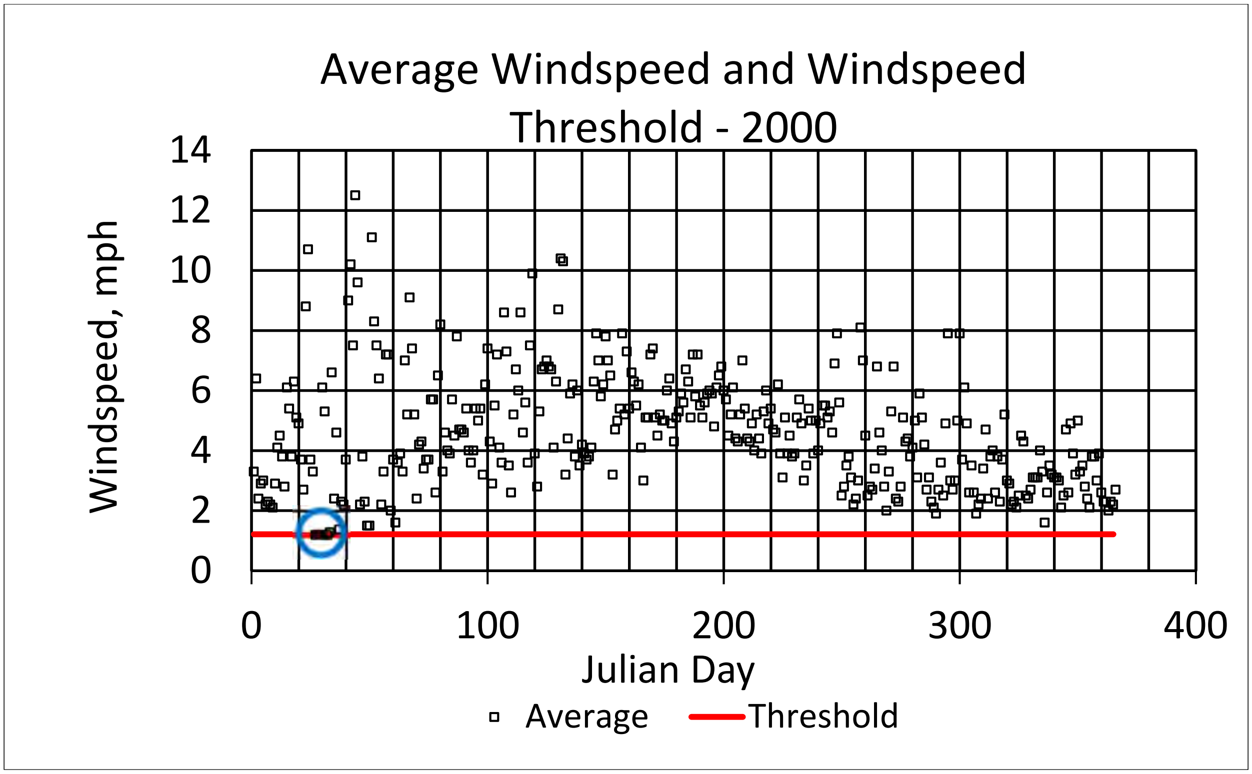

Figure A2.F.f-8. Average Windspeed (mph) for Madera CIMIS station (#145) for 2000 after quality-controlling.

3.2.5 ET_o Results Summary

The average water year ET_o for 1989 – 2015 was 55.34 inches and ranged from 50.64 inches in 1995 to 59.79 inches in 2004. This indicates that the differences in the average ET_o values computed from the weather data collected at the various stations (Table A2.F.f-2) is most likely due to natural and expected variability in the record.

Table A2.F.f-2. Weather Data Time Series Summary for the period 1989 – 2015.

Weather Station	Start Date	End Date	Average Water Year ET_o, inches	Minimum Water Year ET_o, inches	Maximum Water Year ET_o, inches
Fresno State	Oct. 1, 1988	May 12, 1998	55.13	50.64 (1995)	59.27 (1992)
Madera	May 13, 1998	Apr. 2, 2013	55.67	52.56 (2011)	59.79 (2004)
Madera II	Apr. 3, 2013	Dec. 31, 2015	55.51	53.79 (2014)	57.24 (2015)
Overall	Oct. 2, 1988	Dec. 31, 2015	55.34	50.64	59.79

Water year ET_o totals for the complete 1989 to 2015 period are included in Attachment A2.F.f-A.

3.2.6 Precipitation Results Summary

The 26-year average water year precipitation from 1989 to 2015, was 10.11 inches, varying from 3.59 inches in 2014 to 19.62 inches in 1995 (Table A2.F.f-3).

Table A2.F.f-3. Water Year Precipitation Statistics for 1989-2015.

Weather Station	Start Date	End Date	Average Water Year Rainfall, inches	Minimum Water Year Rainfall, inches	Maximum Water Year Rainfall, inches
Fresno State	Oct. 1, 1988	May 12, 1998	12.76	9.14 (1994)	19.62 (1995)
Madera	May 13, 1998	Apr. 2, 2013	8.98	4.35 (2012	12.79 (2006)
Madera II	Apr. 3, 2013	Dec. 31, 2015	4.25	3.59 (2014)	4.90 (2015)
Overall	Oct. 2, 1988	Dec. 31, 2015	10.11	3.59 (2014)	19.62 (1995)

Water year rainfall totals for the complete 1989 to 2015 period are included in Attachment A2.F.f-B.

4 FINDINGS

All weather stations considered near the Chowchilla Subbasin are located in agricultural areas. Quality control and quality assessment protocols were followed with review of hourly data and necessary adjustments performed on AWS data and daily checks and necessary adjustments performed on NOAA data. In conclusion, the time period was of such duration that at some point each parameter needed some adjustment. Minor adjustments to short periods of the wind data were necessary at all three sites. Air temperature data were mostly acceptable with the exception of multiple errors in the minimum temperature values for individual points within each site. Regarding both solar radiation and relative humidity for each site, erroneous trends were noticed and corrected, though the adjustment factors generally remained minimal (under 5%).

The average water year ET_o for 1989 – 2015 was 55.34 inches. The 26-year average precipitation from 1989 to 2015, was 10.11 inches.

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Allen, R. G., I. A. Walter, R. Elliot, T. Howell, D. Itenfisu, and M. Jensen. 2005. The ASCE Standardized Reference Evapotranspiration Equation. Publication, American Society of Civil Engineers.

Attachment A2.F.f-A. List of Quality Control Adjustments Completed

Madera II Weather Station data:

Air Temperature:

2013: bad minimum temperature for 4-2, 10-7, 11-12,

2014: bad minimum temperature on 3-10, 4-7, 11-10, 11-12,

2015: bad minimum temperature on 3-9, 12-8,

2016: bad minimum temperature on 2-26, 5-27, 10-18,

Solar Radiation:

2013: data values need replacement on 4-2, 7-2, 7-5, 8-12, 9-4, 9-11, 9-17,

2014: 1% increase until 6-29, 4% increase the rest of the year, data values need replacement on 3-10, 4-3, 4-7, 6-4, 6-6, 8-12, 9-4, 9-8, 10-22, 11-10, 11-14

2015: 2% increase all year, data values need replacement on 2-9, 3-9, 7-8, 8-17, 9-16, 11-13

Relative Humidity:

2013: increase data up 3% all year (from 4-2 when station starts through the end of year)

2014: apply 3% increase for first half of year

2015: good

Windspeed*:

2013-2015: Good

Fresno State Weather Station data:

Air Temperature:

1989: missing average air temperature for 1-1 and 1-2, 10-13, missing all data for 10-12

1990: missing/bad data for 3-26 and 3-27, missing all data from 8-20 through 9-1

1991: bad data point on 3-8, missing data on 10-18 through 10-21 and 12-23

1992: missing data from 7-10 through 7-13 and from 10-17 through 11-10, data points need replacement on 5-15, 7-8, 7-13, 7-28, 7-29, 7-31, 9-4, 11-6, and 12-1

1993: bad minimum temperature readings on 2-1, 3-23, 4-21, 5-21, 6-25, 7-2, 9-10, and 10-29

1994: bad minimum temperature readings on 5-20, 7-18, 9-9, missing average temperature on 1-3

1995: all good

1996: bad minimum temperature on 4-30, 11-8, 12-31

1997: bad minimum temperature on 7-29, 4-1, 4-18, 10-2, and 10-10

1998: bad minimum temperature on 7-17, 8-17, bad average temp on 9-4

1999: bad minimum temperature on 4-10, 10-15, missing minimum temperature on 6-11, 7-23, 9-22, bad average temperature on 2-25, 3-1

2000: bad minimum temperature values on 4-12, 5-2, 5-16, 10-20,

2001: bad minimum temperature values on 4-10, 5-31, and 10-12

2002: bad minimum temperature values on 2-25, 4-30, 5-28,

2003: bad minimum temperature values on 3-11,

Solar Radiation:

1989: Good

1990: Good

1991: Adjust data down 9% from 5-30 through 6-7

1992: data points need replacement on 5-15, 7-13, 7-29, 7-31, 9-4, 12-1; adjust all data for this year up 2.5%

1993: data points need replacement on 2-1, 5-21, 6-25, 7-2, 9-10, 10-29

1994: data points need replacement on 7-18

1995: adjust data down 1%

1996: Adjust data up 8% from 5-15 on

1997: Adjust data up 8% until 4-1, then no adjustment; data points need replacement on 4-1, 4-18, 7-29

1998: data points need replacement on 5-1, 7-17, 11-25, adjust data down 2% from 5-9 through 7-1

1999: data points need replacement for 4-23, 6-11, 7-23, moved data up 5% from beginning until 8-10, move data up 7% from 8-10 until 9-2, then move data up 12% for the rest of the year

Relative Humidity:

1989: good

1990: move data up 1% for the whole year

1991: move data up 4% from 9-21 through end of the year

1992: move data up 1% all year

1993: Good

1994: Good

1995: Good

1996: Good

1997: Good

1998: Good

1999: Good

Windspeed*:

1989-1999: Good

Madera Weather Station Data:

Air temperature:

1998: Bad minimum temperature on 10-1,

1999: bad minimum temperature on 4-23,

2000: bad minimum temperature on 3-7, 10-2,

2001: bad minimum temperature on 10-11,

2002: bad minimum temperature on 4-15, 4-22, 2-27,

2003: bad minimum temperature on 3-2, 4-8, 5-12, 10-29,

2004: bad minimum temperature on 4-21, 12-5, 12-9,

2005: bad minimum temperature on 1-6, 1-12, 1-31, 4-20,

2006: bad minimum temperature on 2-6,

2007: bad average temperature on 1-1,

2008: bad minimum temperature on 4-14,

2009: bad minimum temperature on 1-16, 3-13,

2010: bad minimum temperature on 1-27,

2011: bad minimum temperatures on 1-22 through 2-1, 2-16, 3-17, 4-14, bad average temperature on 11-29,

2012: bad minimum temperature on 5-9, 2-6, 2-28, 1-23,

2013: good through 4-2 (end of record)

Solar Radiation:

1998: Data points need replacement on 8-26, 12-23, 12-31,

1999: Data points need replacement on 4-2, 4-23, 6-11, 7-2, 9-7, move all data up 3.5%,

2000: move data down 1% until 6-6, and then move data up 1% through the rest of the year

2001: data points need replacement on 7-20, 8-13, 8-15, 9-10, move data up 3% until 5-10, then move data up 4% until 7-11, then unadjusted data through the end of the year

2002: move all data down 1.5%, data points need replacement on 8-21, 8-24, 8-25,

2003: From 7-15 on, move data up 3.5%, data points need replacement on 3-10, 4-8, 5-12, 7-10, 8-14,

2004: data points need replacement on 6-18, 7-19, 8-18, move all data up 2.5%,

2005: data points need replacement on 2-22, 3-15, move all data up 4%

2006: move data up 10% until 6-19, and then move data up 14% through the end of the year

2007: data points need replacement on 8-16, move data down 3% until 5-2, and then move data down 8% until 8-14, then move data up 3% for the rest of the year,

2008: move data up 13% until 4-13, then move data down 12% through the end of the year, 2009: move data down 6% until 6-7, then move data down 2% for the rest of the year, data points need replacement on 6-16, 6-19, 8-7, 8-10,

2010: move data up 2% for the year, data points need replacement on 1-27, 11-24,

2011: move data up 3.5% until 5-25, then move data down 6% until end of year, data points need replacement on 7-18, 9-7, 11-2,

2012: replace data from 4-29 through 5-7, and on 3-19, 5-9, 6-5, 6-6, move data up 5% from 5-14 through the end of the year,

2013: data points need replacement from 3-29 through 4-2

Relative Humidity:

1998: good

1999: apply 2% increase to the second half of the year

2000: apply 2% increase to first half of year, and 3% increase to second half of year

2001: apply 3% increase to first half of year, and 4% increase to second half of year

2002: apply 4% increase all year

2003: apply 4% increase to first half of year, and 6.5% increase to second half of year

2004: apply 7% increase to first half of year, and 8.5% increase to second half of year

2005: apply 9.5% increase to first half of year, and 12% increase to second half of year

2006: apply % increase until 6-9, then no adjustment factor

2007: good

2008: good

2009: apply 2% increase all year

2010: apply 2% increase all year

2011: apply 2% increase all year

2012: apply 1% increase all year

2013: Good

Windspeed*:

1998-2013: Good

*Windspeed values that fell below the threshold may have been replaced with replacement stations data but are not listed here because they were not replaced in the manual review QC process.

Attachment A2.F.f-B. Annual ET_o and Precipitation Results

Table A2.F.f-B-1. Water Year ET_o and Precipitation Results

Water Year	ETo, inches	Precip, inches
1989	52.68	11.96
1990	55.16	11.15
1991	54.96	11.65
1992	59.27	9.52
1993	55.29	16.13
1994	55.75	9.14
1995	50.64	19.62
1996	55.76	11.99
1997	56.63	13.70
1998	53.05	16.55
1999	52.63	6.68
2000	55.02	10.89
2001	56.16	10.16
2002	56.07	9.22
2003	55.42	8.10
2004	59.79	6.73
2005	53.94	11.61
2006	55.44	12.79
2007	57.25	5.18
2008	57.36	7.87
2009	57.62	7.11
2010	53.24	12.21
2011	52.56	12.78
2012	56.89	4.35
2013	54.50	7.35
2014	53.79	3.59
2015	57.24	4.90

APPENDIX 2.F. WATER BUDGET INFORMATION

2.F.g. Development of Daily Time Step IDC Root Zone Water Budget Model

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020

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1 OVERVIEW

The water budget uses available data and estimates to develop an accurate accounting of all water inflows and outflows from the Chowchilla Subbasin. The information supporting the water budget for 1989 through 2015 has been assembled to complete the historical Chowchilla Subbasin water budget. As part of water budget development, the stand-alone root zone water budget modeling tool used with the Integrated Water Flow Model (IWFM) developed and maintained by the California Department of Water Resources (DWR) is used to partition ET into ET from applied water and ET from precipitation. This stand-alone version of the root zone model is known as the IWFM Demand Calculator (IDC). The root zone water budget included with IWFM is designed such that it can be used as a stand-alone model to complete the root zone water budget for agricultural, urban, and native lands. IDC was used to develop time series estimates for the following outputs which were then combined with surface water delivery and groundwater pumping information to complete the subbasin boundary water budget and to provide estimates of the infiltration of precipitation and runoff of precipitation:

- ET of precipitation (ET_{pr});
- ET of applied water (ET_{aw}); and
- Deep percolation of precipitation (DP_{pr})
- Uncollected surface runoff of precipitation (RO_{pr})

IDC files were developed for a stand-alone, daily time step IDC application and these inputs were later adapted into IDC files used to simulate root zone moisture within IWFM. Thus, the IWFM results for the surface layer of the Chowchilla Subbasin area should be carefully reviewed and IDC Model parameters may require some adjustment to align the results with the agricultural lands water budget results. In particular, IDC was not calibrated to ensure estimated applied water demands match historical deliveries and pumping.

Inputs provided to the IDC root zone model include:

- Daily crop evapotranspiration (ET_c) representing actual ET (as compared to potential ET) for each crop or land use class from January 1, 1985 through December 31, 2015 developed by multiplying reference ET (ET_o) by the appropriate crop coefficient (developed from a 2009 SEBAL (remotely sensed energy balance analysis)).
- Daily precipitation (P_r) from January 1, 1985 through December 31, 2015.
- Soil properties for each soil texture simulated
- Rooting depth for each crop or land use class
- Other model parameters for the land use classes and soil texture combinations simulated, including soil moisture parameters and runoff curve numbers

2 IDC MODEL SETUP

The IDC Model was used as a stand-alone root zone modeling tool to develop a surface layer water budget for the Chowchilla Subbasin to provide preliminary information regarding subbasin water overdraft prior to the development of the groundwater model. The IDC Model was then linked with IWFM to develop a groundwater model for the Chowchilla and Madera Subbasins.

The stand-alone IDC Model uses a daily time step to accurately parse crop ET_c into ET_{aw} and ET_{pr} for the Chowchilla Subbasin agricultural water budget between January 1, 1985 and December 31, 2015. The model is set up as a unitized model (as compared to a spatial model) that provides per acre results by specifying one unique land use class-soil-runoff combination per element with the area of each element set to approximately 10,000 acres. A total of 17 land use classes and 15 soil textures were evaluated with one specified curve number representing runoff conditions for each. To allow land use class-soil-runoff combinations to be added in future years, 450 elements comprised of 902 nodes were configured in the model. The land use class-soil-runoff combinations are described in the following sections. The provided input files were used with the IWFM Version 2015.0.0036, Root Zone Component Version 4.0 (DWR, 2015). All land use classes were modeled as non-ponded crops except the urban land use class, which was modeled using the IDC urban module.

The linked IDC Model uses a monthly time step to link with the IWFM groundwater model. The monthly linked model results should match daily model results summed to monthly and annual time steps. Because of the differing time steps, some of the IDC parameters in the daily model must be revised. Those revisions are described in the appropriate sections below.

2.1 Weather Inputs

2.1.1 Evapotranspiration Inputs

Daily reference ET (ET_o) values used for 1985 through 2015 were based on measured weather data from three California Irrigation Management Information System (CIMIS) stations (Table A2.F.g-1). Measured weather parameters supporting daily ET_o calculations were quality controlled following standard procedures (ASCE-EWRI, 2005) to produce a high quality daily ET_o time series for use with crop coefficients to develop the ET time series for each land use class as described in Appendix 2A.

Table A2.F.g-1. Chowchilla Subbasin Weather Data Time Series Summary for the period 1989 – 2015.

Weather Station	Start Date	End Date	Comment
Fresno State (#80)	Jan. 1, 1985	May 12, 1998	CIMIS. Before Madera was installed.
Madera (#145)	May 13, 1998	Apr. 2, 2013	CIMIS. Moved East 2 miles and renamed “Madera II”
Madera II (#188)	Apr. 3, 2013	Dec. 31, 2015	CIMIS.

Crop coefficients were derived using ET_o values described in the previous paragraph and actual ET (ET_a) estimates based on remotely sensed surface energy balance results from Surface Energy Balance Algorithm for Land (SEBAL) (Bastiaanssen, et al. 2005). Spatially distributed ET_a results were available with spatial cropping data for 2009. SEBAL results account for effects of salinity, deficit irrigation, disease, fertilization, immature permanent crops, crop canopy structure, and any other factors resulting in differences between potential and actual crop ET. Studies by Bastiaanssen et al. (2005), Allen et al. (2007, 2011), Thoreson et al. (2009), and others have found that when performed by an expert analyst, seasonal ET_a estimates by these models are expected to be within five percent of actual ET determined using other reliable methods.

2.1.2 Precipitation Inputs

Precipitation values were obtained from the three CIMIS stations (Table A2.F.g-1) for 1985 through 2015 and averaged 10.1 inches per water year during the 1989 through 2015 period. The precipitation records were carefully reviewed and standard quality control procedures (ASCE-EWRI, 2005) were applied as described in Appendix 2.F.f.

2.2 Soil Inputs

2.2.1 Soil Textural Classes and Calibrated Model Parameters

Soil textural classes and associated soil hydraulic parameters were estimated from the Soil Survey Geographic (SSURGO) database (Soil Survey Staff, 2014) for use in IDC. The SSURGO database contains information collected by the National Cooperative Soil Survey (NCSS) about soils in the United States. The United States Department of Agriculture Natural Resources Conservation Service (USDA-NRCS), formerly known as the Soil Conservation Service (SCS), organizes the NCSS and publishes soil surveys. The IDC model includes fifteen soil textures representing approximately 98 percent of the Chowchilla Subbasin area (Table A2.F.g-2). Sandy clay loam and sandy loam soil textures together cover nearly 88 percent of the Chowchilla Subbasin area.

The following five soil parameters were provided as inputs to the IDC Model and are summarized for each soil texture class in Table A2.F.g-3:

1. Permanent Wilting Point (PWP), dimensionless
2. Field Capacity (FC), dimensionless
3. Total Porosity (ϕ), dimensionless
4. Pore Size Distribution Index (λ), dimensionless
5. Saturated Hydraulic Conductivity (K_{sat}) in feet per day (ft/day)

For each soil texture class derived from SSURGO, initial soil hydraulic parameters were estimated based on pedotransfer functions reported by Saxton and Rawls (2006) and refined to provide drainage from saturation to field capacity within a reasonable amount of time, as determined from the percentage of drainage after 3 days (generally exceeding 60-80%), and to predict minimal gravitational drainage once field capacity was reached (Table A2.F.g-3).

2.2.2 Initial Soil Moisture

In many years, sufficient precipitation occurs during the winter months to fill the root zone to field capacity. Thus, the initial soil moisture at the IDC model start date (January 1, 1985) was set to field capacity. The IDC model runs for the Subbasin water budget were started four years before the first year in the water budget period (1989) to minimize any potential effect from incorrectly specifying the initial soil moisture value.

2.3 Non-Ponded Crop Inputs

All land use classes, except for urban, were modeled as non-ponded crops. For non-ponded crops, the IDC model stimulates irrigation events (i.e., applied water) based on user-defined inputs. The following sections describe these land use classes and inputs.

Table A2.F.g-2. Soil Textures by Area.

Soil Texture (% Sand, % Silt, % Clay)	Acres	% of Area	Represented in IDC Model
sandy clay loam (50, 20, 30)	26,566	18.2%	×
sandy loam - sandy clay loam (60, 20, 20)	19,774	13.5%	×
sandy loam (70, 20, 10)	18,335	12.5%	×
loam (50, 30, 20)	16,989	11.6%	×
sandy loam - sandy clay loam (70, 10, 20)	13,547	9.3%	×
silt loam - loam (40, 50, 10)	12,851	8.8%	×
loam (40, 40, 20)	11,073	7.6%	×
loamy sand (80, 20, 0)	7,081	4.8%	×
silty clay loam (20, 50, 30)	4,650	3.2%	×
sandy clay loam (60, 10, 30)	2,906	2.0%	×
clay loam (40, 30, 30)	2,835	1.9%	×
sand (100, 0, 0)	2,600	1.8%	×
clay loam (30, 40, 30)	1,468	1.0%	×
sandy loam (80, 10, 10)	1,144	0.8%	×
clay - clay loam (30, 30, 40)	859	0.6%	×
sandy loam (60, 30, 10)	761	0.5%	
sand (90, 10, 0)	597	0.4%	
clay - clay loam (40, 20, 40)	245	0.2%	
clay (20, 30, 50)	239	0.2%	
silt loam - loam (30, 50, 20)	80	0.1%	
clay (30, 20, 50)	29	0.0%	
loam (50, 40, 10)	5	0.0%	
Other (i.e., water, urban, etc.)	1,690	1.2%	
Total	146,325	100%	

Table A2.F.g-3. Soil Texture with IDC Model Soil Parameters.

Soil Texture (% Sand, % Silt, % Clay)	PWP	FC	φ	λ	Ksat (ft/d)
sandy clay loam (50, 20, 30)	0.16	0.26	0.40	0.16	5.70
sandy loam - sandy clay loam (60, 20, 20)	0.11	0.21	0.39	0.26	8.40
sandy loam (70, 20, 10)	0.07	0.15	0.38	0.48	9.00
loam (50, 30, 20)	0.11	0.22	0.39	0.23	5.75
sandy loam - sandy clay loam (70, 10, 20)	0.09	0.17	0.38	0.38	8.60
silt loam - loam (40, 50, 10)	0.07	0.22	0.38	0.21	9.00
loam (40, 40, 20)	0.15	0.28	0.40	0.15	3.60
loamy sand (80, 20, 0)	0.01	0.07	0.40	1.83	10.60
silty clay loam (20, 50, 30)	0.16	0.32	0.42	0.14	0.60
sand (100, 0, 0)	0.01	0.04	0.42	10.10	15.50
sandy clay loam (60, 10, 30)	0.15	0.24	0.39	0.19	5.85
clay loam (40, 30, 30)	0.16	0.29	0.41	0.14	3.00

Soil Texture (% Sand, % Silt, % Clay)	PWP	FC	φ	λ	Ksat (ft/d)
clay loam (30, 40, 30)	0.19	0.33	0.42	0.10	2.50
clay - clay loam (30, 30, 40)	0.26	0.39	0.46	0.06	2.00
sandy loam (80, 10, 10)	0.04	0.10	0.39	0.93	10.50
clay (30, 20, 50)	0.27	0.40	0.47	0.07	0.90

2.3.1 Agricultural Water Supply Requirement (Target Soil Moisture Fraction)

Water supplied to each crop is estimated within the simulation. The target soil moisture data file allows the user to specify irrigation target soil moisture as a fraction of field capacity. When simulating an irrigation event, the IDC model will apply water until the soil reaches the specified percent of field capacity. Target soil moisture fractions were estimated as approximately 1.0 for all land use classes based on common irrigation methods and scheduling practices in the Chowchilla Subbasin, where growers typically irrigate to field capacity.

When IDC is run on a monthly time step, if the TSMF used for the daily model is used, greater volumes of deep percolation results. This is because when the IDC equations are applied on a monthly basis, the TSMF values used for the daily model result in greater values of soil moisture in the equation computing deep percolation. Thus, the TSMF values must be adjusted to result in deep percolation of applied water volumes consistent with the daily model results. The revised TSMF values are also adjusted to simulate the increase in consumptive use fraction that occurs when over time flood irrigation systems are converted to pressurized systems.

2.3.2 Minimum Soil Moisture

The minimum soil moisture value for each crop corresponds to the moisture content at the Management Allowable Depletion (MAD) specified for that crop. Management Allowed Depletion (MAD) is defined as the desired soil water deficit at the time of irrigation and can vary with growth stage (ASABE, 2007). The MAD is often set as the percent of total available moisture that the crop can withstand without suffering stress or yield loss. Water stress is estimated within the IDC model when the percent of total available moisture exceeds 50 percent. The IDC Model allows different values to be input for different crops and different growth stages. Values for the minimum soil moisture were set to 50 percent for all land use classes at all growth stages to prevent stress from occurring in the simulation. It is important to note here that the crop coefficients, as described previously, are developed from remotely sensed energy balance ET data and thus already include ET reductions that may have occurred due to water stress or other factors.

2.3.3 Irrigation Period

The irrigation period determines the cropped and non-cropped periods for each crop. A value of one represents a cropped period, during which IDC calculates applied water demand for the crop. A value of zero represents a non-cropped period, during which IDC does not compute applied water for the crop. Different irrigation periods can be defined for different land use types if necessary. In this application the irrigation period was set to one between March and October for all land use classes except corn, grain, and idle lands, and roughly corresponded with the irrigation season in the Chowchilla Subbasin. For idle lands, the irrigation period was set to zero for all months.

2.3.4 Reuse and Return Flow

The return flow fraction determines the proportion of applied water that can leave the land use cell as runoff, while the reuse fraction determines the proportion of applied water that is captured and reused for irrigation. A value of one each indicates that all applied water can leave as runoff, but that all applied water is captured and reused for irrigation. A value of zero each indicates that no applied water leaves the land use cell or is reused for irrigation. For this simulation, irrigation water return flow and reuse fractions have been set to zero in the IDC model. Return flow and reuse are internal flow paths and thus are not included in the Subbasin boundary water budget.

2.3.5 Root Depth

Root depths for each of the 17 land use classes were estimated primarily from ASCE (2016) with consideration given for local conditions. A list of the land use classes and their associated rooting depths are provided in Table A2.F.g-4. IDC provides an option that models changing root growth as the season progresses for annual crops. For this application, all land use classes were modeled with constant root depths.

Table A2.F.g-4. Root Depths Used in IDC Model by Land Use Class.

Land Use Class	Root Depth (ft)
Alfalfa	6.0
Almonds	4.0
Citrus and Subtropical	4.0
Corn (double crop)	3.5
Grain and Hay Crops	3.5
Grapes	4.0
Idle	3.0
Miscellaneous Deciduous	4.0
Miscellaneous Field Crops	3.5
Miscellaneous Truck Crops	2.5
Mixed Pasture	3.0
Native	6.0
Pistachios	4.0
Semi-agricultural	4.0
Walnuts	6.0
Water	4.0
Urban	4.0

2.3.6 Runoff Curve Numbers

The IDC uses a modified version of the SCS curve number (SCS-CN) method to compute runoff of precipitation. A curve number for each land use class and soil type is required as input to the model. Curve numbers are used as described in the National Engineering Handbook Part 630[1] (USDA, 2004, 2007)

[1] Table 1. Runoff curve numbers for agricultural lands.

based on land use or cover type, treatments (straight rows, bare soil, etc.), hydrologic condition, and hydrologic soil group. An area weighted average curve number for each land use-soil texture combination was calculated based on the area in each hydrologic soil group assuming good hydrologic conditions (Table A2.F.g-5). The total area of each soil group within the Chowchilla Subbasin was estimated from the NRCS SSURGO database and is described in Table A2.F.g-2.

When IDC is run on a monthly time step, if the curve number used for the daily model is used, greater volumes of runoff of precipitation result. Thus, the curve number values must be adjusted to result in runoff of precipitation volumes consistent with the daily model results.

