TECHNICAL MEMORANDUM:

MADERA SUBBASIN

Sustainable Groundwater Management Act (SGMA)

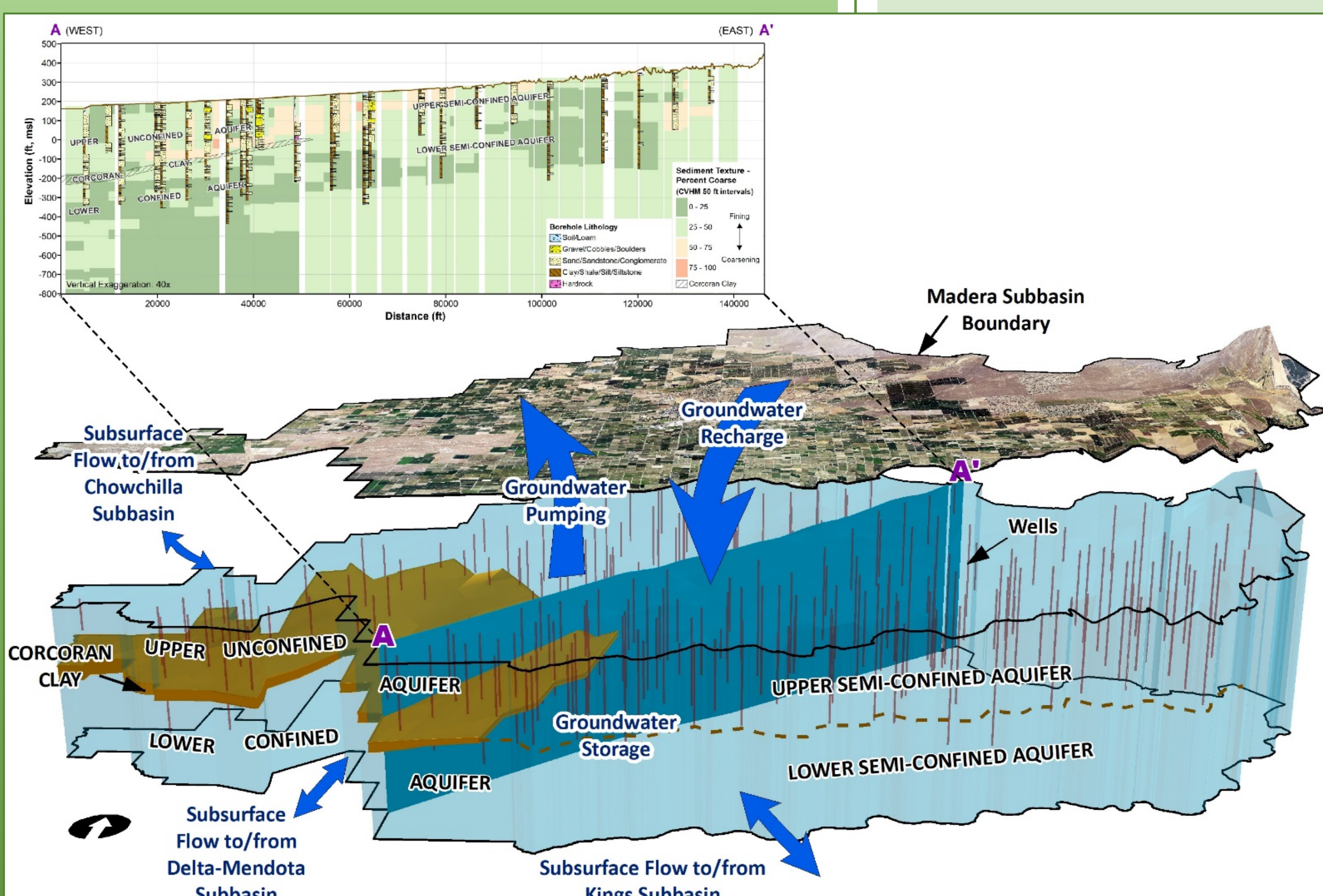
DATA COLLECTION AND ANALYSIS

July 2017

Prepared by

DAVIDS ENGINEERING, INC

LUHDORFF & SCALMANINI CONSULTING ENGINEERS



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Prepared For

Madera Subbasin Coordinating Committee

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and

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ES 1 EXECUTIVE SUMMARY

Agriculture is an important economic driver in the Madera area, and groundwater represents an important water supply for crop irrigation in the Madera Subbasin. Thus, the sustainable management of groundwater is important to the long-term prosperity of the community. The Sustainable Groundwater Management Act of 2014 (SGMA) allows for local control of groundwater resources while requiring sustainable management of these resources.

The Madera Subbasin covers about 347,600 acres in Madera County. Seven Groundwater Sustainability Agencies (GSAs) have formed to cover the subbasin in its entirety (**Figure ES-1**). The objective of this study is to compile available data for the subbasin, identify data gaps, prioritize actions related to development of a Groundwater Sustainability Plan (GSP), and estimate costs to fill the identified data gaps.

This Technical Memorandum (TM) includes a description of the data acquisition process, a preliminary description of the Hydrogeologic Conceptual Model (HCM) (including groundwater conditions), and a description of the conceptual water budget. The TM also summarizes the data gap analysis and provides recommendations for filling high-priority data gaps.

ES 1.1 Data Compilation

Data for the subbasin were received from eight local entities including the City of Madera, Madera County, Madera Irrigation District, Madera Valley Water Company (within Madera County GSA), Madera Water District, New Stone Water District, Root Creek Water District, and Gravelly Ford Water District. Most of the submitted data relate to groundwater levels, water quality, well locations, well construction details, groundwater pumping, water use, and land use. Publicly available data were also compiled and evaluated. Public data were obtained from the U.S. Geological Survey (USGS), the California Data Exchange Center (CDEC), the California Department of Water Resources (DWR), the State Water Resources Control Board (SWRCB), the U.S. Bureau of Reclamation, the U.S. Department of Agriculture (USDA), and several others. Most public data were acquired from online databases. Data compiled from local entities and public data sources, primarily well data, water quality, land use, stream flows, weather and planning documents, are incorporated into the descriptions of the HCM and conceptual water budget.

ES 2.1 Hydrogeologic Conceptual Model

The preliminary HCM described in this TM is based on previous studies and information obtained through the data request for this study. The hydrogeologic conditions for the Madera Subbasin are documented in several reports by USGS and various consultants. The overall geologic setting and subbasin lateral and vertical boundaries are described herein. Several geologic cross-sections were obtained from previous studies, and those cross-sections are compiled and described. The major aquifers and aquitards are delineated using existing geologic cross-sections, and associated data describing aquifer properties were compiled. Additionally, groundwater levels, storage change, and groundwater quality are relatively well documented and included herein, along with available information describing subsidence and groundwater – surface water interaction. The preliminary HCM provides a foundation for developing the HCM required for the GSP.

ES 3.1 Water Budget

The water budget schematics provided in this TM were developed through a process of reviewing historical and current land and water use in the subbasin to identify water use sectors and by reviewing the water sources available for use in the subbasin. After identifying water use sectors and water source types, all inflows and outflows (flow paths) between water use sectors and accounting centers[1] were identified, and the data types and data sources needed to support quantification of each flow path were reviewed to assess data gaps. In addition to defining the required components of the water budget (flow paths), the GSP regulations specify minimum requirements for the water budget time period. The most recent available information is required to characterize current conditions, and information for at least the most recent ten years is required to characterize historical conditions. A longer historical water balance typically provides information that better describes how variability in hydrology, water supplies, and water demands have affected aquifer conditions and better informs the evaluation of sustainability indicators and potential future management actions. Based on the data acquired for the Madera Subbasin, a 27-year base period of 1989 through 2015 is preliminarily recommended.

ES 4.1 Data Gap Assessment

The elements of an HCM (geologic and groundwater conditions) and water budget required for a GSP can generally be prepared based on synthesis of information compiled from existing reports and the data acquired for this study. The following additional efforts are needed prior to GSP development or as a first phase of GSP development: 1) a detailed quality assessment and quality control (QA/QC) check of various data sets, 2) further integration of data collected for this study (e.g., DWR well completion reports), and 3) installation of dedicated monitoring wells. Existing wells to be included in the GSP monitoring network will require known construction details to facilitate an understanding of groundwater elevations and water quality in the upper aquifer versus the lower aquifer. At present, a major data gap is the lack of a sufficient number of water level and water quality monitoring wells with known construction details. A major data gap for the water budget is a lack of surface water outflow stream gages on or near the subbasin boundaries.

For the required water budget analyses, sufficient data exist to complete all of the necessary data types, except that the available record of surface water outflows based on gage data is short. This will require estimates to be prepared from available data and supporting analyses. Also, complete, quality controlled data sets are not available, and all data will require some degree of QA/QC and gap filling for relatively short, intermittent periods.

ES 5.1 Recommendations

Three priority levels of data gaps and related recommendations are presented in this report, with the high and medium priority recommendations summarized in the following sections, respectively. The last section of the report presents data gaps and recommendations in all three priority levels.

ES 5.1.1 High Priority

The high priority recommendations are actions that are key to developing a compliant, high quality, successful GSP and should be initiated immediately. The recommended high priority actions are listed below and summarized in **Tables ES-1** and **ES-2**. The total cost for all high priority recommendations is \$1.795 million including \$1.65 million for new monitoring wells, \$90,000 for the installation of new stream gages, and \$55,000 for analyses to associate data from well completion report (WCR) locations with existing wells and to develop a complete surface water outflow record.

[1] Accounting centers represent subareas (volumes) within the larger water budget domain.

- Conduct detailed review of DWR WCRs acquired for this study and associate WCRs with wells with water level data but unknown construction details to further expand the database of wells with known construction details and better characterize groundwater conditions in the upper and lower aquifers.
- Conduct outreach with existing well owners. Identify wells with known construction details that are not currently part of the groundwater monitoring network. If the well owner is willing to participate and has a well that is representative of either the upper or lower aquifer (but not both), consider adding the well to the GSP monitoring network.
- Install new dedicated monitoring wells at locations (**Figure ES-2**) where existing wells with known construction details are lacking to fill data gaps in the existing monitoring network.
- Plan for and install three new gages to measure surface water outflows from the subbasin on Cottonwood Creek, Eastside Bypass, and the Fresno River.
- Review available surface water outflow records and use standard, accepted methods to estimate missing records.

ES 5.1.2 Medium Priority

The medium priority recommendations are actions that are also key to developing a compliant, high quality, successful GSP and need to be initiated soon, but not as soon as the high priority actions. The recommended medium priority actions are listed below and summarized in **Table ES-3**. The total cost for all medium priority recommendations is $145,000 for eight individual analyses.

- Initiate QA/QC and conduct analyses to fill missing record on the following seven time series data sets for flow paths required for the basin boundary water budget:
    1. Meteorological,
    2. Surface Water Inflows,
    3. Land Use,
    4. Water Use (Evapotranspiration),
    5. Surface Water Diversions,
    6. Agricultural Groundwater Pumping, and
    7. Applied Water
- Evaluate potential groundwater dependent ecosystems (GDEs) mapped by The Nature Conservancy (TNC) to determine if the areas truly represent GDEs and, if so, whether they may be adversely impacted by regional pumping.

Table ES-1
High Priority Data Gaps and Cost to Fill

Data Type	Data Use	Required Action/Analysis	Priority*	Estimated Cost
Groundwater Levels	HCM, Groundwater Model, GSP Monitoring Network	Review DWR WCRs to match with existing wells with water level data; identify existing wells to add to monitoring network	High	$30,000-$50,000
		Install new dedicated monitoring wells	High	$95,000-$125,000 per nested well
Groundwater Quality	HCM, Groundwater Model, GSP Monitoring Network	Review DWR WCRs to match with existing wells with water quality data; identify existing wells to add to monitoring network	High	Included in groundwater level cost
		Install new dedicated monitoring wells	High	Included in groundwater level cost
Groundwater Levels and Quality	HCM, Groundwater Model, GSP Monitoring Network	Conduct outreach with existing well owners. Identify wells with known construction details that are not currently part of the groundwater monitoring network. If the well owner is willing to participate and has a well that is representative of either the upper or lower aquifer (but not both), consider adding the well to the GSP monitoring network.	High	$15,000-$25,000
Surface Water Outflows	Fill data gap for future monitoring of surface water outflows	Add and maintain stream gage records on Fresno River, Chowchilla Bypass, and Cottonwood Creek	High	$90,000
Surface Water Outflows	Develop historical data for 50 year period for planning and water budget for 30 years	Review available records and use standard, accepted methods to estimate missing records	High	$15,000

*All identified data gaps will need addressing for the GSP. Data gap priority is assigned based on relative importance and timing sequence.

Table ES-2
Recommended New Monitoring Well Locations, Priority, and Cost

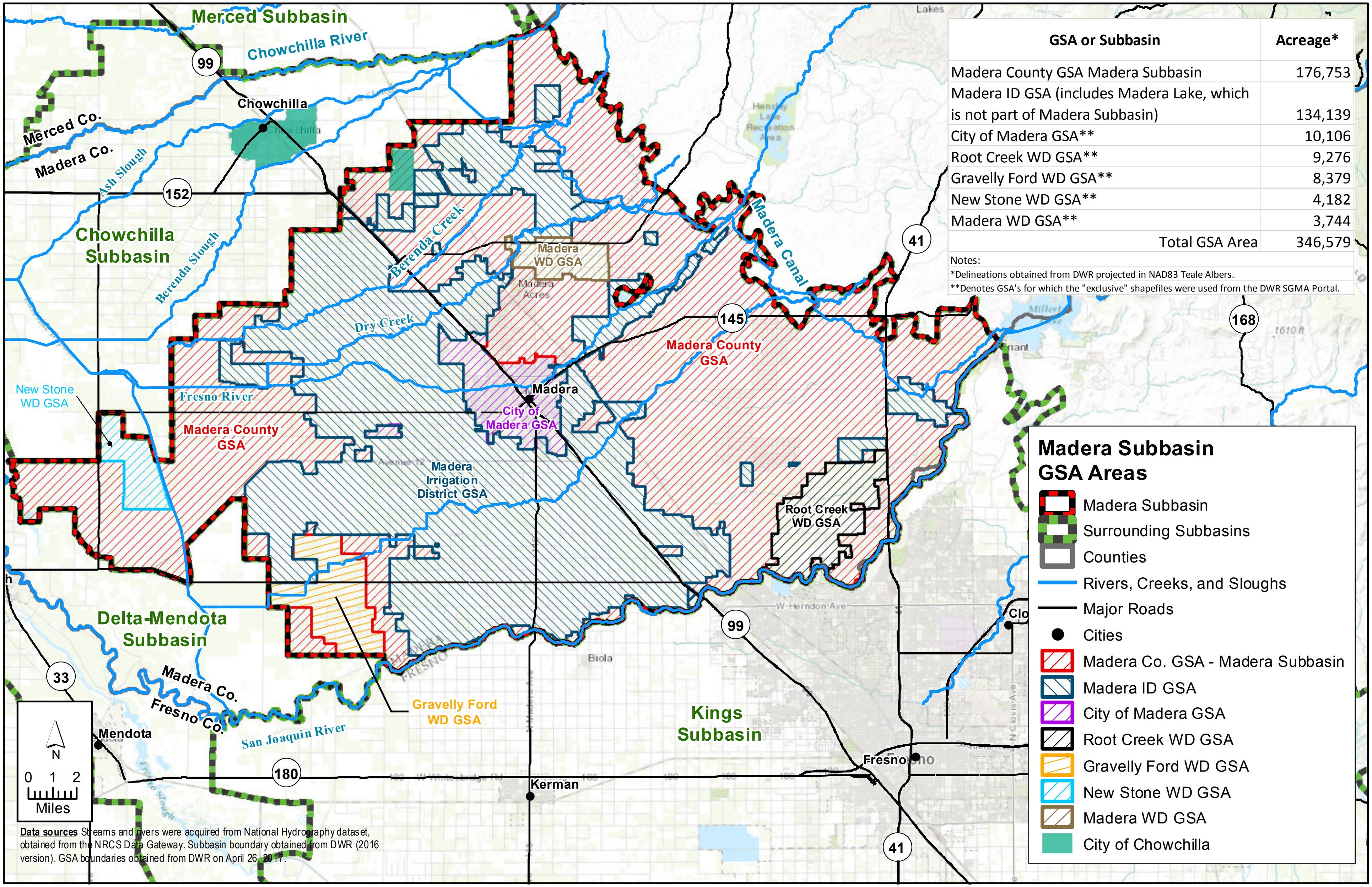
New Monitoring Well*	Approximate Location	Purpose	Priority**	Estimated Cost
4	East of City of Madera	Groundwater Levels/Quality; Upper/Lower Semi-Confined Aquifer; lack of wells in area	High	$95,000-$125,000
5	South central basin boundary	Groundwater Levels/Quality; Upper/Lower Semi-Confined Aquifer; near San Joaquin River; base boundary flow	High	$95,000-$125,000
6	Northeast basin boundary	Groundwater Levels/Quality; Upper/Lower Semi-Confined Aquifer; limited wells in area; basin boundary flows; 2016 groundwater depression	High	$95,000-$125,000
9	Central basin; west of City of Madera	Groundwater Levels/Quality; Upper/Lower Semi-Confined Aquifer; limited wells in area	High	$95,000-$125,000
13	West basin boundary	Groundwater Levels/Quality; Upper Unconfined/Lower Confined Aquifers; lack of wells in area	High	$95,000-$125,000
1	Southeast basin boundary	Groundwater Levels/Quality; Upper/Lower Semi-Confined Aquifer; contours missing in this area due to lack of data	Medium	$95,000-$125,000
2	Southeast basin	Groundwater Levels/Quality; Upper/Lower Semi-Confined Aquifer; limited wells in area	Medium	$95,000-$125,000
3	East basin boundary	Groundwater Levels/Quality; Upper/Lower Semi-Confined Aquifer; contours missing in this area due to lack of data	Medium	$95,000-$125,000
7	Central basin; in City of Madera	Groundwater Levels/Quality; Upper/Lower Semi-Confined Aquifer; lack of upper aquifer wells in area	Medium	$95,000-$125,000
8	North central basin	Groundwater Levels/Quality; Upper/Lower Semi-Confined Aquifer; lack upper aquifer wells in area; basin boundary flows; 2016 groundwater depression	Medium	$95,000-$125,000
10	Northwest basin boundary	Groundwater Levels/Quality; Upper Unconfined/Lower Confined Aquifers; limited wells in area; basin boundary flows; 2016 groundwater depression	Medium	$95,000-$125,000
11	West basin boundary	Groundwater Levels/Quality; Upper Unconfined/Lower Confined Aquifers; limited wells in area	Medium	$95,000-$125,000
12	Southwest basin boundary	Groundwater Levels/Quality; Upper Unconfined/Lower Confined Aquifers; lack of lower aquifer wells in area; basin boundary flows	Medium	$95,000-$125,000

* New monitoring well numbers are identified on Figure 5-5.
** New monitoring well priority is assigned according to existing hydrogeologic data need and importance for future monitoring.