2.4 Urban Module Inputs

Urban areas were modelled using the IDC urban module. Urban inputs are described below.

2.4.1 Population

The City of Chowchilla is the only city that overlies the Chowchilla Subbasin. Population estimates were obtained from the California Department of Finance. In 1996, the City of Chowchilla annexed two local prisons into the city limits. The prisons are located approximately 7 miles east of the city limits within the Chowchilla Subbasin boundary. The prisons operate and maintain their own water supply system separate from the City of Chowchilla. Prison populations were subtracted from the City of Chowchilla population estimates following the 1996 annexation.

2.4.2 Groundwater Pumping

The City of Chowchilla pumps groundwater to serve residences within the city limits. Monthly pumping records were provided by the City from 2003 through 2016. Groundwater pumping from 1985 through 2002 were estimated based on annual population records from the California Department of Finance and the average per capita water use from 2003 through 2016.

Table A2.F.g-5. Curve Number Used to Represent Runoff Conditions in Chowchilla Subbasin.

Soil Texture (% Sand, % Silt, % Clay)	Alfalfa	Almonds	Citrus and Subtropical	Corn	Grain and Hay Crops	Grapes	Idle	Misc. Deciduous	Misc. Field Crops	Misc. Truck Crops	Mixed Pasture	Native	Pistachios	Semi-agricultural	Walnuts	Water	Urban
silt loam - loam (40, 50, 10)	58	58	58	78	75	58	86	58	78	78	58	58	58	74	58	78	69
clay - clay loam (30, 30, 40)	78	79	79	89	87	79	94	79	89	89	78	78	79	86	79	89	
clay loam (40, 30, 30)	73	74	74	86	84	74	92	74	86	86	73	73	74	83	74	86	
clay loam (30, 40, 30)	78	79	79	89	87	79	94	79	89	89	78	78	79	86	79	89	
loam (40, 40, 20)	71	72	72	85	83	72	91	72	85	85	71	71	72	82	72	85	
loam (50, 30, 20)	73	74	74	86	84	74	92	74	86	86	73	73	74	83	74	86	
sandy clay loam (60, 10, 30)	78	79	79	89	87	79	94	79	89	89	78	78	79	86	79	89	
loamy sand (80, 20, 0)	30	32	32	67	63	32	77	32	67	67	30	30	32	59	32	67	
sandy loam - sandy clay loam (70, 10, 20)	78	79	79	89	87	79	94	79	89	89	78	78	79	86	79	89	
sand (100, 0, 0)	58	59	59	80	77	59	87	59	80	80	58	58	59	74	59	80	
sandy clay loam (50, 20, 30)	76	77	77	88	86	77	93	77	88	88	76	76	77	85	77	88	
sandy loam (80, 10, 10)	52	52	52	76	72	52	84	52	76	76	52	52	52	71	52	76	
silty clay loam (20, 50, 30)	58	58	58	78	75	58	86	58	78	78	58	58	58	74	58	78	
sandy loam (70, 20, 10)	59	59	59	78	75	59	86	59	78	78	59	59	59	74	59	78	
sandy loam - sandy clay loam (60, 20, 20)	59	59	59	78	75	59	86	59	78	78	59	59	59	74	59	78	

2.4.3 Indoor Use Fractions

Applied water estimates are divided into the amount of water that is used indoors versus outdoors based on user-defined indoor use fractions. Monthly time series of indoor use fractions were estimated based on indoor water use divided by the total amount of groundwater pumped. Indoor water use was estimated as 90% of the groundwater pumped in February and was assumed to be constant throughout the year.

2.4.4 Urban Main Inputs

The urban main input file contains several pertinent inputs necessary to estimate runoff and evapotranspiration. These inputs include the pervious fraction and curve number. It is assumed that only pervious areas are available for ET. In all impervious areas, the ET is assumed to be zero. The ET of pervious areas was assumed equal to the ET of pasture. The pervious fraction was estimated as 0.66 based on the proportion of 'built-up' and undeveloped areas within the city limits. The curve number was estimated as 69 for urban areas, which was based on Hydrologic Soil Group B, fair hydrologic condition, and pasture. Root zone depth for urban lands was assumed to be two feet.

2.5 Land Use Inputs and Parameters

2.5.1 Land Use

Annual land use was estimated based primarily on spatially distributed land use information from DWR Land Use surveys for Madera and Merced Counties and Land IQ[2] remote sensing-based land use identification for 2014. Madera County DWR Land Use surveys were available for 1995, 2001, and 2011. Merced County DWR Land Use surveys were available for 1995, 2002, and 2012. County Agriculture Commission land use areas were used to interpolate between years with available spatial land use information. Lands in the Subbasin were assigned to one of 17 land use classes.

The Chowchilla Subbasin overlies both Madera and Merced Counties. The following five steps were used to develop the Madera and Merced County-wide annual, spatial land use datasets.

1.) Developed spatial land use coverages for:
Madera County: 1995, 2001, 2011, and 2014
Merced County: 1995, 2002, 2012, and 2014
and made adjustments to the spatial coverage, including:
    a) Filled missing area from LandIQ coverage with 2011 DWR coverage (native, semi-agricultural, urban, and water account for 86% of the missing area in Madera County and 95% of missing area in Merced County)
    b) Madera County: Used the water area from 2001 for the 1995 DWR survey (water surfaces were not included in the 1995 DWR survey).

2.) Calculated agricultural area:
    a) Assumed county data does not include idle land (county data has idle equal to zero for all years)
    b) Excluded idle land from DWR agricultural totals to be consistent with county totals

[2] Land IQ is a firm that was contracted by DWR to use remote sensing methodologies to identify crops in fields.

   c) Calculated the ratio of the DWR agricultural total area (not including idle lands) to county agricultural production area for years with DWR (or Land IQ) land use data
   d) Estimated agricultural area for missing years between the first and last available county data by interpolating the ratio calculated in step (c)
   e) Estimated agricultural area for missing years outside the available county data by extending the annual trend or estimating as equal to the nearest available county data

3.) Multiplied county agricultural acres for each crop by the ratio calculated in step 2 (c) to adjust county agricultural areas for each crop scaling each crop area in each year by an estimate of the difference between the areas in the DWR land use surveys and County Commissioner reports. This procedure assumes DWR areas are the most accurate.
   a) Interpolated native, semi-agricultural, urban, and water land uses between DWR years.
   b) Calculated idle area as the remaining area (total DWR land use minus total cropped area)

4.) Reviewed calculated idle and crop area graphs and adjusted individual annual cropped areas with abnormal crop area shifts based on professional judgement to eliminate calculated negative idle areas.

   Madera County:
   a) 1996 adjustments--replaced high miscellaneous truck areas with interpolated values between 1995 and 1997
   b) 2002, 2003, 2004 and 2005 adjustments--replaced high areas for mixed pasture and alfalfa between 2001 and 2011 DWR areas by interpolating areas between 2001 and 2011.
   c) 2012 adjustments--replaced high miscellaneous deciduous, field and truck with interpolated value between 2011 and 2013

   Merced County:
   a) Almond acreage adjustments--interpolated years 2013 and 2015 using 2012 and 2014 land use coverages
   b) Citrus and Subtropical acreage adjustments--interpolated between 2002 and 2015 using 2002, 2012, and 2014 land use surveys
   c) Grain and Hay Crops--interpolated years 2013 and 2015 using 2012 and 2014 land use coverages
   d) Grapes--interpolated between 1989 through 2015 using land use surveys
   e) Miscellaneous Field Crops--replaced low acreage in 1991 by interpolating between 1990 and 1992
   f) Miscellaneous Truck Crop--interpolated years 2006, 2009, 2010, 2013, and 2015 based on land use surveys
   g) Water--assumed acreage from 1995 DWR survey for 1989 through 1994

5.) Implemented the DWR Land Use interpolation tool to create annual spatial cropping data sets.

Complete land use areas for the entire subbasin for 1989 through 2015 are provided in Section 2 of the GSP.

3 RESULTS

Table A2.F.g-6 summarizes average acreage and evapotranspiration rates across Chowchilla Subbasin based on the IDC model and land use analysis.

Table A2.F.g-6. Average Acreages and Annual Evapotranspiration Rates for Chowchilla Subbasin, 1989 to 2014.

Land Use Sector	Land Use Class	Acres	ET_c (in)	ET_{pr} (in)	ET_{aw} (in)
Agricultural	Alfalfa	22,743	38.4	7.3	31.1
	Almonds	26,296	41.5	7.7	33.8
	Citrus and Subtropical	65	40.2	7.7	32.5
	Corn (double crop)	17,325	34.9	5.5	29.5
	Grain and Hay Crops	5,642	19.6	5.8	13.7
	Grapes	9,976	26.6	7.0	19.6
	Idle	6,624	6.8	6.8	0.0
	Miscellaneous Deciduous	3,791	32.5	7.4	25.1
	Miscellaneous Field Crops	14,377	30.7	5.8	24.9
	Miscellaneous Truck Crops	1,537	30.4	5.7	24.7
	Mixed Pasture	6,424	28.5	6.6	22.0
	Pistachios	3,951	36.9	7.3	29.7
	Walnuts	315	33.9	7.7	26.2
Native Vegetation	Native	17,702	7.9	7.9	0.0
	Water	1,397	8.1	8.1	0.0
Urban	Urban	4,691	14.2	7.2	6.9
	Semi-agricultural	3,467	13.8	7.0	6.7

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APPENDIX 2.G. CHOWCHILLA SUBBASIN DOMESTIC WELL INVENTORY

Prepared as part of the

Groundwater Sustainability Plan
Chowchilla Subbasin

January 2020
Revised July 2022

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Technical Memorandum:

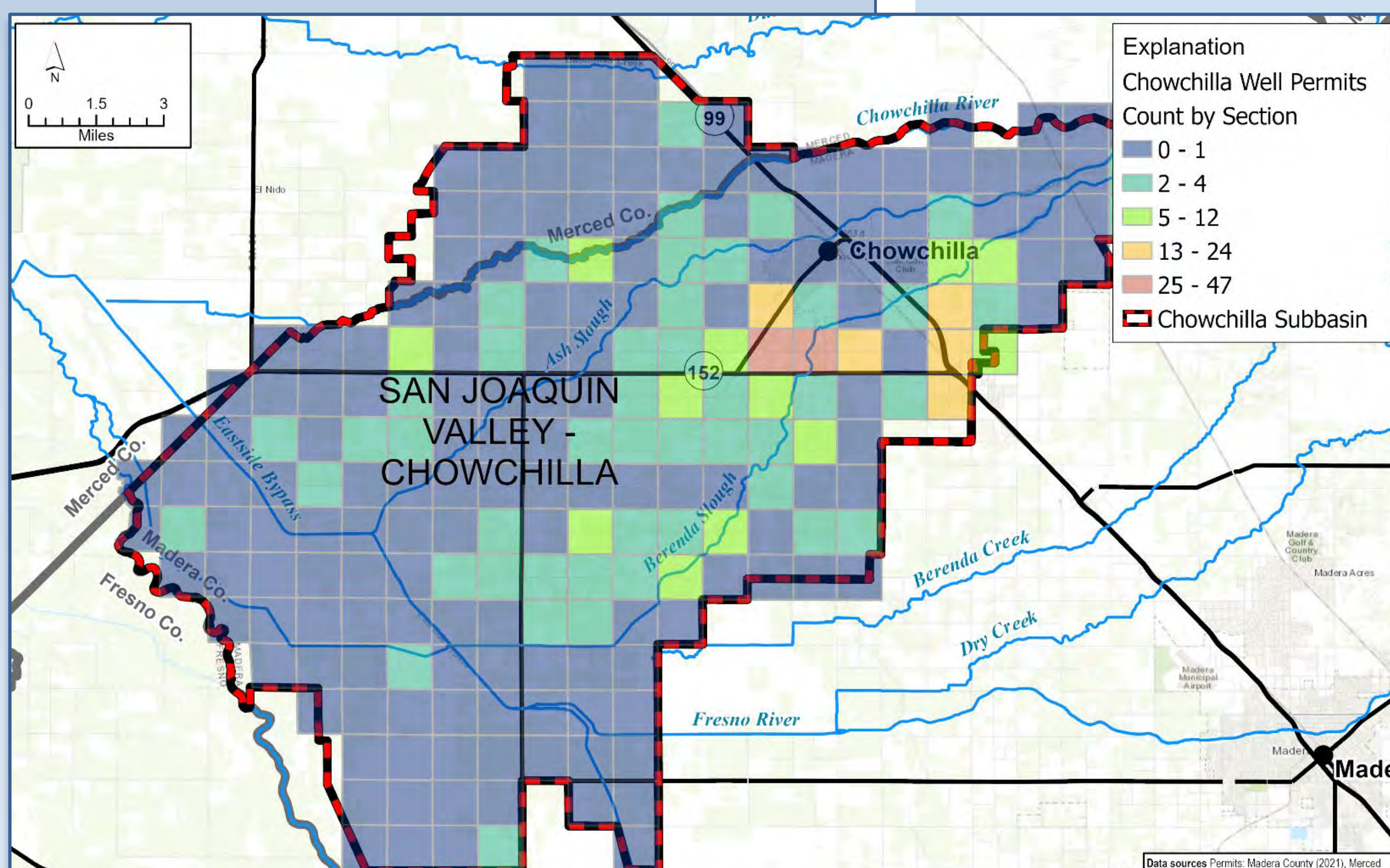
Domestic Well Inventory for the Chowchilla Subbasin

Prepared for Madera County and the
Chowchilla Subbasin Groundwater Sustainability Agencies

April 2022

Prepared by

Luhdorff & Scalmanini
Consulting Engineers



Technical Memorandum:

Domestic Well Inventory for the Chowchilla Subbasin

This memorandum was prepared for Madera County and the Chowchilla Subbasin Groundwater Sustainability Agencies to support implementation of the Chowchilla Subbasin Groundwater Sustainability Plan.

Luhdorff and Scalmanini Consulting Engineers conducted the Domestic Well Inventory project for the Chowchilla Subbasin and prepared this technical memorandum with assistance from ERA Economics.

Madera County and the Chowchilla Subbasin Groundwater Sustainability Agencies appreciate and acknowledge funding received from the California Department of Water Resources under the Sustainable Groundwater Planning Grant Program, authorized by the California Drought, Parks, Climate, Coastal Protection, and Outdoor Access for All Act of 2018 (Proposition 68). This grant funding supported the completion of the Chowchilla Subbasin Domestic Well Inventory project.

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LIST OF ABBREVIATIONS & ACRONYMS

Acronym	Meaning
APN	Assessor Parcel Number
CDP	Census-Designated Place
CDWR	California Department of Water Resources
CEHTP	California Environmental Health Tracking Program
DAC	Disadvantaged Communities
DDW	Division of Drinking Water
DTW	depth to water
GPS	Global Positioning Satellite
GSP	Groundwater Sustainability Plan
LSCE	Luhdorff & Scalmanini, Consulting Engineers
LSWS	Local Small Water System
MCSIM	groundwater model
MD	Maintenance District
MHI	median household income
OSWCR	Online System for WCRs
PLSS	Public Land Survey System
PWS	Public Water System
SDAC	Severely Disadvantaged Communities
SDWIS	Safe Drinking Water Information System
SGMA	Sustainable Groundwater Management Act
SHE	Self-Help Enterprises
SSWS	State Small Water System
SSWS	State Small Water System
SWRCB	State Water Resources Control Board
TM	Technical Memorandum
WCR	Well Completion Report

1 INTRODUCTION

The Chowchilla Subbasin Groundwater Sustainability Plan (GSP) includes maps, figures, analysis, and discussion of domestic wells and potential impacts from continued decline in regional groundwater levels during the GSP Implementation Period (2020 through 2040) while the Subbasin works to achieve sustainability. The GSP provided the background and data analyses to illustrate the need for a Domestic Well Mitigation Program in Chowchilla Subbasin and described how it is the most economically viable way to transition from current overdraft conditions to sustainable conditions in 2040. However, there was insufficient time during GSP development to conduct the more thorough inventory of domestic wells and the potential range of impacts to domestic wells under various scenarios of future groundwater conditions. This study supplements domestic well information provided in the GSP and provides an updated analysis that includes anticipated impacts to domestic wells during the GSP Implementation Period.

Madera County was successful in applying for a DWR grant under Prop 68 to conduct a more detailed well inventory, which is documented in this Technical Memorandum (TM). In addition, the grant funding provides for drilling and installation of nested monitoring wells at three sites in proximity to clusters of domestic wells to provide monitoring of current and future groundwater levels and quality. This TM includes recommendations for locations of these three nested well sites.

To prepare this domestic well inventory, approximations of the number, depths, and locations of domestic wells were developed from multiple available data sources. The total number of domestic wells indicated to be present according to different data sources were reviewed and compared. Domestic well depths were then compared to historical, current, and predicted future local groundwater depths based on observed and modeled data from the groundwater model (MCSIM) developed for and described in the 2020 Chowchilla Subbasin GSP. Due to the uncertainty in future climatic conditions for the GSP Implementation Period; two primary future condition scenarios were evaluated to bracket the range of domestic wells that are estimated to go dry during the GSP Implementation Period. Estimates of costs to replace domestic wells are included in this TM.

This TM documents the available data sources for estimating numbers and locations of domestic wells, domestic well construction details, and occurrence of domestic wells inside and outside of public and small community water systems, analyses to estimate the number of domestic wells that may go dry through 2040 based on two different climatic sequences, and sensitivity analyses to evaluate how various assumptions impact estimates of the number of dry wells. Using the results from the domestic well inventory and analysis, an updated economic analysis was also conducted comparing the tradeoffs of implementing a Domestic Well Mitigation Program during the Implementation Period versus immediately implementing demand reduction in the Subbasin to avoid significant and unreasonable adverse impacts on domestic well users. This economic analysis is included as **Attachment 1** (Domestic Well Replacement Economic Analysis) and provides an update to Appendix 3.C of the Chowchilla Subbasin GSP. **Attachment 1** incorporates the latest results from the domestic well inventory relative to the total number of domestic wells estimated to go dry during the GSP Implementation Period. The economic analysis evaluated the difference in costs for implementing a Domestic Well Mitigation

Program concurrent with gradual reductions in groundwater pumping over the twenty-year Implementation Period compared to not having a Domestic Well Mitigation Program and immediately implementing demand management and other PMAs to eliminate the overdraft in the Subbasin.

2 DOMESTIC WELL INVENTORY DATA SOURCES AND COMPILATION

Data from a variety of public agencies were assembled for consideration in the project. Compiled datasets included the following.

- Well Completion Report (WCR) Database from California Department of Water Resources (CDWR) Online System for WCRs (OSWCR)
- Madera County well permit database (records since 1990)
- Madera County Assessor's Parcel data
- Merced County well permit database (records since 1999)
- Merced County Assessor's Parcel data
- Public Water System (PWS) service area boundaries and PWS well locations from State Water Resources Control Board (SWRCB) Division of Drinking Water (DDW)
- State Small Water System (SSWS) service area boundaries from Madera County
- Census block-level household counts from the US Census Bureau
- Disadvantaged Community boundaries from DWR

With the exception of the Madera and Merced County well permit databases, all of the above-listed datasets were available in geospatial (e.g., GIS) formats. The well permit databases were provided as tabular data, which were converted to geospatial information as described below.

2.1 DWR WCR Database

The primary source for well construction data in the Subbasin is the CDWR OSWCR database (CDWR, 2020). Well drillers are required to submit a WCR to DWR for all wells drilled and constructed in the State of California. DWR has tabulated information from WCRs for the State, including data from WCRs dating as far back as the early 1900s. The tabulated WCR information include well type and construction characteristics such as the intended use of the well, well depths, and screened intervals along with location, construction date, permit information, and other details included on the WCR. Although completed WCRs commonly include additional notes on borehole lithology and a variety of other types of information; however, lithology and some other well information included on WCRs is not entered or maintained in the OSWCR database. It is notable that many well attributes in the WCR database are blank or incomplete because of missing or illegible information provided on the WCRs. Additionally, well locations in the WCR database are commonly only provided to the center of the Public Land Survey System (PLSS) section in which it is located, which translates to a locational accuracy of approximately +/- 0.5 mile.

2.1.1 Domestic Well WCRs

As part of the project, initial quality checks were conducted on the WCR database to identify obvious inconsistencies in well data, including conflicting well locations (e.g., latitude, longitude, PLSS coordinates) and construction (e.g., well depths, top and bottom of screens). Such questionable information and records were flagged for additional consideration during subsequent analyses. For the purpose of this domestic well inventory project, only WCRs indicated to be domestic water supply wells were included in the analysis. To limit potential double counting of domestic wells, only WCRs for new well construction (i.e., not well repairs/modifications or destruction) were included in the domestic well inventory.

The number of well records within the Chowchilla Subbasin in the WCR database exhibit a notable increase starting in about 1970 as indicated by domestic WCR counts by decade presented in **Table 1**. This shift may be partly due to changes in the Water Code relating to well data collection methods and reporting requirements that were instituted in 1969. The number of WCRs for domestic wells in the Chowchilla Subbasin increased by a factor of two around 1970, from 46 WCRs in the 1960s to 76 in the 1970s.

2.1.2 WCR Dates

The typical lifespan of a small water well is estimated to be 30 to 50 years based on the durability and longevity of typical domestic well materials, which are commonly constructed of steel or polyvinyl chloride (PVC) casing. Wells drilled prior to 1970 are also less likely to still be in operation because of long-term trends in groundwater levels in the Subbasin.

For these reasons, only WCRs for wells with dates on or after 1970, were included in the domestic well inventory and associated analyses. The OSWCR database includes 62 domestic well new construction WCRs located in the Chowchilla Subbasin that do not have any recorded installation or permit dates. For this well inventory and analysis, these 62 wells were included in the analysis even though some fraction of them may have been constructed prior to 1970. A total of 500 domestic wells constructed since 1970 were considered in the project based on WCR records.

2.1.3 WCR Locations

Wells with WCRs marked as domestic were selected and mapped based on one of four geolocation methods, depending on what information was available in the tabulated data. Only wells with installations in 1970 or later were considered, or those with no available date of installation. The geolocation methods, in order of priority, are as follows:

1. Assessor Parcel Number (APN) – 236 wells
2. Address – 95 wells
3. Public Land Survey System (PLSS) – 169 wells

A total of 500 domestic well were located within the Chowchilla Subbasin using these methods (**Figure 1a**). Wells located by PLSS are typically placed at the center of the section in which they are located, and thus may be out of position by as much as about 0.5 mile (half the typical width of a section). Other sources of location error include changes in APNs over time; poorly matched addresses; and incorrect WCR entries for PLSS values, GPS coordinates, APNs, or addresses. Since many of the location dots for domestic wells plot on top of each other in **Figure 1a**, the locations of domestic wells in the Subbasin by Township/Range/Section are displayed in **Figure 1b**. Of the 500 domestic well WCRs, only 17 are located in Merced County, and the rest are located in Madera County.

2.2 Well Permit Records

Madera and Merced Counties require a well permit be obtained prior to drilling and constructing a domestic well. Records of well permits were provided by Madera and Merced Counties as tabular datasets (Madera County Environmental Health, 2020; Merced County Environmental Health, 2020); no GIS data were initially available for the well permits. The period of record for the well permits begins in 1990 for Madera County and 1998 for Merced County. Limited information on individual wells is available in the well permit dataset, although most well permits include Assessor Parcel Numbers (APNs) or well addresses that can be used for locating wells. Well uses in the permit dataset were inconsistently entered and required considerable review and assessment to standardize well uses for identifying likely domestic well permits.

2.2.1 Domestic Well Permits

2.2.1.1 Madera County Domestic Well Permits and Locations

A subset of 7,505 permits for all of Madera County was identified as likely domestic wells based on the indicated well use. The well uses retained as representative of likely domestic wells include the following:

1. Domestic (7300 permits),
2. Domestic Replacement (25 permits),
3. Shared (54 permits),
4. Dairy (36 permits),
5. No Use listed (90 permits).

“Shared” wells are typically domestic wells that are also used for irrigation. “Dairy” wells are typically used for semi-industrial, and irrigation uses on a dairy, but in some cases can also be used for domestic water supply. Wells without a listed use were included in an effort to be conservative in the domestic well inventory.

Of the 7,505 domestic well permits (7,362 with APNs) for all of Madera County, the portion applicable to Chowchilla Subbasin were identified based on locations derived from APNs and addresses. Multiple permits refer to the same APN in some cases with only 6,498 unique APNs listed as having domestic well permits in the database. Domestic well permits in the County well permit database were located by matching the listed APN with the county parcel data when possible. Following this approach, 426 permits were matched to 378 unique parcel locations within Chowchilla Subbasin. For the 143 Madera County well permits without APNs, 8 permits were expected to be located within the Subbasin based on the fraction of permits with APNs that were determined to be within the Subbasin.

In addition to APNs, the Madera well permit database includes site addresses for most (7,323) of the wells. Through geocoding of addresses in the well permit database, 6 more well permits were located within the Subbasin.

Through locating of well permits based on APNs and site addresses, approximate locations for 6,709 of the 7,505 Madera County domestic well permits were determined. Using these locations, the total number of domestic well permits in the Madera County portion of the Chowchilla Subbasin was determined to be 432 permits (at 384 unique locations) out of 7,505 domestic well permits in the data base. Madera County well permit information is summarized in **Table 2 and Figures 2a and 2b**.

2.2.1.2 Merced County Domestic Well Permits and Locations

Two datasets of well permit records were provided by Merced County. The first well permit dataset includes 2,034 domestic wells drilled since 1996, with depths and locations (as latitude and longitude) provided for all wells. Locations for these wells were determined using the coordinates included in the dataset. None of these wells are located in the Chowchilla Subbasin. The second dataset of well permit information available from Merced County includes 291 domestic wells that were installed in 1998 and later. These permit locations were determined based on addresses provided in the dataset for all wells. Most of these wells (all but 12) also have depth information. Seven of these 291 domestic wells with permits are located within the Chowchilla Subbasin. Merced County well permit information is summarized in **Table 2 and Figures 2a and 2b**.

2.3 County Assessor Parcel Data

County Assessor parcel GIS data were provided by Madera and Merced Counties (Madera County Assessor's Office, 2020; Merced County Assessor's Office, 2020), including land use and other characteristics for each APN indicating the presence of a dwelling. The Madera County parcels dataset includes 7,033 unique APNs within the Chowchilla Subbasin. Of those, 4,494 are listed as having dwellings associated with them. The Merced County parcels dataset includes 160 unique APNs within the Subbasin. Of those, four are listed as having dwellings associated with them, for a total of 4,498 in the Subbasin (**Figure 3)**. Although the County parcel datasets do not include records related to the presence of domestic wells on parcels, the presence of a dwelling on a parcel is interpreted to suggest the presence of a drinking water supply, including in some areas the potential for a domestic well to exist. This includes parcels that are located within a public water system service area.

2.4 Water System Data

Public Water System (PWS), State Small Water System (SSWS), and Local Small Water System (LSWS) service area boundaries from State and local data sources were used to map and evaluate where and how many inferred well locations occur inside of a water system service area and therefore may not be supplied by a domestic well. Water system boundaries are a key dataset for comparing with potential domestic well locations identified through analysis of WCRs, parcels, and permits. The service area boundaries for water systems identified in the Subbasin are presented on **Figure 4** based on the evaluation of PWS, SSWS, and LSWS boundaries as described below

2.4.1 State Regulated Systems

The PWS boundaries are part of an archived dataset developed by the California Environmental Health Tracking Program (CEHTP) and now maintained by the State Water Resources Control Board (SWRCB) Division of Drinking Water (DDW) (SWRCB, 2021). This dataset is a publicly available GIS feature class of system boundaries provided voluntarily by water system operators over the period from 2012 to 2019. Previous assessments of this dataset suggest it includes approximately 85 percent of community water systems, although this can vary by region within the state. Of the state regulated community PWS boundaries, two were identified to have service areas within Chowchilla Subbasin.

2.4.2 County Regulated Systems

The PWS service area dataset from DDW is not intended to include county-regulated systems. Madera County Public Works provided additional service area boundary data for county-regulated water systems (Madera County Environmental Health, 2021), but none of these County water system boundaries are within the Chowchilla Subbasin. Merced County Environmental Health was asked to provide locations of county-regulated systems in the Chowchilla Subbasin and indicated that none exist in that area.

2.4.3 Public Water System Wells

PWS well locations were downloaded from the SWRCB GAMA website (SWRCB, 2021) and used to check for any water system wells in areas not covered by the water systems service area boundaries data. All PWS wells were located within previously delineated water system service area boundaries.

2.5 Community Data

2.5.1 Census

United States Census data (US Census, 2016) were used for cross-checking and comparison with domestic well WCRs, domestic well permits, and parcels with dwellings in the Subbasin. The Census data include counts of households by Census area (e.g., block, tract, designated place). The Census data were evaluated to assess whether they could inform the count and locations of domestic wells in the Subbasin. To approximate the number of households that might have a domestic well, Census block area were converted to randomly located points within each block equal in number to the count of households per block. The resulting 2,739 points represent an estimate of the total number of households within the Subbasin that might have a domestic well (**Figure 5**). This includes households that are included within a public water system service area.

2.5.2 Disadvantaged Communities

DWR defines Disadvantaged Communities (DACs) as communities with an annual median household income (MHI) less than 80 percent of the Statewide annual MHI (PRC Section 75005(g)), and SDACs as communities with an annual MHI less than 60 percent of the Statewide annual MHI. The statewide median household income (MHI) for the Census American Community Survey (ACS): 2014-2018 dataset is $71,228. Therefore, a community where the MHI is less than $56,982 meets the DAC threshold and a community where the MHI is less than $42,737 meets the SDAC threshold.