Table ES-3
Medium Priority Data Gaps and Cost to Fill

Data Type	Data Use	Required Action/Analysis	Priority*	Estimated Cost
Meteorological	Develop reference ET by crop and precipitation for 50 year period for planning projections	Use standard, accepted ASCE Manual 70 methods to develop ET_o and precipitation daily time series from available weather data	Medium	$10,000
Surface Water Inflows	Develop water budget for 30 years and 50 year hydrology for planning projections	Review available records and use standard, accepted methods to estimate missing records	Medium	$5,000
Land Use	Assign land use to each water balance area each year for 30 year historical period	Based on available spatial data and crop reports, assign crops to water balance areas	Medium	$15,000
Water Use (Evapotranspiration)	Outflow from subbasin and basis for estimate of agricultural groundwater pumping	Root zone water balance based on meteorological, remotely sensed energy balance ET estimates and land use data to estimate crop water use.	Medium	$20,000
Surface Water Diversions	Develop water budget for 30 years	Review available records and use standard, accepted methods to estimate missing records	Medium	$30,000
Agricultural Groundwater Pumping	Develop water budget for 30 years	Use standard, accepted methods to estimate historical groundwater pumping	Medium	$15,000
Applied Water	Develop water budget for 30 years	Review available records and use standard, accepted methods to estimate missing records	Medium	$15,000
Groundwater Dependent Ecosystems	HCM, Groundwater Model, GSP Monitoring Network	Evaluate potential GDEs mapped by TNC/DWR to determine if could be impacted by regional pumping	Medium	$20,000-$35,000

*All identified data gaps will need addressing for the GSP. Data gap priority is assigned based on relative importance and timing sequence.



GSA or Subbasin	Acreage*
Madera County GSA Madera Subbasin	176,753
Madera ID GSA (includes Madera Lake, which is not part of Madera Subbasin)	134,139
City of Madera GSA**	10,106
Root Creek WD GSA**	9,276
Gravelly Ford WD GSA**	8,379
New Stone WD GSA**	4,182
Madera WD GSA**	3,744
Total GSA Area	346,579

Notes:
*Delineations obtained from DWR projected in NAD83 Teale Albers.
**Denotes GSA's for which the "exclusive" shapefiles were used from the DWR SGMA Portal.

Data sources Streams and rivers were acquired from National Hydrography dataset, obtained from the NRCS Data Gateway. Subbasin boundary obtained from DWR (2016 version). GSA boundaries obtained from DWR on April 26, 2017.

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FIGURE ES-1

Madera Subbasin Map

Madera County - Madera Subbasin
SGMA Data Collection and Analysis

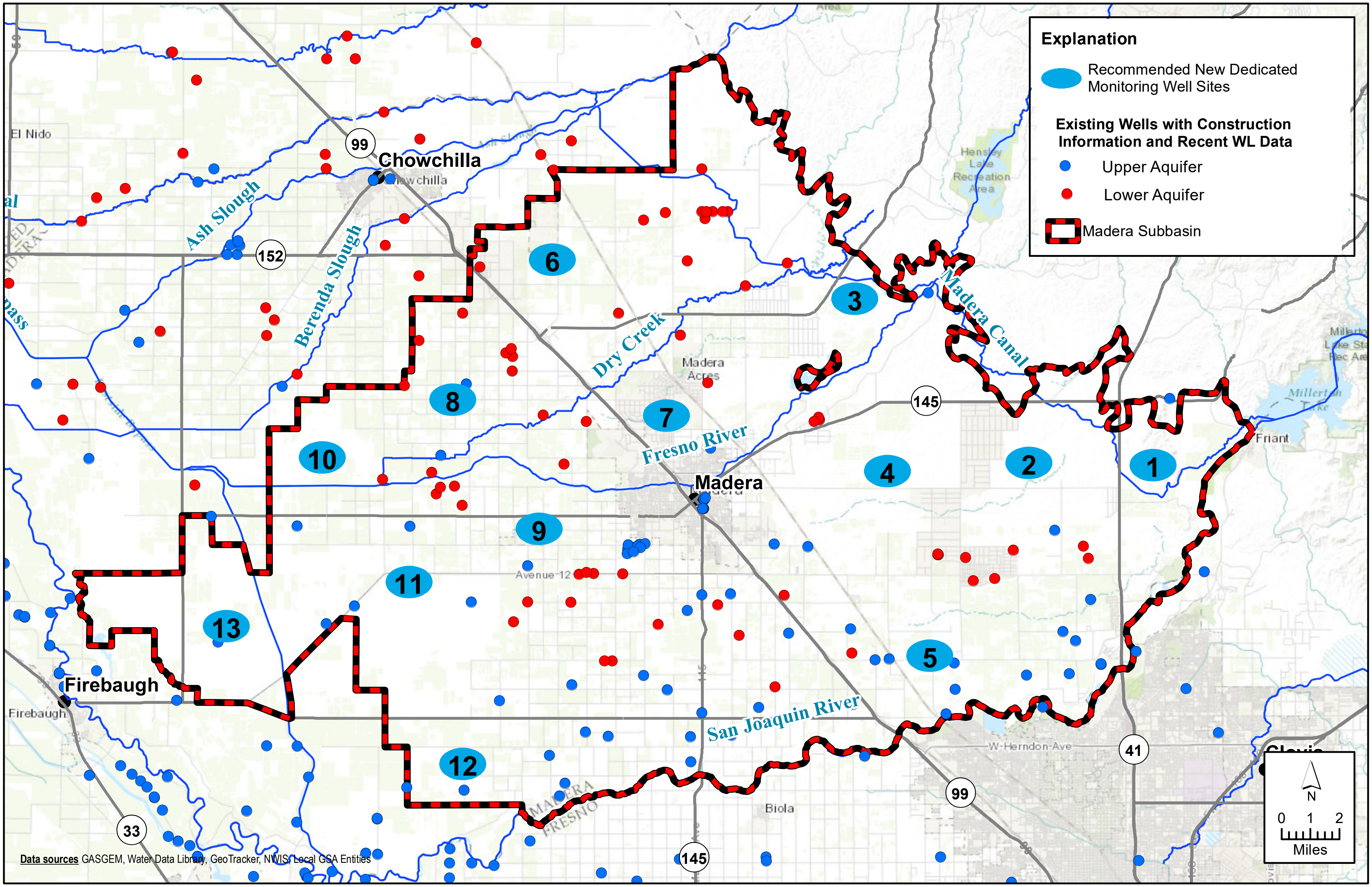

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FIGURE ES-2

Preliminary Recommendations for New Dedicated Monitoring Well Sites

Madera County: Madera Subbasin
SGMA Data Collection and Analysis

1 INTRODUCTION

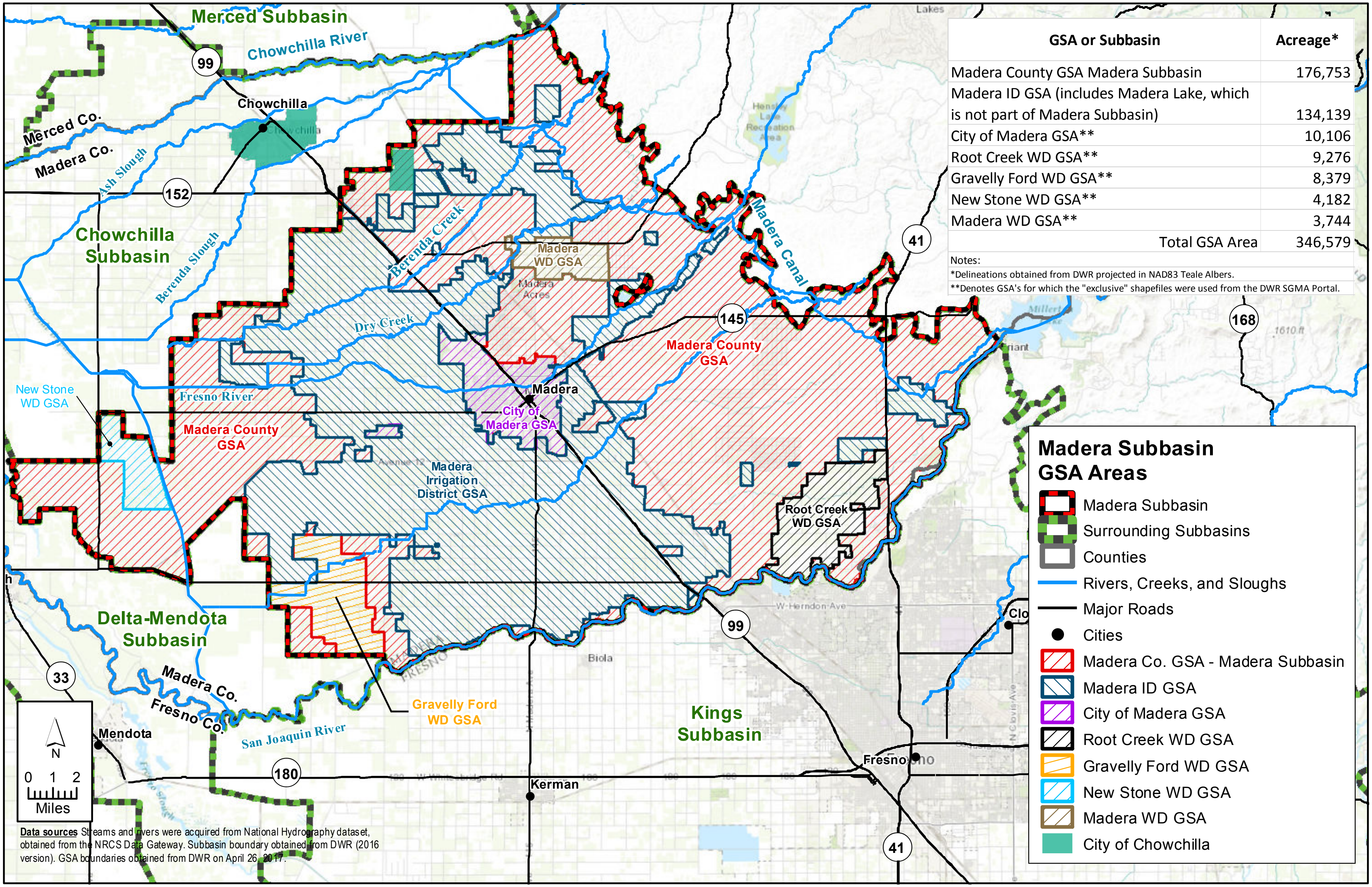
Agriculture is an important economic driver in the Madera area and groundwater represents an important agricultural water supply source in the Madera Subbasin. Thus, the sustainable management of groundwater is important for the long-term prosperity of the community. The Sustainable Groundwater Management Act (SGMA) allows for local control of groundwater resources while requiring sustainable management of these resources.

The Madera Subbasin covers about 347,600 acres all within Madera County. Seven Groundwater Sustainability Agencies (GSA) have formed to cover the subbasin (**Figure 1-1**). The largest of these is the Madera County GSA covering about 176,750 acres. The Madera Irrigation District GSA covers about 134,140 acres in Madera County. The remainder of the subbasin is covered by five additional GSAs including the City of Madera GSA, Root Creek Water District GSA, Gravelly Ford Water District GSA, New Stone Water District GSA, and Madera Water District GSA, each individually covering areas between about 3,700 and 10,000 acres within the subbasin.

The Madera Subbasin has been identified by the California Department of Water Resources (DWR) as a critically overdrafted subbasin and this technical memorandum (TM) documents one of several tasks that have been identified by the Madera Subbasin Coordinating Committee as initial steps towards addressing SGMA requirements and the development of a Groundwater Sustainability Plan (GSP). The objective of this data gap analysis was to collect all the available local and publicly available data pertaining to preparation of GSPs, to review the data for gaps in coverage or other deficiencies, and to develop a plan to fill the most critical data deficiencies.

Specifically, DWR has recently published draft guidance and Best Management Practice (BMP) documents related to the development of GSPs (DWR, 2016). The GSP outline includes four distinct components for the Basin Setting section: HCM, Current and Historical Groundwater Conditions, Water Budget Information, and Management Areas. This TM documents a systematic process to compile and review data needed to prepare these GSP components, and to identify critical data gaps. Special emphasis has been placed on the elements outlined in the GSP regulations, DWR's BMPs, and GSP outline.

This TM includes a description of the data acquisition process preliminary descriptions of the Madera Subbasin HCM (including groundwater conditions) and conceptual water budget, a summary of the gap analysis, and recommendations for next steps.



GSA or Subbasin	Acreage*
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FIGURE 1-1

Madera Subbasin GSA Map

Madera County - Madera Subbasin
SGMA Data Collection and Analysis

2 DATA COMPILATION

The SGMA data collection and analysis effort for the Madera Subbasin was conducted to address key requirements for completion of the HCM, water budget, and associated analyses required for the GSP. **Table 2-1** highlights the key data categories related to these GSP requirements, which guided the data compilation.

As an initial step in this data collection and analysis, a meeting was held on February 15, 2017 with representatives of the GSA entities and other local stakeholder entities, to discuss the objectives of the project, types of data required for GSP development, potential data sources, and proposed approaches for acquiring available data and assessing data gaps. Following that meeting, a detailed data request was distributed to local entities within the subbasin outlining the types and forms of local data of interest and the process for local entities to provide these data for incorporation in the data compilation and assessment. The data request was formulated with the intent to acquire as much locally available data as possible, including all data that might be relevant to future GSP HCM and water budget analyses and other GSP development activities, without burdening local entities with collecting data available online from public sources. The request described the interest in a wide variety of data helpful for a broad range of potential analytical tools yet to be determined. The major data content areas in the request included the following:

- General geographic data
- Water planning documents
- District water infrastructure and basemap data
- Hydrogeology
- Groundwater levels
- Groundwater quality
- Land subsidence
- Groundwater pumping
- Surface water diversions and deliveries
- Surface water inflows and outflows
- Land use and water demand
- Climate
- Other data (including available estimates of conveyance losses, groundwater-dependent ecosystems and future conditions).

The complete data request packet is included in **Appendix A**.

Because of the compressed schedule associated with GSP development for critically overdrafted subbasins such as the Madera Subbasin, the timeline for local entities to respond to the data request was short. Data from local entities were requested by April 1, 2017, allowing approximately six weeks to respond to the request. The local entities were very responsive to the data request, and despite the short period in which to provide data, considerable local data were submitted by April 1 for compilation and preliminary analysis.

Data were received from eight local entities within the Madera Subbasin area. Furthermore, local entities also provided data on groundwater conditions such as water levels to DWR and other public entities as part of ongoing monitoring programs (e.g., California Statewide Groundwater Elevation Monitoring [CASGEM]); these data were also acquired from public data sources as discussed below. Those local entities within the subbasin that provided data in response to the data request were the City of Madera, Madera County, Madera Irrigation District, Madera Valley Water Company (within Madera

County GSA), Madera Water District, New Stone Water District, and Root Creek Water District. Most of the submitted data related to groundwater levels, water quality, well locations, well construction details, groundwater pumping, water use, and land use. **Table 2-2** summarizes the basic data types provided by local entities for this project. The types and forms of data submitted vary greatly between different entities as does the temporal period represented by the data. Some of the data files provided were in formats that could be readily evaluated (e.g., Excel spreadsheets, GIS maps), while others were in formats such as Portable Document Format (PDF), which could not be as easily assessed. In select circumstances, well location coordinates and construction information provided in non-tabular formats, were entered into a spreadsheet or other tabular formats for presentation and evaluation on maps. **Figure 2-1** highlights the spatial distribution of groundwater data that were provided for wells that could be readily located. As illustrated in **Table 2-2** and **Figure 2-1**, most of the local entities in the subbasin contributed some data as part of the effort. A complete list of the data provided by local entities is included in **Appendix A. Figure 2-1** also includes data obtained from the DWR CASGEM database for wells monitored by local entities, which includes both formal CASGEM wells and volunteer wells. The formal CASGEM wells have either known screen intervals or known well depths, whereas most of the volunteer wells have unknown well construction details. Additional wells in the CASGEM database that are monitored by DWR or other non-local entities are not shown on **Figure 2-1**, but are incorporated on figures in **Section 5**.

Concurrent with efforts to acquire local data, publicly available data were also compiled and evaluated by the consultant team. Public data sources considered included the U.S. Geological Survey (USGS), DWR, State Water Resources Control Board (SWRCB), U.S. Bureau of Reclamation, U.S. Department of Agriculture (USDA), and many others. Most of the public data were acquired from online databases. As part of the public data acquisition, a Well Completion Report (WCR or well log) request was also submitted to DWR for the entire subbasin area. In response, DWR provided available WCRs for all wells in the subbasin constructed prior to approximately mid-2015. DWR also provided a summary table with approximate well locations, well types, and limited well construction information. Public data sources considered during the data collection effort are listed in the data request packet (**Appendix A**). A summary of public groundwater data compiled for this project is presented in **Table 2-3** and a summary of water budget public data that were acquired is included in **Table 2-4**. A complete list of acquired public data is included in **Appendix A**.