DWR provides a standardized GIS layer of Disadvantaged Communities and Severely Disadvantaged Communities (DACs, SDACs) (DWR, 2021). These data are available as Census Designated Places, Census Tracts, or Census Blockgroups. The Tract-level data are simply aggregated from the Blockgroup-level data and were not used in the current analysis. Place-level data are not congruent with Blockgroups or Tracts, typically following established neighborhood boundaries. Place-level data provide a more focused description of the regions that qualify as DAC or SDAC; however, the Place-level data is only available in Census-Designated Places (CDPs), and these do not capture more diffuse residential neighborhoods. DACs and SDACs are found in both urban and rural areas in Chowchilla Subbasin. **Figure 6** shows the locations of the Census Designated Places and Census Blockgroups identified as DACs or SDACs by the definition above.

3 ANALYSIS AND RESULTS

Estimates of domestic wells were developed through analysis and comparison of the data sources discussed above. Evaluation of the number and locations of domestic wells in Chowchilla Subbasin were made using four different sources of data and approaches: from WCRs, well permits, parcels with dwellings, and Census households. Domestic well WCRs and well permits provide a more direct indication of the existence (past or present) of a domestic well, whereas the parcel data and Census data provide a basis for inferring the existence of domestic wells. The County well permit databases are believed to provide the most accurate estimate of the numbers and locations of domestic wells constructed during the available data record (since 1990 in Madera County and from 1998 in Merced County).

The completeness of the well records in County well permit data are expected to be greater than the WCR database because although regulations state that WCRs are required to be submitted to DWR for all constructed wells, there has historically been little or no verification at the County or State level that a well driller submits a WCR to DWR after a well is completed. In cases where a WCR is submitted, the time elapsed between when a well is drilled and when a WCR is submitted to DWR can be highly variable and information provided on WCRs may not be complete. There are also additional steps involved in entering WCRs into DWR's database after receiving a WCR, which may also introduce timing delays or data entry errors. In contrast, although there is generally no information about a given well's design provided in the County well permit database, there is a fee to obtain a well permit and permits are typically obtained by the driller immediately prior to starting work on a project. Therefore, it is believed that most permitted wells are constructed even if a corresponding WCR is never submitted to DWR by the well driller.

The locational accuracy of well permit records are also believed to be better because most well permit records include data on the parcel where the well is permitted. Many of the WCR records only indicate location by the PLSS section in which the well is located.

Although the well permit data are believed to be more complete and provide better locational accuracy of wells, only the WCR data have information on well depths and other well construction details (**Figure 7a**, **Figure 7b**). Additionally, while WCRs and well permits generally have a date associated with each record indicating the approximate date of well construction, the parcel and Census datasets do not.

However, estimates of well counts based on parcel and Census data do provide a sense for the maximum possible number of domestic wells, and also a comparative check on the relative spatial density of domestic wells in the Subbasin.

Water system service area boundaries were used to refine domestic well estimates derived from parcel and Census household counts, with the expectation that all parcels and households within a water system boundary are served water from the water system and therefore do not rely on a domestic well. The locations and count of permits and WCRs were assumed to be correct, regardless of their location relative to a PWS service area.

With this information, estimated locations and counts of domestic wells in the Subbasin were developed and well depths were compared to historical groundwater levels and model-simulated future groundwater levels (based on the modeling conducted during GSP development) to evaluate potential impacts to domestic wells from changing groundwater levels in the Subbasin. The methods and results from these analyses are described below.

3.1 Analysis of Domestic Well Locations and Counts

3.1.1 Domestic Well WCRs

The domestic well WCRs since 1970 were compared with water system boundaries. Because the WCRs are records of actual wells that were constructed, those located within a water system service area are assumed to be correctly located. It is possible that wells that pre-existed the establishment of a water system in an area may remain in use after the water system is operational; however, the frequency of this occurring is not known.

Of the 500 domestic wells represented by WCRs in the Subbasin, 12 are located within the known water system boundaries (**Figure 8**). This represents 2.4 percent of the domestic well WCRs in the Subbasin. Some of these domestic well WCRs may be associated with wells that no longer actively supply domestic drinking water. Nevertheless, WCRs within a water service area boundary were still considered in the domestic well inventory and analysis described below, which is a conservative assumption relative to likely domestic well counts.

3.1.2 Domestic Well Permits

Similar to the WCR estimate, permits are expected to accurately identify well locations, but domestic well permits may exist for wells drilled and constructed prior to the operation of a water system in an area. The use of such wells may have been discontinued when a residence was hooked up to a water system, although this may not always be the case and some domestic wells within water system service areas may still be operational.

In contrast to the WCR dataset, which relies on submittal and entry of a WCR in DWR's database, the County well permit datasets are expected to be a more comprehensive representation of the wells drilled in the County for the period it covers (1990 to present for Madera, 1998 to present for Merced). Although the comparisons across different datasets described below highlight differences between data sources and the estimates of domestic wells derived from each, this study did not attempt to assess the accuracy of the well permit database in relation to actual domestic wells.

Of the 439 domestic well permits in the Subbasin, two are located within known water system boundaries, which represents about 0.5 percent of the domestic well permits in the Subbasin. These two permits within a water service area boundary were still considered in the domestic well inventory and analysis described below.

3.1.3 Parcels with Dwellings

For the purpose of assessing the maximum possible number of domestic wells in the Subbasin, all parcels with a dwelling but not within a water system service area were counted. In this approach, a parcel is considered within a water system service area if its centroid is within the service area.

Based on these criteria, within the Chowchilla Subbasin there are a total of 4,498 parcels with dwellings, 967 (963 in Madera County, four in Merced County) of which are outside of water system service area boundaries. These 967 parcels representing potential domestic well locations are presented on **Figure 9**. There are several areas within the Chowchilla Subbasin with a relatively high density of parcels with dwellings that are not covered by a water system boundary.

3.1.4 Census households

Due to the irregular shape of Census blocks and the inconsistent alignment of blocks with other important boundaries in the Subbasin (e.g., Subbasin, water service areas) the Census data provided have limited utility to inventory domestic wells, although they do provide an approximate check on the maximum overall number of potential domestic wells in the Subbasin. Conversion of the Census household counts to points and comparing to water system service areas provides as estimate of 1,294 potential households outside of water system service areas. Within that set of 1,294 potential wells, 1,241 are in Madera County, and 53 are in Merced County. Although the total number of parcels with dwellings is almost twice as large as the total number of households within the Subbasin, the number of households estimated to be outside of the water system service areas is about 33% higher than the number of parcels outside of the water system service areas.

3.1.5 Comparisons of Domestic Well Location Information Sources

3.1.5.1 Domestic Wells Within PWS Service Areas

While most residences within a PWS service area are supplied with drinking water by that PWS, it is not unusual for wells drilled prior to the creation of the PWS would be retained and used for part or all of a residence's use, including for drinking water or landscape irrigation.

Of the 500 WCRs since 1970 located in the Chowchilla Subbasin, 12 are located within a water system service area. Of the 436 permits (since 1990) located within the Madera County portion of the Chowchilla Subbasin, two were located within a water system service area. None of the seven permits (since 1998) located within the Merced County portion of the Chowchilla Subbasin were located within a water system service area. Overall, less than 0.5 percent of domestic well permits are located within a water system service area.

Of the 4,498 parcels with dwellings noted in the two county APN datasets, 3,531 are within a water system boundary. Of the 2,739 households in the Subbasin indicated by the 2010 Census data, 1,445 are within a water system service area.

The count of known locations of permits and WCRs within water systems, when compared to the number of residences within those systems based on parcel and Census data, represent between zero and three percent of the number of residences within those service areas. This suggests that the number of domestic well permits and WCRs located within water system boundaries is a very small fraction of the number of likely residences within those water system areas. Accordingly, this comparison suggests that neither the WCR nor well permit data identify a large number of domestic wells within water system boundaries. Although this does not speak to the accuracy of the WCR and well permit data in locating wells in other areas of the Subbasin, they do not appear to identify an unreasonable number of domestic wells within areas covered by water systems.

3.1.5.2 Comparing WCR Locations to Well Permits

The Madera County well permits dataset is believed to be more complete in representing wells drilled in the County, but it only extends back to 1990. To provide an appropriate comparison between the WCR dataset and the well permit dataset, a subset of the WCRs since 1990 (those dated after 1989), were considered. In the Madera County portion of Chowchilla Subbasin, 304 domestic well WCRs have construction dates after 1989. An additional 58 domestic well WCRs have no installation date recorded. For this analysis, WCR records without dates are assumed to be drilled in 1990.

The subset of domestic wells with WCRs since 1990 has many similar characteristics as the dataset for WCRs since 1970, with several noteworthy differences. As shown in **Table 3**, proportionally, the WCR dataset since 1990 has fewer WCR records located in water system service areas. This is reasonable, as it is consistent with the understanding that many of the domestic well WCRs located within water system service areas are for wells drilled prior to the creation or expansion of those water systems.

There is no direct linkage between WCRs and well permits on record (i.e., WCRs commonly do not indicate well permit numbers) for majority of the wells, and the available method for geolocating records for a given well present in both datasets may differ. However, it was determined that 166 of the parcels associated with permit locations coincided with WCR locations for domestic wells for Madera County (and another two wells for Merced County), and the spatial distribution of Madera and Merced County domestic well permits and WCRs are similar within the Subbasin (**Figure 10**).

This relatively low rate of coincidence is most likely a function of poor accuracy of the WCR locations. The permit location error is generally related to the area of the parcel within which they are located and is commonly less than half the distance of the maximum parcel dimension. As parcel size decreases, the accuracy of the locating of well permits tends to increase. Many WCR locations have much higher error, especially those that rely on locations from the PLSS section centroid. In addition, the subset of domestic well WCRs since 1990 in the Madera County portion of the Chowchilla Subbasin has a similar spatial distribution to the dataset of WCRs since 1970. Therefore, the WCRs since 1970 likely reasonably represent the distribution of permits since 1970 similar to the way WCRs from 1990 and later represent permits from 1990 and later.

The Merced County well permits dataset only has records for 1998 and later, so a comparison with the WCRs for the Merced County portion of the Chowchilla Subbasin can only be made with WCRs from 1998 and later. Of the 17 WCRs for wells in the Merced County portion of the Chowchilla Subbasin, eight were installed after 1998. Four more WCRs in the area had no installation date.

Two of the seven permits for wells in the Merced County portion of the Chowchilla Subbasin are on the same parcel as WCRs for the area. Of those two, one also shares an address with the WCR that overlies it. Another permit shares an address with a WCR, but is not located on the same parcel, based on the APN location of the WCR. This may be due to an error on the WCR, or to changes in the APN since the well was installed. The APN identified on the permit matches the APN identified on a WCR for four of the wells.

3.1.5.3 Comparing Domestic Well Permits with Parcel Characteristics

Of the 439 domestic well permit locations identified within the Chowchilla Subbasin, 350 (80 percent) are located on parcels with dwellings, as indicated in the parcel datasets for Madera and Merced Counties, suggesting that a residence is present on the parcel associated with the well permit (**Figures 11a and 11b**).

3.1.5.4 Comparisons of Parcels with Dwellings and WCRs

Of the 967 parcels listed as having dwellings in the Chowchilla Subbasin, and not within a water system boundary, 202 coincide with the location of domestic well WCRs located as described above. All 202 of these were in Madera County. Only one parcel listed (in Madera County) with a dwelling was located within a water system and also coincided with a WCR location (**Figure 12**). As discussed above, WCRs are poorly located due to lack of APN, GPS, or address data.

3.1.6 Final Domestic Well Count and Location Estimates

The Madera County permit database includes 432 domestic (or considered domestic for this analysis) wells installed since 1990. For providing a direct comparison of the domestic wells counts from the WCR database, the count of WCRs was limited to WCRs with dates since 1990 (362 domestic well WCRs) to allow for direct comparison to available County permits. This comparison yields a ratio of 1.19 between the domestic well permit count and the domestic well WCR count. Well permits are believed to provide a more complete representation of wells constructed in the Subbasin, but these permit records do not contain information on well perforations and depths and only date back to 1990. As a result, the ration of well permits to WCRs for the period since 1990 provides a useful scaling metric of results derived during the evaluation of potential impacts on domestic wells from changing water levels, an analysis which relies heavily on well construction information available only on WCRs. The domestic well impacts analysis is described below.

3.2 Evaluation of Potential Domestic Well Impacts

A key consideration in the implementation of the GSP for the Chowchilla Subbasin is the potential occurrence of impacts to domestic well users due to declining water levels. As part of implementing the GSP, the Subbasin is in the process of evaluating and designing a Domestic Well Mitigation Program targeting domestic wells that may be impacted by future declines in groundwater levels. To support this effort, the effects of historical and future groundwater levels on domestic wells in the Subbasin were evaluated.

This analysis involved comparing domestic well perforation and depth information to historical groundwater levels and potential future groundwater levels, as simulated by the groundwater model (MCSim) utilized during the GSP development. Simulated groundwater level conditions from MCSim were used to estimate the number of domestic wells that may go dry during the GSP implementation period from 2020 through 2040, the period during which the Subbasin will be working towards achieving sustainability as required by SGMA. WCR records for domestic wells (and the well construction information provided on WCRs) were used to estimate well depth information for evaluating impacts. The ratio of well permits to WCRs (1.19) was used to upscale the results derived from these analyses conducted using WCR data.

3.2.1 WCR Domestic Well Construction Information

Of the 500 domestic well WCRs in the Chowchilla Subbasin, 479 included some information on bottom of perforated interval (top and bottom of perforations) or total depth. As mentioned earlier, several inconsistencies in construction information were noted in the initial WCR dataset (e.g., total well depth less than depth to top of perforations, depth to bottom of perforations less than top of perforations), so multiple levels of quality checks were conducted on the well construction data in the WCR database to assess the reliability of the information. Only WCR records determined to have sufficiently reliable well construction information (i.e., lack of obviously conflicting information on the well construction) were included in the summary and analyses relating to domestic well construction in the Subbasin. In analyses using well perforations (screens), where data for bottom of perforations was not available, the reported total well depth was used. A total of 454 WCRs included top of screened interval information. For wells lacking information for either bottom of perforations or top of perforations, the average values for wells in the same section were used. Where a section had fewer than three wells with reported depth or top of screen data, the average values from wells in the same section and the eight surrounding sections were used. This resulted in estimates of top and bottom of perforated Intervals for all 500 domestic well WCRs in the Subbasin. **Figure 7a** and **Figure 7b** show the depth of domestic wells in the Subbasin based on these estimates.

3.2.2 Domestic Well Impacts Analysis Methods

Simulated groundwater levels output from the MCSim model developed by Luhdorff & Scalmanini Consulting Engineers (LSCE) and described in the 2020 GSP for Chowchilla Subbasin were queried to produce depth to water (DTW) datasets for the Subbasin for the period from 1989 through 2070. MCSim is a multi-layered model and based on review of the well data and consideration of the hydrogeologic conceptual model and groundwater conditions described in the GSP, model layers 3 and 4 were determined to most appropriately correspond with the production zones for most domestic wells in the Subbasin. The simulated DTW datasets for model Layers 3 and 4 were used to extract DTW values for different time periods at all WCR locations; DTW values at each domestic well WCR location were compared with the top and bottom of perforations (screens) values for each WCR. Based on this comparison, the wells were assigned DTW values for either model Layer 3 or 4. If a well was screened at least 50 percent in Layer 4 or deeper, the well was assigned DTW values for Layer 4. If more than 50 percent of the screened interval was above Layer 4 (in Layer 3 or shallower) then Layer 3 DTW values were assigned to the well.

Simulated depth to water model output for Layers 3 and 4 for the years from 1989 to 2039 were then compared to the screened intervals for each domestic well (WCR) to assess if each well was wet or dry during each year. For each year, the fall simulated DTW (on October 31st) in Layers 3 and 4 of the model were assessed for each well location.

The analysis was performed using different analysis periods and methods. Generally, the analysis was conducted using five-year analysis periods, with the first analysis period starting in 1989 and extending to 2014 or 2015 followed by shorter five-year intervals thereafter. Analyses included comparisons based on snapshots of DTW conditions at the end of each analysis interval (generally five-year analysis periods) and separate comparisons based on the maximum depth to water found during each analysis period. Variations of analyses were also performed using simulated model output from the projected model run used in the GSP, and also separately for a model run utilizing a projected future hydrology that included drier conditions during the early years of the GSP Implementation Period, conditions that are more consistent with the recent hydrology experienced in the area. In all analyses, if the simulated DTW in the assigned model layer at a well location falls below the required minimum level of saturation in relation to the depth of the well, either at the end of each analysis period (or in the year within each five-year period that generally had the lowest water levels for the maximum DTW scenario), the well was considered to have gone dry during the analysis period. Once a well was concluded to have gone dry in an analysis scenario, it was removed from the pool of potential wells that could go dry in subsequent years. The sensitivity of model results to different assumptions, analysis periods, and WCR data restrictions were tested and evaluated.

The parameters used in the analysis are defined as follows:

P = the base year for the analysis periods. This defines the end of the initial historical analysis period (after 1989) during which wells were evaluated for historically having gone dry. This is generally Fall 2019, indicating a historical analysis period of 1989-2019, but 2018 was also used as the ending year for the historical period during sensitivity analyses (because groundwater levels in 2018 were generally lower than in 2019).

S = minimum saturation threshold above the well total depth for a well to remain wetted. This is assumed to be 10 feet in the baseline analysis, but the sensitivity of analysis results to varying this value was conducted to evaluate the influence of this parameter on analysis results.

E = the earliest year of installation for the WCRs considered. This reflects the cutoff year for the construction date on WCRs intended to reflect wells that may have been active at the time of the base year considered based on typical domestic well life expectancy.

Appropriate scaling of the results of these impacts analyses based on WCR was also considered based on the ratio (1.19) of domestic well permits to domestic well WCRs determined previously. The ratio is developed from a direct comparison of domestic well permits and WCRs with dates since 1990. The scaling ratio is applied for the entire Subbasin (including the Merced County portion) and is assumed to have limited spatial or temporal bias across the Subbasin or across the period since 1990. The potential for bias in the ratio has not been evaluated.

The baseline analysis scenario of potential domestic well impacts involved the parameters listed below.

- Snapshots of DTW at the end of each analysis period
- The ending year for historical analysis is 2019, with historical analysis period 1989-2019 (P = 2019). Corresponding analysis periods as follows:
    - 1989-2019
    - 2020-2024
    - 2025-2029
    - 2030-2034
    - 2035-2039

  The analysis periods were selected to correspond with the dates of the Interim Milestones and preparation of Five-Year Update Reports.

- Minimum well saturation threshold of 10 feet (S = 10).
- Using projected model run from GSP (without early sequence of dry years).
- Wells analyzed based on the WCR count of wells installed since 1970 (E = 1970).

Because the early years of the projected model period, including during the early GSP implementation period, have been dry, an alternative analysis scenario evaluated potential domestic well impacts based on simulated groundwater levels from a model run that starts with a drier sequence of years. This analysis involved the same parameters as the baseline analysis (described above) but used simulated groundwater levels from a different projected model run with an early dry period.

3.2.3 Results of Domestic Well Impacts Analyses for Baseline GSP Climate Scenario

In the baseline analysis scenario described above, a total of 95 of the 500 domestic wells (from WCRs) analyzed are indicated to have gone dry during years prior to 2020. A total of 83 wells are projected to go dry between 2020 and 2039 (**Table 4a**). The analysis suggests 40 of the total of 83 domestic wells are estimated to become dry between 2020 and 2024. **Table 5a** includes the results for this analysis when scaled up by a multiplier of 1.19, the ratio of well permits to WCRs.

3.2.3.1 Spatial Distribution of Dry Wells

Figures 13a to **13e** show the distribution of dry wells (and remaining wetted wells) in each of the analysis years for the baseline analysis. The predicted dry wells are generally north of Highway 152 and south of the Chowchilla River.

Most of the domestic wells that are predicted to go dry over the 20-Year GSP Implementation Period in the Base Case occur in the 2020-2024 and 2030-2034 five-year intervals (**Tables 4a and 5a**). Groundwater levels stabilize and begin to recover after 2035 and no additional wells are predicted to go dry in the Base Case after 2035. The timing of domestic wells going dry is closely related to the assumed sequence of average, dry, and wet years applied for the Base Case, which is based on a historical sequence of years that represent overall average conditions for the 20-year Period.

3.2.3.2 Impacts on Disadvantaged Communities

Some dry domestic wells are predicted to occur in DAC and SDAC areas, but these areas are not disproportionately impacted by groundwater level declines. The analysis suggests that the percent of domestic wells in DAC/SDAC areas estimated to go dry is similar to the Subbasin as a whole although it is slightly lower than for areas outside of DACs or SDACs..

Some DACs and SDACs in the Chowchilla Subbasin are located near urban centers, and thus near existing water system service areas. Opportunities for annexation or consolidation of DACs and SDACs in close proximity to existing (or creating new) State- or County-regulated systems may provide a better solution than replacement of existing wells in these areas.

3.2.3.3 Scaling Estimates

The previous analyses are all based on WCR counts of wells drilled since 1970 or 1990. A more accurate number of wells, however, is more likely the number of Permits in the permit database provided by Madera County.

Figure 14 shows that the spatial distributions of the two datasets are similar. As shown in that figure, the agreement between WCR and permit data is relatively good in most of Madera County; however, interspersed throughout the region there are sections with some differences between the numbers of permits and WCRs. The largest portion of the Subbasin is represented by ratios (permits to WCRs) near 1.0 (from 0.5 to 1.5). One section near the town of Chowchilla had notably higher numbers of permits compared to WCRs, but this is likely due to the denser population and presence of municipal water systems in that area of the Subbasin. The relatively similar distributions of permits and WCRs indicates that simply scaling the count of wells up for each period should be adequate. The number of Permits for wells installed since 1990 is 119% of the number of WCRs for wells in the same period, averaged over the Subbasin (**Table 2**).

Scaling the results up to match the expected number of wells based on the Permits-to-WCRs ratio of 1.19:1 yields 99 domestic wells going dry between 2020 and 2040 (**Table 5a**).

3.2.4 Results of Domestic Well Impacts Analyses for Alternative Dry-Start Climate Scenario

The same analysis was conducted as described above for the GSP Climate Scenario, but instead using an alternative climate sequence for the GSP Implementation Period with more dry years at the beginning of the 20-year climate sequence. In the alternative analysis scenario, a total of 100 of the 500 domestic wells (from WCRs) analyzed are indicated to have gone dry during years prior to 2020. A total of 147 wells are projected to go dry between 2020 and 2039 (**Table 4b**); the analysis suggests 85 dry wells of the total of 147 occurring during the period 2020-2024. **Table 5b** includes the results for this analysis when scaled up by a multiplier of 1.19 based on the ratio of well permits to WCRs.

3.2.5 Sensitivity Analyses on Potential Domestic Well Impacts

To understand influences from different analysis assumptions and parameters, sensitivity analyses were conducted on a number of aspects of the analysis. These sensitivity analyses evaluated different approaches to evaluating the DTW at well locations over each analysis period (e.g., DTW at end of period vs maximum DTW during analysis period), the required minimum saturation threshold for concluding a well is dry, and different cutoff dates for WCRs included in the analysis.

3.2.5.1 Snapshot of Depth at End of Reporting Period vs. Maximum Depth During Reporting Period

The baseline analysis described above compares domestic well depths to groundwater levels at the end of each Five-Year Update reporting period using the years 2019, 2024, 2029, 2034 and 2039. As noted previously, these baseline analysis periods were selected because the final year of each period aligns with the IM and Five-Year Update reporting periods. However, if the lowest groundwater levels do not align with the end of each analysis period, this method may not capture the full extent of potential impacts on domestic wells.

By choosing analysis period ending years as 2023, 2028, 2033, and 2038, the lowest groundwater levels in each five-year period will typically be captured along with the lowest pre-2020 groundwater levels (generally occurring in 2015 or 2018). Therefore, a separate analysis was performed using the maximum DTW in each five-year period. This analysis results in a slight decrease (2 wells) in the total number of wells (81) expected to go dry between 2020 and 2040 compared to the Base Case (**Table 6**). The reason for the decrease of dry well occurrence between 2020 and 2040 is this analysis has more wells going dry prior to the start of the GSP implementation period in 2020 due to the lowest pre-2020 groundwater levels occurring prior to Fall 2019, (which is the year used in the Base Case to determine well going dry prior to 2020). Therefore, the base case with a greater number of wells going dry between 2020 and 2040 is used for further sensitivity analyses described below because it is a more conservative estimate of dry wells.

3.2.5.2 Minimum Saturation Threshold

The baseline analysis comparing DTW, and total well depths included a minimum well saturation threshold that a well is considered dry when the groundwater levels fall below a level less than 10 feet above the bottom of the well. This baseline assumption was based on the expectation that the required saturation in a domestic well is not great because of the generally low pumping rates required for domestic wells. The sensitivity of analysis results for this minimum saturation assumption were evaluated using alternative minimum well saturation levels. Sensitivity to the minimum saturation threshold was tested by varying the parameter (S) and observing the change in the count of wells going dry in each analysis period (**Table 7**).

The number of wells going dry over the period from 2020 to 2039 increases as the minimum saturation threshold is increased from 0 feet to 30 feet and then decreases with greater minimum saturation thresholds (**Figure 15**). The reason for this pattern is that at minimum saturation thresholds exceeding 30 feet, more wells are considered to be going dry before 2020 relative to after 2020 for those greater thresholds (i.e., the threshold applies both before and after 2020). The number of dry wells at the saturation threshold of 10 feet is 83 wells, it increases to 100 wells at 30 feet, and at 50 feet it declines to 84 wells. This analysis suggests that the number of wells expected to go dry is sensitive to the saturation threshold applied, but the relationship between saturation threshold and number of dry wells predicted after 2019 varies depending on how many wells go dry before 2020. Considering the results of this sensitivity analysis and the previous discussion regarding saturation needed to support typical domestic well pumping rates, the application of a minimum saturation threshold of 10 feet is interpreted to be a reasonable threshold for estimating the potential number of domestic wells that may go dry during the GSP implementation period.

3.2.5.3 WCR Cutoff Dates

The influence on results from varying the earliest year of WCR records used in the dry well analysis was also evaluated. As expected, the average well depths for older wells tend to be shallower than younger wells, likely because of the declining water levels that have occurred in the area and the resulting need to drill to greater depths to ensure reliable water supply. This trend towards deeper wells is illustrated in a comparison of the average total well depths for WCRs since 1970 and those since 1990 and 1998, as presented in **Table 3.**

The changes in the numbers of total wells analyzed and the resulting numbers of dry wells drop as the cutoff date for WCRs is increased. The change from a WCR cutoff year of 1970 to 1975 has minimal (less than 10 percent) impact on all counts, but as this cutoff date in increased further the dry well count drops faster than the total well count (**Table 8**). The implication of this trend is that as the WCR cutoff date is moved forward in time from 1970, older wells that would be counted as going dry are not included in the analysis, resulting in a smaller number of wells predicted to go dry. Although many wells constructed since 1970 likely are no longer in existence or active use, the 1970 WCR cutoff date provides an appropriately conservative estimate of wells predicted to go dry during the implementation period.

3.2.6 Potential Replacement Costs for Wells Impacted

The potential costs for addressing domestic well issues were evaluated in some detail. These costs were largely based on discussions with drillers who install domestic wells and replace pumps on a regular basis. These costs are summarized in **Table 9**, and include lowering a domestic well pump ($1,000 to $2,000), replacing a domestic well pump ($5,000 to $7,000), and drilling/installing a new domestic well to replace an existing well ($25,000 to $35,000). Estimates of total costs for a Domestic Well Mitigation Program were based on estimates of total number of dry wells expected to occur between 2020 to 2039, with WCRs scaled to the number of County well permits and considering both the GSP climate scenario and the alternative dry-start climate scenario for the GSP Implementation Period.

3.2.7 Updated Economic Analysis

As described in the Introduction, **Attachment 1** (Domestic Well Replacement Economic Analysis) incorporates updated estimates provided in this TM for the number of dry domestic wells into an economic analysis intended to replace Appendix 3.C of the Chowchilla Subbasin GSP with newer information. The economic analysis evaluated the difference in costs for implementing a Domestic Well Mitigation Program concurrent with gradual reductions in groundwater pumping over a twenty-year period vs. not having a Domestic Well Mitigation Program and immediately implementing demand management and other PMAs to eliminate the overdraft in the subbasin to avoid significant and unreasonable adverse impacts on domestic well users. The overall conclusion remains consistent with the GSP: the cost of implementing a Domestic Well Mitigation Program is significantly less than the alternative.

3.3 Public Water System Wells

PWS wells data are maintained by the State Water Resources Control Board Division of Drinking Water in the Safe Drinking Water Information System (SDWIS); however, these data are incomplete at this time. In the Chowchilla Subbasin, only 8 PWS wells (7 for Chowchilla City Water Department, and one for Valeta Municipal Services District 85) are listed in SDWIS. Therefore, the WCR database was queried for PWS wells. There were 18 PWS wells drilled in the Subbasin and tagged as “Municipal” or “Public” on the WCR. This discrepancy may be due, in part, to the fact that WCRs do not typically distinguish between Public Water Systems and other residential water systems serving more than one household. When a well driller fills out the WCR, the “Municipal” box is checked if the well is to be used for any purpose other than irrigation, industrial processes, or domestic single-household use. These can include PWS wells but can also include Local Small and State Small Water System wells (LSWS and SSWS, respectively), and wells used for drinking water at facilities such as rest stops, churches, schools, and other locations that sometimes are not supplied by a local PWS. The wells identified here are shown in **Figure 16**.

Depth to the bottom of perforated interval ranged from 174 to 980 feet below ground surface in these wells. Of the 18 PWS wells, three were drilled prior to 1970 and are not considered here. The remaining 15 wells were compared to the snapshots of groundwater DTW results for the model years 2019, 2024, 2029, 2034, and 2039, with the GSP climate scenario. **Table 10** shows the results of this analysis.

Based on the comparison with the modeled groundwater levels at the 5-year intervals, one PWS well is expected to have gone dry by 2020, and another one over the implementation period. Further analysis with data provided by individual well-operators would be required to identify specific water systems that are vulnerable.