For all data acquired, data quality assessment, quality control, or other processing were conducted to the extent necessary to assess the completeness of data (spatially and temporally). Additionally, groundwater level, groundwater quality, well locations (from WCRs), and other data were preliminarily characterized as part of the data assessment. All data files and related information acquired and generated as part of this data collection and analysis effort are being provided as part of a separate digital data transfer.

The data compiled from local entities and public data sources are incorporated into the descriptions of the Hydrogeologic Conceptual Model (**Section 3**) and Conceptual Water Budget Model (**Section 4**) discussed below, and some of the data are presented in tables and figures associated with these sections. Additional data compiled for this project are presented in summary form in different appendices.

Table 2-1
GSP Data Needs and Sources

Data Type	Relevant GSP Components			Potential Data Sources
	Hydrogeologic Conceptual Model	*Groundwater Conditions*	*Water Budget*	
Topography	●	●	●	USGS
Surficial soils	●		●	NRCS
Geology/hydrogeology	●	●	●	
Aquifer/aquitard properties	●	●	●	DWR, USGS, local/regional studies
Meteorological (e.g., temp, precip, ET)			●	DWR, PRISM, CIMIS, NOAA, USBR, CalSIMETAW, UCCE
Hydrology/streamflow	●		●	DWR, USGS, local entities
Land/water use (e.g., crop, irrig)			●	DWR, USDA, FMMP, AWMPs, UWMPs, UCCE, county Ag Commissioners, General Plans, local entities
Surface water diversions			●	Local entities, SWRCB, DWR, USBR
Groundwater pumping	●	●	●	AWMPs, UWMPs, DWR, USGS, local entities
Groundwater conditions	●	●	●	
Well information	●	●	●	DWR, USGS, local entities
Groundwater levels	●	●	●	DWR, USGS, local entities
Groundwater quality	●	●		DWR, USGS, DPR, local entities
Subsidence	●	●	●	USGS, DWR, NASA
Future conditions (e.g., pop, climate)		●	●	DWR, USGS, USBR, UWMPs, CA Dept. of Finance, Census

Table 2-2
Data Received from Local Entities

Local Entity	Groundwater Levels	Water Quality	Groundwater Pumping	Well/Aquifer Tests	Water Use	Land Use	Well Locations	Well Construction	Subsidence
City of Madera	X	X	X	X	X		X	X	
Madera County	X						X		
Madera ID	X	X			X		X	X	
Madera Valley WC	X				X			X	
Madera WD	X		X		X			X	
New Stone WD				X	X	X			
Root Creek WD	X	X		X	X	X	X	X	
Gravelly Ford WD					X				

Note: Many local entities provide groundwater data to public data sources such as DWR as part of broader groundwater monitoring programs. These data were compiled through public data acquisition.

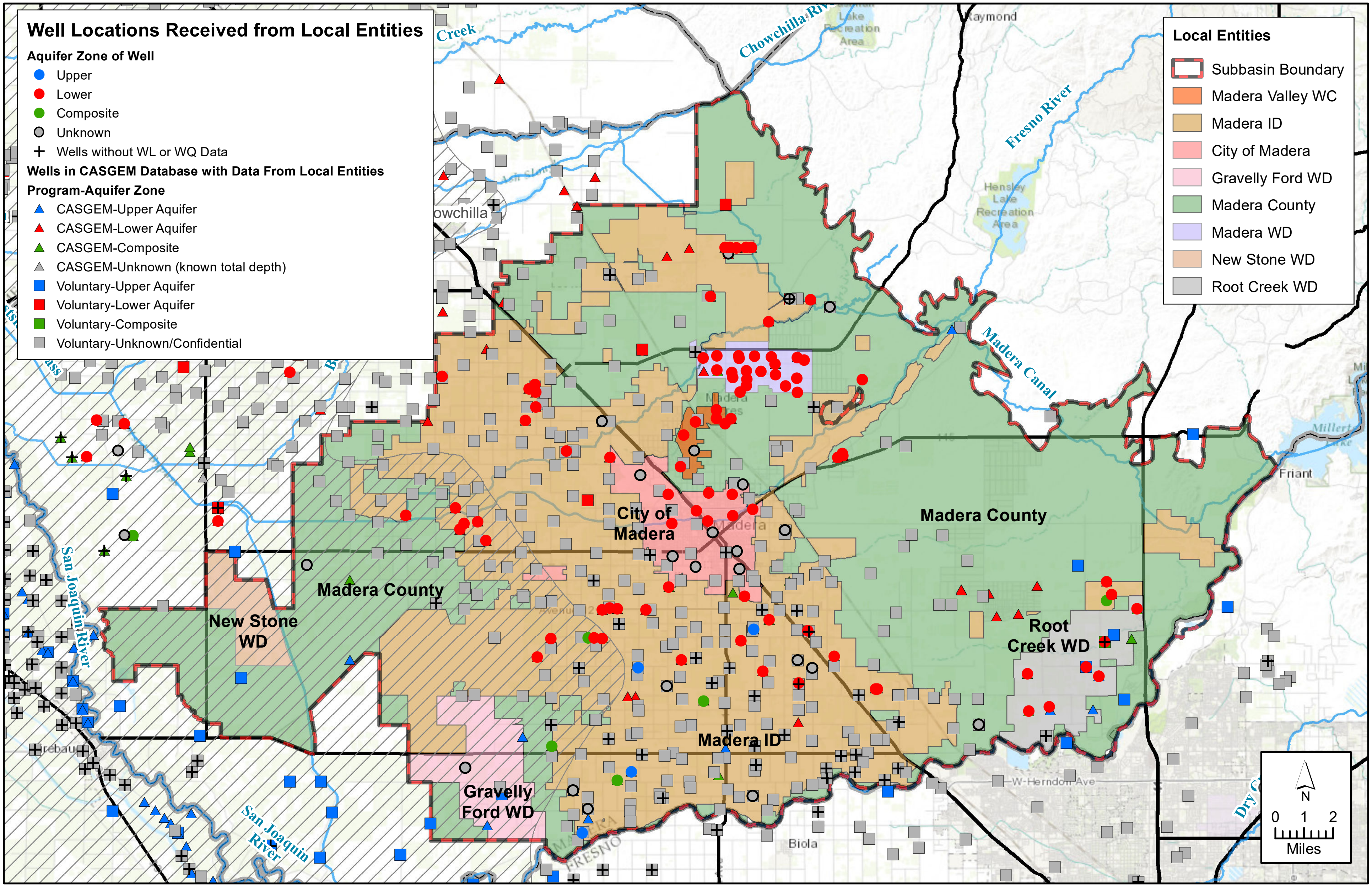
Table 2-3
Summary of Public Well Data

Data Source	Data Type	Description	Period of Record
DWR	Water Level	Data downloaded for Madera, Merced and Fresno Counties. ~8,400 wells with one or more measurement	1920-present
DWR	Well Construction	Well construction data for Madera, Merced, and Fresno Counties. Data includes total depth of well and screen interval. ~1,400 wells with data	n/a
USGS	Water Level	Data downloaded for Madera, Merced, and Fresno Counties. ~5,900 wells with measurements	1901-present
USGS	Well Construction	Well construction data for wells in Madera, Merced, and Fresno Counties. Includes total depth of well. ~5,080 wells with data	n/a
USGS	Water Quality	All surface water and groundwater quality data acquired for Madera, Merced, and Fresno Counties. ~1,700 sites with TDS and nitrate measurements data	1925-present
SWRCB	Water Level	Water level data for Madera, Merced, and Fresno Counties, ~3,200 wells with data (Not all wells surveyed). Water level data from GAMA, >33,000 sites state wide.	1993-present
SWRCB	Well Construction	Well construction data for Madera Merced, and Fresno Counties. Included screen interval. ~1,900 wells. (Very few within Madera Subbasin)	n/a
SWRCB	Water Quality	Surface and groundwater quality data for Madera, Merced, and Fresno Counties. ~1,400 sites with data. Groundwater data from GAMA, ~5,200 sites with data	2000-present
CEDEN	Water Quality	Surface water quality for Madera, Merced and Fresno Counties. ~80 sites with TDS or nitrate measurements.	2002-2014

Table 2-4
Summary of Public Water Budget Data Acquired

Entity	Data Type	Data Description	Period of Record
USGS CIDA	Evapotranspiration Data	Monthly ETa values for Madera Subbasin area and 20-mile buffer	2000-2015
CDFA	Land Use	Contains information for crops in all California counties, including harvested acres, yield, price, production, and value	1980-2015
DWR	Land Use	Land Use surveys for Madera County	1995 and 2011
USDA Cropscape	Land Use	Land usage data with crop delineations and crop-pixel linkages	2007-2016
USGS NLCD	Land Use	California coverage of land usage by crop	2001, 2006, 2011
SSURGO	Soils	Mapped soil characteristics	
STATSGO	Soils	Mapped soil characteristics for California	
DWR	Surface Water Inflows	Streamflow data for station at Cottonwood Creek near Friant	1998-2017
DWR	Surface Water Inflows	Streamflow data for station at Chowchilla Bypass at Head Below Control Structure	1978-1991
DWR	Surface Water Outflows	Streamflow data for station at Fresno River 8 miles West of Madera	1980-1990
DWR	Surface Water Inflows	Streamflow data for station at San Joaquin River Below Friant	1997-2002
DWR	Surface Water Outflows	Streamflow data for station at Delta-Mendota Canal to Mendota Pool	1969-1990
DWR	Surface Water Outflows	Streamflow data for station at San Joaquin River Below Control Structure	1978-1991
DWR	Water Year Type	San Joaquin Valley water year runoff, index, and type	1901-2016
SWRCB	Surface Water Diversion Data	Water rights point of diversions	n/a
USBR	Water Planning Documents	City of Fresno Service Area Water Management Plan	2013
USBR	Water Planning Documents	Madera Water District Water Management Plan	2013
USBR	Water Planning Documents	City of Madera Urban Water Management Plan	2015 and 2017
USBR	Water Planning Documents	Gravelly Ford Water District Water Management Plan	2009 and 2011
USBR	Water Planning Documents	Colombia Canal Company Water Management Plan, some data also located within the Westside San Joaquin Integrated Water Resources Plan	2014
CIMIS	Weather Data	CIMIS station weather data include: ETo, precipitation, solar radiation, average vapor pressure, minimum/maximum/average air temperature, minimum/maximum/average relative humidity, dewpoint, average wind speed, wind run, average soil temperature	1998-2017
NOAA	Weather Data	Daily precipitation and temperature data	1928-2017
PRISM	Weather Data	National values for precipitation, mean/minimum/maximum temperature, mean dewpoint temperature, minimum/maximum vapor pressure deficit, and elevation	1895-2016

CDFA - California Department of Food and Agriculture (CDFA), and County Agricultural Commissioner; SSURGO - Soil Survey Geographic Database; STATSGO - State Soil Geographic Database; CIDA - Center for Integrated Data Analytics; NLCD - National Land Cover Data; SWRCB – State Water Resources Control Board



X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Figure 2-1 updat.mxd

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FIGURE 2-1

Map of Well Data Received from Local Entities

Madera County: Madera Subbasin
SGMA Data Collection and Analysis

3 HYDROGEOLOGIC CONCEPTUAL MODEL

The preliminary HCM provided in this TM is based primarily on previous studies, but it also utilizes some of the information obtained through the data request made for this study. The Data Gaps section of this TM further describes how data obtained for this study may be used to further refine and develop the HCM during the GSP process.

This TM describes the preliminary HCM for the Madera Subbasin with lateral boundaries as defined in **Figure 1-1**. The HCM, as defined in SGMA, focuses primarily on geologic conditions, whereas groundwater conditions are considered as a separate element of the GSP. The term HCM, as used in this TM, incorporates discussion of both geologic and groundwater conditions.

3.1 Geologic Conditions

The geologic conditions portion of the HCM in this TM includes discussion of the regional geologic and structural setting, the subbasin's lateral and vertical boundaries, the major aquifers/aquitards, and aquifer parameters. Geologic cross-sections are described in the discussion of major aquifers and aquitards. Much of the information obtained from previous studies related to geologic conditions is provided in **Appendix B**.

3.1.1 Regional Geologic and Structural Setting

The Madera Subbasin (DWR Subbasin No. 5-22.06) is generally comprised of relatively flat topography that slopes gently downward to the west. Topographic elevations vary from about 350 feet above mean sea level (MSL) in the east to about 150 feet MSL in the west over a distance of about 20 miles (**Figure 3-1**). The major geomorphic features of the subbasin are the alluvial fan and floodplain associated with sediment deposition from the Fresno and San Joaquin Rivers (Mitten et al., 1970). A map of hydrologic soil groups in Madera Subbasin is provided in **Figure 3-2**, and a map of soil saturated hydraulic conductivity (K_{sat}) is provided in **Figure 3-3**. These maps indicate that soils with higher permeability and infiltration rates are present along river channels (Fresno River, Cottonwood Creek, and San Joaquin River) and west/south of the City of Madera (between the Fresno River and Cottonwood Creek). Another zone of higher soil permeability is present in the south central portion of the subbasin between Cottonwood Creek and the San Joaquin River.

Surface geology maps are provided in **Figure 3-4** and in **Appendix B**. The surficial geology of the Madera Subbasin is dominated by Younger and Older Alluvium (generally equivalent to Modesto, Riverbank, and Turlock Lake Formations), which are described in more detail below. Younger Alluvium is most prevalent along the Fresno and San Joaquin Rivers and in an area immediately south and west of the City of Madera. Existing geologic cross-sections are distributed throughout the subbasin, and vary considerably in quality and level of detail as described in the section on Major Aquifers/Aquitards.

The stratigraphy of the Madera Subbasin from the surface down is comprised primarily of Continental Deposits of Quaternary Age (Younger and Older Alluvium), Continental Deposits of Tertiary and Quaternary age, Marine and Continental sedimentary rocks, and crystalline basement rock. The Continental Deposits are unconsolidated, and underlying sedimentary and basement rocks are consolidated. It is uncertain if Mehrten and Ione Formation are present in the Madera Subbasin. Younger Alluvium is generally limited to 50 feet thickness and typically unsaturated. The Older Alluvium consists of up to 1,000 feet of interbedded clay, silt, sand, and gravel. Older Alluvium becomes finer-grained with depth and is underlain by the generally finer-grained Continental deposits of Tertiary and Quaternary age (Mitten et.al., 1970). The primary water bearing unit is Older Alluvium, although recent deeper drilling of agricultural wells is tapping into the underlying Continental Deposits of Tertiary/Quaternary age (Provost & Pritchard, 2014).

The Corcoran Clay occurs in the western portion of Madera Subbasin within the upper portion of Older Alluvium (Mitten et al., 1970). The Corcoran Clay is also considered to be a member of the Turlock Lake Formation (Page, 1986). The depth to top of the Corcoran Clay ranges from about 150 to 400 feet (Provost & Pritchard, 2014). The Corcoran Clay is comprised of clay and silt ranging in thickness from 10 feet at its eastern extent to 80 feet on the western edge of Madera County (Mitten et al., 1970).

3.1.2 Lateral and Vertical Subbasin Boundaries

The Madera Subbasin is bordered by the Sierra Nevada Mountains to the east, Kings Subbasin to south, Chowchilla Subbasin to the north, and Delta-Mendota Subbasin to the west (**Figure 1-1**). Bedrock to the east represents a hydrogeologic boundary, whereas the other three boundaries are political/agency boundaries across which groundwater flow can and does occur. There is a small amount of fractured bedrock groundwater inflow to Madera Subbasin on the east.

The base of fresh water was evaluated by Page (1973), and defined as including water with conductivity up to 3,000 umhos/cm. Overall, the base of freshwater was mapped as ranging from elevation -400 to -1,200 feet msl. In general, the shallowest depths to base of fresh water were along the western boundary of the subbasin, and the greatest depths were areas located just north of the City of Madera in the eastern portion of the subbasin (**Figure 3-5).**

3.1.3 Major Aquifers/Aquitards

Geologic cross-sections are a key element of the HCM required in a GSP under SGMA. This study included review of existing literature to extract the available geologic cross-sections. This section of the TM provides a general description and documents the locations of available geologic cross-sections.

Geologic cross-sections were obtained from Davis et al. (1959), Mitten et al. (1970), Page (1986), KDSA (2001), KDSA (2006), Provost & Pritchard (2014), and LSCE (2017) for the Madera Subbasin. Davis et al. (1959), Mitten et al. (1970), Page (1986), Provost & Pritchard (2014), and LSCE (2017) provide regional coverage, while KDSA (2001 and 2006) contain local project-specific cross-sections in the southeastern portion of the subbasin. The locations of geologic cross-sections extracted from these reports are provided in **Figure 3-6**, and the individual cross-sections are provided in **Appendix B**. A summary of the available geologic cross-sections is provided below.

3.1.3.1 <u>Davis et al. (1959)</u>

Cross-section B-B’ runs from southwest to northeast somewhat diagonally across the center of the Madera Subbasin, and extends to a depth of about 400 feet bgs. The Corcoran Clay is present at depths ranging from about 110 to 225 feet, decreasing in thickness and depth to the northeast. Sediments are typically sand, clay, silt, and silty sand to clay, silty clay, and shale, with intermittent layers of sand and gravel.

Cross-section D-D’ runs from southwest to northeast through the center of the Madera Subbasin, and extends to a depth of about 800 feet bgs. The Corcoran Clay is indicated to be present at an approximate depth of 400 feet bgs at the western edge Madera County, with depth and thickness decreasing towards the northeast (to a depth of about 200 feet at the eastern edge of the clay layer). Sediments consist primarily of sands to sandy clay and silty clay to clay and shale. Layers of gravel are present in the upper 200 feet primarily in the center of Madera County. Mitten et al. (1970)

Cross-section B-B’ runs southwest to northeast across the northern portion of the Madera Subbasin, and extends to an elevation of -1,400 feet msl. The E-Clay (Corcoran Clay) is present in the western portion of the section and tapers off towards the center, with depth decreasing west to east from an approximate depth of 350 feet bgs (elevation of -180 feet msl) to approximately 150 feet bgs (elevation of 100 feet msl). Thin deposits of Quaternary floodplain deposits (Qb) and younger Quaternary alluvium (Qya) are present at the surface in the western and central areas, respectively, and are underlain by older Quaternary alluvium (Qoa). Qoa overlies Tertiary and Quaternary continental deposits (QTc). Pre-Tertiary basement complex (pTb) is present at the surface on the eastern edge of the section.