3.4 Comparison of Estimated Domestic Well Impacts to Online Databases

The estimated numbers and locations of dry wells described in this TM (modeled dry wells) were compared to two available datasets related to reported domestic well supply issues: DWR’s Household Water Supply Shortage Reporting System, and Self-Help Enterprises (SHE) Tank Water Program participants (**Attachment 2**). While the assumptions underlying the estimates of modeled dry wells in this TM differ in some regards to the well issues included in these two datasets, the spatial patterns in modeled dry wells are very similar to the spatial patterns in the DWR and SHE datasets. Overall, the total numbers of modeled dry wells estimated in this TM are greater than the number of well issues included in the DWR and SHE datasets; however, it is likely that not all dry wells have been reported in these other two datasets. More details on the DWR Household Water Supply Shortage Reporting System dataset and the SHE Tank Water Program participants dataset and comparisons of these datasets to modeled dry wells presented in this TM are provided in **Attachment 2**.

4 PRIORITIZATION OF AREAS FOR ADDITIONAL MONITORING

Expansion of monitoring network is important for areas of the Subbasin with higher densities of domestic drinking water wells. In addition, the domestic well impacts analyses provide a guide to locating areas that should be more closely monitored. The monitoring network should consider the presence of vulnerable populations, such as those reliant on groundwater and DAC/SDAC areas. Another key variable was to consider the locations of existing nested monitoring wells installed recently at eight locations throughout the Chowchilla Subbasin.

The domestic well inventory analysis conducted for this study illustrates that domestic wells are most concentrated along the Highway 152 corridor, and that the occurrence of dry domestic wells are predicted to be most common along and just north of Highway 152. There are four existing nested monitoring wells relatively far to the north of Highway 152, and four existing nested monitoring wells relatively far to the south of Highway 152 in Chowchilla Subbasin. Two large and dense clusters of domestic wells occur just north of the junction of Highway 152 and Highway 99 and just northeast of the junction of Highway 152 and Highway 233 (Robertson Blvd.). These are considered primary areas for siting of new nested monitoring wells (**Figure 17**). A third primary area is located further west and south of Highway 152 between Robertson Blvd. and Berenda Slough. Two secondary areas for potential consideration of monitoring well siting are in areas of significant, but somewhat less dense, clusters of domestic wells; these locations would fill gaps between existing nested monitoring wells and improve overall spacing and density of dedicated nested well monitoring sites in the Chowchilla Subbasin.

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6 TABLES

Table 1. Summary of Domestic Well WCRs by Decade (no WCRs prior to 1950).

WCR Date Range	WCRs in Date Range	Cumulative WCRs
1950-1959	3	3
1960-1969	46	49
1970-1979	76	125
1980-1989	49	174
1990-1999	82	256
2000-2009	123	379
2010-2019	107	486
2020-Plus	1	487
Unknown	62	549

Table 2. Comparisons Between Different Domestic Well Count Estimation Methods.

	WCRs Chowchilla SB 1970+	WCRs Madera Co. Chowchilla SB 1990+	WCRs Merced Co. Chowchilla SB 1999+	Permits Madera Co. Chowchilla SB 1990+	Permits Merced Co. Chowchilla SB 1999+
Domestic Well Count	500	362	12	436	7
Domestic Well Count Outside of Water System Boundaries	488	350	12	434	7
Domestic Well Count Inside Water System Boundaries	12	12	0	2	0
Percent of WCR-Based Count (since Permit earliest date)	n/a	n/a	n/a	120%	58%
With Depth Recorded	500	362	12	0	7
Location Precision	Varies	Varies	Varies	Parcel	Parcel

Table 3. Relative Similarity Between Wells Recorded Since 1970 and Those Recorded Since 1990.

	Count of WCRs within the Chowchilla Subbasin		
	Since 1970	Since 1990	Since 1999
Total Count	500	375	303
Count within PWS	12	8	7
Count Outside of PWS	488	367	296
Average Total Depth (ft)	377	402	423

Table 4a. Summary of Dry Wells for Base Case. Wells drilled in 1970 or later, based on snapshot of depth to groundwater at end of period. Assumes 10 feet of well saturation above bottom of screen.

Year Range	New Wells Drilled	Total Wetted Wells Year Start	**Wells Going Dry**	Total Wetted Wells Year End	Sum Of Dry Wells
2020 to 2024	6	405	**40**	365	40
2025 to 2029	0	365	**0**	365	40
2030 to 2034	0	365	**42**	323	82
2035 to 2039	0	323	**1**	322	83
During the period 1989 to 2019, prior to the implementation period, the model suggests 95 wells went dry.				Total	**83**

Table 4b. Summary of Dry Wells for Dry Start Case. Wells drilled in 1970 or later, based on snapshot of depth to groundwater at end of period. Assumes 10 feet of well saturation above bottom of screen.

Year Range	New Wells Drilled	Total Wetted Wells Year Start	**Wells Going Dry**	Total Wetted Wells Year End	Sum Of Dry Wells
2020 to 2024	6	400	**85**	315	85
2025 to 2029	0	315	**61**	254	146
2030 to 2034	0	254	**1**	253	147
2035 to 2039	0	253	**0**	253	147
During the period 1989 to 2019, prior to the implementation period, the model suggests 100 wells went dry.				Total	147

Table 5a: Adjusted Estimates of Dry Wells for Base Case Based on WCRs Since 1970 Upscaled Using Ratio of Permits to WCRs (1.19).

Year Range (Oct 31st Minimums)	New Wells Drilled	Total Wetted Wells Year Start	**Wells Going Dry**	Total Wetted Wells Year End	Sum Of Dry Wells
2020 to 2024	7	486	48	438	48
2025 to 2029	0	438	0	438	48
2030 to 2034	0	438	50	388	98
2035 to 2039	0	388	1	387	99
During the period 1989 to 2019, prior to the implementation period, the model suggests 114 wells went dry.				Total	99

Table 5b: Adjusted Estimates of Dry Wells for Dry Start Case Based on WCRs Since 1970 Upscaled Using Ratio of Permits to WCRs (1.19).

Year Range (Oct 31st Minimums)	New Wells Drilled	Total Wetted Wells Year Start	**Wells Going Dry**	Total Wetted Wells Year End	Sum Of Dry Wells
2020 to 2024	7	480	102	378	102
2025 to 2029	0	378	73	305	175
2030 to 2034	0	305	1	304	176
2035 to 2039	0	304	0	304	176
During the period 1989 to 2019, prior to the implementation period, the model suggests 120 wells went dry.				Total	176

Table 6: Dry Well Summary Based on Snapshots of Groundwater Depth at End of Periods Ending in 2015, 2018, 2023, 2028, 2033, and 2038.

Year Range (Oct 31st Minimums)	New Wells Drilled	Total Wetted Wells Year Start	**Wells Going Dry**	Total Wetted Wells Year End	Sum Of Dry Wells Based on 5-Year Minimum
2019 to 2023	10	378	**30**	348	30
2024 to 2028	0	348	**1**	347	31
2029 to 2033	0	347	**50**	297	81
2034 to 2038	0	297	**0**	297	81
During the period 1989 to 2018, prior to the period described in this table, the model suggests 122 wells went dry.				Total	81

Table 7: Effect of Varying Saturation Requirement on Dry Well Counts.

Saturation Setting	Dry Wells Total After 2019
0	76
10	83
20	98
30	100
40	90
50	84
60	72
70	66
80	63
90	60
100	55

Table 8: Effect of Varying Minimum Installation Year on Counts of Wells and Dry Wells.

Well Counts	Earliest Installation Year						
	1970	1975	1980	1985	1990	1995	2000
Total Count of WCRs in Comparison	500	459	424	401	375	331	293
Fraction of 1970 (Total Count of Wells)	1.00	0.92	0.85	0.80	0.75	0.66	0.59
Total Count of Dry Wells	178	159	144	127	117	91	67
Fraction of 1970 (Dry Wells)	1.00	0.89	0.81	0.71	0.66	0.51	0.38
Count of Dry Wells Prior to 2020	95	85	77	66	59	41	30
Fraction of 1970 (Dry Prior to 2020)	1.00	0.89	0.81	0.69	0.62	0.43	0.32
Count of Dry Wells from 2020 to 2039	83	74	67	61	58	50	37
Fraction of 1970 (Dry Wells 2020 to 2039)	1.00	0.89	0.81	0.73	0.70	0.60	0.45

Table 9: Summary of Domestic Pump and Well Costs.

Issue	Type of Problem	Solution	Related to GSP	Typical Cost
Water level in well below pump setting depth	**Pump**	**Lower Pump**	**Yes/No**	**$1,000 to $2,000**
Pump not working (old age or pump-related issue)	**Pump**	**Replace Pump and Equipment**	**No**	**$5,000 to $7,000**
Well casing/screen failure (due to old age)	**Well**	**Replace Well**	**No**	**$25,000 to $35,000**
Water level below bottom of well	**Aquifer**	**Replace Well**	**Yes**	**$25,000 to $35,000**

Table 10: PWS and other Municipal Wells - Dry Well Summary Based on Snapshots of Groundwater Depth at End of Periods ending in 2024, 2029, 2034, and 2039, for the Base Case Climate Scenario.

Year Range (Oct 31st Minimums)	New Wells Drilled	Total Wetted Wells Year Start	**Wells Going Dry**	Total Wetted Wells Year End	Sum Of Dry Wells
2020 to 2024	1	15	1	14	1
2025 to 2029	0	14	0	14	1
2030 to 2034	0	14	0	14	1
2035 to 2039	0	14	0	14	1
During the period 1989 to 2019, prior to the implementation period, the model suggests one well went dry.				Total	1

7 FIGURES

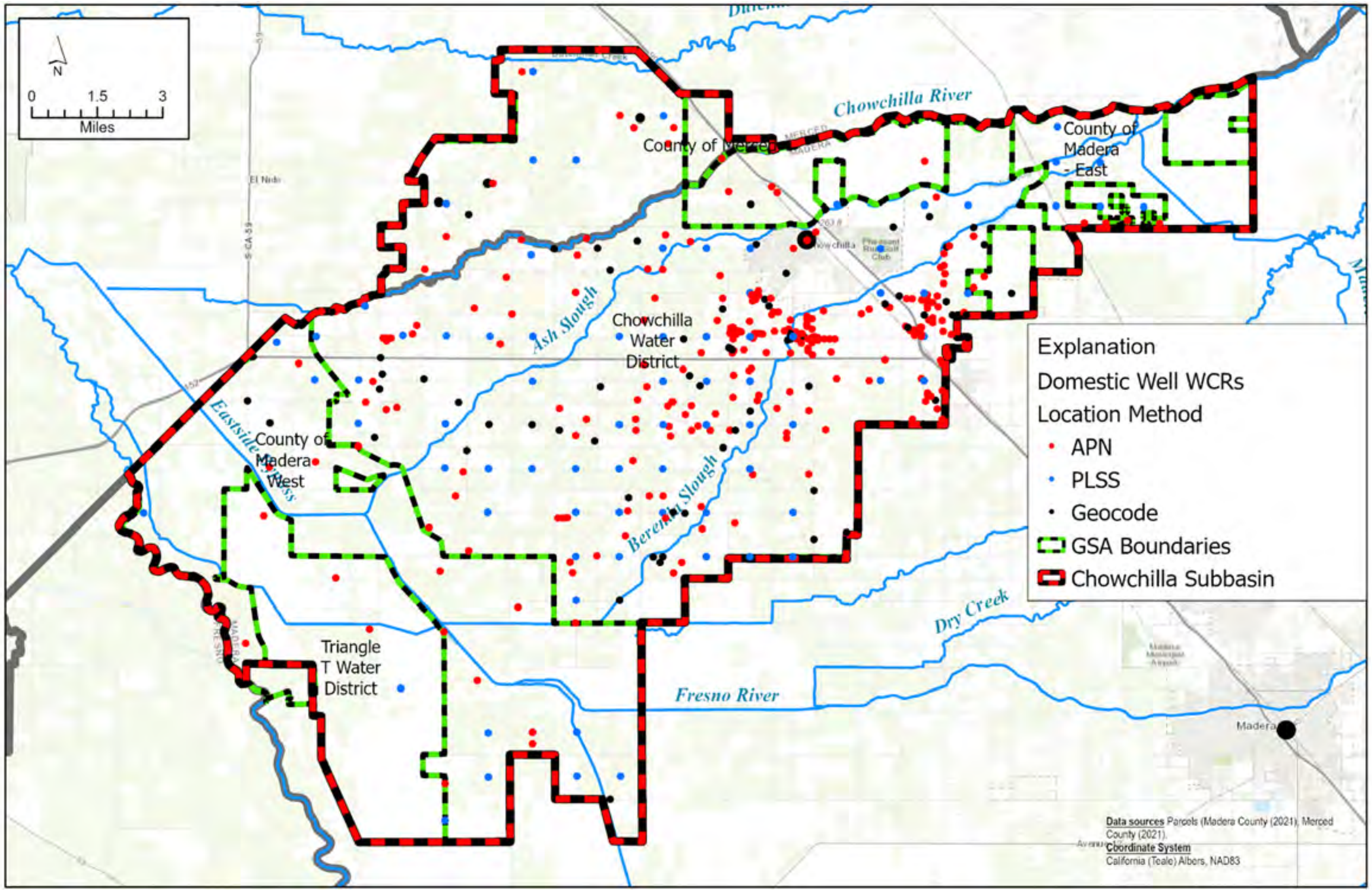

Figure 1a. Well Completion Report new construction domestic wells located by best available method.

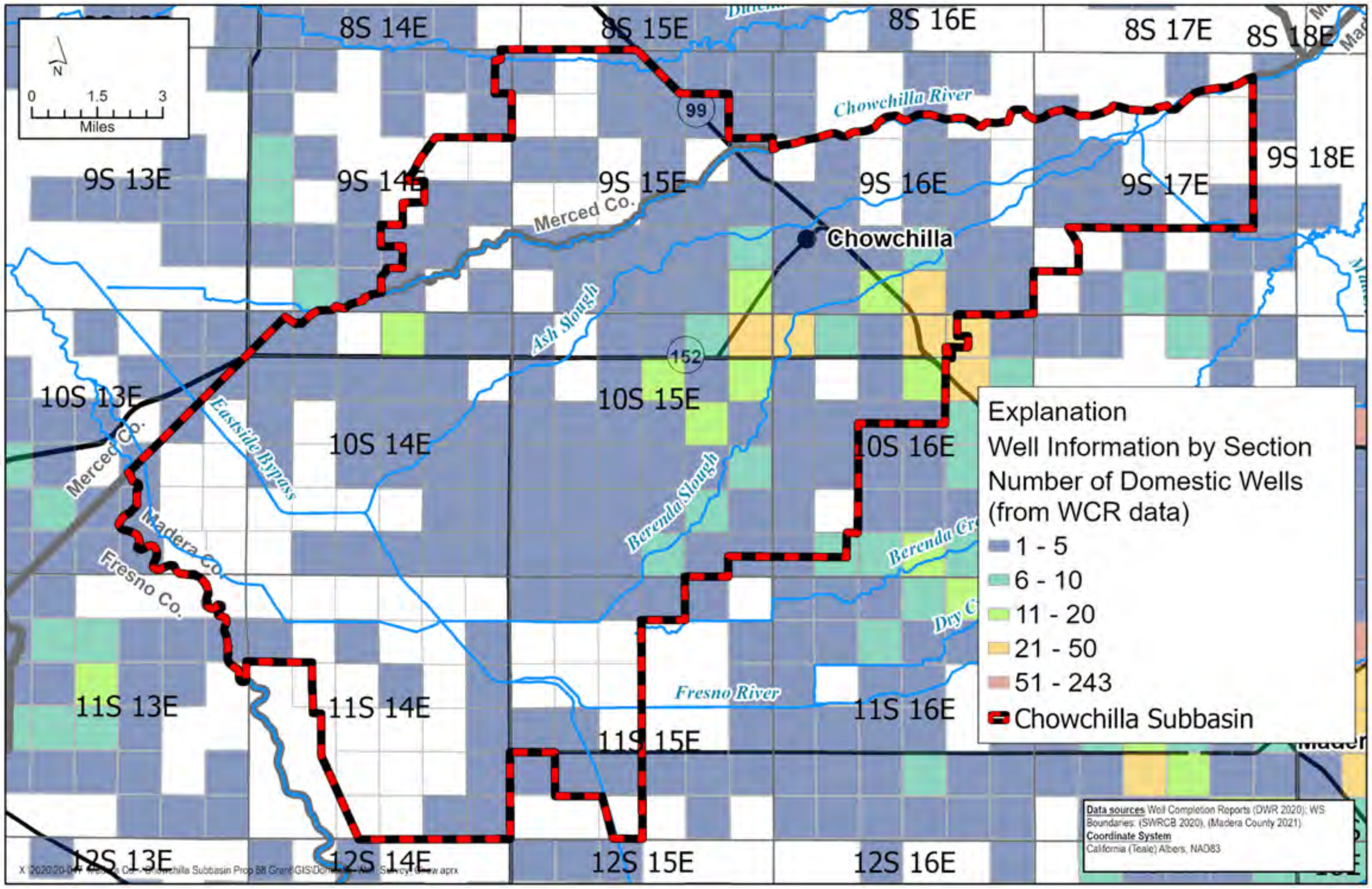

Figure 1b. Well Completion Report new construction domestic well counts by Section.

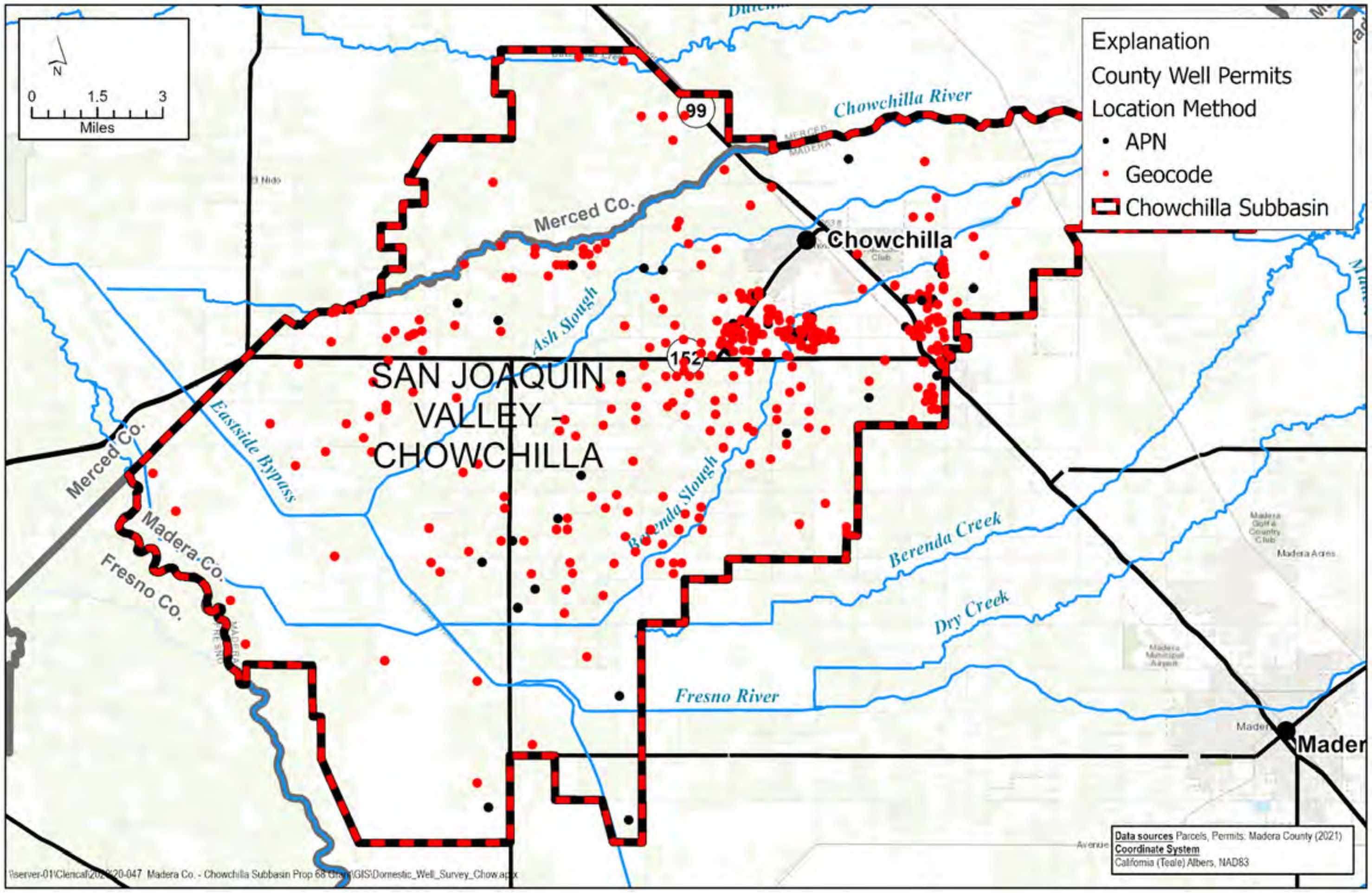

Figure 2a: Permit locations and geolocation method in Chowchilla Subbasin.

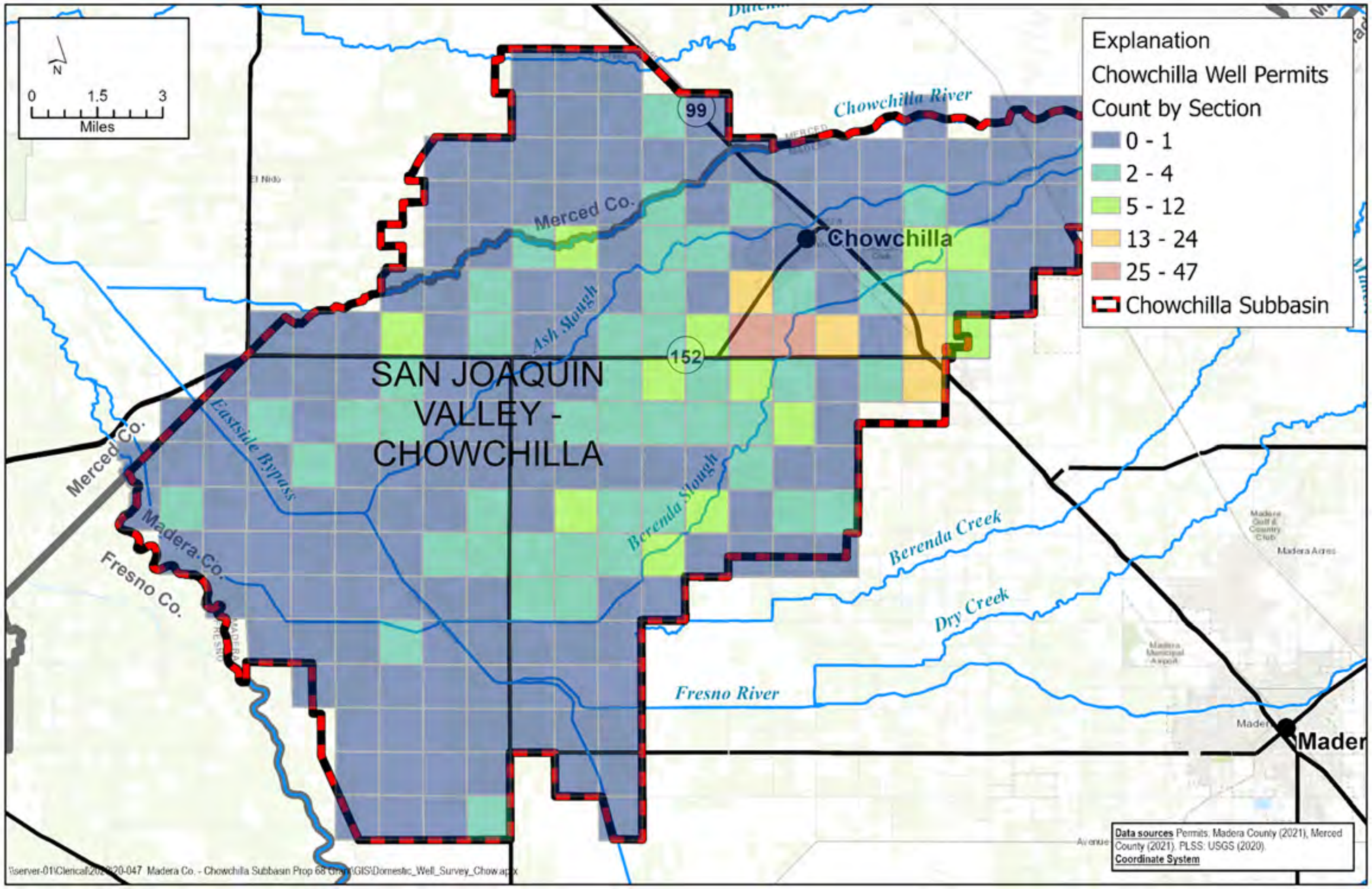

Figure 2b. Permit location counts by Township/Range/Section.

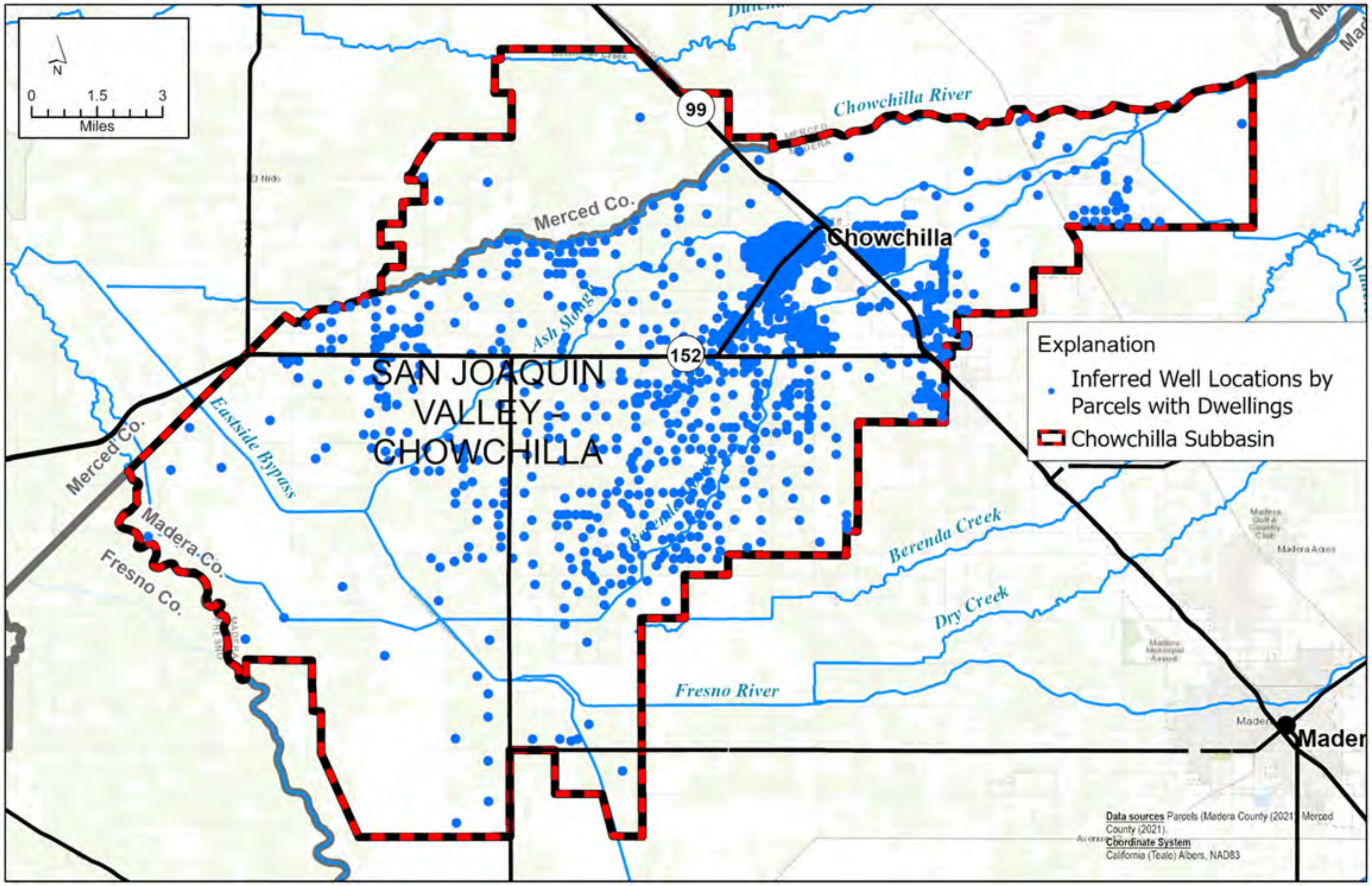

Figure 3: Inferred well locations based on Parcel Dwelling Status.