Cross-section C-C’ runs west to east across the southern portion of the Madera Subbasin, and extends to an elevatiion of -1,400 feet msl. The E-Clay (Corcoran Clay) is present in the western portion of the section at an elevation of about -200 feet msl, tapering out towards the center of the cross-section. The top elevation of the E-Clay depth decreases from west to east, from approximately -200 feet msl to approximately zero feet msl. A thin deposit of Qya is present at the surface in the western portion of the section and are underlain by Qoa. Qoa is underlain by Qtc in the western through central portions of the section.

Cross-section D-D’ runs northwesst to southeast through the western edge of the Madera Subbasin, and extends down to an elevation of -1,400 feet msl. The E-Clay (Corcoran Clay) is present throughout the section and increases in depth from north to south, with the top elevation ranging from approximately -150 feet msl to approximately -200 feet msl in the Madera Subbasin portion of the cross-section. Qoa is present at the surface in the Madera Subbasin and underlain by QTc in this cross-section.

Cross-section E-E’ runs northwest to southeast through the central-eastern portion of the Madera Subbasin, and extends down to an elevation of -1,400 feet msl. The E-Clay (Corcoran Clay) is not present in this section. Qoa over most of the surface is underlain by Qtc throughout the section, and TpTu (i.e., bedrock) underlies QTc in the northern portion of the section at depths of 1,000 to 1,500 feet bgs.

3.1.3.2 Page (1986)

Cross-section B-B’ runs northwest to southeast through the western edge of the Madera Subbasin, and extends down to an elevation of 9,000 feet msl. Within the Madera Subbasin, the Corcoran Clay is present throughout, at an elevation of approximately -100 feet msl. Thin deposits of Quaternary flood-plain deposits (Qb) are present at the surface, underlain by Quaternary continental rocks and deposits (QTcd). A layer of Tertiary marine rocks and deposits interfinger the QTcd layer. A layer of Pre-Tertiary and Tertiary continental and marine rocks and deposits underlies these units.

3.1.3.3 LSCE (2017)

LSCE prepared and presented a geologic cross-section in the team’s proposal for this project that trends southwest to northeast through the central portion of Madera Subbasin. Data presented on the cross-section were obtained from soil texture files for the USGS Central Valley Hydrologic Model (CVHM). The Corcoran Clay is present over one-third of the cross-section line, beginning at a depth of about 350 feet (Elevation -190 feet msl) on the western end and ending at a depth of about 220 feet (10 feet msl) at its easternmost extent. Sediments above the Corcoran Clay are relatively coarse-grained, and sediments below the Corcoran Clay are a mix of fine and coarse-grained materials from the base of the Corcoran Clay to a depth of about 500 feet below the base of the Corcoran Clay (approximate elevation of -700 to -500 feet msl). In the eastern portion of the cross-section where the Corcoran Clay is not present, the semi-confined aquifer consists of a mix of fine- and coarse-grained sediments.

3.1.3.4 KDSA (2001)

Cross-section A-A' runs southwest to northeast across the southeastern portion of the Madera Subbasin (generally parallel to the San Joaquin River), and extends to a depth of about 1,000 feet bgs (elevation of -700 feet msl). Primarily coarse-grain deposits are present at the surface, with the exception of the northeast edge of the section. Underlying the surface deposits are primarily fine-grained deposits, with thin, discontinuous layers of coarse-grained deposits. The Corcoran Clay is not present within this section.

Cross-section B-B' runs northwest to southeast across the southeastern portion of the Madera Subbasin (perpendicular to the San Joaquin River), and extends to a depth of about 900 feet bgs (elevation of -600 feet msl). Primarily coarse-grained deposits exist in the upper 150 feet, underlain by discontinuous layers coarse-grained deposits separated by more continuous fine-grained layers. The Corcoran Clay is not present in this section.

3.1.3.5 KDSA (2006)

Cross-section A-A' runs north to south in the southeastern portion of the Madera Subbasin, and extends to a depth of about 800 feet (elevation of -400 to -450 feet msl). A relatively continuous sequence of coarse-grained deposits are present in the upper 200 feet beneath and adjacent to the San Joaquin River. Layers of coarse-grained sediments alternate with fine-grained sediments to the north of the San Joaquin River.

Cross-section B-B' runs southwest to northeast in the southeastern portion of the Madera Subbasin, and extends to a depth of up to 950 feet (elevation of -600 feet msl). Overall, fine-grained deposits are more abundant in this cross-section with relatively discontinuous coarse-grained layers.

3.1.3.6 Provost & Pritchard (2014)

Cross-section D-D' depicted in this report is taken from cross section d-d' in Davis et al. (1959), which is discussed above.

3.1.3.7 Geologic Cross-Section Summary

The geologic cross-sections provided in Mitten et al. (1970) and Page (1986) illustrate the vertical distribution of major geologic formations, but do not provide any detail on distribution of fine and coarse-grained sediments of the major aquifer units. The LSCE (2017) cross-section focuses more on the general occurrence of fine and coarse-grained sediments in discrete intervals (e.g., every 50 feet) within the two major aquifers. The KDSA (2001, 2006) cross sections provide the greatest detail regarding the specific occurrence intervals of the fine and coarse-grained sediments, albeit on a more local scale than other cross sections.

3.1.3.8 Groundwater System Conceptualization

The Madera Subbasin is underlain by the Corcoran Clay over approximately the western one-third of the subbasin area. The depth to top of Corcoran Clay varies from 100 to 150 feet at its northeastern extent to in excess of 300 feet in the southwestern portion of the subbasin (**Figure 3-7**). Where the Corcoran Clay aquitard exists, the aquifer system is subdivided into an upper unconfined aquifer above the Corcoran Clay and a lower confined aquifer below the Corcoran Clay (**Figure 3-8**). The available cross-sections provided in **Appendix B** generally indicate that approximately the upper 500 feet of the lower confined aquifer are comprised of a greater percentage of coarse-grained sediments as compared to deeper zones within the lower aquifer. Thus, it can be anticipated that most wells will obtain close to their maximum yield within approximately the upper 800 feet of sediments. The vast majority of water wells are constructed within the upper 1,000 feet because sediments generally become finer with depth and towards the center of the valley (Provost and Pritchard, 2014).

In the eastern portions of the subbasin where the Corcoran Clay does not exist, the aquifer system is generally considered to be semi-confined with discontinuous clay layers interspersed with more permeable coarse-grained units (**Figure 3-8**). For discussion purposes, in the eastern part of the subbasin, the semi-confined aquifer can be subdivided into an upper semi-confined aquifer and a lower semi-confined aquifer at a generally arbitrary depth that may range from 200 to 400 feet bgs.

3.1.4 Aquifer Parameters

Aquifer parameter data were compiled from existing reports and the data request for this study, and mapped with regard to general locations (**Figure 3-9**). A summary of the available data is provided in **Table 3-1**. The available data indicate specific capacities (pumping rate divided by drawdown) ranging from 2 to 258 gallons per minute per foot (gpm/ft) for the various wells included in **Table 3-1**. The average specific capacities for City of Madera, Madera Water District, New Stone Water District, and Root Creek Water District wells were 41, 17, 47, and 29 gpm/ft, respectively. Using the rule of 2000 to convert specific capacity data to transmissivity values (Driscoll, 1986) yield, estimated transmissivity values ranged from 34,000 to 94,000 gallons per day per foot (gpd/ft). Combined with transmissivity values obtained from Mitten et al. (1970), the overall range of transmissivity values is 18,000 to 94,000 gpd/ft. Existing available data for Madera Subbasin were limited, but it is anticipated that these data can be supplemented with specific capacity data from DWR well completion reports obtained for this study.

For Madera County as a whole, the recently completed Madera Regional Groundwater Management Plan (year) indicates the Older Alluvium generally has transmissivity values ranging from about 20,000 to 250,000 gpd/ft. Well test data indicate that wells tapping a significant thickness of coarse-grained materials in the upper 500 feet tend to have the highest specific capacities. The underlying Continental Deposits are reported to have transmissivities ranging from 10,000 to 30,000 gpd/ft (Provost and Pritchard, 2014).

Specific yield (Sy) values for Madera County were evaluated in previous studies for use in groundwater storage change calculations (Provost and Pritchard, 2014; Todd, 2002). These county-wide studies used Sy values ranging from 0.10 to 0.13. A study specific to Madera Subbasin (DWR, 2004) cited a specific yield value of 0.104 for use in calculating total groundwater in storage. Given that sediments generally become finer grained with depth, it is possible that the Sy value from DWR (2004) being on the lower end of the county-wide range is due to evaluation of specific yield to a deeper depth than in the other studies.

3.2 Groundwater Conditions

The groundwater conditions portion of the HCM includes discussion of groundwater levels, groundwater quality, subsidence, and surface water-groundwater interaction. The discussion of groundwater levels describes groundwater contour elevation maps, hydrographs, and groundwater level/storage change. Much of the information obtained from previous studies related to groundwater conditions is provided in **Appendices C, D, and E**.

3.2.1 Groundwater Levels

Historical groundwater level data are available from a number of wells in the Madera Subbasin. These data have been used to generate groundwater elevation contour maps, hydrographs, and groundwater level/storage change maps in previous studies. The existing data and maps are described below, along with updated groundwater hydrographs created from data obtained for this study. The discussion of groundwater contour maps focuses on Spring (as opposed to Fall) maps in order to minimize influences from pumping wells. However, Fall groundwater contour maps were compiled and are included in **Appendix C**.

3.2.1.1 Groundwater Elevation Contours

Maps from the early 1900s indicate groundwater flow from northeast to southwest prior to significant development of groundwater in the Madera Subbasin. The western portion of the subbasin was considered part of an "artesian zone" running through the center of the San Joaquin Valley (Mendenhall, 2016). Groundwater elevation contour maps developed by DWR are available for selected years between 1958 and 1989, and annual maps were published from 1989 to 2011 (**Appendix C**). Groundwater elevation data and GIS files of groundwater contours are also available from DWR for 2012 to 2016 (**Appendix C**). Although the DWR maps are developed with water level measurements that include wells with unknown construction details, DWR has categorized these groundwater contour maps as being representative of unconfined and semi-confined aquifer groundwater levels across the Madera Subbasin. The groundwater contour maps referenced in the discussion below are provided in **Appendix C**.

The Spring 1958 DWR groundwater elevation contours run generally north to south. Groundwater elevation ranges from 140 feet msl at the northwestern edge to greater than 240 feet msl towards the eastern edge of the basin. Groundwater elevations are somewhat higher along the Fresno River through the City of Madera and along the San Joaquin River, and a small depression exists towards the bottom of Cottonwood Creek. Near the City of Madera, groundwater elevations range from 190 to 220 feet msl

The Spring 1962 DWR groundwater elevations ranged from 120 feet msl in the northwestern portion of the subbasin to 400 feet msl at the eastern edge of the subbasin. Groundwater elevations are somewhat higher along the Fresno River through the City of Madera and along the San Joaquin River, and a small depression exists towards the bottom of Cottonwood Creek. Another groundwater depression area began to form in the northwest portion of the basin. Near the City of Madera, groundwater elevations range from 180 to 220 feet msl.

Spring 1969 DWR groundwater elevations ranged from 110 feet msl in the northwestern portion of the subbasin to 400 feet msl at the eastern edge of the subbasin. Groundwater elevations are somewhat higher along the San Joaquin River. The groundwater depression in the northwest portion of the basin had started to expand. Near the City of Madera, groundwater elevations ranged from 170 to 220 feet msl.

Spring 1976 DWR groundwater elevations range from 100 feet msl in the western portion of the subbasin to over 200 feet msl east of the City of Madera. Groundwater elevations are somewhat higher along the San Joaquin River. The groundwater depression in the northwest portion of the basin has expanded to cover a larger portion of the west side of the subbasin. Near the City of Madera, groundwater elevations range from 170 to somewhat greater than 200 feet msl.

The Spring 1984 DWR contour map showed groundwater elevations ranging from 90 feet msl in the western portion of the subbasin to over 220 feet msl east of the City of Madera. Groundwater elevations are somewhat higher along the Fresno River through the City of Madera and along the San Joaquin River. The groundwater depression is still present in the western portion of the basin. Near the City of Madera, groundwater elevations range from 170 to 220 feet msl.

Spring 1989 DWR groundwater elevations ranged from 100 feet msl in the western portion of the subbasin to over 200 feet msl east of the City of Madera. Groundwater elevations declined near the City of Madera, where groundwater elevations ranged from 140 to 190 feet msl.

Spring 1993 DWR groundwater elevations ranged from 70 feet msl in the western portion of the subbasin to over 180 feet msl east of the City of Madera. The western groundwater depression has deepened with elevations falling to as low as 70 feet msl. Groundwater elevations declined further near the City of Madera, where groundwater elevations ranged from 120 to 180 feet msl. In addition, a new groundwater depression had formed in the southeast portion of the subbasin. The highest groundwater elevations in the subbasin at this time are along the San Joaquin River at the southeast boundary at 200 feet msl.

Spring 1999 DWR groundwater elevations ranged from 60 feet msl in a newly formed groundwater depression along the north central boundary of the subbasin to 200 feet msl beneath the San Joaquin River along the southeast boundary of the subbasin. Groundwater elevations declined further near the City of Madera, where groundwater elevations ranged from 120 to 160 feet msl. The groundwater depression in the southeast portion of the subbasin has deepened.

Spring 2004 DWR groundwater elevations ranged from 50 feet msl in groundwater depressions to 200 feet msl beneath the San Joaquin River along the southeast boundary of the subbasin. The areas of groundwater depressions in the western and north central portions of the subbasin have continued to deepen (lows of 50 feet msl). There were insufficient data in this year to map the southeastern groundwater depression. Groundwater elevations in the City of Madera were maintained at 120 to 160 feet msl.

Spring 2009 DWR groundwater elevations ranged from 20 feet msl in groundwater depressions to 200 feet msl beneath the San Joaquin River along the southeast boundary of the subbasin. The areas of groundwater depressions in the western and north central portions of the subbasin have continued to deepen. There are insufficient data in this year to map the southeastern groundwater depression. Groundwater elevations in the City of Madera declined considerably and ranged from 20 to 150 feet msl.

Spring 2012 DWR groundwater elevations in the western groundwater depression declined to -40 feet msl. In other areas, groundwater elevations ranged from 10 to 200 feet msl. Groundwater elevations in the City of Madera ranged from 60 to 120 feet msl.

Spring 2016 DWR groundwater contours for Madera Subbasin were based on limited well data for this year, but a broad area of groundwater elevations below 0 feet msl is apparent in the northeastern and north central portion of the subbasin. Groundwater elevations in the City of Madera ranged from 10 to 90 feet msl.

The potential saturated thickness of the upper unconfined aquifer above the Corcoran Clay was evaluated by overlying DWR groundwater elevation contour maps with the map of the top elevation of the Corcoran Clay. **Figure 3-10** provides a map of the difference between DWR groundwater elevation contours and top of Corcoran Clay elevation contours for three different years – 1988, 2012, and 2016. To the extent that DWR groundwater elevation contours may be considered to be representative of the upper unconfined aquifer, this map generally shows the expansion of the unsaturated area of the upper unconfined aquifer over time from 1988 to 2016, corresponding to the long term (and steeper recent) decline in groundwater elevations. However, it should be noted that it is uncertain as to how representative DWR groundwater elevations are for the upper unconfined aquifer, and this will require further evaluation in the future.

Review of available data for groundwater contour mapping indicates it is not possible to map groundwater elevations of the upper unconfined aquifer (or upper semi-confined aquifer to the east) separate from the lower confined aquifer (or lower semi-confined aquifer to the east) because there are an insufficient number of wells with known construction details. In addition, some wells with known construction details are composite wells with screens in both aquifers. Thus, as described in the discussion of data gaps, additional work is needed to expand the water level database to allow for distinct mapping of groundwater levels for the upper and lower aquifers (which is required for the GSP).

3.2.1.2 Groundwater Hydrographs

Groundwater hydrographs with a relatively long period of record and recent data (at least through 2014) were reviewed to evaluate long-term trends (**Appendix C**). Selected hydrographs in different areas of the subbasin are displayed in **Figure 3-11**. Well 3F1 in the northeastern portion of the subbasin shows a sustained long-term decline in groundwater elevations from about 215 feet msl in the late 1950's to -25 feet msl in 2014. Well 16H1 in the middle of the subbasin shows year-to-year climatic fluctuations combined with an overall decline from about 80 feet msl to 0 feet msl from 1955 to 2014. Well 6K1 in the southern portion of the subbasin along the San Joaquin River shows very consistent and stable groundwater elevations from 1955 to 2014 with an overall net decline from about 200 feet msl to 180 feet msl.

Overall, long-term declines and very steep recent declines (between 2012 and 2016) were prevalent in the northwestern and northeastern portions of the subbasin. More stable areas of the subbasin include along the San Joaquin River in the southern portion of the subbasin and an area extending northwest and across the subbasin from the San Joaquin River in the western portion of the subbasin (**Figure 3-12**).

3.2.1.3 Groundwater Storage Change

Previous estimates of groundwater storage change for Madera County include DWR (1992), Todd (2002), and Provost & Pritchard (2014). DWR (1992) estimated groundwater storage decline from 1970 to 1990 to be 74,115 AFY. Todd (2002) calculated a groundwater storage decline of 68,338 AFY for the period from 1990 to 1998.

The most recent evaluation of groundwater level and storage change is included in the 2014 Groundwater Management Plan (Provost & Pritchard, 2014), and covers the time period from 1980 to 2011 (**Figure 3-13**). In general, groundwater levels declined between 30 and 150 feet throughout Madera County, or an average of 1 to 5 feet per year. Groundwater storage change was not quantified by subbasin. For the Madera County area included in the plan (not including areas of Root Creek Water District, Madera Water District, Aliso Water District, or Columbia Canal Company) studied in 2014 (plus the area of Merced County included in Chowchilla Water District), groundwater storage between 1980 and 2011 was estimated to have declined at an average rate of 143,000 AFY, which equates to a total decline of 4.4 million acre-feet over the 31-year period.