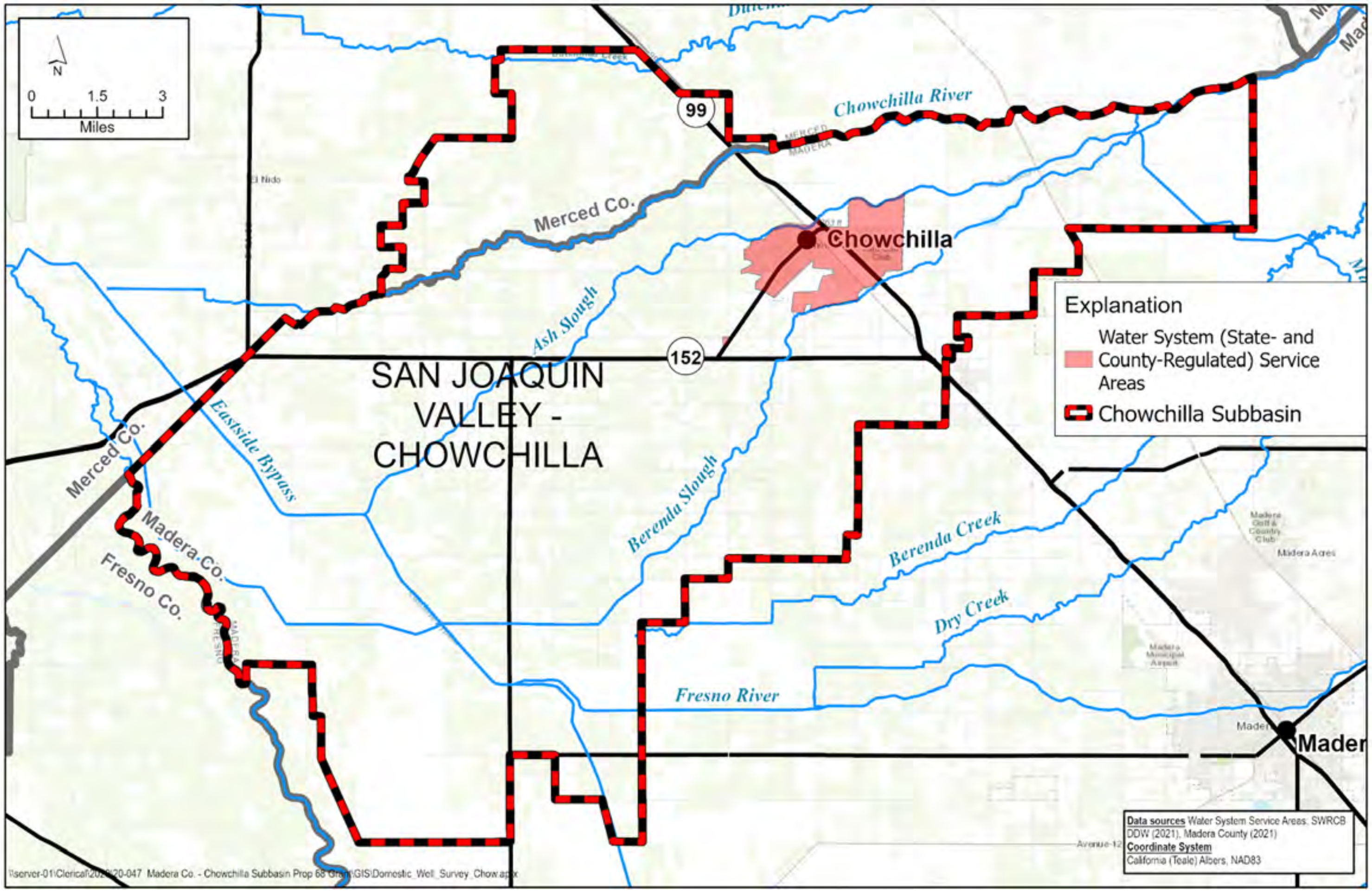

Figure 4: Water System Boundaries in Madera County.

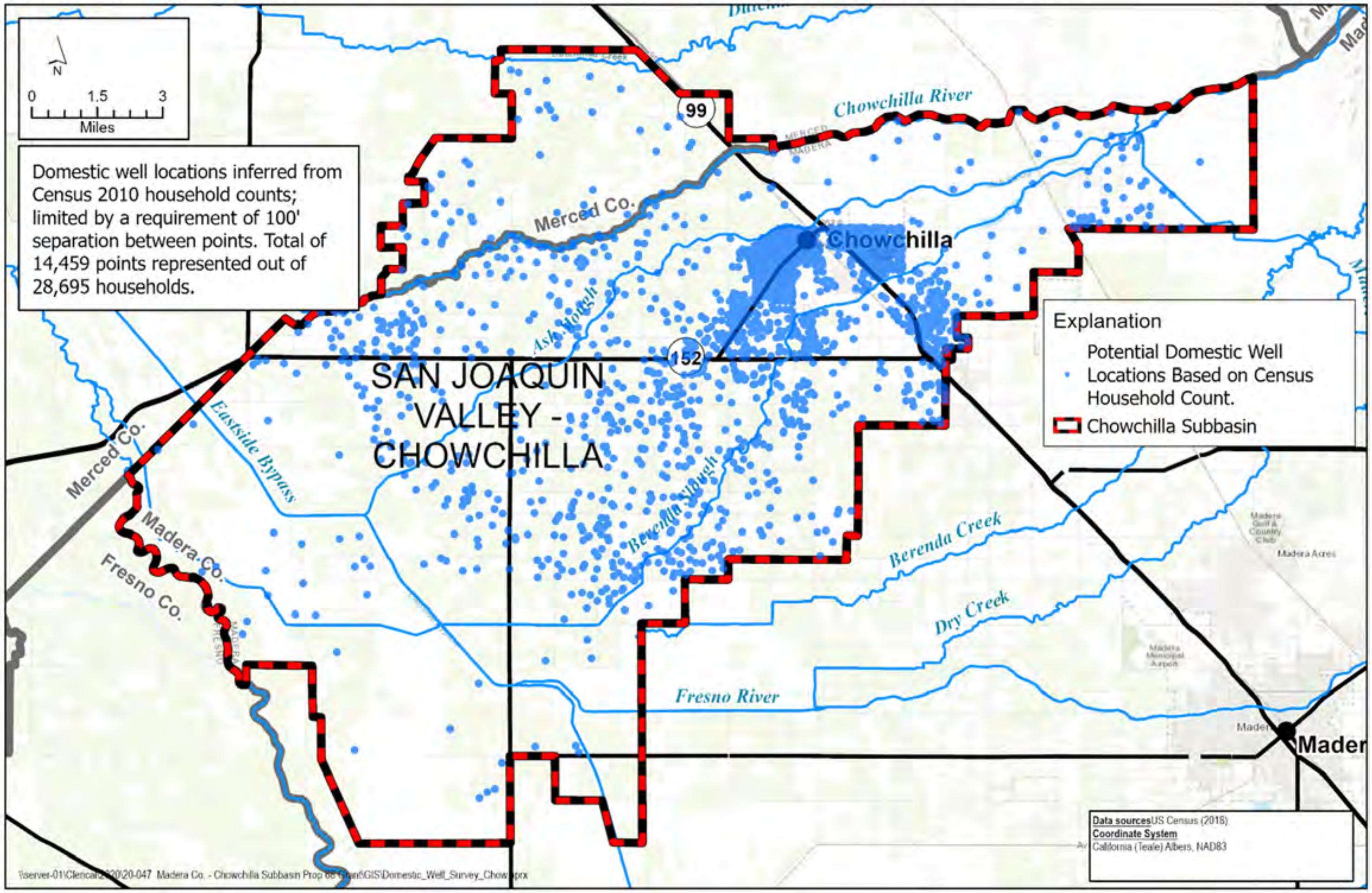

Figure 5: Inferred well locations based on 2010 Census Household counts.

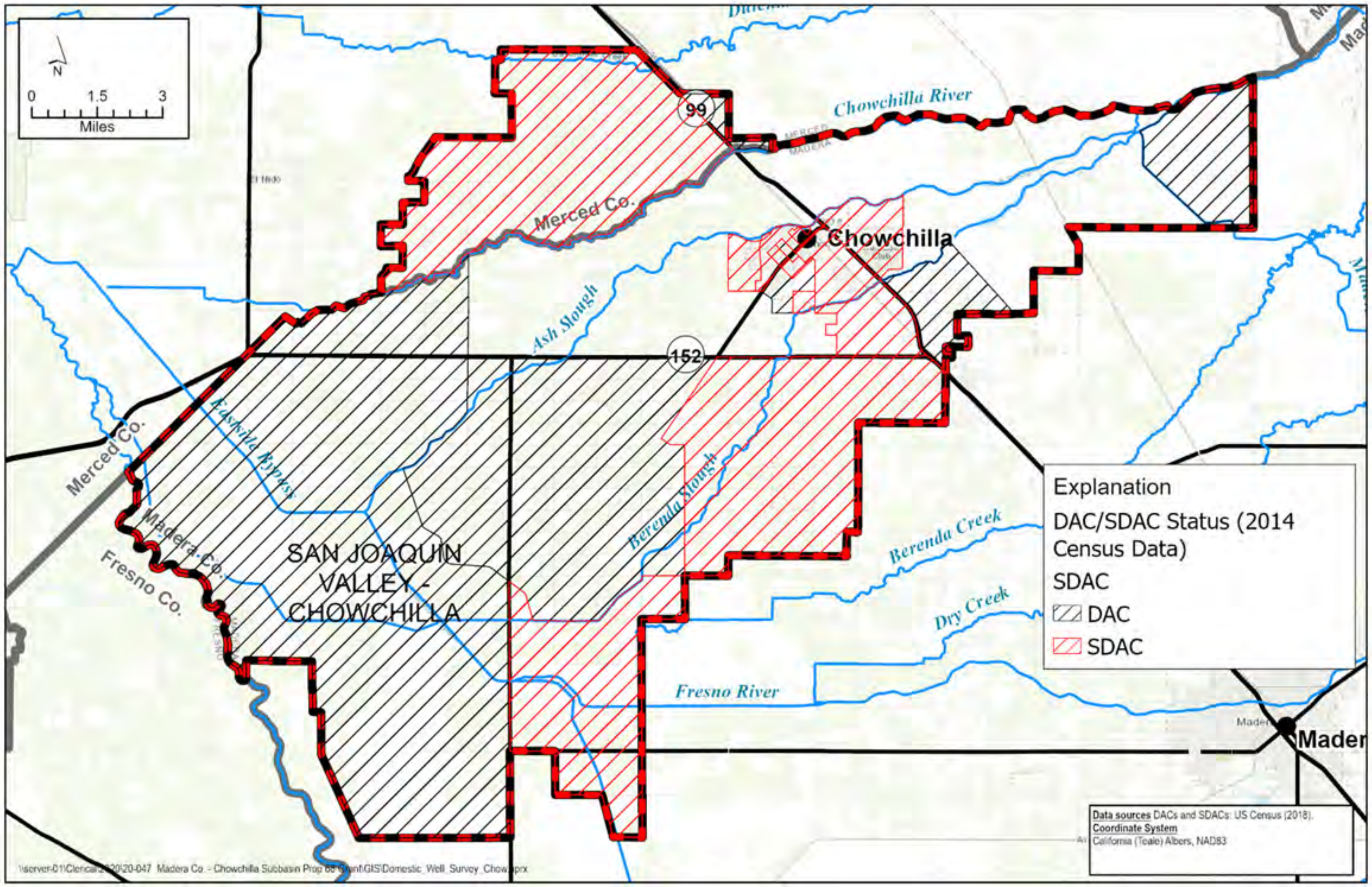

Figure 6: DACs and SDACs in the Chowchilla Subbasin.

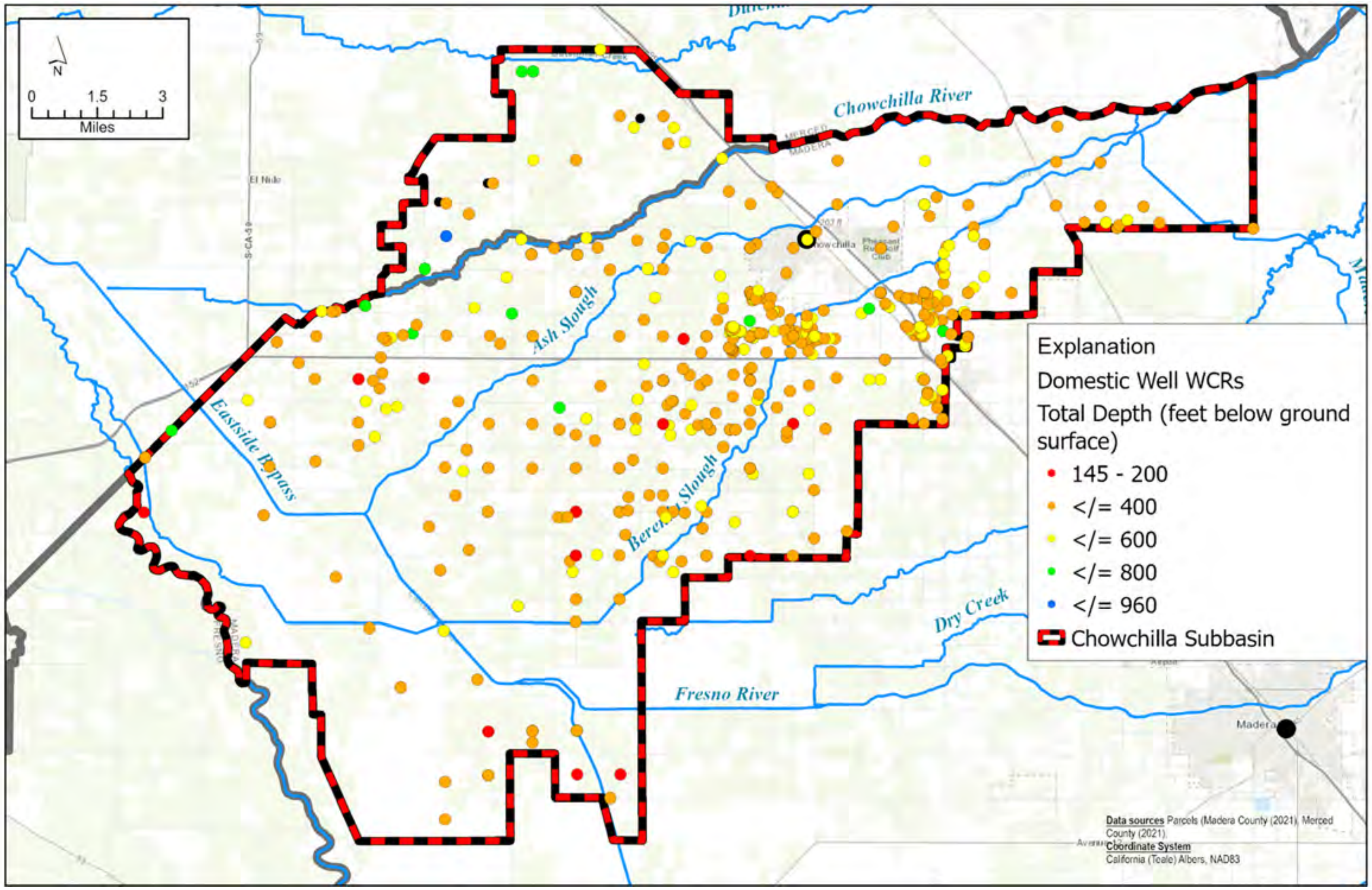

Figure 7a: Domestic wells in Chowchilla Subbasin with depth from WCR.

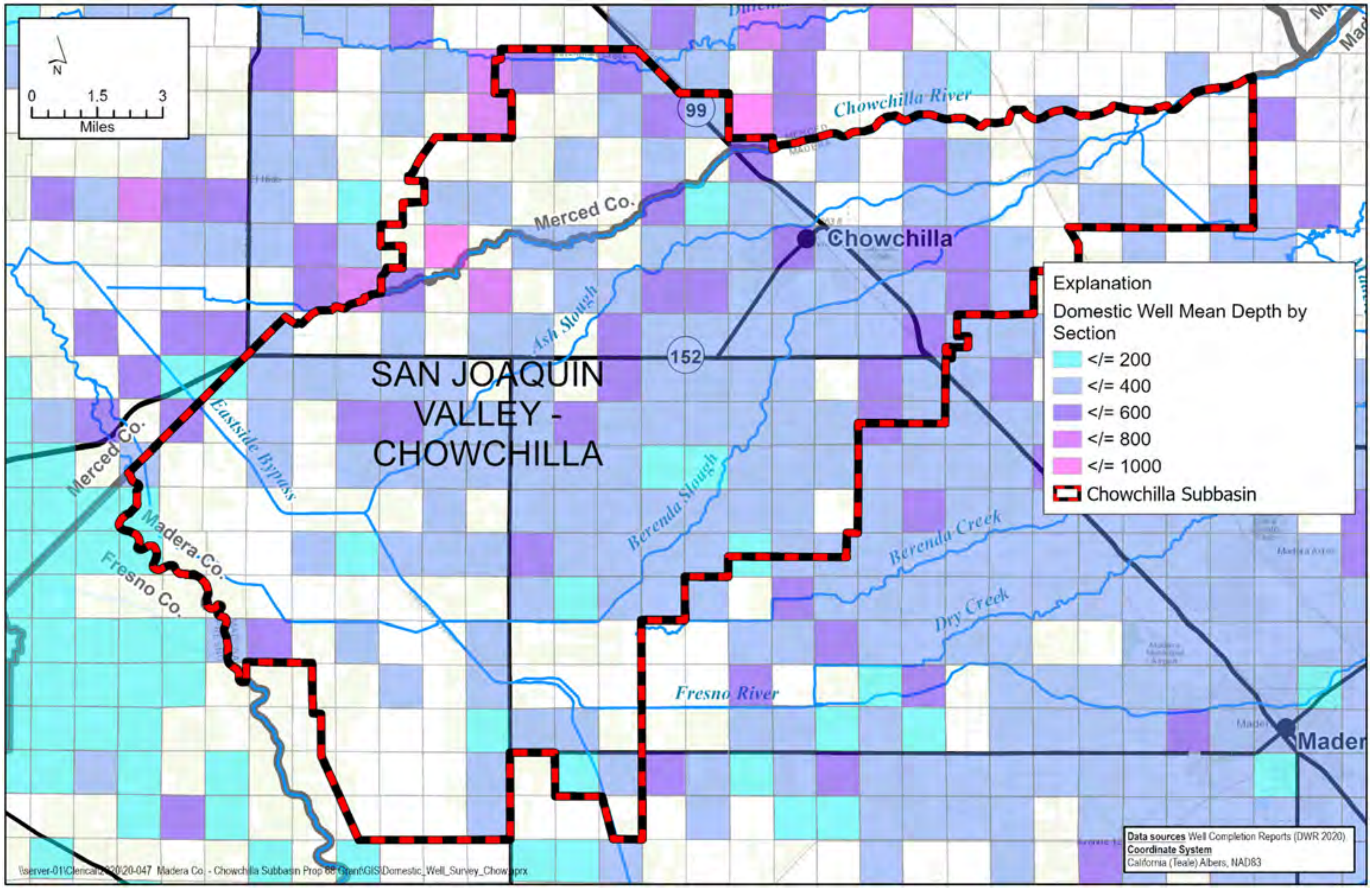

Figure 7b. Domestic Wells in Chowchilla Subbasin with Average Depth by Township/Range/Section from WCRs.

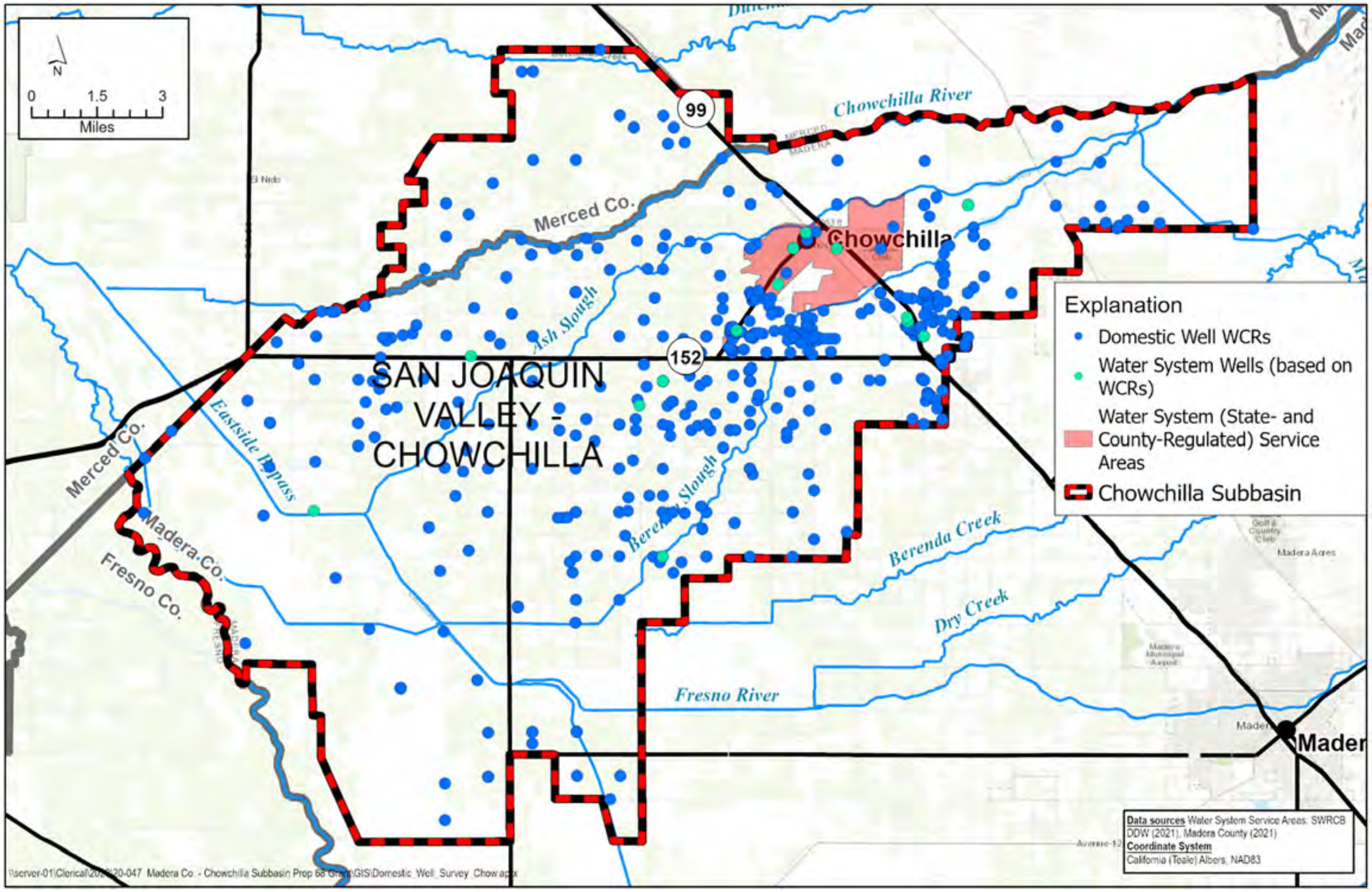

Figure 8: Domestic WCRs compared with Community PWS, County Maintenance Districts, and Community Service Areas.

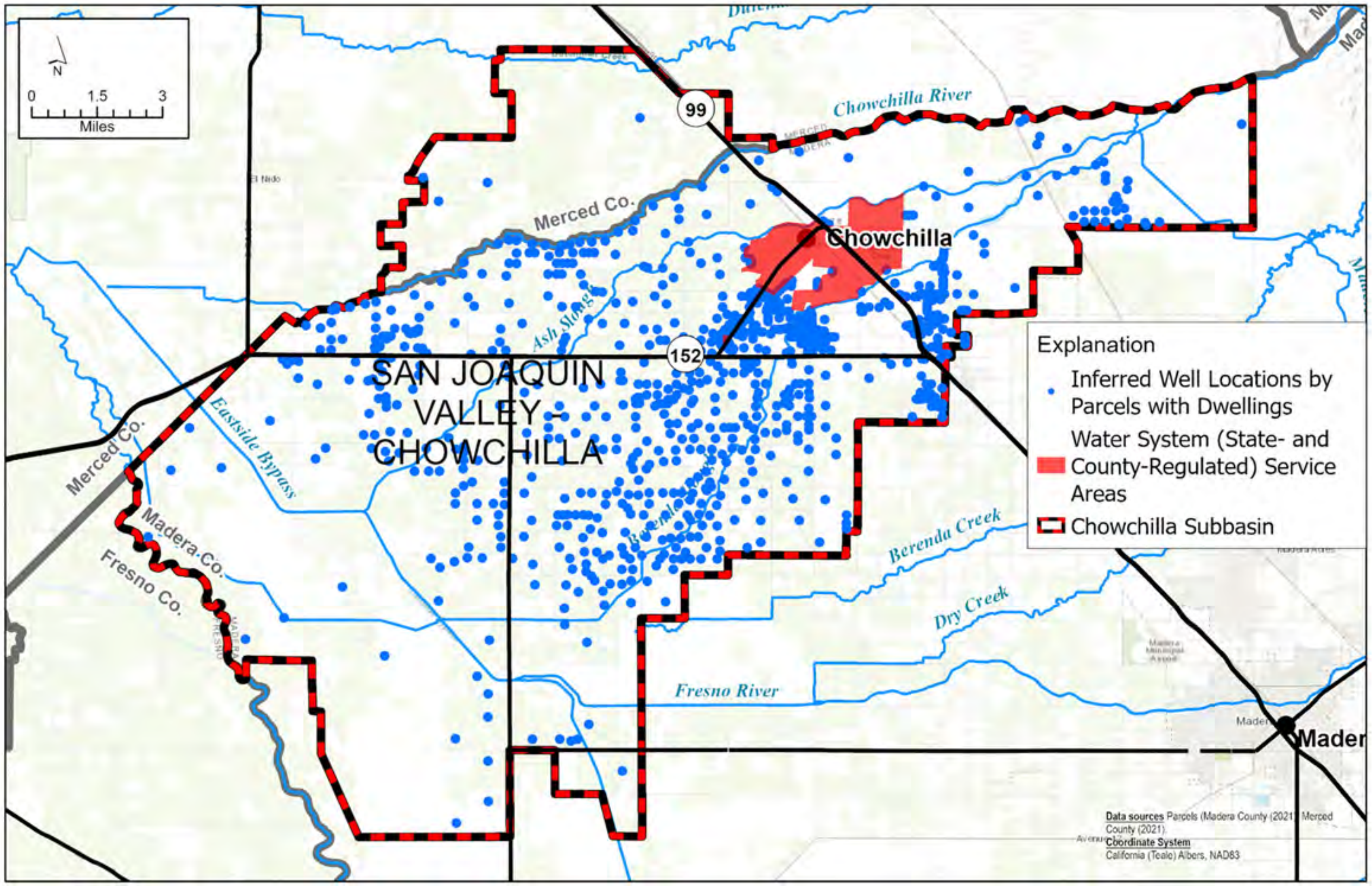

Figure 9: Parcels with Dwellings as Inferred Well Locations, outside of Community PWS, County Maintenance Districts, and Community Service Areas.

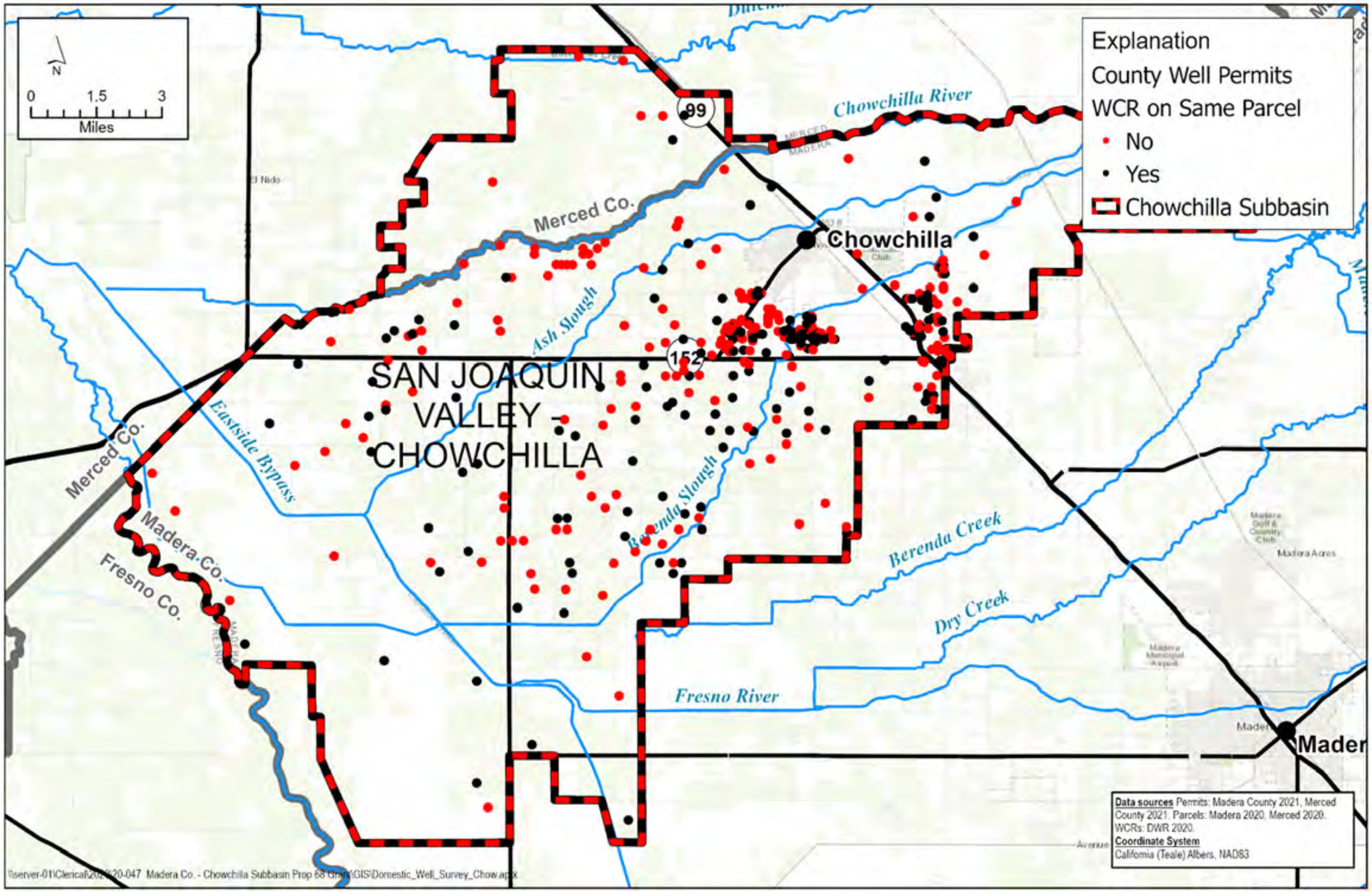

Figure 10: Parcels with Permits and WCRs.

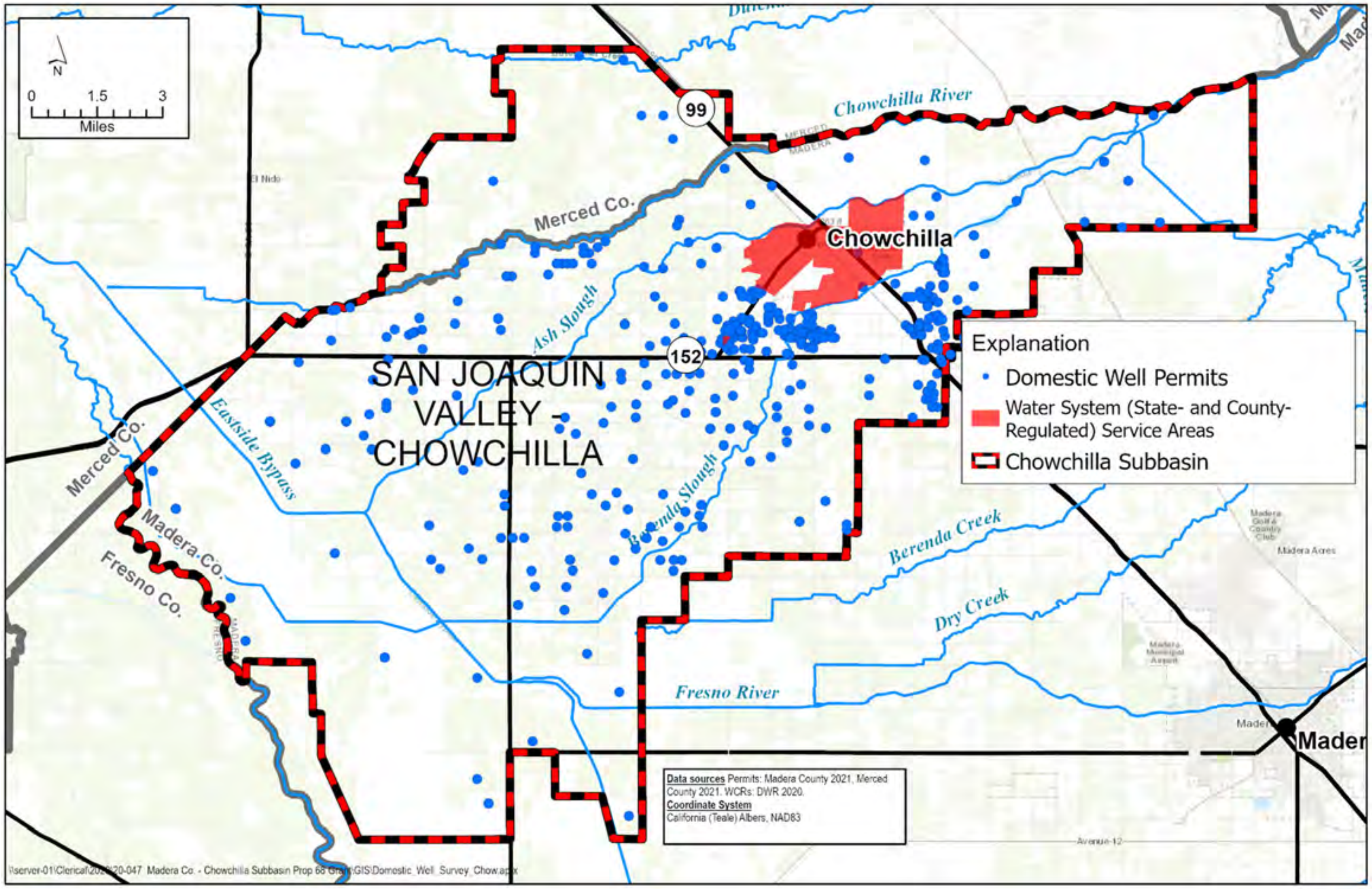

Figure 11a: Domestic Well Permits Compared with PWS, Community Service Districts and County Maintenance Districts.

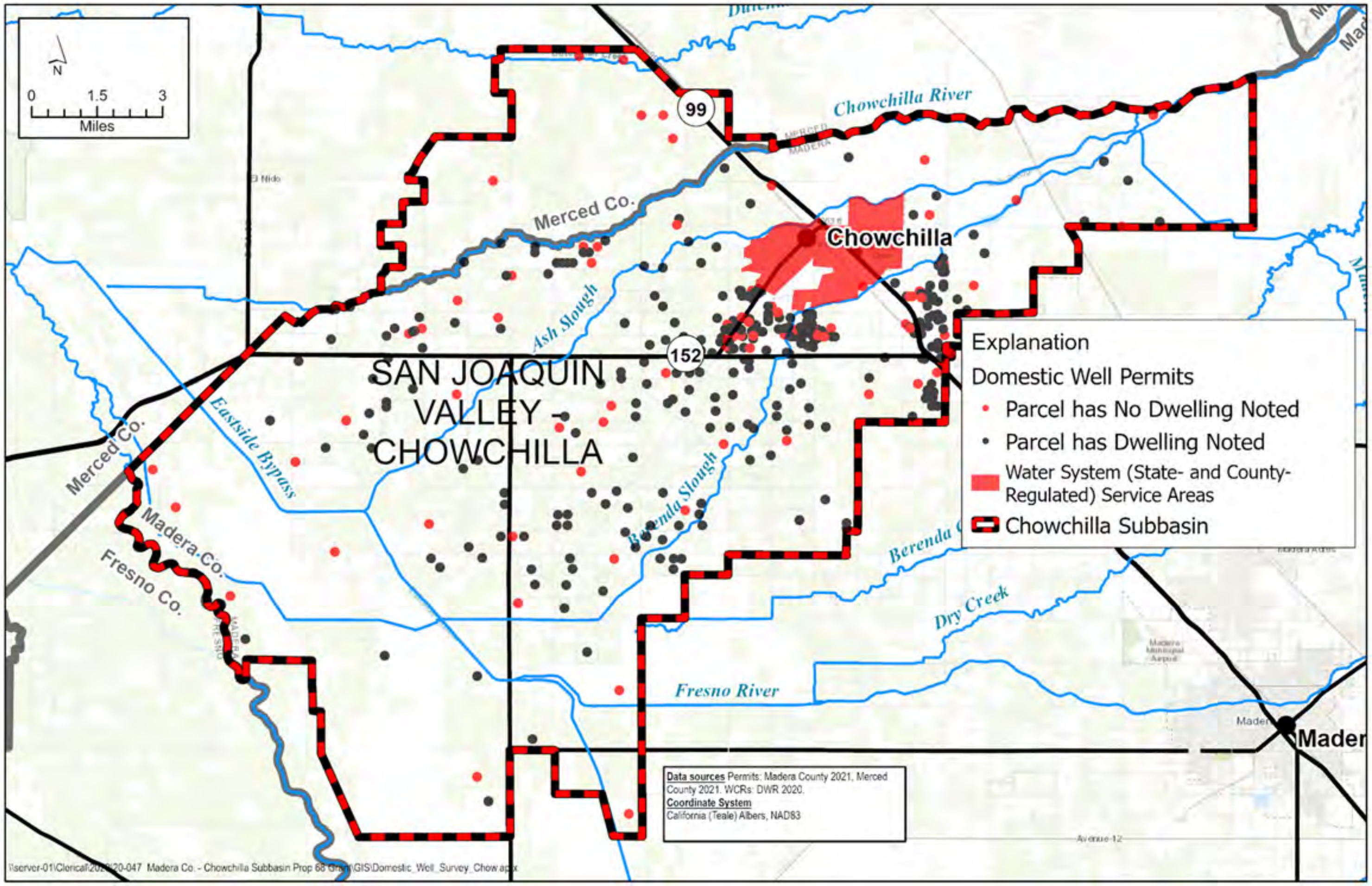

Figure 11b: Domestic Well Permits Compared with Parcel Characteristics.

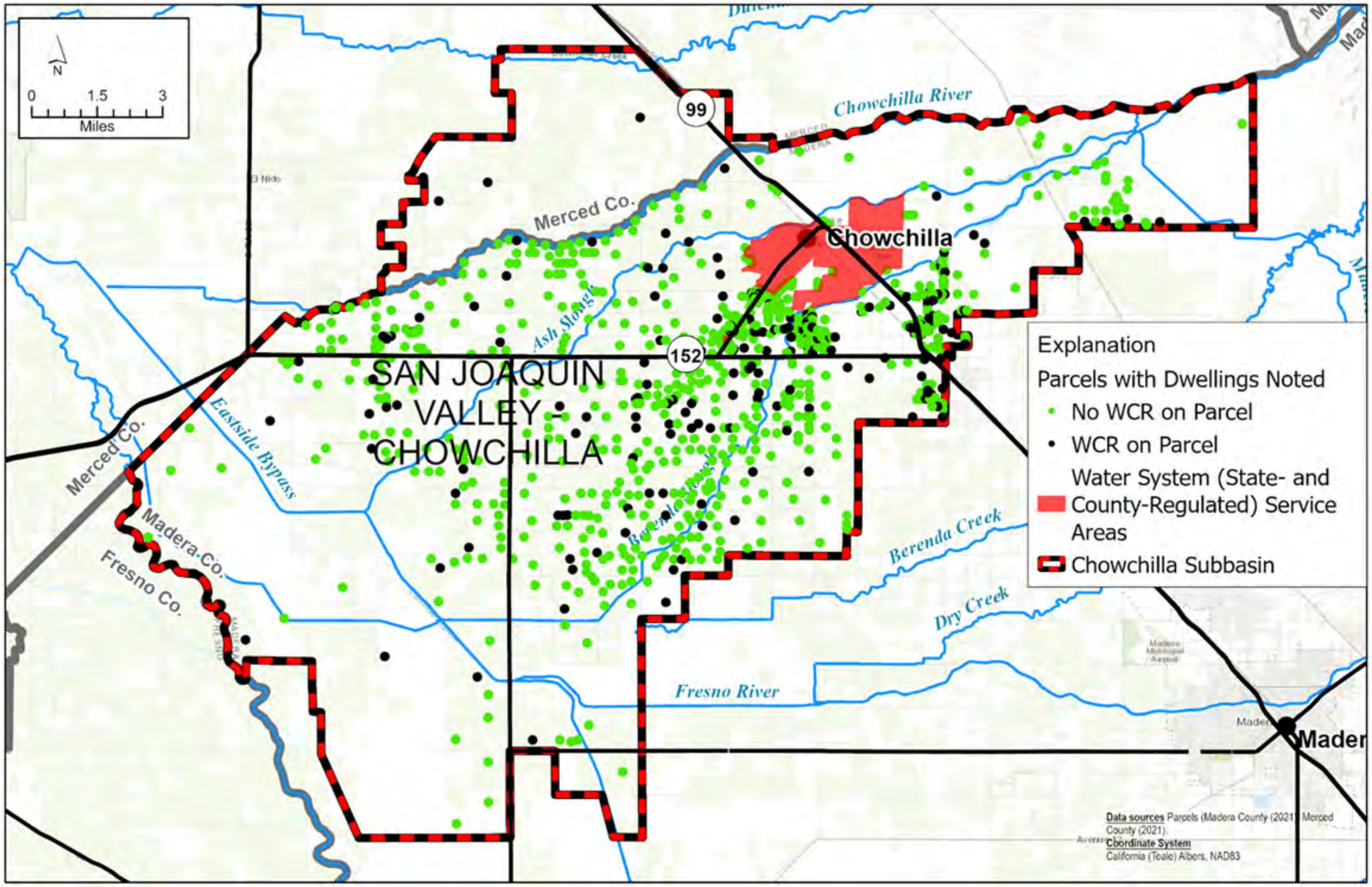

Figure 12: Inferred Domestic Well locations Based on Parcels with Dwellings, with Water Systems and Presence/Absence of WCRs on Parcel.

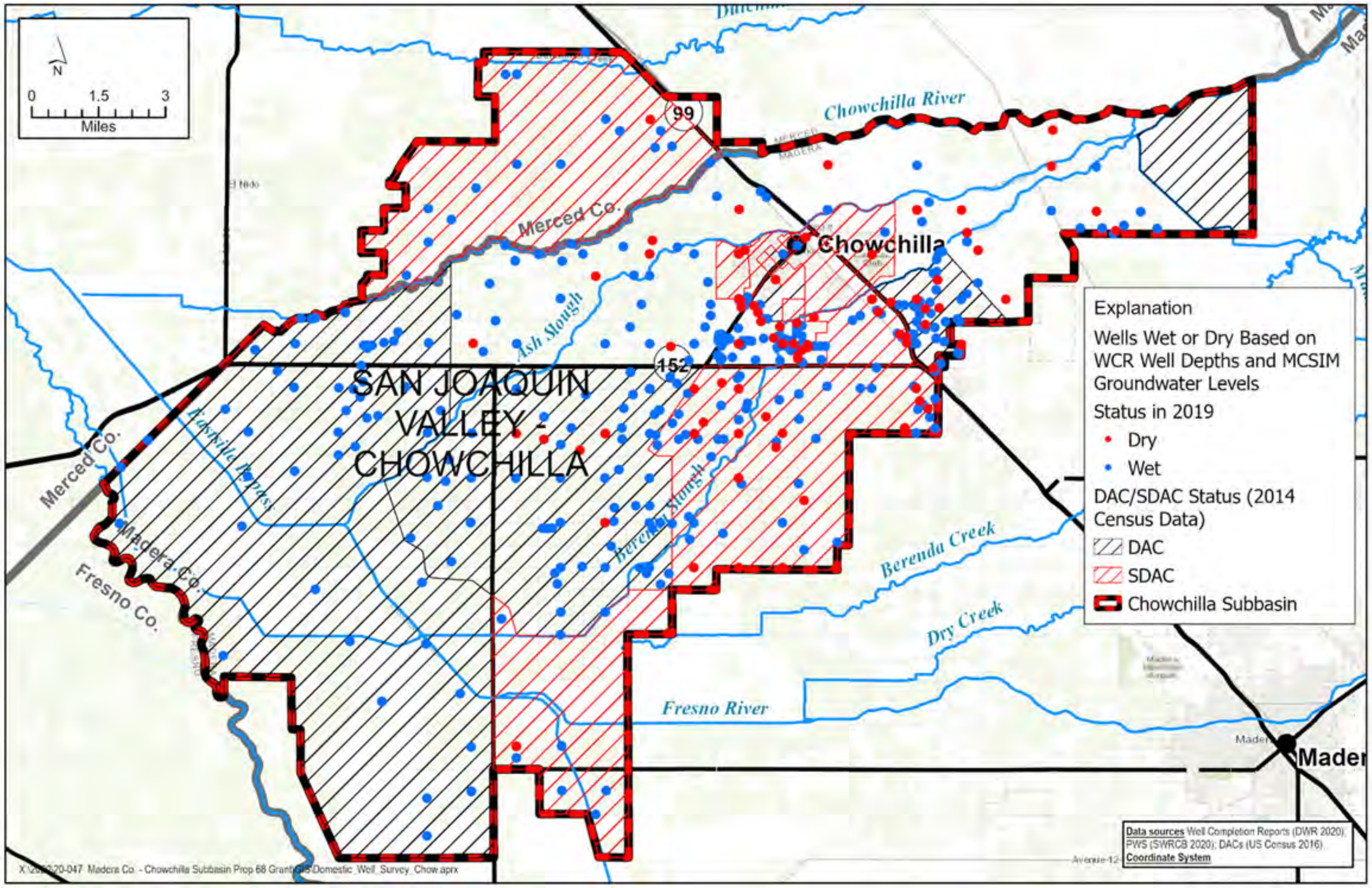

Figure 13a: Status of Domestic Wells in 2019 - Based on WCR Well Depths and Locations Compared to MCSIM Groundwater Depths.

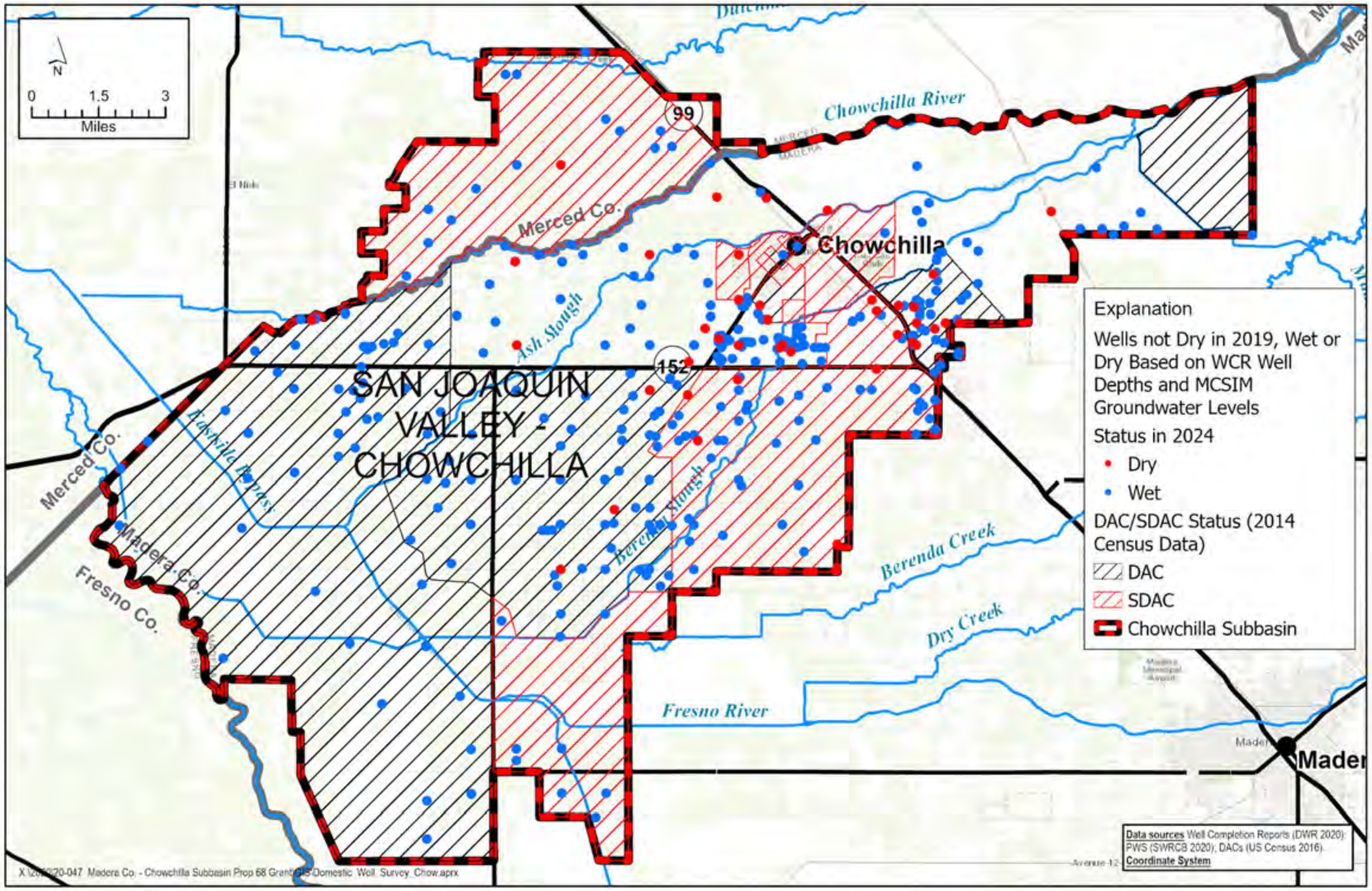

Figure 13b: Status of Wells in 2024 - Based on WCR Well Depths and Locations Compared to MCSIM Groundwater Depths.

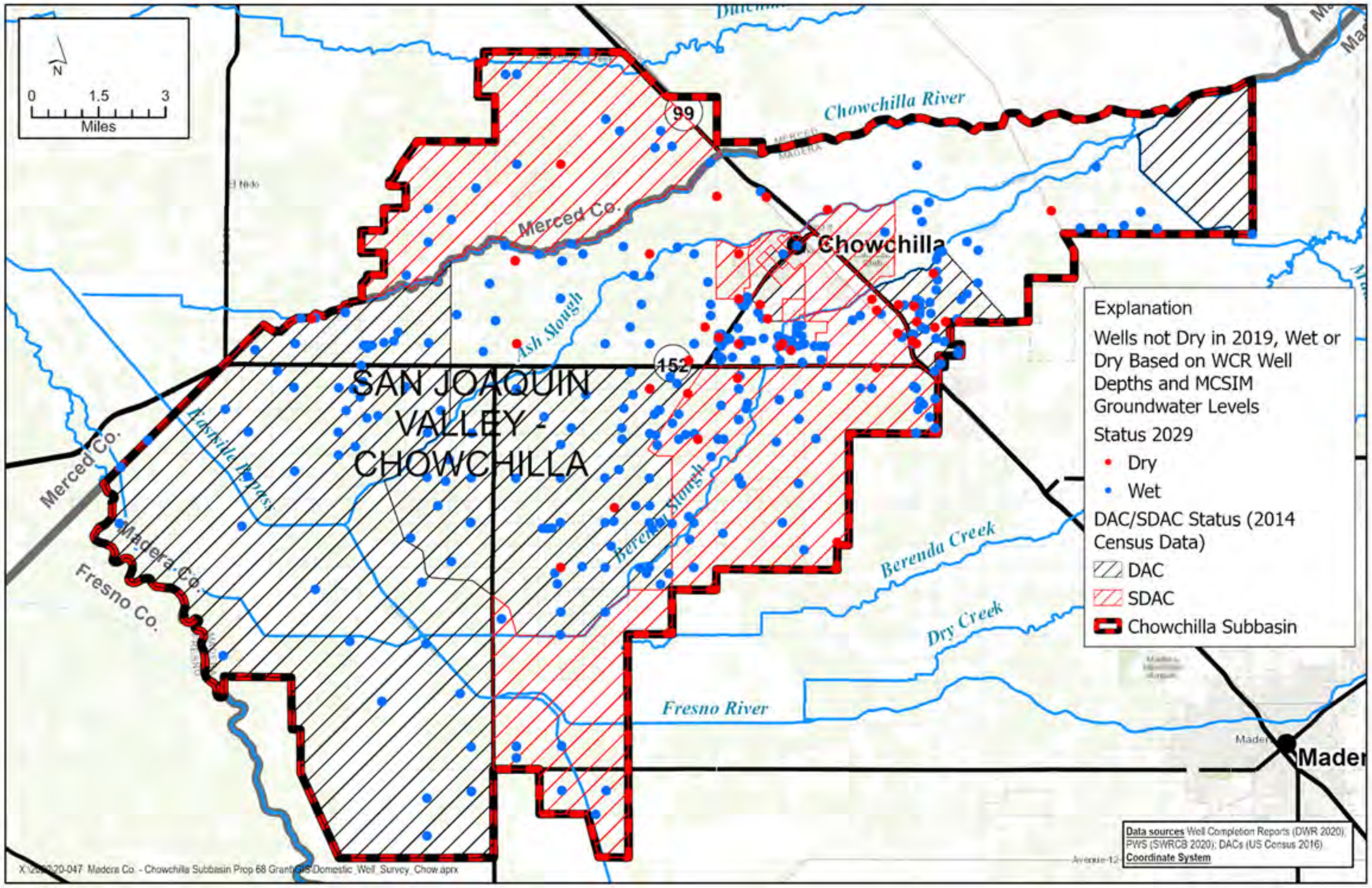

Figure 13c: Status of Wells in 2029 - Based on WCR Well Depths and Locations Compared to MCSIM Groundwater Depths.

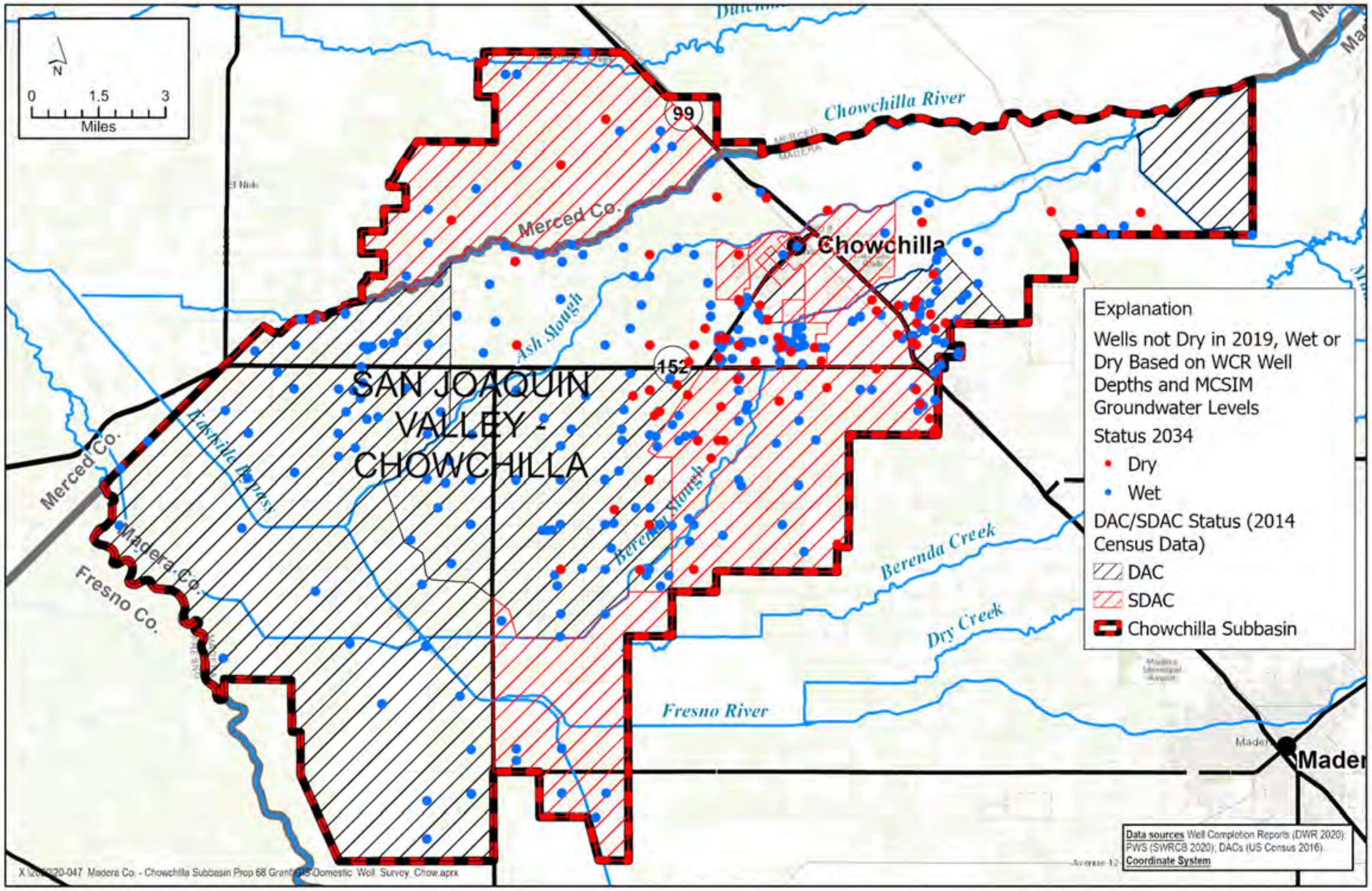

Figure 13d: Status of Wells in 2034 - Based on WCR Well Depths and Locations Compared to MCSIM Groundwater Depths.

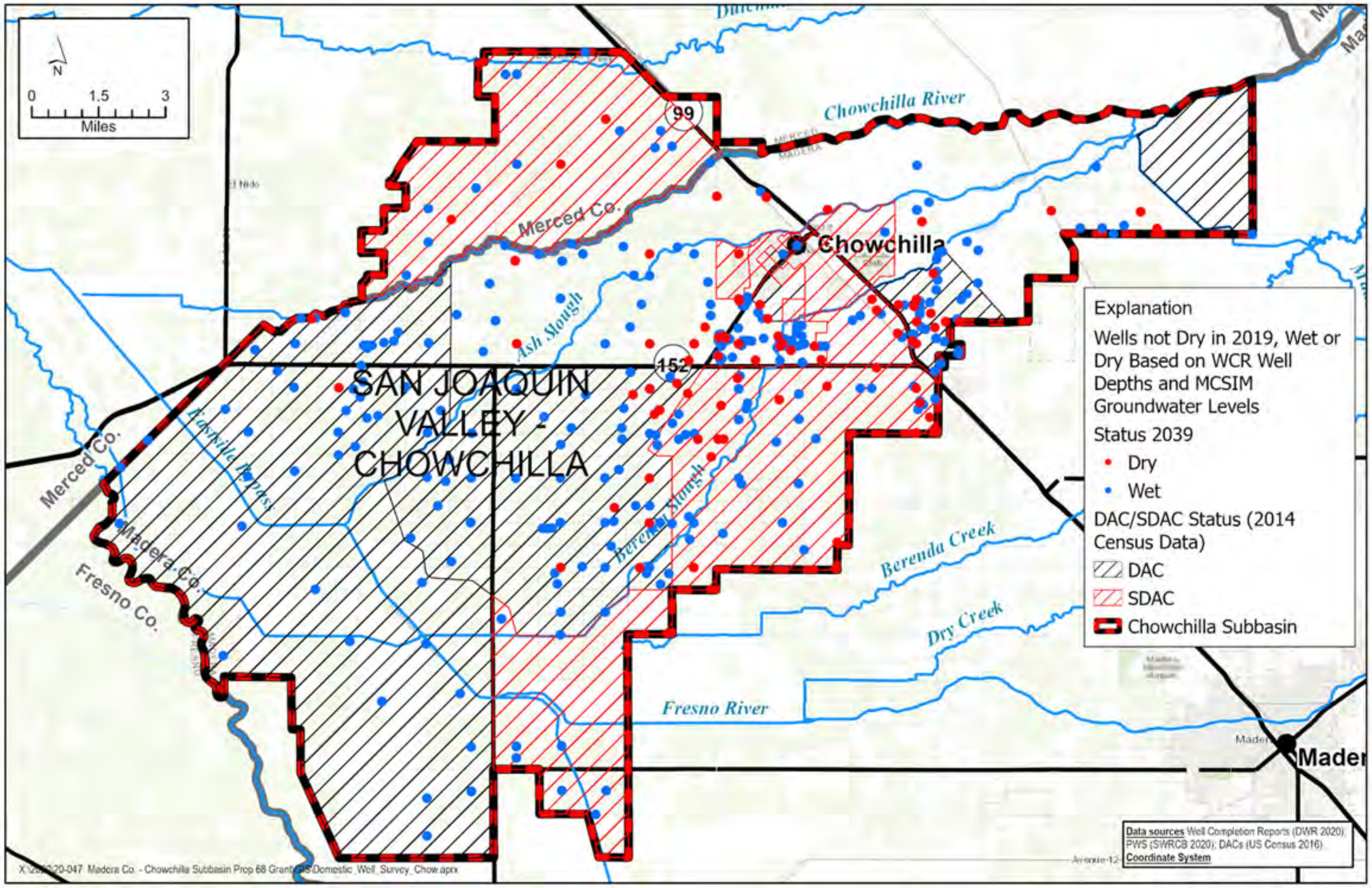

Figure 13e: Status of Wells in 2039 - Based on WCR Well Depths and Locations Compared to MCSIM Groundwater Depths.