As described in the discussion of groundwater contour maps and hydrographs, additional declines in groundwater levels (and hence groundwater storage) have occurred since 2012. Therefore, the groundwater storage change since 2011 is expected to have declined further, although the effects of a very wet 2016-2017 winter season are not yet reflected in the data included in this report.

3.2.2 Groundwater Quality

Several studies and maps of regional groundwater quality have been prepared in recent years, and the various maps are included in **Appendix D**. Regional groundwater quality mapping for the CV-SALTS project was conducted for TDS and nitrates (LSCE and LWA, 2016). TDS mapping for the upper zone (of the upper aquifer) showed generally increasing TDS from east to west across Madera Subbasin. TDS ranged from less than 250 mg/L in the east to greater than 1,000 mg/L in the southwestern corner of the subbasin. Lower zone (of the upper aquifer) TDS mapping showed a similar pattern of increasing TDS from east to west, but with a smaller area of high TDS groundwater. Mapping of nitrate in the upper zone (of the upper aquifer) showed a small area exceeding the MCL in the northwestern part of the subbasin, while nitrate in the lower zone (of the upper aquifer) was indicated to exceed the MCL in similar but somewhat larger area in (compared to upper zone of upper aquifer) the northwest portion of the subbasin.

LSCE (2014) conducted groundwater quality mapping for the San Joaquin Valley for various constituents including TDS, nitrate, arsenic, vanadium, uranium, DBCP/fumigants, herbicides, solvents, and perchlorate. Although the maps were not necessarily aquifer specific (shallow wells were distinguished from deeper wells for this study primarily based upon well use type), they do illustrate general concentrations in wells across the subbasin. For example, TDS concentrations were low to moderate for most shallow and deep wells, with the exception of a couple deep wells, and one well with arsenic exceeding the drinking water Maximum Contaminant Level (MCL) is located in the southeast portion of the subbasin. Uranium showed a pattern of lower concentration in the east and some wells with high concentrations in the western part of the subbasin. Groundwater quality maps for other constituents listed above are provided in **Appendix D**.

Other mapping of regional groundwater quality was included in the Regional Groundwater Management Plan (Provost & Pritchard, 2014). Typically, the major considerations for municipal/domestic and agricultural use with respect to groundwater quality include salinity (specific conductance, TDS), nutrients (nitrate), and metals (arsenic, manganese). For the purposes of this groundwater quality discussion, Provost & Prichard (2014) defined shallow wells (0 to 400 feet), intermediate wells (400 to 600 feet), and deep wells (greater than 600 feet deep). This nomenclature differs slightly from the HCM defined in this TM, and is utilized only for the discussion of groundwater quality in this section of the TM. Overall groundwater quality is generally good for municipal/domestic and agricultural use. Groundwater quality maps from previous reports are provided in **Appendix D**.

Based on limited existing data, specific conductance is generally less than 900 umhos/cm over the eastern and central portions of Madera Subbasin for the shallow wells. The western portion of Madera Subbasin includes one well with specific conductance between 900 and 1,600 umhos/com and one well greater than 1,600 umhos/com. Available data for intermediate zone wells show specific conductance of less than 900 umhos/cm in and around the City of Madera and in the southeast portion of the subbasin. One well in the western portion of the subbasin exceeds 1,600 umhos/cm. Available data for deep wells show specific conductance of less than 900 umhos/cm in and around the City of Madera and in the southeast portion of the subbasin. No deep wells are available in the western portion of the subbasin.

Based on limited existing data, nitrate is generally less than 45 mg/L (as NO_3) throughout the subbasin with the exceptions of one shallow well in the western portion and one intermediate depth well in the southeastern portion of the subbasin. Among wells of unknown screen/depth interval, five wells in the central to western portion of the subbasin had nitrate greater than 45 mg/L. However, the five wells with high nitrate was a relatively small proportion of the total wells shown with unknown depths.

Arsenic concentrations for wells less than 400 feet deep and from 400 to 600 feet deep were below the MCL of 10 ug/L. Available data from Provost & Pritchard (2014) for deep wells indicates the majority are at less than the MCL for arsenic, but there were two wells exceeding 10 ug/L in the southeastern portion of the subbasin. The MCL for manganese was exceeded by three shallow wells, but no intermediate or deep wells had manganese in excess of the MCL of 10 ug/L.

3.2.3 Land Subsidence

Recent land subsidence has been a major concern in the northwestern portion of Madera County, primarily impacting the western portion of the adjacent Chowchilla Subbasin. Subsidence mapping using InSAR data for the 2007 to 2011 time period is shown in **Figure 3-14**. The maximum subsidence of about one foot for this time period occurred in the northwest part of the Madera Subbasin.

Other mapping of recent subsidence is included in **Appendix E**. In northwest Madera Subbasin, subsidence from 2008 to 2010 was less than one foot. Mapping by USBR between July 2012 and December 2016 showed total subsidence ranging up to two feet in northwest Madera Subbasin. Various ongoing subsidence monitoring programs are being funded and/or conducted by DWR, USGS, USBR, and NASA-JPL.

3.2.4 Groundwater - Surface Water Interaction

The primary surface water features in Madera Subbasin are the Fresno River, Cottonwood Creek, and San Joaquin River (**Figure 3-15**). Each of these streams is considered to be a natural source of recharge to the subbasin. A review of historical groundwater levels compared to stream thalweg 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 (stream bottom) elevations) along the Fresno River and Cottonwood Creek in Madera Subbasin. However, comparison of historical groundwater levels to the stream thalweg (i.e., deepest portion of stream channel) indicate that the San Joaquin River along the southern and western subbasin boundaries was connected with groundwater from 1958 (and likely before) through 1984. Groundwater levels were generally below (and apparently disconnected from) the San Joaquin River by about 10 to 50 feet from 1989 through 2008 except at the extreme northwestern tip of the subbasin where the river may still have been connected to groundwater. The San Joaquin River appeared to be entirely disconnected from groundwater for the entire length of the southern and western subbasin boundaries between 2009 and 2016.

Available data related to wetlands and riparian vegetation are also displayed in **Figure 3-15**. Areas of marsh and wetland were identified in the western portion of Madera Subbasin. Areas of riparian vegetation were mapped along the Fresno River in the east central portion of the subbasin, and along the San Joaquin River at the southern and western boundaries of the subbasin. Wetland and riparian vegetation areas will require more detailed evaluation during GSP preparation.

DWR and The Nature Conservancy are working on mapping of groundwater dependent ecosystems (GDE), but results are not currently available. Our current understanding is that the initial public roll out of the GDE mapping may be available in June 2017. In addition, we understand that The Nature Conservancy will refer to these mapped areas as potential GDEs that will require more detailed assessment by local stakeholders within each groundwater subbasin to determine if vegetation within the mapped areas is dependent on the same groundwater system that is being tapped by local water supply wells.

3.3 HCM Summary and Data Gap Assessment

As described in the previous sections discussing HCM Geologic Conditions and Groundwater Conditions, the hydrogeologic conditions for the Madera Subbasin are relatively well understood and documented. The overall geologic setting and subbasin lateral and vertical boundaries are described in this TM. Several geologic cross-sections were obtained from previous studies, and those geologic cross-sections are compiled and described. The major aquifers and aquitards were able to be delineated from existing geologic cross-sections, and associated aquifer property data were compiled. Additionally, groundwater levels, storage change, and groundwater quality are relatively well documented and available information on subsidence, and groundwater-surface water interaction has also been compiled and described in this TM.

A summary of data gaps for the HCM geologic conditions and groundwater conditions is provided in **Table 3-2**. SGMA requirements for the HCM (geologic conditions) can mostly be met with use of figures, tables, and data from existing reports and data collected for this study. The preliminary HCM provided in this TM provides the first step in the process of compiling and synthesizing all the relevant information for meeting HCM geologic conditions requirements under SGMA. The data gaps identified relative to geologic cross-sections and aquifer parameters are primarily related to potential development of a groundwater model. Recommendations for next steps and additional work to be conducted related to the geologic conditions portion of the HCM during GSP development are provided in **Section 5**.

The data gap assessment for groundwater conditions indicates that some additional work is needed to complete the historical and current groundwater conditions portion of the HCM for the subbasin in the GSP. In particular, identified data gaps for groundwater conditions are primarily related to groundwater levels and quality, for which the data gaps are mostly due to the lack of known construction details (e.g., screen/perforation interval) for many of the wells in the water level and water quality data sets (see additional discussion of monitoring wells below). Additional potential data gaps for groundwater conditions are dependent on further evaluations of surface water – groundwater interaction and groundwater dependent ecosystems. If it is determined that surface water – groundwater interaction along the San Joaquin River needs to be addressed in the GSP, there will be a need for upper unconfined aquifer monitoring wells to evaluate/monitor surface water – groundwater interaction along the San Joaquin River on the western boundary of the subbasin. When groundwater dependent ecosystem mapping becomes available from TNC and DWR, potential GDEs identified in that mapping will require further evaluation to determine if any GDEs need to be addressed in the GSP. The preliminary HCM provided in this TM provides the first step in the process of meeting groundwater conditions requirements under SGMA. Recommendations for additional work to be conducted related to the groundwater conditions portion of the HCM during GSP development are provided in **Section 5**.

This study included review of data gaps related to the existing groundwater monitoring network and what is likely to be required of the monitoring network under SGMA. There are many wells with good records of historical and current water level and/or water quality data, but many existing monitored wells have unknown construction details. Monitoring wells with known screen intervals are necessary to develop a better understanding of groundwater elevations (and quality) in the different aquifers. Therefore, a primary data gap is the need for additional wells with known construction details to include in the GSP groundwater monitoring network. This data gap can be filled by a combination of the following tasks: 1) identify selected wells with good water level datasets but with unknown construction details and try to match them with DWR well completion reports showing screen intervals, 2) identify selected wells with no history of water levels but known construction details (or possibly obtain well videos from well owners to determine construction details) to add to the network for future monitoring, and 3) identify sites for drilling of new monitoring wells for future monitoring. Recommendations for additional work to be conducted to fill data gaps in the monitoring well network are provided in **Section 5**. As discussed above, existing wells may provide information that can be used to fill a portion of the monitoring well data gaps, and maps illustrating the spatial availability of DWR wells logs in the subbasin that may be used for this purpose are presented in **Appendix F**. Additional discussion of the importance and rationale for maximizing use of existing well water level data (via matching of DWR WCRs to existing wells with unknown construction details) is provided in **Section 5.1**.

Table 3-1
Summary of Existing Well/Aquifer Test Data

Entity	Well ID	Total Well Depth (ft)	Perforation Interval (ft, bgs)	Date	Duration (hr)	Static Water Level (ft)	Pumping Water Level (ft)	Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Efficiency	Transmissivity (gpd/ft)	Step Test No.	Other
City of Madera	15									65				
	16									<15				and falling
	17									22				and rising
	18									44				
	20									90				
	21									70				and falling
	22									45				
	23									37				
	24									32				
	25									40				and falling
	26									40				
	28									15				
	29									25				Variable
	30									35				and falling
	31									43				
	32									65				and rising
	33									20				and falling
	34									12				
Madera WD	1	460		6/27/1994		238.8	281.6	692	42.8	16.2	62.8%			
	1	460		7/8/2003		318.1	357.4	749	39.27	19.1	56.5%			
	2	500	200-500	10/20/1994		248.0	300.0	1,225	52	23.6	67.2%			
	2	500	200-500	7/8/2003		309.9	363.0	982	53.13	18.5	59.4%			
	2	500	200-500	8/14/2014		377	457	499	80	6.2	58%			
	3	500	200-500	10/20/1994		239.5	245.0	1,419	5.5	258.0	58.6%			
	3	500	200-500	7/8/2003		298.4	365.4	1,192	66.99	17.8	74.4%			

Table 3-1 (continued)
Summary of Existing Well/Aquifer Test Data

Entity	Well ID	Total Well Depth (ft)	Perforation Interval (ft, bgs)	Date	Duration (hr)	Static Water Level (ft)	Pumping Water Level (ft)	Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Efficiency	Transmissivity (gpd/ft)	Step Test No.	Other
Madera WD	4	500	200-500	10/20/1994		265.4	326.0	797	60.6	13.2	60.1%			
	4	500	200-500	7/8/2003		288.8	415.8	627	127.05	4.9	59.8%			
	4	500	200-500	8/15/2014		440	486	219	46	4.8	47%			
	5	500	200-500	10/19/1994		240.5	281.0	933	40.5	23.0	61.9%			
	6	500	200-500	10/19/1994		260.8	266.8	984	6	164.0	62.3%			
	6	500	200-500	7/8/2003		319.6	409.7	998	90.09	11.1	76.3%			
	6	500	200-500	8/15/2014		357	389	307	32	9.6	53%			
	7	500	200-500	10/20/1994		225.0	300.0	772	75	10.3	54.3%			
	7	500	200-500	7/8/2003		268.0	438.9	612	170.94	3.6	52.2%			
	7	500	200-500	8/14/2014		378	460	230	82	2.8	48%			
	8	537	200-537	9/12/2003		276.8	401.6	797	124.77	6.4	64.1%			
	8	537	200-537	8/28/2014		347	500	362	153	2.4	59%			
	9	536	200-536	10/19/1994		255.7	295.0	1,057	39.3	26.9	55.6%			
	9	536	200-536	9/12/2003		302.2	364.6	1,087	62.37	17.4	68.1%			
	9	536	200-536	8/27/2014		361	485	724	124	5.8	58%			
	10	515	200-515	8/15/2014		409	485	204	76	2.7	41%			
	Z	600	180-570	10/19/1994		263.8	300.0	1,661	36.2	45.9	65.1%			
	14	780	300-770	7/8/2003		278.0	380.0	1,006	102	9.9	80.5%			
	15	680	300-670	10/19/1994		243.3	295.0	1,176	51.7	22.7	63.6%			
	15	680	300-670	9/12/2003		306.9	360.0	886	53.13	16.7	58.6%			
	15	680	300-670	8/28/2014		410	579	403	169	2.4	52%			
	16	990	345-970	10/20/1994		299.0	350.0	862	51	16.9	60.4%			
	17	870	250-870	8/14/2014		464	496	684	32	21.4	50%			
	18	840	240-840	8/15/2014		377	387	364	10	36.4	58%			
	19	800	250-800	8/14/2014		426	664	467	238	2.0	44%			
	20	800	380-800	8/15/2014		382	453	1,012	71	14.3	64%			
	21	760	259-759	8/14/2014		418	482	805	64	12.6	62%			
	23	720	460-720	8/14/2014		438	496	741	58	12.8	53%			

Table 3-1 (continued)
Summary of Existing Well/Aquifer Test Data

Entity	Well ID	Total Well Depth (ft)	Perforation Interval (ft, bgs)	Date	Duration (hr)	Static Water Level (ft)	Pumping Water Level (ft)	Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Efficiency	Transmissivity (gpd/ft)	Step Test No.	Other
New Stone WD	#1			9/28/1998		45.3	57.3	1023	12	85.3				
	#11			9/18/2004		128	138	677.7	10	67.77	69%			
	#13			3/28/2015	1.25	99	138	2200	39	56.41			1	Step test
	#13			3/28/2015	1.5		133	1750					2	Step test
	#13			3/28/2015	1.25		128	1200-					3	Step test
	#13			3/28/2015	1.5		126	1100					4	Step test
	#14			3/7/2011		120.5	148	1139	28	41.4	53%			Run 1
	#14			3/7/2011		120.5	143	1048	23	46.6	58%			Run 2
	#16			4/27/2000		65	83	1272.15	18	70.68				Questio
	#17			5/8/2000	0.25	71	118	1185.95	47	25.23				
	#19			6/15/2013		180	213	1337	33	40.5	64%			
	#2			1/26/2011		135	158	1300						
	#2			6/1/2011		128	148	1300						
	#20			2/16/2011		122	160	1003	38	26.4	70%			Run 1
	#20			2/16/2011		122	170	1287	48	26.8	71%			Run 2
	#21			1/30/2009		121.6	153	913	32	29	53%			
	#23			5/17/2000		73	156	1505	83	18.13				
	#24			1/3/2011		128	144	950						
	#24			6/1/2011		126	139	950						
	#25			7/18/1998		84	100	636.07	16	39.75	24.18%			
	#26			11/21/2015	1	138	175	1000	37	27.03			1	Step test
	#26			11/21/2015	1		194	1250					2	Step test
	#28			4/5/2012		168	211	1134	43	26.4	66%			
	#3			4/27/2000	0.25	54	60	1352.66	6	225.44				
	#34			9/10/2016	2.25	190	202	1300	12	108.33				
	#35			5/2/1997		124.6	188.6	1298	64	20.3	60.80%			