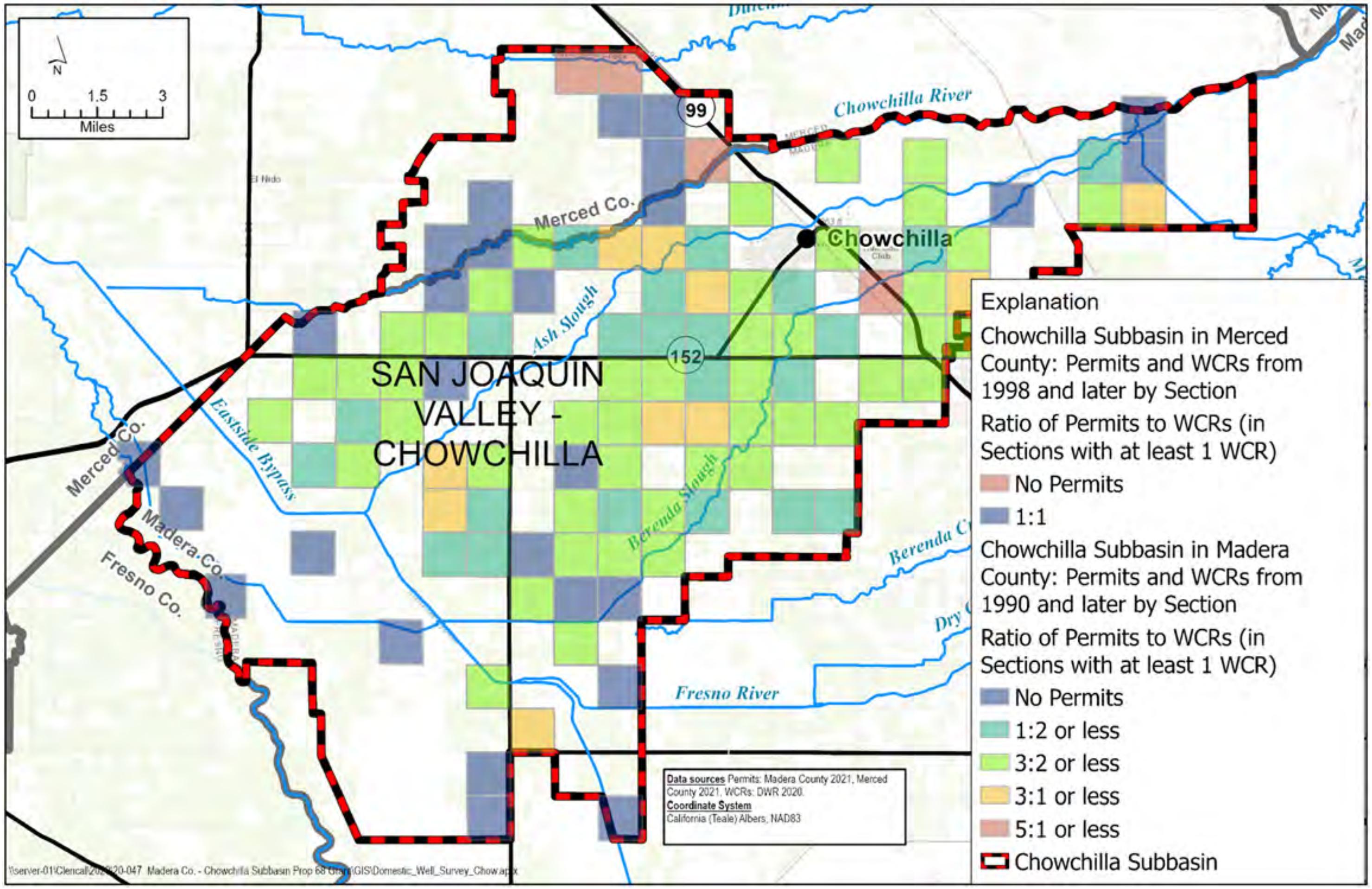

Figure 14: Map of Domestic Well Permits Compared to Domestic Well WCR (from 1990 and later) Locations.

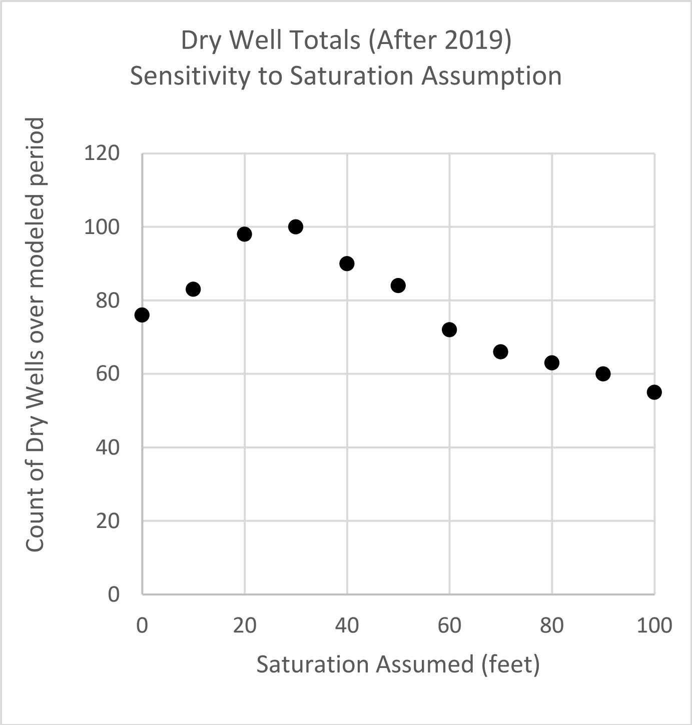

Figure 15: Counts of Dry Wells as a Function of Minimum Saturation Threshold.

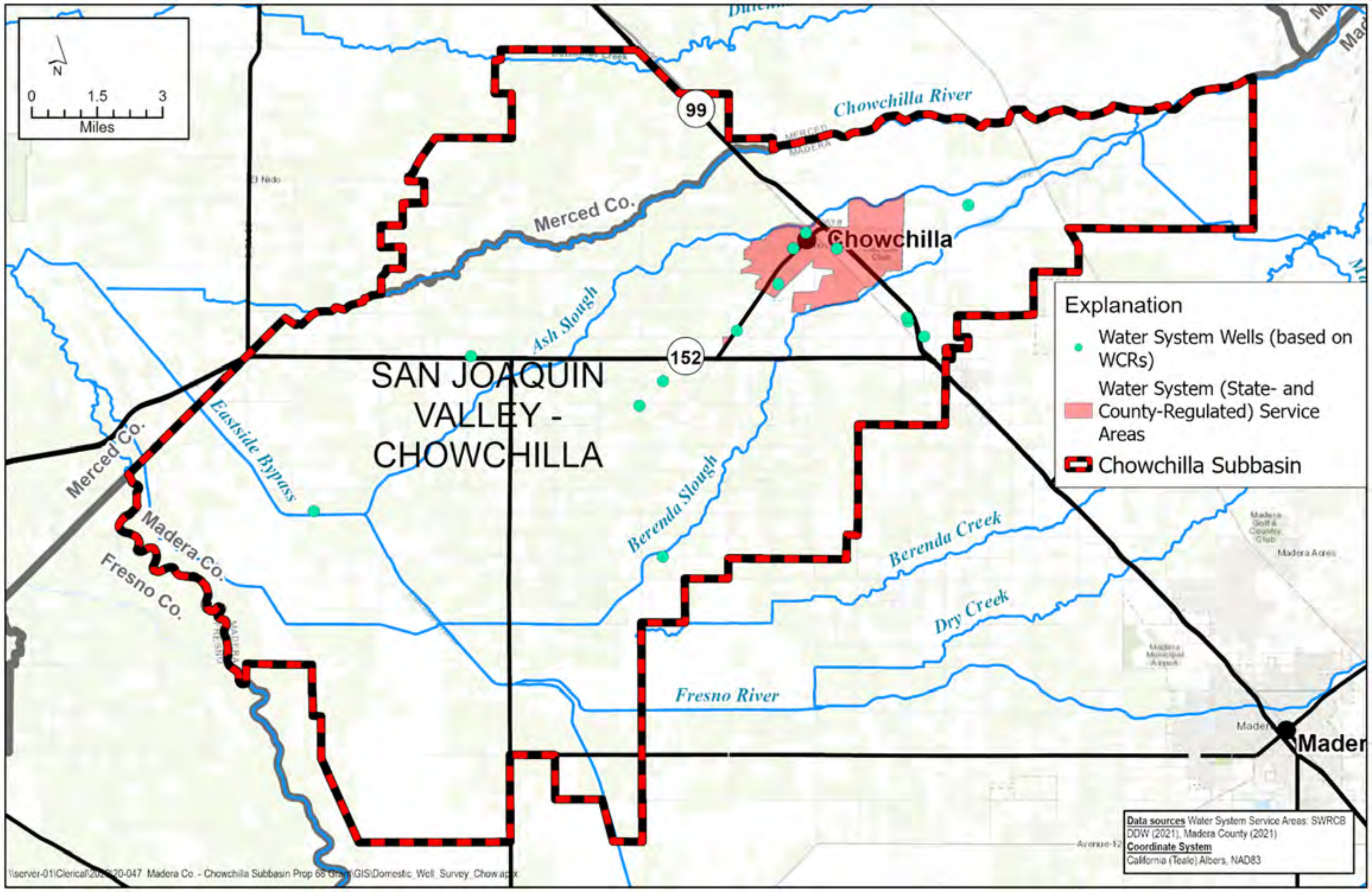

Figure 16: Public Water System and Other Municipal or Community Water System Wells. Based on WCR data.

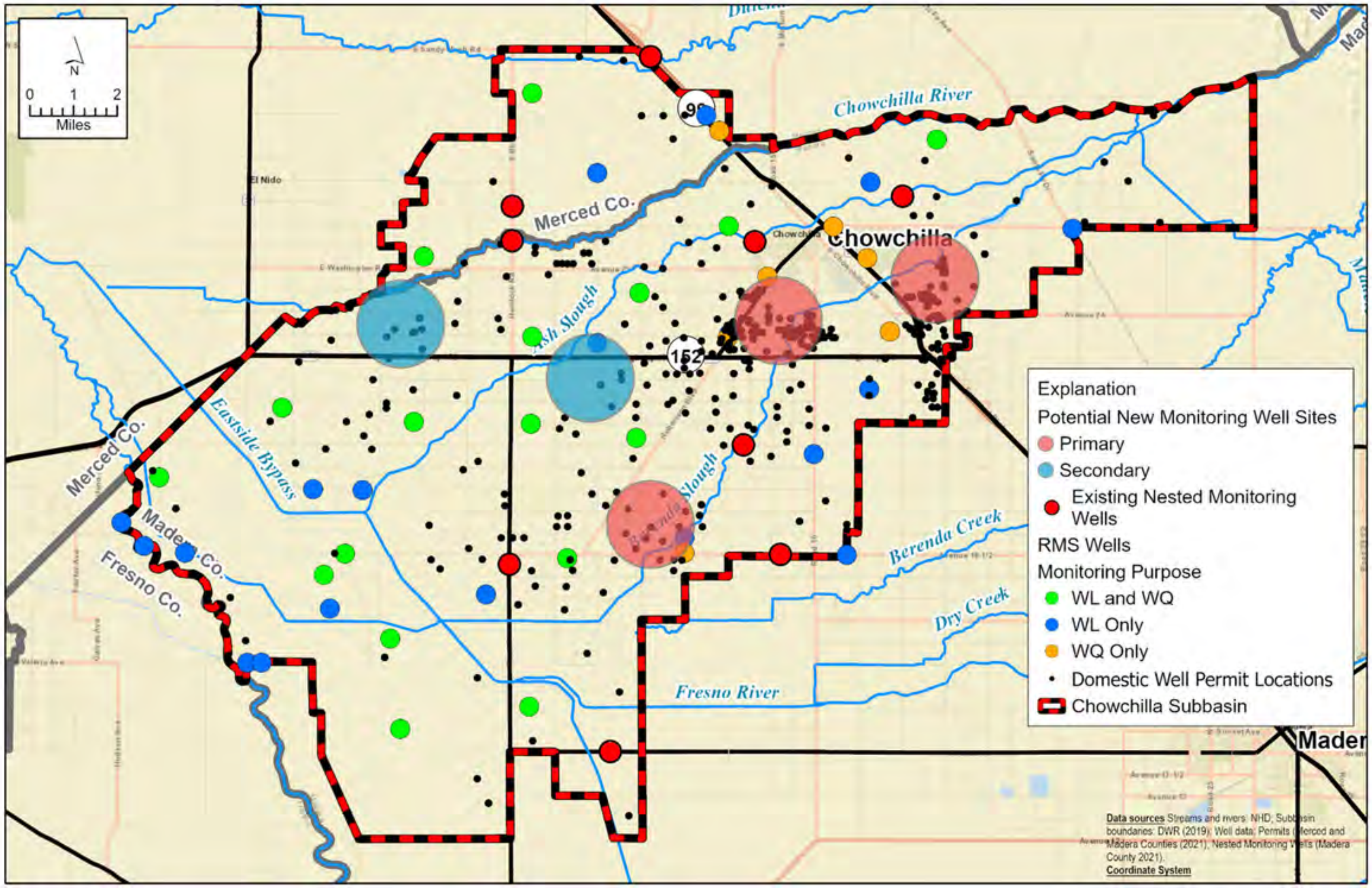

Figure 17: Map of Proposed New Monitoring Well Sites.

ATTACHMENT 1

Domestic Well Replacement Economic Analysis – Chowchilla Update

ERA Economics
1111 Kennedy Place, Suite #4
Davis, CA 95616

Technical Memorandum

Subject: Domestic Well Replacement Economic Analysis – Chowchilla Update

By: ERA Economics

To: LSCE and the Madera County GSA

Date: January 10, 2022

Purpose and Background

In June 2019 ERA provided a technical memorandum (TM) estimating the cost and benefit of more rapid implementation of demand management under the Chowchilla Subbasin GSP. The economic analysis was included as Appendix 3C to the Chowchilla Subbasin GSP. The analysis was prepared with the best available data and information at that time. After finalizing the GSP, the LSCE and DE consultant teams have continued to assist the Chowchilla Subbasin GSAs with GSP implementation and annual GSP reporting. LSCE was engaged by the Madera County GSA to prepare an updated domestic well inventory for the subbasin.

The economic analysis included as Appendix 3C to the Chowchilla Subbasin GSP estimated the total cost of replacing domestic wells potentially impacted by declining groundwater levels under baseline conditions without SGMA and under the draft proposed GSP implementation plan (so-called "with-SGMA" scenario).

This technical memorandum (TM) serves as an update to those estimates by: (i) updating the project and demand management schedule to reflect the adopted allocation in the Chowchilla Subbasin, (ii) incorporating updated data and analysis on potentially impacted wells from the domestic well inventory, (iii) updating all costs and benefits to current dollars (e.g., well replacement costs), and (iv) refining the economic analysis to compare the cost and benefit of accelerating demand management specified in the GSP. That is, the 2019 analysis compared the draft GSP implementation to baseline conditions without SGMA, whereas this analysis compares the proposed plan with phased implementation of projects and management actions (PMAs) to an accelerated, immediate implementation of PMAs, notably with immediate full demand management to avoid further domestic well impacts.[1]

These updates to the data affect the resulting economic analysis and results. The 2019 estimate of domestic wells needing to be replaced without increased demand management was 40 wells, which at that time was doubled to account for potential under-reporting. In addition, a sensitivity calculation as

[1] Whereas the cost of immediate demand management implementation has been included, the effect on cost of accelerating recharge and supply projects has not yet been estimated. A full cost estimate of projects for all GSAs in the subbasin is still under development. If this additional cost were included, it would strengthen the conclusion of this analysis.

part of the earlier analysis verified that the conclusions would have held even if the number of affected wells were substantially larger. The updated domestic well inventory puts the number of domestic wells potentially needing replacement at 176 over the 20-year GSP implementation period. This TM briefly summarizes the updated analysis, results, and summary conclusions.

Summary Conclusions

Results of this updated analysis comparing the cost of accelerated PMA implementation to the benefit of avoided domestic well replacement costs support the general conclusion of the 2019 analysis. The loss in agricultural value from more rapid demand management still greatly exceeds domestic well replacement costs even though the estimated number of potentially dewatered domestic wells has increased and the cost of replacement for each domestic well has increased by 20 percent. That is, the results of the economic analysis show that the additional cost of more rapid demand management is substantially greater than the cost of replacing potentially dewatered domestic wells and paying higher pumping costs due to lower water levels. This supports the phased implementation schedule and domestic well mitigation program defined in the GSP.

Updated Assumptions

Assumptions and results below are summarized for each of the cost categories considered. All costs (or savings) are expressed as constant 2021 dollars converted to present value using a 3.5 percent real (inflation-free) discount rate[2]. The two implementation scenarios compared are referred to as *GSP implementation* (the phased implementation as described in the GSP) scenario and the *immediate demand reduction* (full demand reduction to eliminate overdraft from 2021 onward) scenario.

1. **Number of dewatered wells needing replacement**. Revised estimates of dewatered wells are calculated and described in the Technical Memorandum prepared by LSCE for the Chowchilla Subbasin Domestic Well Inventory. For this analysis, a total of 176 wells were estimated to be dewatered, spread across four 5-year periods. The cost analysis further assumed that well impacts would be evenly divided by year within each 5-year period[3]. For the comparison scenario with immediate demand reduction, it was assumed that none of those wells would need replacement.
2. **Costs to replace dewatered domestic wells**. The 2019 estimate of an average $25,000 per replaced domestic well is updated to $30,000 per domestic well.
3. **Groundwater pumping depth to water (DTW).** The average DTW for the GSP implementation scenario was provided from groundwater model projections described in the Chowchilla Subbasin GSP. The immediate demand reduction scenario is intended to represent immediate elimination of average annual overdraft. A time series was created that followed the

[2] The current federal discount rate for water projects is 2.25%, but a real rate of 3.5% better reflects borrowing conditions in Madera County. A 1.5% increase or decrease in the real discount rate does not affect the conclusions of the analysis.
[3] The timing of the well replacement within each 5-year period does not affect the conclusions of this analysis.

general hydrologic variation estimated for the GSP implementation scenario but held the DTW the same on average during the 2021-2040 implementation period. The ending (2040) difference in DTW between the two scenarios was then carried forward beyond 2040. These pumping depth differences are the basis for the estimated annual pumping cost savings.

4. **Changes in variable costs to pump groundwater, for both domestic and agricultural users.** Energy prices, estimated using a mix of PG&E's latest electricity rates for agricultural pumping, have increased substantially. The analysis now uses an average of PG&E's 2021 AG-B and AG-C peak and off-peak summer rates, resulting in an estimate of $0.40 per acre-foot per foot of lift for the variable cost to pump groundwater. As a result, more rapid demand management provides greater savings (avoided pumping lift) for domestic and agricultural pumping. All agricultural and domestic groundwater pumping in the basin would receive this avoided lift benefit from faster demand reduction.

5. **Costs of demand management under GSP implementation**. Costs of demand reduction have been revised based on the latest estimates of the net return to agricultural water use developed for planning the SALC program. In addition, pumping volumes have been updated to reflect current conditions and the planned ramp-down adopted in the Madera County GSA groundwater allocation ordinance (applicable to the GSP implementation scenario only). These values do not represent average returns to all lands and crops in the subbasin but rather the lands and crops more likely to participate in a demand reduction program. For purposes of this analysis, the lost net return from demand reduction is valued at $200 per acre-foot[4].

Results

The following discussion compares costs between the GSP implementation scenario and the (alternative) immediate demand management scenario. General observations are:

- Demand management costs are greater in the immediate implementation scenario because demand management would be implemented sooner (immediately) and for more years during the GSP implementation period. Recharge and supply projects' costs have not been included in this analysis, but their present value costs would also increase because they would be implemented sooner.
- Pumping costs are lower in the immediate demand reduction scenario because, by definition, the average annual overdraft is eliminated immediately. The effect (smaller DTW and lower pumping cost) is carried throughout the remaining years of GSP implementation and in perpetuity.

[4] The value of water depends on future crop market conditions. Note that a higher value (greater than $200 per acre-foot applied in this TM) would further increase the cost of accelerated demand management relative to avoided well replacement and additional pumping costs.

- Well replacement costs occur in the GSP implementation scenario but are not required in the immediate demand reduction scenario.
- The net effect of these differences in costs results in the GSP implementation scenario having a substantial cost advantage (by about $36 million in present value, or 16 percent) over the immediate demand reduction scenario. In other words, the Chowchilla Subbasin is better off (i.e., realizes benefits that exceed costs) implementing its phased GSP implementation plan and developing/funding the domestic well mitigation program to replace impacted wells than it is if it were to implement immediate demand reduction to avoid dewatering any domestic wells.

Table 1 summarizes the results of the economic analysis. All values are expressed in present value terms. The first two rows show the number of and cost to replace wells estimated to go dry in each scenario. The next rows present the pumping cost savings of the immediate demand reduction scenario relative to the GSP implementation scenario, broken down by domestic pumping and agricultural pumping. The next row shows the demand management costs. For the GSP implementation scenario, demand management is phased in at two percent per year initially, increasing to 6 percent per year until full demand management is reached by 2040. In contrast, the immediate demand reduction scenario implements the full demand management required in 2020, resulting in substantially higher demand management costs.

Table 1. Costs of GSP Implementation Scenario Compared to Costs of Immediate Demand Reduction Scenario - Summary Results for Chowchilla Subbasin, Present Value ($ in Millions)

	GSP Implementation with Well Replacement	Immediate Demand Reduction	Difference
Domestic Well Replacement			
Number	176	0	176
Cost, PV	$4.60	$0.0	$4.60
Pumping Cost (Savings), PV			
Domestic	NA	-$2.87	$2.87
Agricultural	NA	-$79.58	$79.58
Demand Mgmt. Cost, PV	$219.43	$342.37	-$122.94
Total Cost, PV*	$224.03	$259.91	-$35.88

* Totals may not add exactly due to rounding.

Discussion

Results indicate that the cost of implementing demand management on a faster trajectory (in this case, in year one of the implementation period) would not be cost effective from a subbasin-wide perspective. The avoided costs (fewer domestic wells requiring replacement) would be small ($4.6 million) relative to the additional lost agricultural net return[5] from immediate implementation ($122.9 million) for the Chowchilla Subbasin, even after accounting for pumping cost savings ($82.5 million). The general conclusions are robust to the assumptions used. That is, results are not sensitive to reasonable ranges in key assumptions, including the loss in net return per acre-foot of demand management, the total level of demand management, when demand management begins to scale in, or the cost of replacing a domestic well.

This analysis only compares the cost of well replacement to net costs of immediate demand management implementation; it has not considered the timing of other projects such as new surface water supplies or groundwater recharge. That comparison is not possible with current information, and the GSP implementation schedule already reflects an aggressive timeline for project implementation. The cost (in present value) of accelerating implementation of projects has also not been included here.The additional cost of accelerating a recharge project by, say five years, would be the increased present value of the project's capital and O&M cost stream. Costs of new supply and recharge projects have not been accelerated, so the present value of costs for immediate implementation is underestimated. Simply stated, including these additional costs would further support the conclusions of the analysis.

[5] Note that demand management would result in additional economic impacts to other county businesses and industries. These additional indirect impacts are not considered in this updated analysis but would only further support its conclusions.

ATTACHMENT 2

Chowchilla Subbasin – Evaluation of DWR Household Water Supply Shortage Reports and Self-Help Enterprises Tank Water Participants

Technical Memorandum

DATE: February 8, 2022 PROJECT: 20-1-047

TO: File – Chowchilla Subbasin Domestic Well Inventory

FROM: Pete Leffler, Nick Watterson, Aaron King

SUBJECT: **Chowchilla Subbasin - Evaluation of DWR Household Water Supply Shortage Reports and Self-Help Enterprises Tank Water Participants**

1. INTRODUCTION

To support efforts related to implementing the Chowchilla Subbasin Groundwater Sustainability Plan (GSP), the Subbasin completed a Domestic Well Inventory project that identified potential domestic wells in the Subbasin and analyzed potential impacts to domestic wells caused by lowering of groundwater levels historically and during the 20-year GSP implementation period starting in 2020. The Domestic Well Inventory for the Chowchilla Subbasin compiled information on domestic wells in the Subbasin from Well Completion Reports and County well permit datasets and compared these data to modeled groundwater levels in the Subbasin from the GSP over the period from 2014 through 2040. During development of the GSP, historical and future groundwater levels throughout the Subbasin were modeled based on historical conditions and projected future conditions. This memorandum summarizes a review of records in the Department of Water Resources (DWR) Household Water Supply Shortage Reporting System and also participants in the Self-Help Enterprises (SHE) Tank Water program, and includes a comparison of these two datasets with the results from analyses of domestic well impacts conducted as part of the Chowchilla Subbasin Domestic Well Inventory.

2. DWR HOUSEHOLD WATER SUPPLY SHORTAGE REPORTING SYSTEM

Overview of the Household Water Supply Shortage Reporting System

The DWR Household Water Supply Shortage Reporting System (https://mydrywell.water.ca.gov/report/) is a site for reporting of problems with private (self-managed, not served by public water system) household water supplies. The site was initially created in 2014 as part of drought emergency response efforts and continues to be used to collect information on household water supply shortages from private well or surface water sources. The data in the reporting system reflect information on water supply shortage issues voluntarily submitted by private, local, state, federal, and non-governmental individuals and organizations. Because the data do not undergo review or quality control by DWR, the reported information is not suggested to be complete in its accounting for all water supply shortages and it is also noted by DWR that there may be errors and omissions in data, duplicate entries, and records for non-household related water supply issues. Furthermore, during review of the data, many incomplete and inconsistent records were noted, with many reports providing very little detail for use in understanding the cause of the issue reported. There are a variety of potential causes for issues related to the quantity or quality of water produced by a well, and this can include issues related to the well pump, water distribution system, or the well structure, without relationship to groundwater conditions in the aquifer.

The submission of information to the Household Water Supply Shortage Reporting System is done through completion of a report submittal form (https://mydrywell.water.ca.gov/report/public/form), which includes questions related to the issue, including required entries on the following:

- Type of shortage: a) Dry well, b) low streamflow, or c) other
- Description of the water issue: a) well is dry (no longer producing water), b) reduction in water pressure/lower flows, c) well pumping sand/muddy water, d) well is catching air (have to wait to be able to pump, e) reduction in water quality, or f) other
- Primary use of the well or creek: a) household, b) agriculture/irrigation, c) combination of household/agriculture, or d) other
- Approximate date problem started
- County

As of January 2022, the reporting system included 3,769 entries across the state of California, with dates when the problem started spanning the period from 2012 through 2021.

Household Water Supply Shortage Records within Chowchilla Subbasin

The Household Water Supply Shortage Reporting System contains a total of 46 reports with locations in the Chowchilla Subbasin. The reports within the Subbasin were grouped into two categories according to the type of water supply issue indicated: 1) dry wells, and 2) reduced flow or impaired water quality. **Figure 1** presents the number of reported well-related issues by year within the Chowchilla Subbasin. Of the 46 reports within Chowchilla Subbasin, 41 were categorized as a dry well issue and six were categorized as reduced flow or impaired water quality issues. As illustrated on **Figure 1**, most water supply issues in the system were reported to have started in 2014, 2015, and 2021, with relatively fewer during other years. The greatest number of reports occurred during 2015 after multiple years of drought conditions in the area. **Figure 2** shows the locations of the water supply issue reports in the system. Most water shortage reports in the Subbasin are located in the central Subbasin.