Table 3-1 (continued)
Summary of Existing Well/Aquifer Test Data

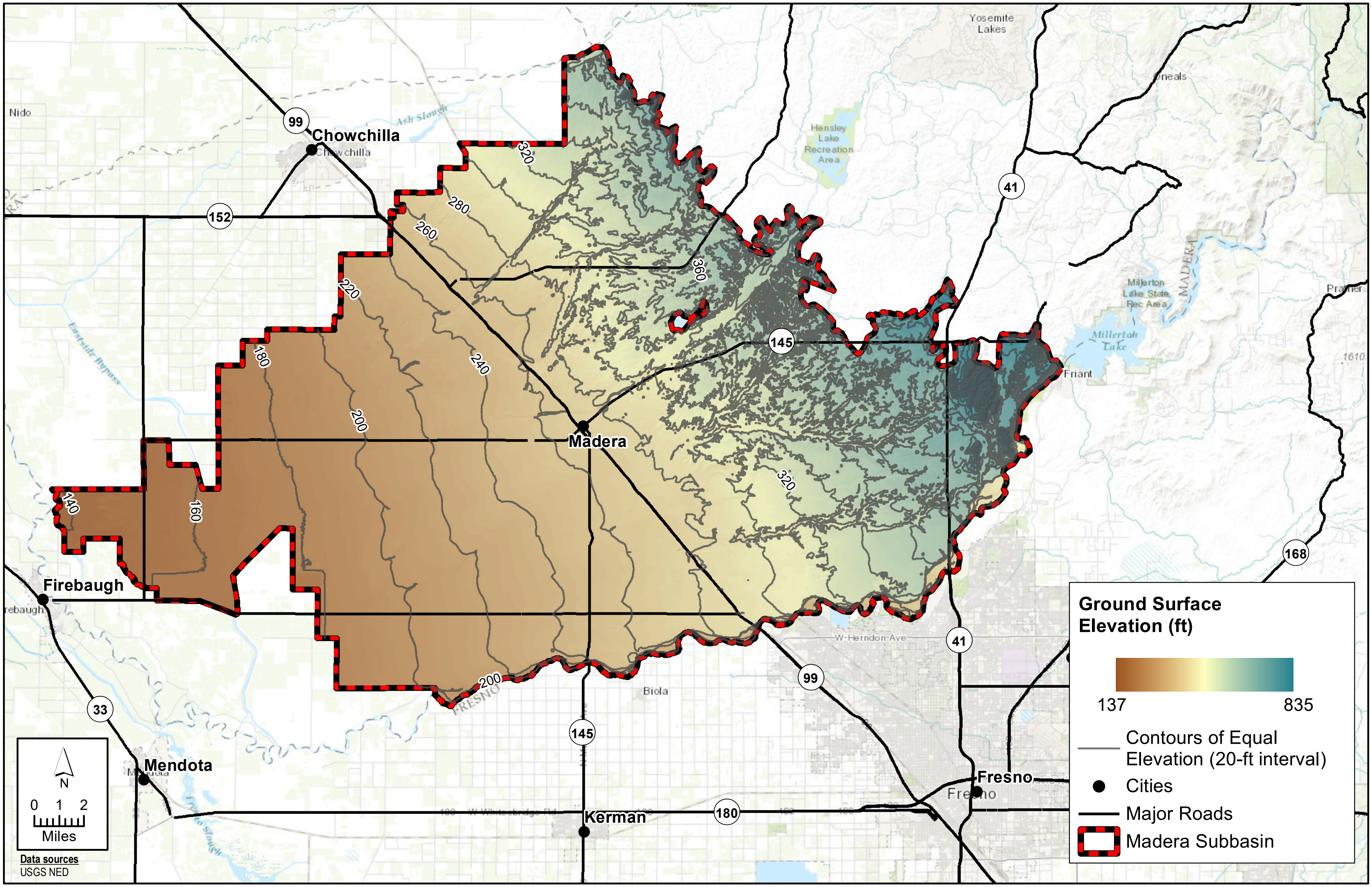
Entity	Well ID	Total Well Depth (ft)	Perforation Interval (ft, bgs)	Date	Duration (hr)	Static Water Level (ft)	Pumping Water Level (ft)	Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Efficiency	Transmissivity (gpd/ft)	Step Test No.	Other
New Stone WD	#36			7/16/2010		212	266	868	54	13.6	66%			Question-able
	#37			4/6/2011		202.9	284	2175	81	26.9	60%			
	#38			8/17/2013		160	280	2479	56	44.3	67%			
	#39			11/26/2014	2	145	175	1000	30	33.3			1	
	#39			11/26/2014	2		193	1225		26			2	
	#39			11/26/2014	2		207	1500		24.6			3	
	#39			11/26/2014	2		212	1750		26.6			4	
	#39			11/24/2014	6.5	143	242	2600	99	26.26				Development
	#39			11/24/2014	8	145	242	2600	97	26.80				Development
	#41			1/29/2013		143	238	2261	45	23.8	58%			
	#5			9/18/2004		100	123	748.8	23	32.56	68%			
	#7			4/27/2000	0.25	86	118	1280.2	32	40.01				
	New Stone Ranch #12			1/29/2009		119.7	164	961	44	21.7	73%			
	Newstone #10													
	Newstone #9			5/9/2012		120	147	910	27	33.7	48%			
Root Creek WD	Riverstone Well 1	460	340-445; 675-690; 750-880	10/15/2014	4	297.6	325.2	1000	24.6	36.2		48,000	1	Step test
	Riverstone Well 1	460	340-445; 675-690; 750-880	10/15/2014	4		332.8	1195	35.3	33.9			2	Step test
	Riverstone Well 1	460	340-445; 675-690; 750-880	10/15/2014	4		340.1	1400	42.6	32.9			3	Step test
	Riverstone Well 1	460	340-445; 675-690; 750-880	10/16/2014	10	300.2	338.8	1310	38.6	33.9		45,000		Constant rate test
	Well No. 2	930	635-920	1/9/2015	9	292	500	2100	208	10.10				Constant rate test

Table 3-1 (continued)
Summary of Existing Well/Aquifer Test Data

Entity	Well ID	Total Well Depth (ft)	Perforation Interval (ft, bgs)	Date	Duration (hr)	Static Water Level (ft)	Pumping Water Level (ft)	Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Efficiency	Transmissivity (gpd/ft)	Step Test No.	Other
Mitten et al., 1970 (USGS)	10S/16E-08E01	405	165-272		20.83							30,000		Hantush method (Jacob method, T=59,000)
	10S/16E-24H01	183	136-172		15.83							18,000		Hantush method
	13S/17E-01L01	345	200-250		20.83							50,000		Hantush method (Jacob method, T=99,000)
	9S/17E-30F01	580	136-336		5.83							24,000		Jacob method

Table 3-2
HCM Data Gap Assessment Summary

Data Type	Relevant GSP Regulation	Data Source	Data Use	Data Gap Assessment	Data Gap Assessment-Detailed Comments	Future Needs
Geologic and Structural Setting	§ 354.14.b1	Existing Reports	HCM	No Gaps		
Topography	§ 354.14.4d1	USGS	HCM	No Gaps		
Surface Soil Properties	§ 354.14.4d3	NRCS, SSURGO	HCM	No Gaps		
Surface Geology	§ 354.14.4d2	Existing Reports	HCM	No Gaps		
Lateral Basin Boundaries	§ 354.14.4b2	Existing Reports	HCM, Groundwater Model	No Gaps		
Vertical Basin Boundaries	§ 354.14.4b3	Existing Reports	HCM, Groundwater Model	No Gaps		
Geologic Cross Sections	§ 354.14.c	Existing Reports	HCM, Groundwater Model	More needed for groundwater model	Additional geologic cross-sections will be needed to develop model layering; data necessary for this work has been compiled	Work can be conducted during GSP model preparation
Aquifer Parameters	§ 354.14.b4A	Existing Reports; Local Agencies	HCM, Groundwater Model	More needed for groundwater model	Additional aquifer parameter data will be needed to develop model aquifer property zones; data necessary for this work has been compiled	Work can be conducted during GSP model preparation
Groundwater Levels	§ 354.16.a § 354.16.b	DWR, USGS, Local Agencies	HCM, Groundwater Model	More depth-specific monitoring wells needed	Many wells with water level data lack construction details; need to expand water level database of wells with known construction details	Continue collecting groundwater level data
Groundwater Quality	§ 354.14.b4D § 354.16.d	DWR, USGS, Local Agencies	HCM, Groundwater Model	More depth-specific monitoring wells needed	Many wells with water level data lack construction details; need to expand water quality database of wells with known construction details	Continue collecting groundwater quality data
Land Subsidence	§ 354.16.e	DWR, USGS, USBR	HCM, Groundwater Model	No Gaps	Currently dependent on monitoring being conducted by DWR/USGS/USBR	Verify continued subsidence data collection by DWR/USGS/USBR
Groundwater - Surface Water Interaction	§ 354.16.f		HCM, Groundwater Model	TBD	Requires more detailed assessment to determine if there may be a need for shallow monitoring wells adjacent to San Joaquin River	Work can be conducted during GSP preparation
Groundwater Dependent Ecosystems (GDEs)	§ 354.16.g	TNC/DWR	HCM, Groundwater Model	Data from TNC/DWR pending	Will need to review and incorporate data from TNC/DWR	Data provided by TNC/DWR will represent potential GDEs; additional analysis needed to identify actual GDEs



X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Figure 3-1 Madera Subbasin Topographic Map.mxd

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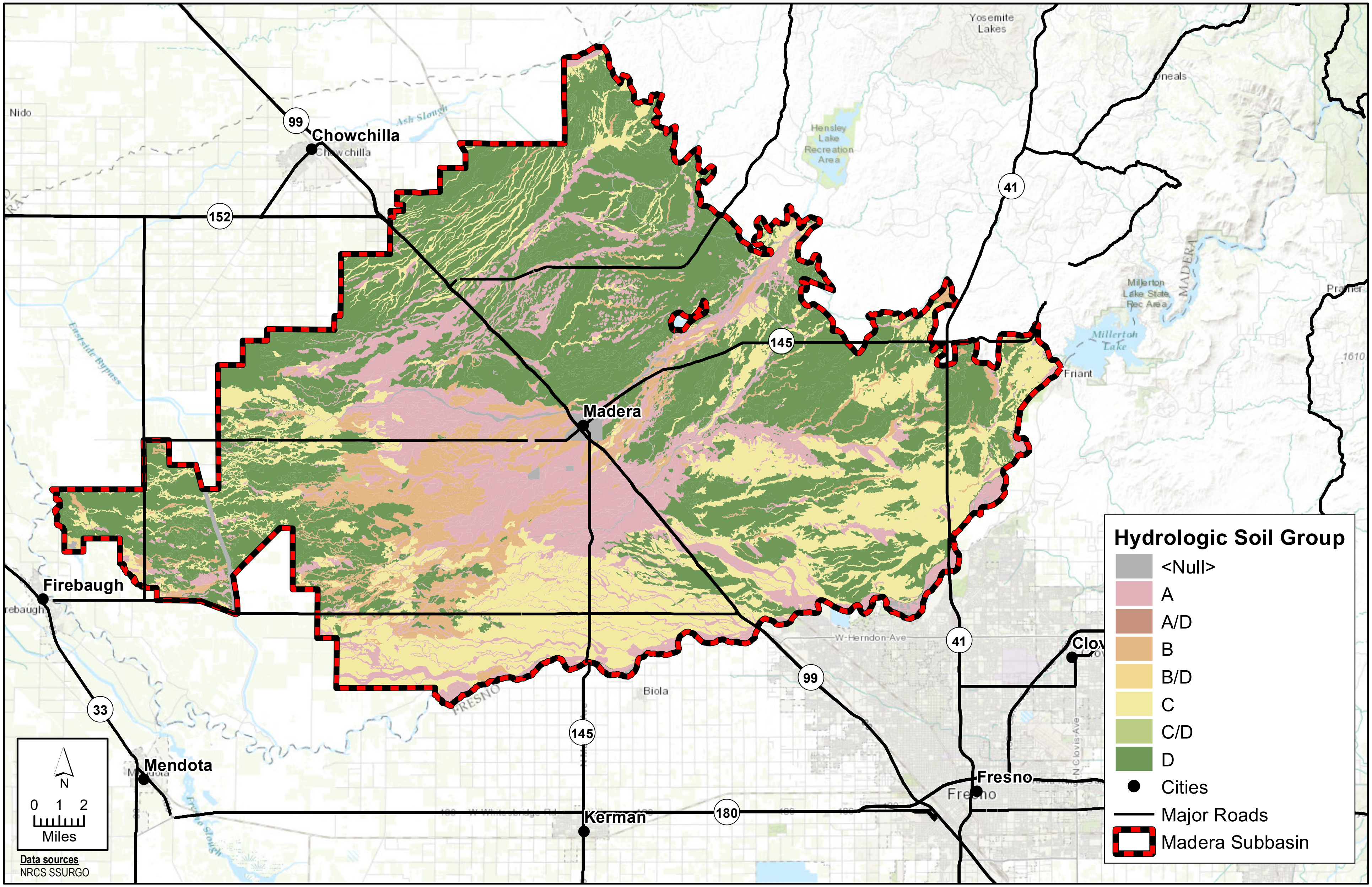
FIGURE 3-1
Topographic Map

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Figure 3-2 Madera Subbasin Soil Unit Map v2.mxd

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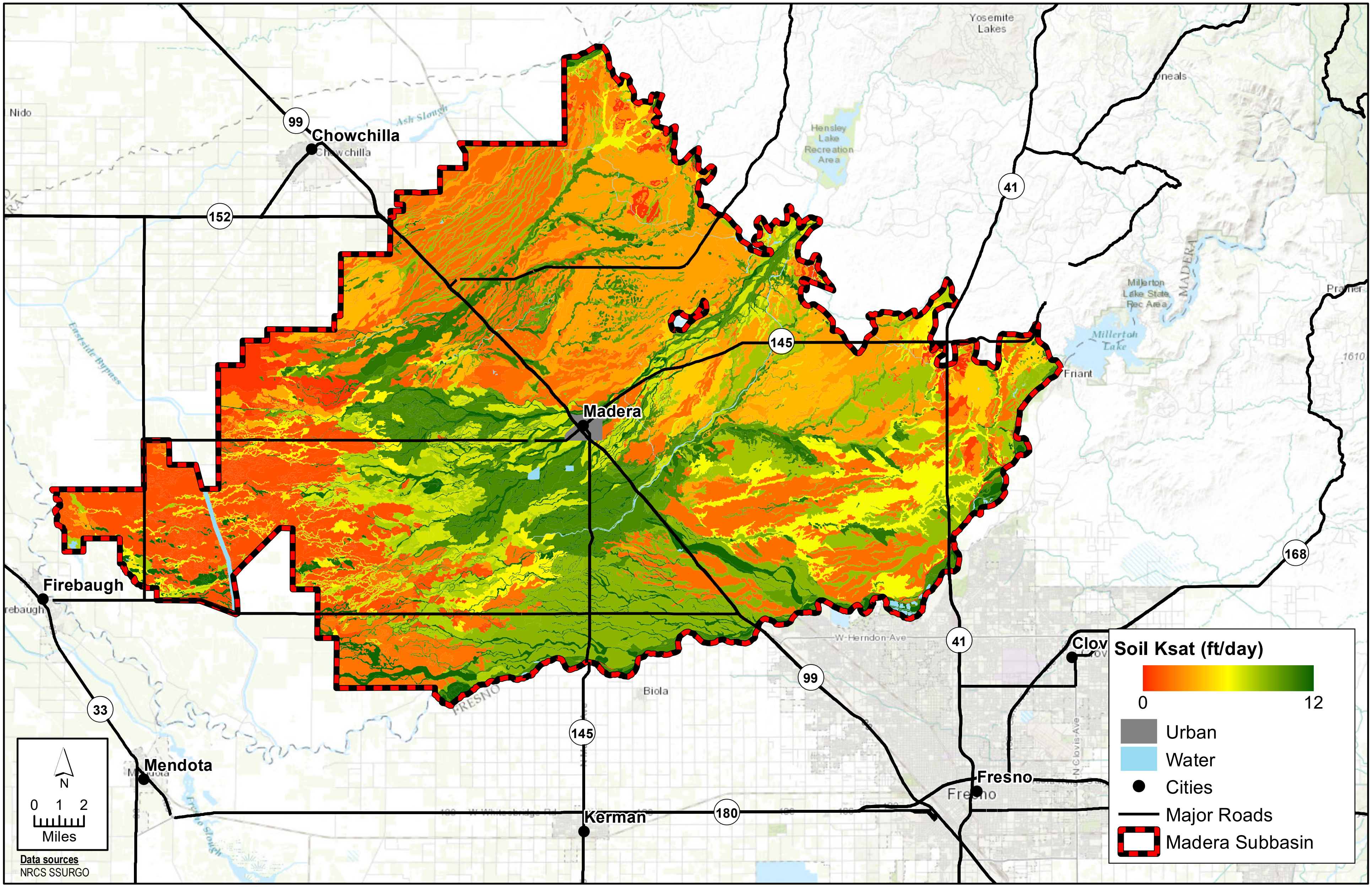
FIGURE 3-2
Soil Unit Map

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Figure 3-4 Madera Subbasin Soil Saturated K Map.mxd

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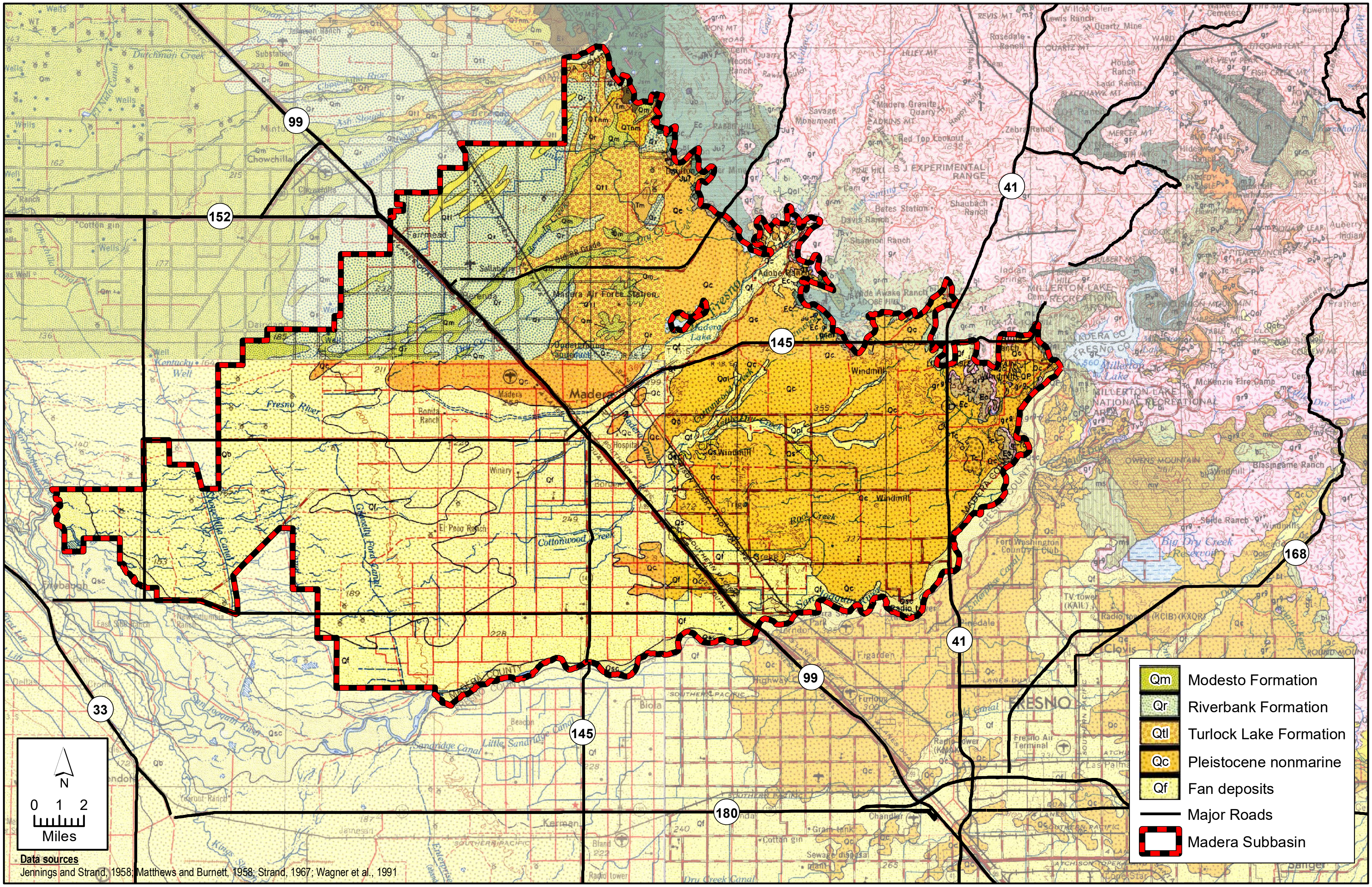
FIGURE 3-3
Soil Saturated Hydraulic Conductivity Map