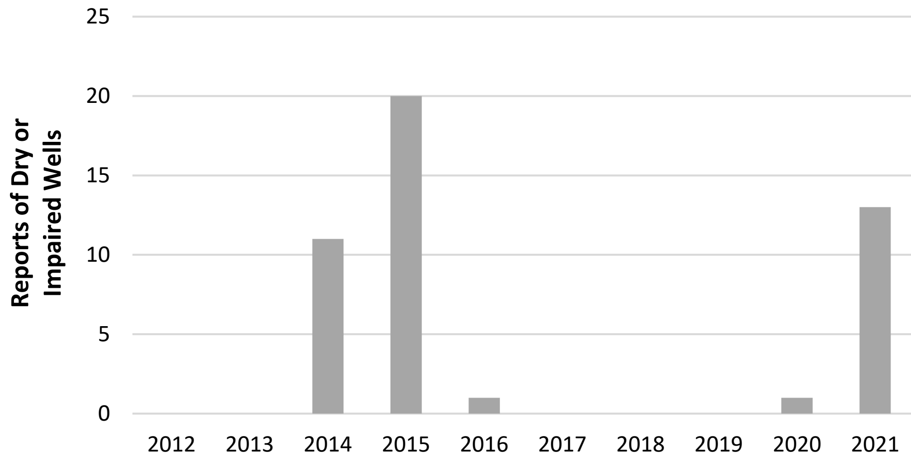

Figure 1. Chart of Household Water Supply Shortage Report Records in Chowchilla Subbasin

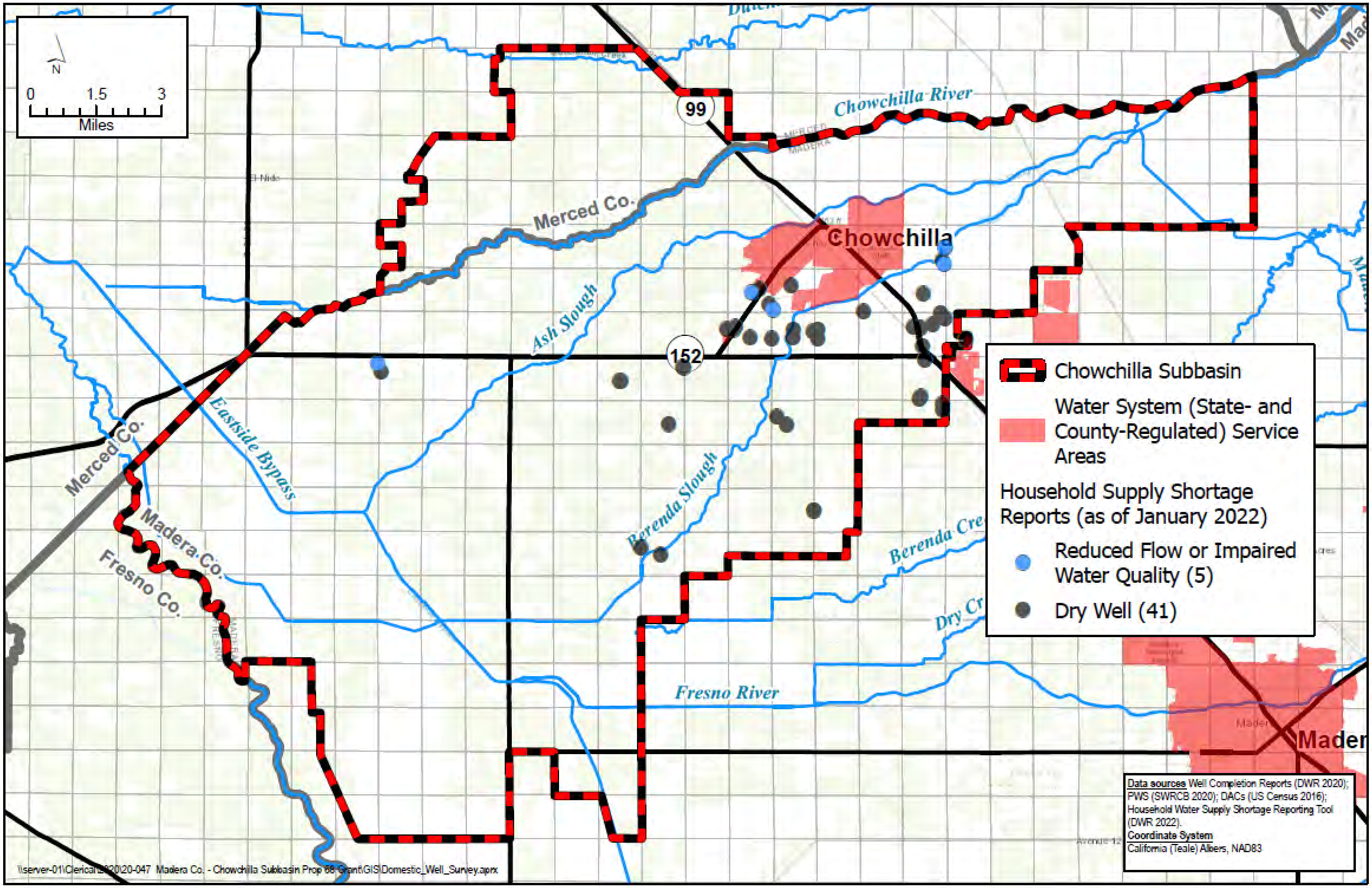

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Figure 2
DWR Household Water Supply Shortage Reporting Data
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Groundwater Sustainability Planning

3. SHE TANK WATER PROGRAM PARTICIPANT DATA

Overview of the SHE Tank Water Participant Data

The SHE Tank Water Program provides a temporary water supply solution for households experiencing a well water shortage in eight counties in and adjacent to the San Joaquin Valley: Fresno, Kern, Kings, Madera, Mariposa, Merced, Stanislaus, and Tulare. The SHE Water Tank Program assists households experiencing well water shortages by installing a water tank and hauling water and filling the tank to restore access to water for the home. The SHE Tank Water Program is intended as a short-term solution to provide participants access to water for one year while working towards a long-term solution. Data on participants in the SHE Water Tank Program as of January 2022 were provided by SHE (https://www.arcgis.com/home/webmap/viewer.html?webmap=377849cbc9c54046917d864a635e9674&extent=-120.0525,34.8083,-117.2593,36.0392). As of January 2022, the SHE Tank Water Program includes 769 participants in the eight-county area served by the program. The available Tank Water Program participant data only provide locations for participants without other attributes indicating the date or type of issue necessitating the reliance on tank water. There are a variety of potential causes for issues related to the quantity or quality of water produced by a well, and this can include issues related to the well pump, water distribution system, or the well structure, without relationship to groundwater conditions in the aquifer.

SHE Tank Water Participants within Chowchilla Subbasin

The Tank Water Program covers eight counties within the San Joaquin Valley, along with some areas located outside of the San Joaquin Valley and outside of DWR-designated groundwater basins (e.g., foothills areas). The SHE Tank Water Program includes 22 participants within the Chowchilla Subbasin. **Figure 3** presents a map of the Tank Water Program participants within the Chowchilla Subbasin. As illustrated on **Figure 3**, most of the Tank Water Program participants in the Chowchilla Subbasin are located in the area south of the City of Chowchilla. **Figure 4** is a map comparing the locations of SHE Tank Water participants and dry wells in the DWR Household Water Supply Shortage dataset. The spatial distribution of Tank Water participants and dry wells reported in the DWR dataset are very similar and likely include some of the same wells, although no information is available to evaluate such direct relationships in the two datasets.

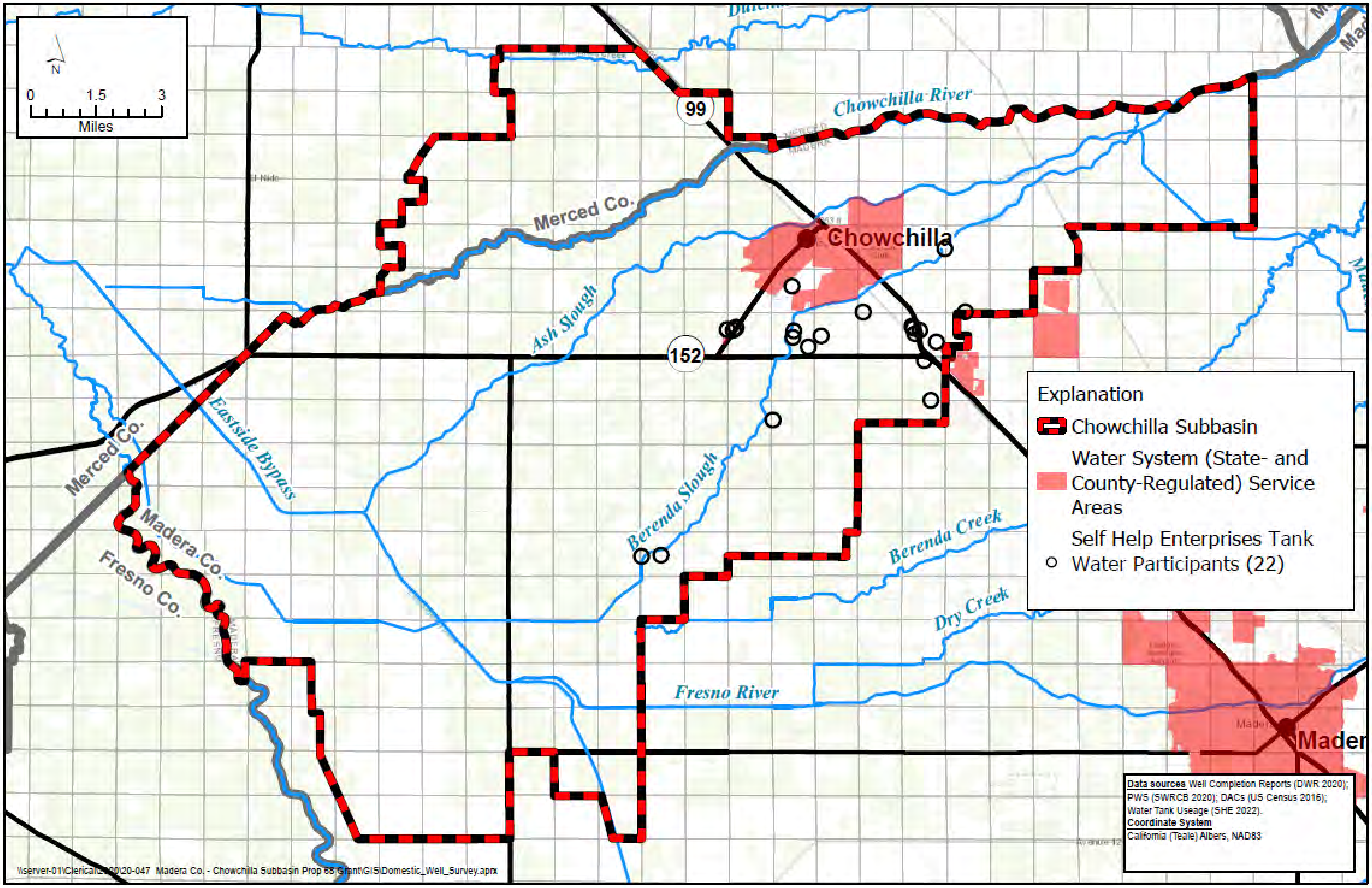

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Figure 3
Locations of Self Help Enterprises Tank Water Participants
Chowchilla Subbasin Groundwater Sustainability Planning

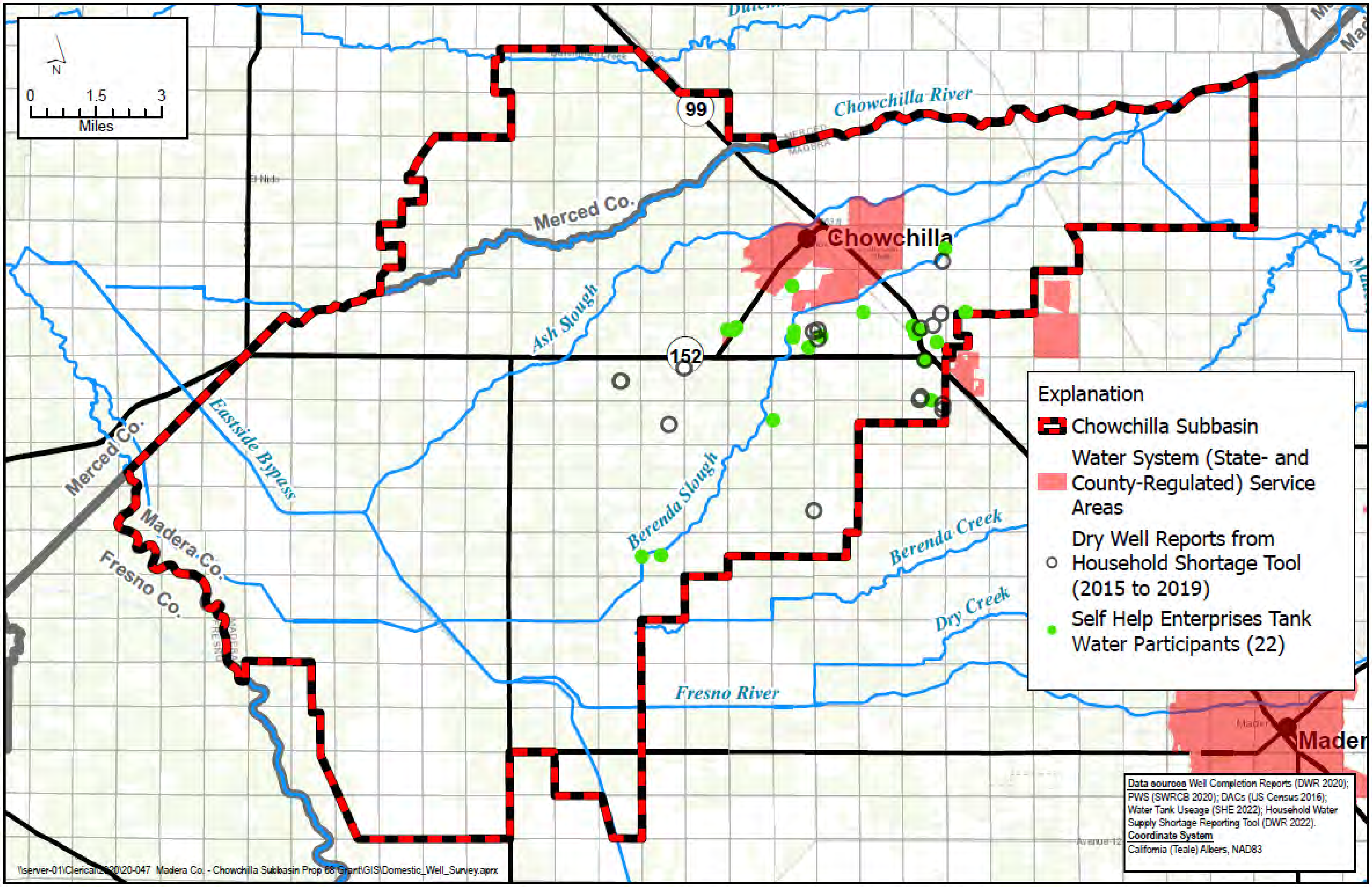

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Figure 4
Comparison of SHE Tank Water Participants and DWR Dry Well Reports
Chowchilla Subbasin
Groundwater Sustainability Planning

4. COMPARISONS OF DWR DRY WELL RECORDS AND SHE TANK PARTICIPANTS WITH ANALYSES OF DRY WELLS FROM THE DOMESTIC WELL INVENTORY

Analyses of potential domestic well impacts in the Domestic Well Inventory were conducted at five-year intervals based on modeled groundwater levels across the Subbasin. To understand differences between dry wells reported to the Household Water Supply Shortage Reporting System and also SHE Tank Water Program participants in relation to estimates of potential dry wells from the Chowchilla Subbasin Domestic Well Inventory analyses, the spatial distribution of dry wells in the Household Water Supply Shortage Reporting System dataset and Tank Water Participants were compared with modeled dry wells over the period from 2015 through 2024.

The comparisons presented in this TM are intended to provide a general sense for the spatial distribution of the different datasets, recognizing the datasets present different types of information related to domestic well issues. As noted above, there are a variety of potential causes for a well experiencing issues related to the quantity of water produced by a well that may be unrelated to groundwater conditions in the aquifer. Some of these issues may be reflected in the DWR Water Supply Shortage Reports and SHE Tank Water Program participants list. It is also likely that many households with wells that have gone dry have not reported such occurrences to the DWR Household Water Supply Shortage Reporting System and many of these households have also not participated in the SHE Tank Water Program. As described in the technical memorandum summarizing the Chowchilla Subbasin Domestic Well Inventory, analyses of potential dry domestic wells in the Domestic Well Inventory are based only on the relationship between available well construction (e.g., screen depth and total well depth) and simulated groundwater levels at each domestic well location.

Comparison of DWR Dry Well Records with Modeled Dry Wells in the Domestic Well Inventory

Maps comparing dry well records in DWR's Household Water Supply Reporting System with dry wells modeled as part of the Domestic Well Inventory are presented in **Figures 5 and 6**. **Figure 5** presents a comparison of all reported dry wells in DWR's system (2012 through 2021) with modeled dry wells estimated for the period 2015 through 2024 in the Domestic Well Inventory. **Figure 6** presents a comparison of reported dry wells during the years 2015 through 2019 in DWR's system with modeled dry wells between 2015 and 2019 in the Domestic Well Inventory. **Figure 6** provides a more direct spatial comparison of dry wells in the two datasets over the same five-year period, whereas **Figure 5** presents an overview of the spatial relationship between the two datasets spanning a longer timeframe. Although there are considerably more modeled dry wells than reports of dry wells in DWR's system in either comparison, the spatial patterns in the two datasets show many similarities, with most modeled dry wells and reports of dry wells occurring in areas south and southwest of the City of Chowchilla. Some of the differences in locations between the modeled dry wells and reported dry wells in **Figures 5 and 6** are likely a result of differing resolutions of locational information available in the two datasets.

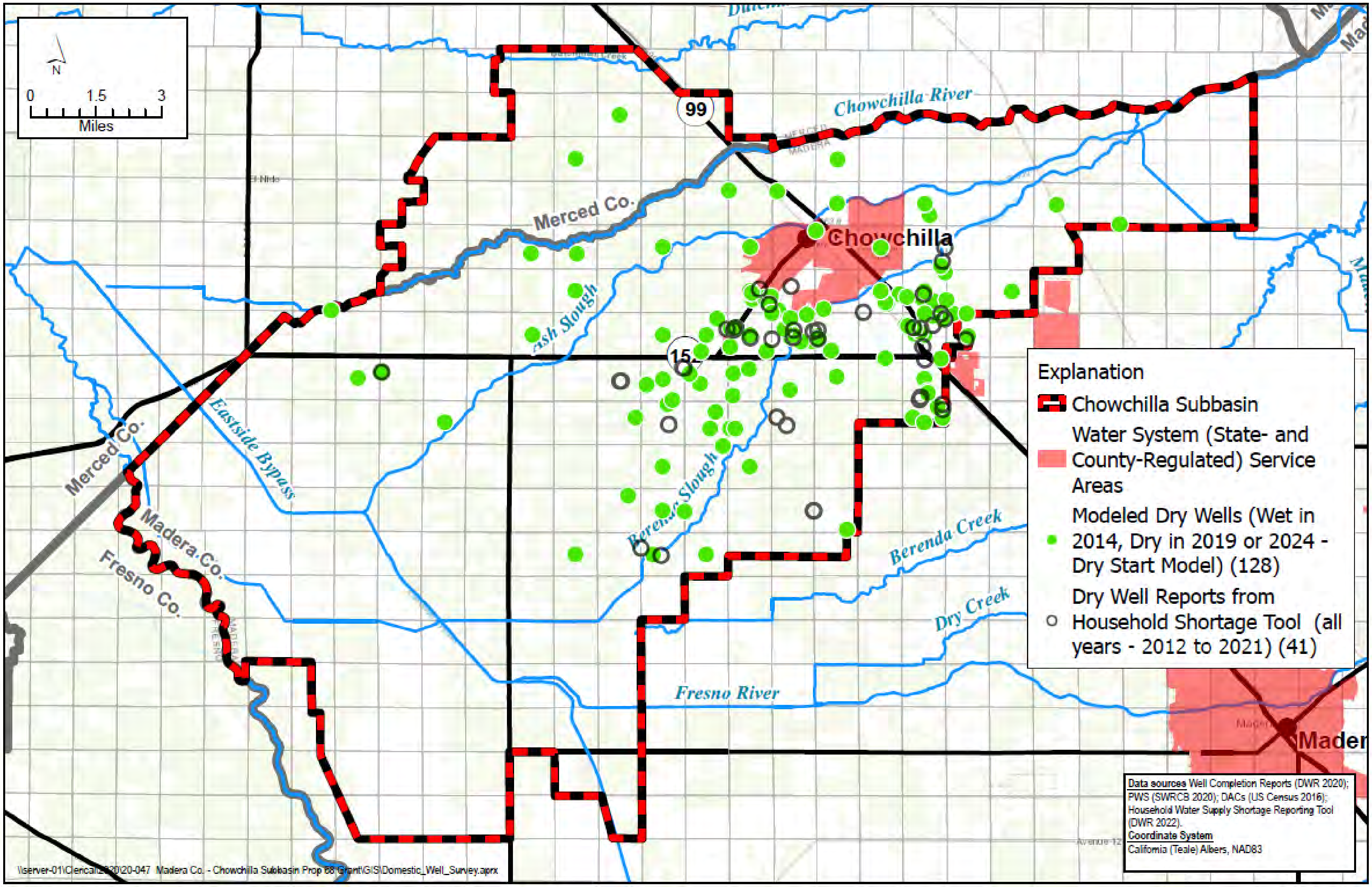

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Figure 5
Comparison of DWR Dry Well Reports with Modeled Dry Wells Between 2015 and 2024
Chowchilla Subbasin Groundwater Sustainability Planning

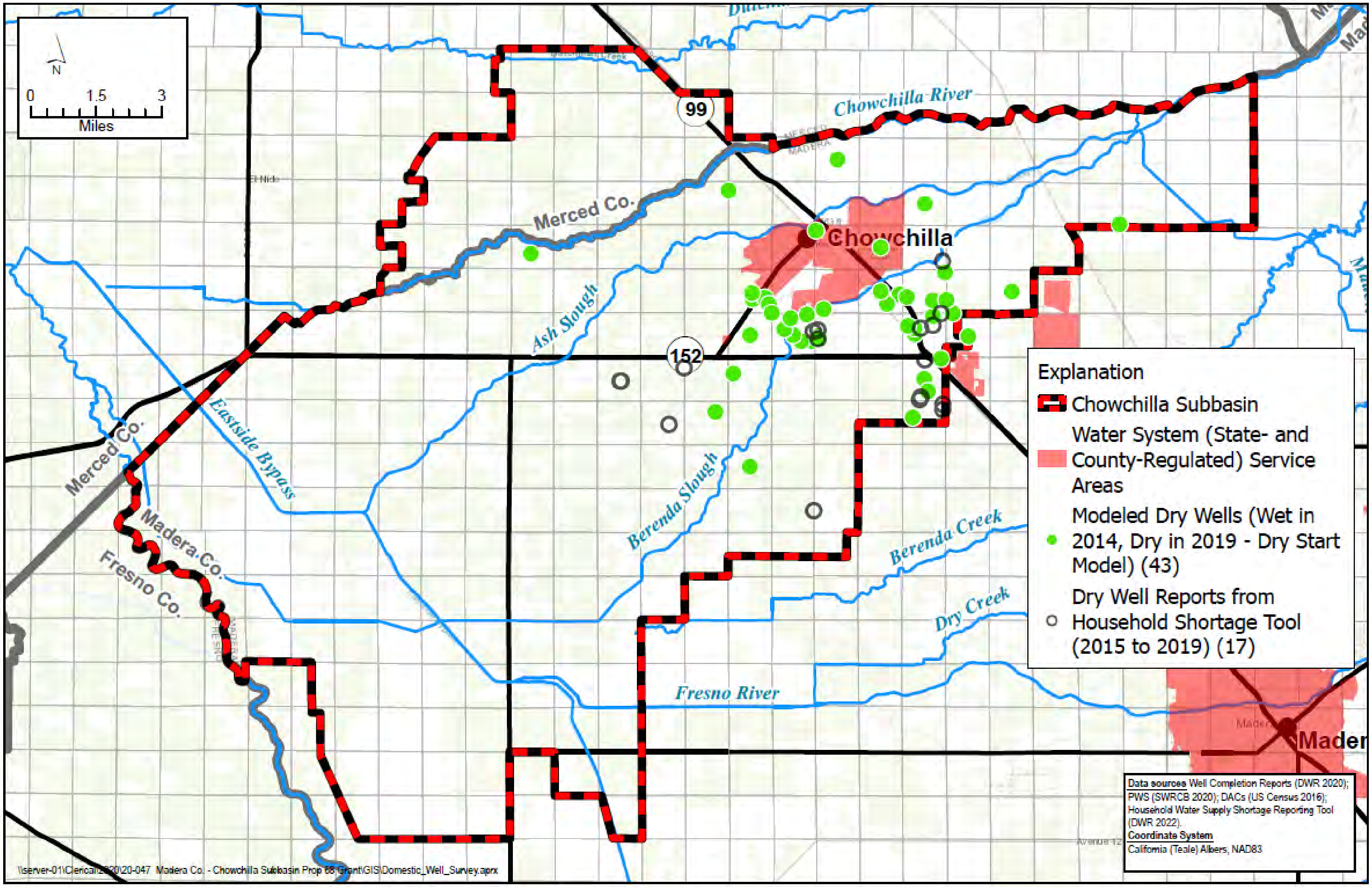

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Figure 6
Comparison of DWR Dry Well Reports with Modeled Dry Wells Between 2015 and 2019
Chowchilla Subbasin
Groundwater Sustainability Planning

Comparison of SHE Tank Water Participants with Modeled Dry Wells in the Domestic Well Inventory

A map comparing SHE Tank Well Participants with dry wells modeled as part of the Chowchilla Subbasin Domestic Well Inventory are presented in **Figure 7**. **Figure 7** presents a comparison of all SHE Tank Water Program participants in the Subbasin as of January 2022 with modeled dry wells estimated for the period 2015 through 2024 in the Domestic Well Inventory. Although there are considerably more modeled dry wells than Tank Water Participants (as is the case with dry well reports in DWR's Household Water Supply Shortage System), the spatial patterns in the two datasets show many similarities with most modeled dry wells and SHE Tank Water Participants occurring in areas south and southwest of the City of Chowchilla.

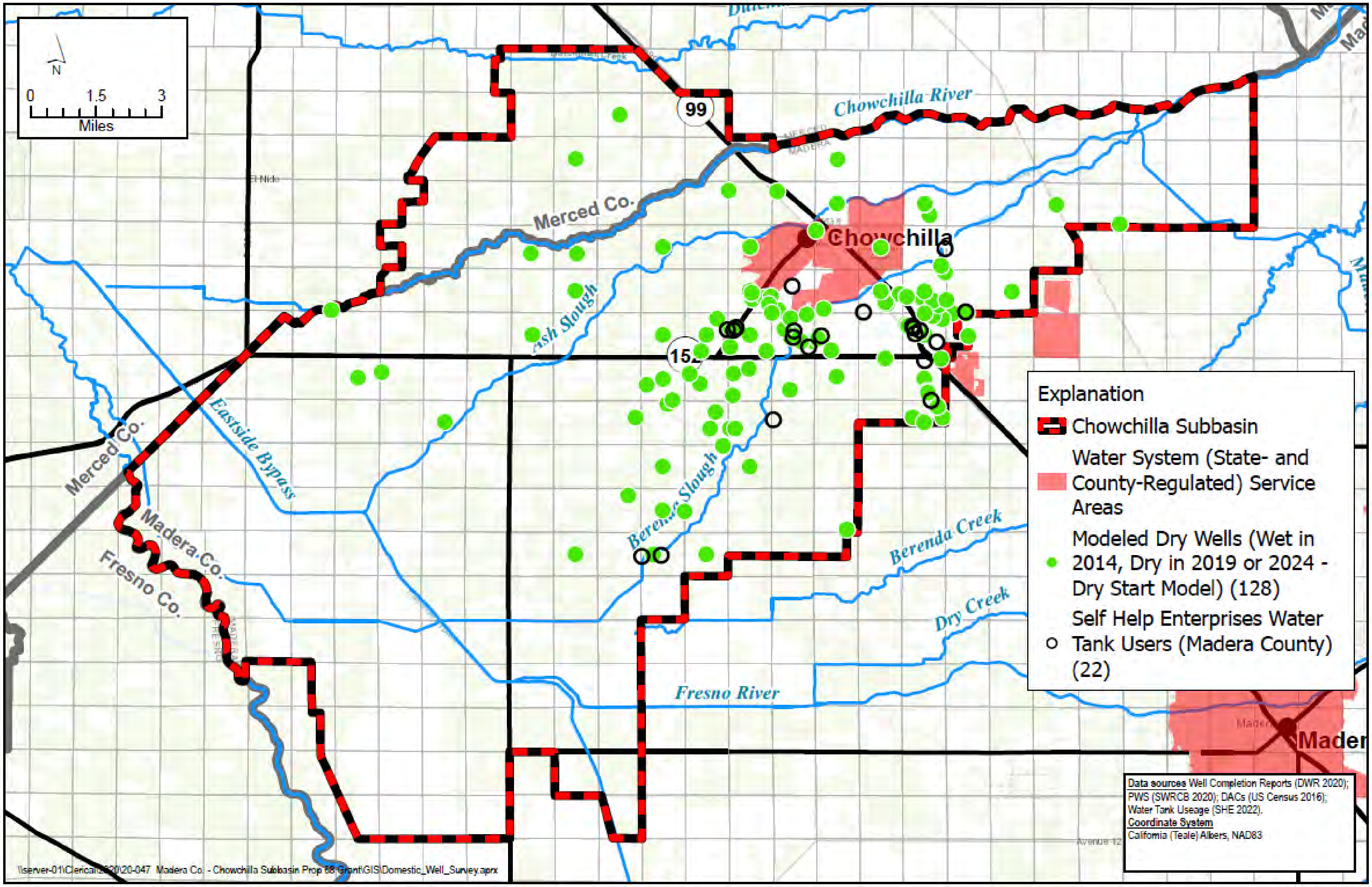

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Figure 7
Comparison of SHE Tank Water Participants with Modeled Dry Wells Between 2015 and 2024
Chowchilla Subbasin
Groundwater Sustainability Planning