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Figure 3-4 Madera Subbasin Surficial Geology Map.mxd

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FIGURE 3-4
Surface Geology Map

Madera County: Madera Subbasin
SGMA Data Collection and Analysis

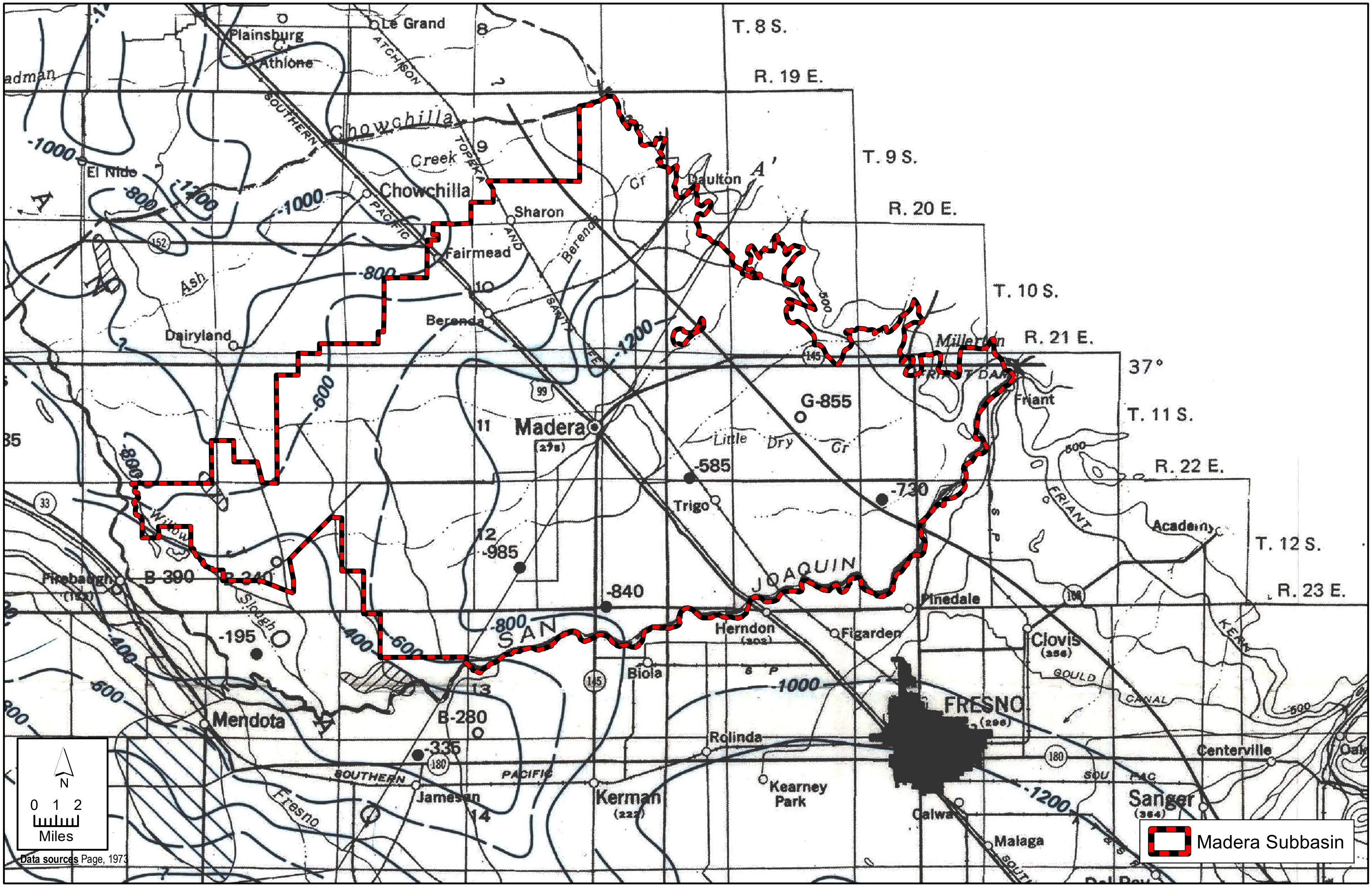

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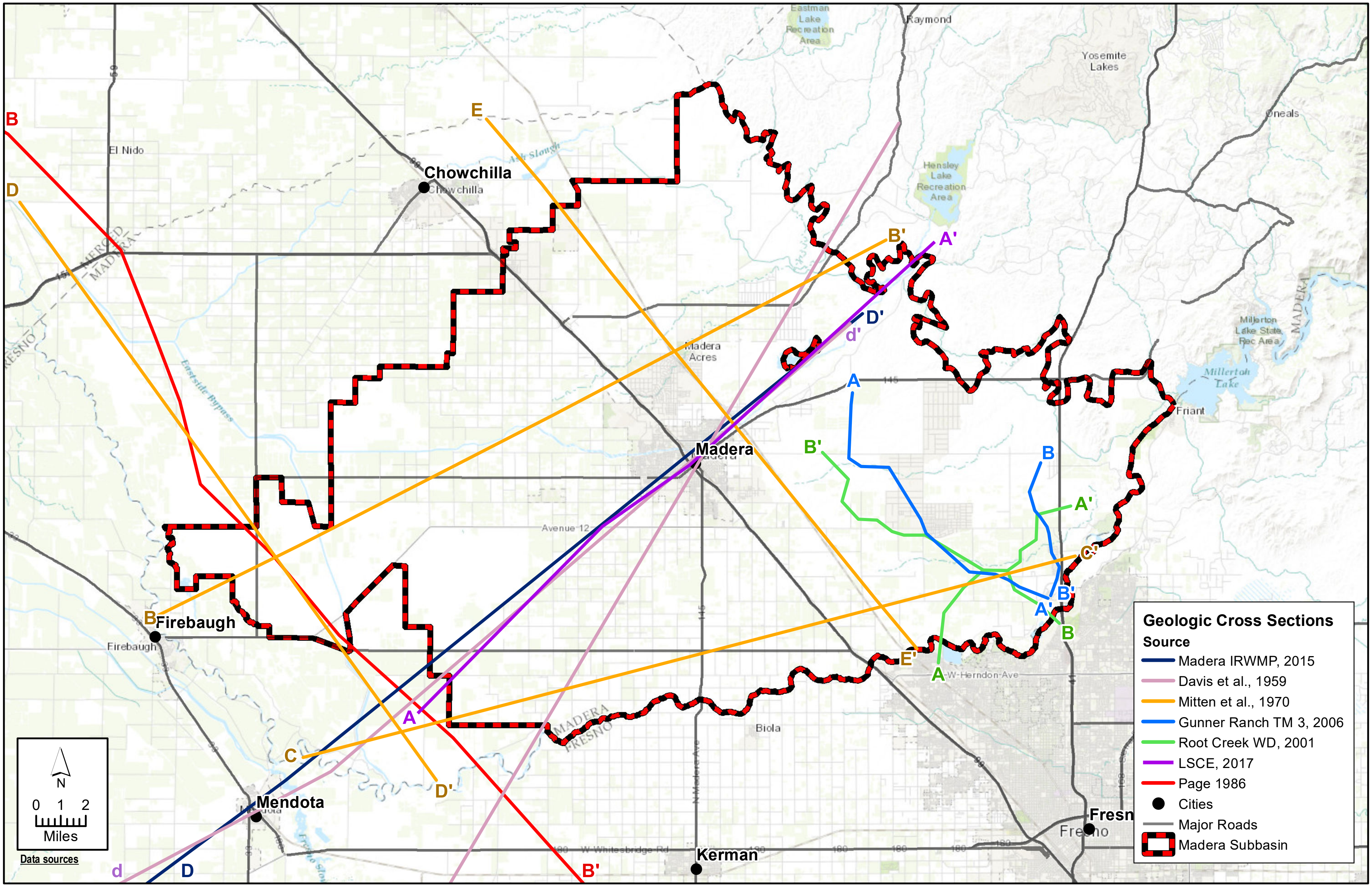
FIGURE 3-5
Base of Freshwater:
Elevation Contours from Page (1973)

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Figure 3-6 Madera Subbasin Geologic Cross-Sections Location Map.mxd

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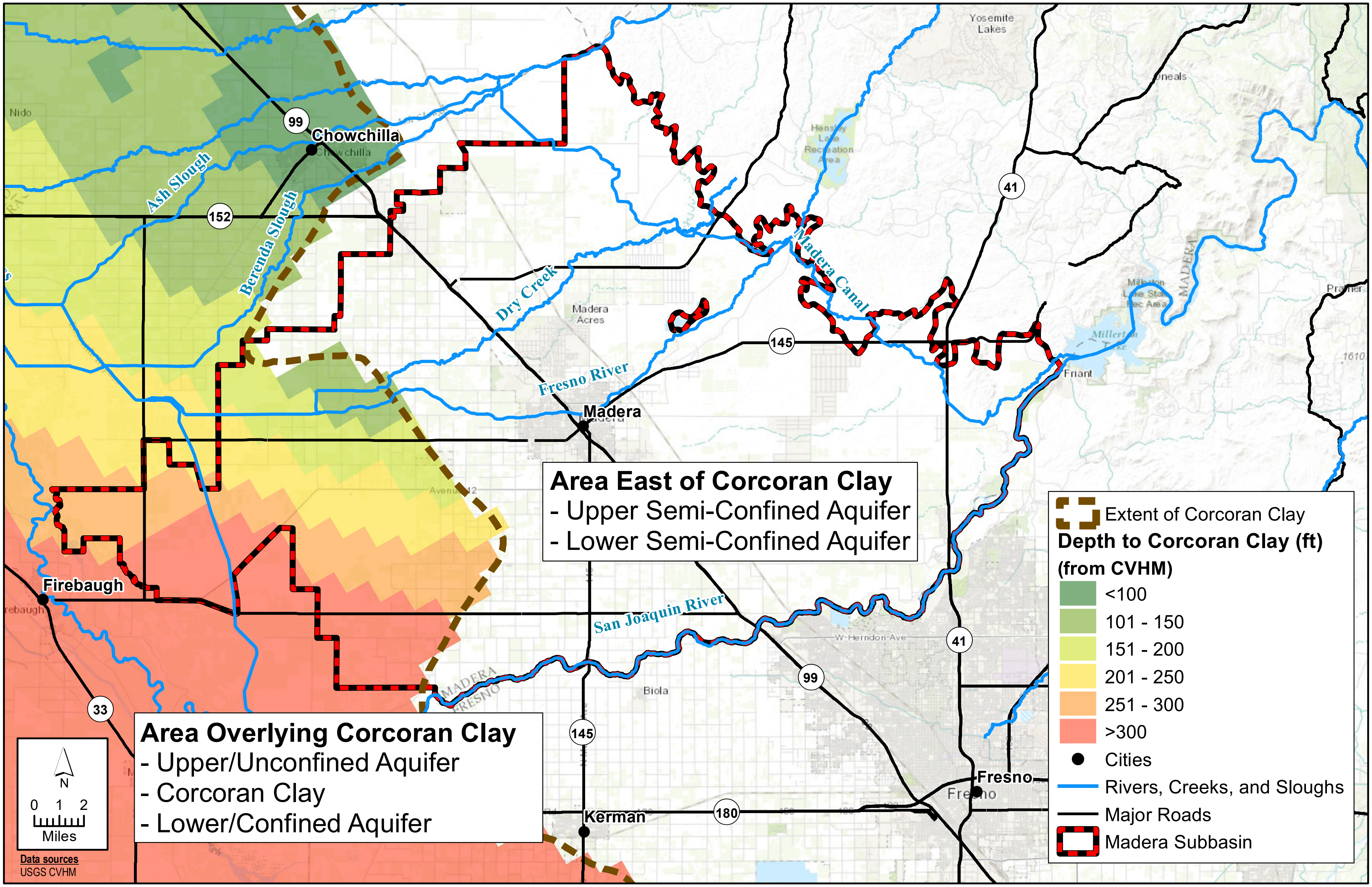
FIGURE 3-6
Geologic Cross-Sections Location Map

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Figure 3-7 Madera Subbasin Depth to Top of Corcoran Clay.mxd

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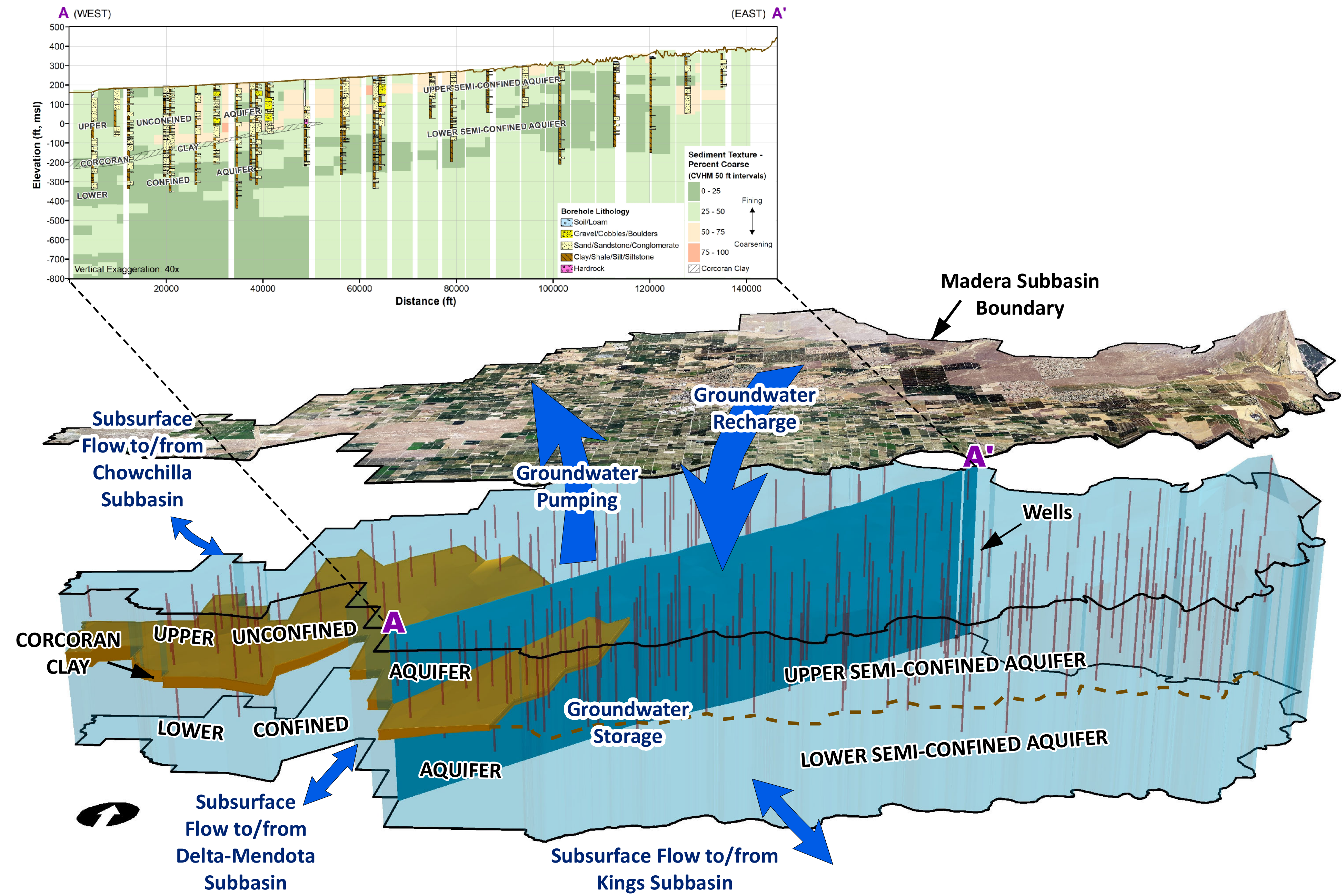
FIGURE 3-7
Depth to Top of Corcoran Clay

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Figure 3-8 3D Diagram of Hydrogeologic Conceptual Model.mxd

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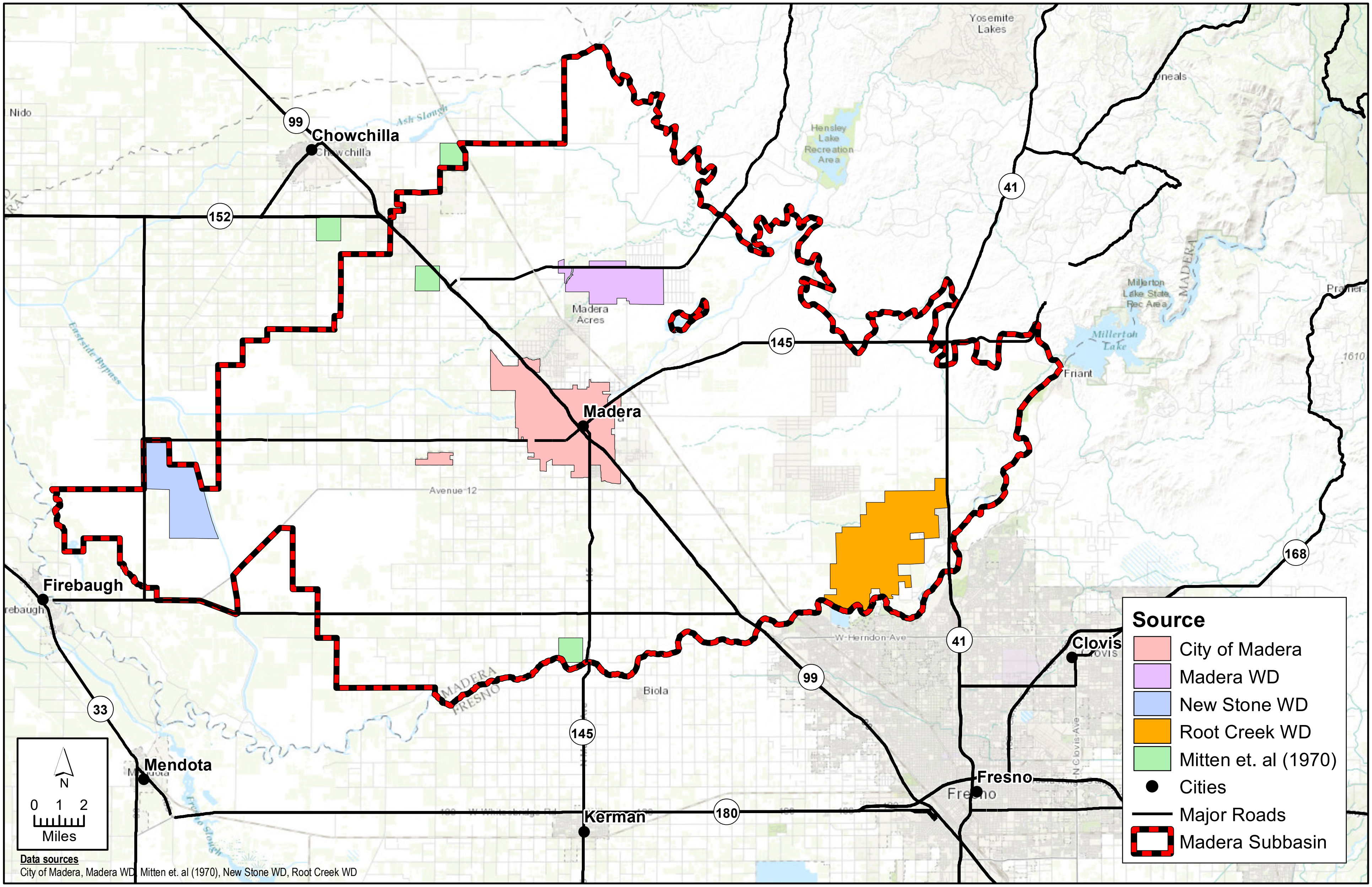
FIGURE 3-8

Madera Subbasin Conceptual Hydrogeologic System

Madera County - Madera Subbasin
SGMA Data Collection and Analysis



X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Figure 3-9 Madera Subbasin Location Map for Existing Aquifer Test Data.mxd

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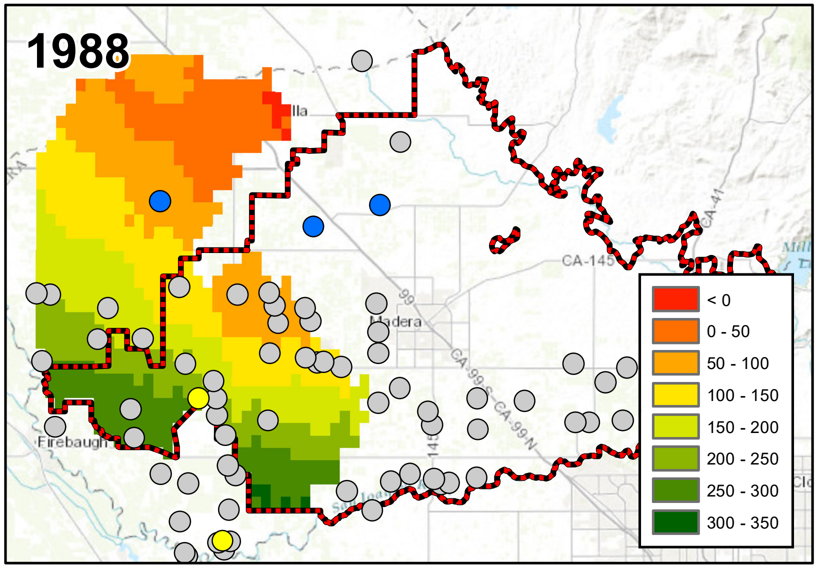
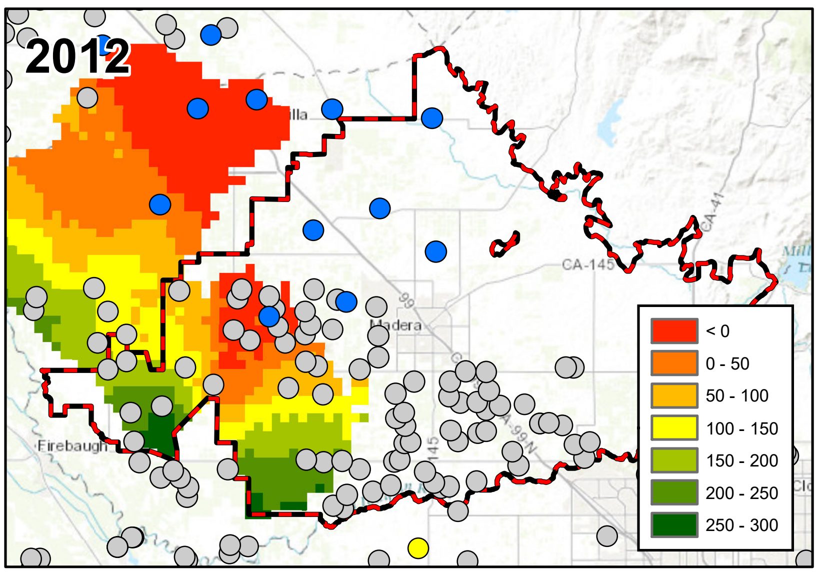
FIGURE 3-9
Location Map for Existing Aquifer Test Data

Madera County: Madera Subbasin
SGMA Data Collection and Analysis

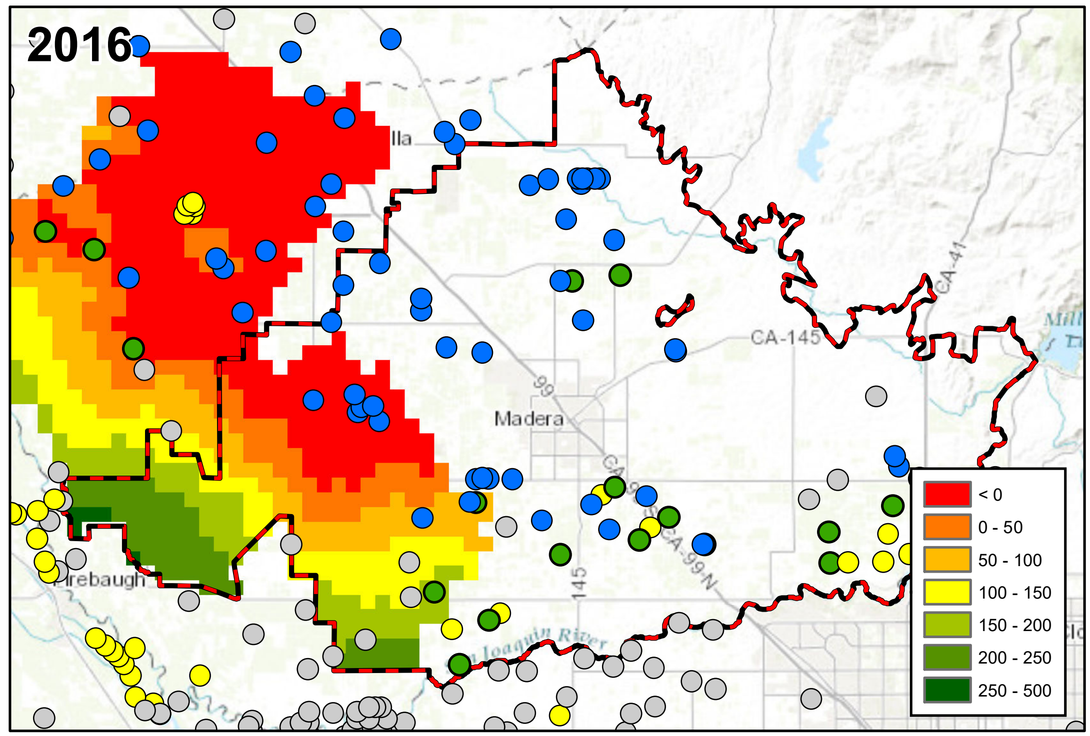
Difference Between Groundwater Elevation Contours and Top of Corcoran Clay





Wells Used for DWR Groundwater Elevation Contour Maps by Aquifer

- Upper
- Lower
- Composite
- Unknown



Note: Values represent groundwater elevations minus top of Corcoran Clay (in feet).

X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Figure 3-10 Madera Subbasin Comparison of DWR Groundwater Elevation Contours to Top of CC.mxd

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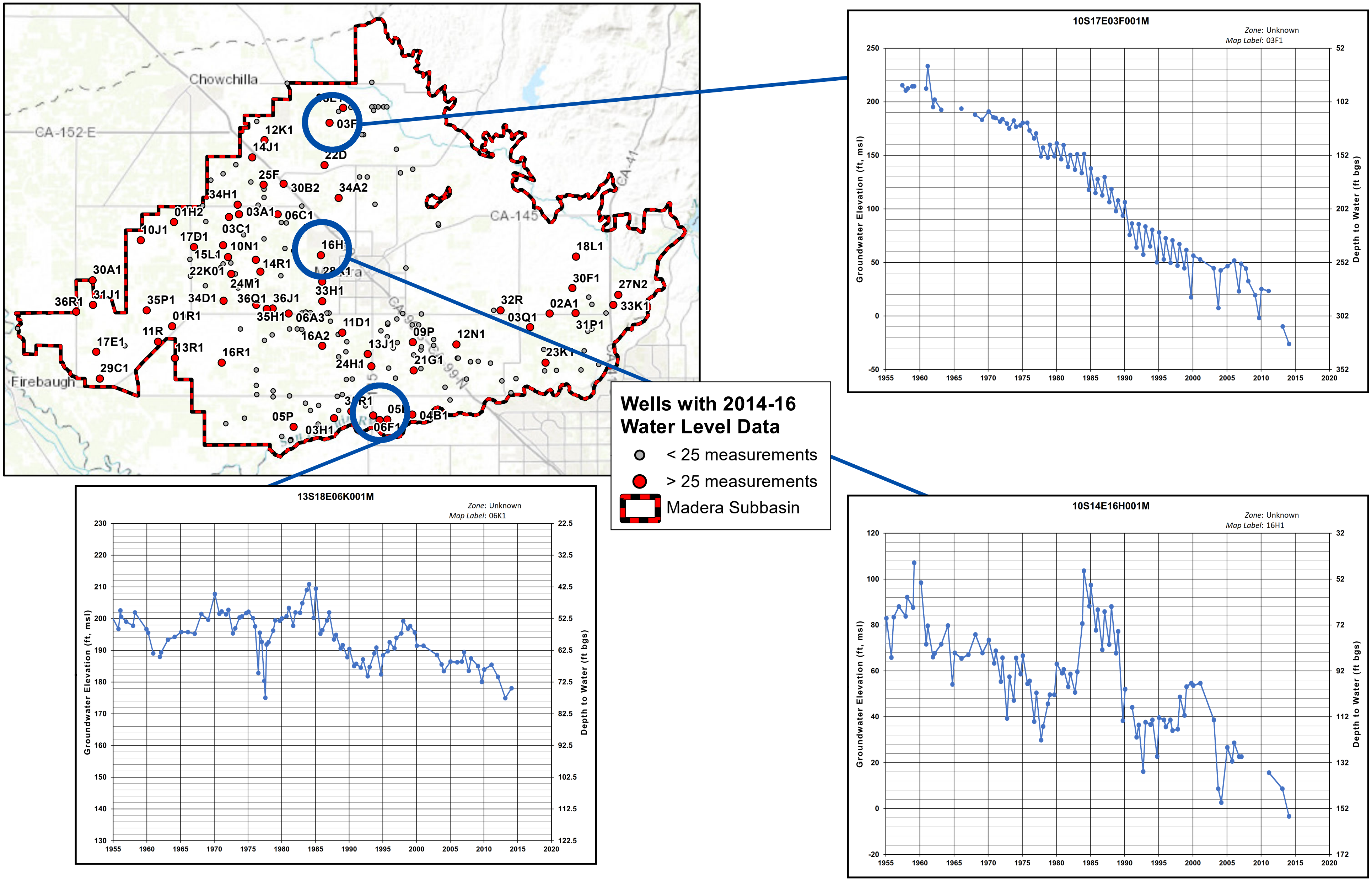
FIGURE 3-10
Comparison of DWR Groundwater Elevation Contours to Top of Corcoran Clay

Madera County - Madera Subbasin
SGMA Data Collection and Analysis



X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Figure 3-10 Madera Subbasin Selected Groundwater Hydrographs.mxd

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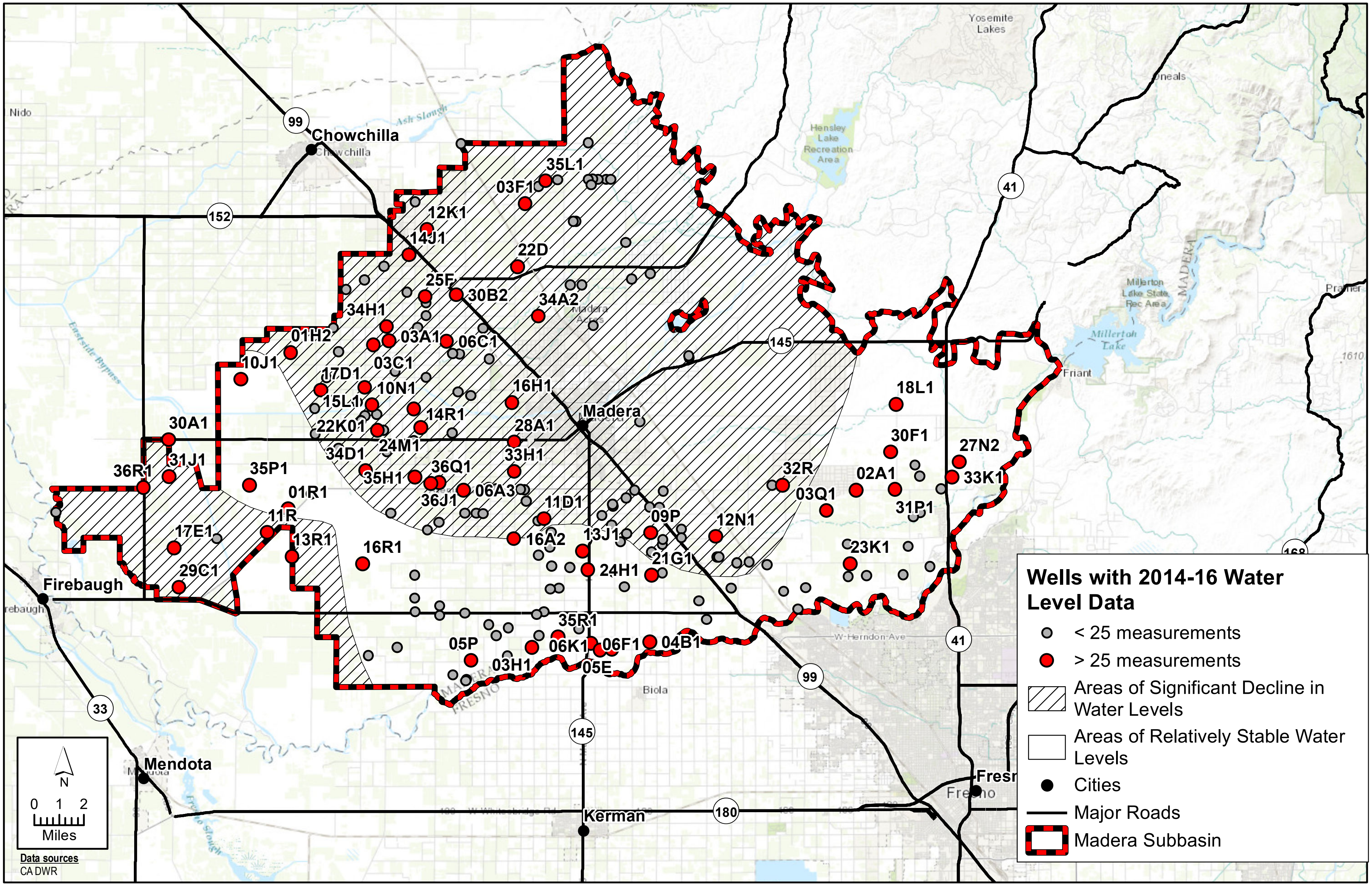
FIGURE 3-11
Selected Groundwater Hydrographs

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Figure 3-11 Madera Subbasin General Areas of Declining and Stable Water Levels.mxd

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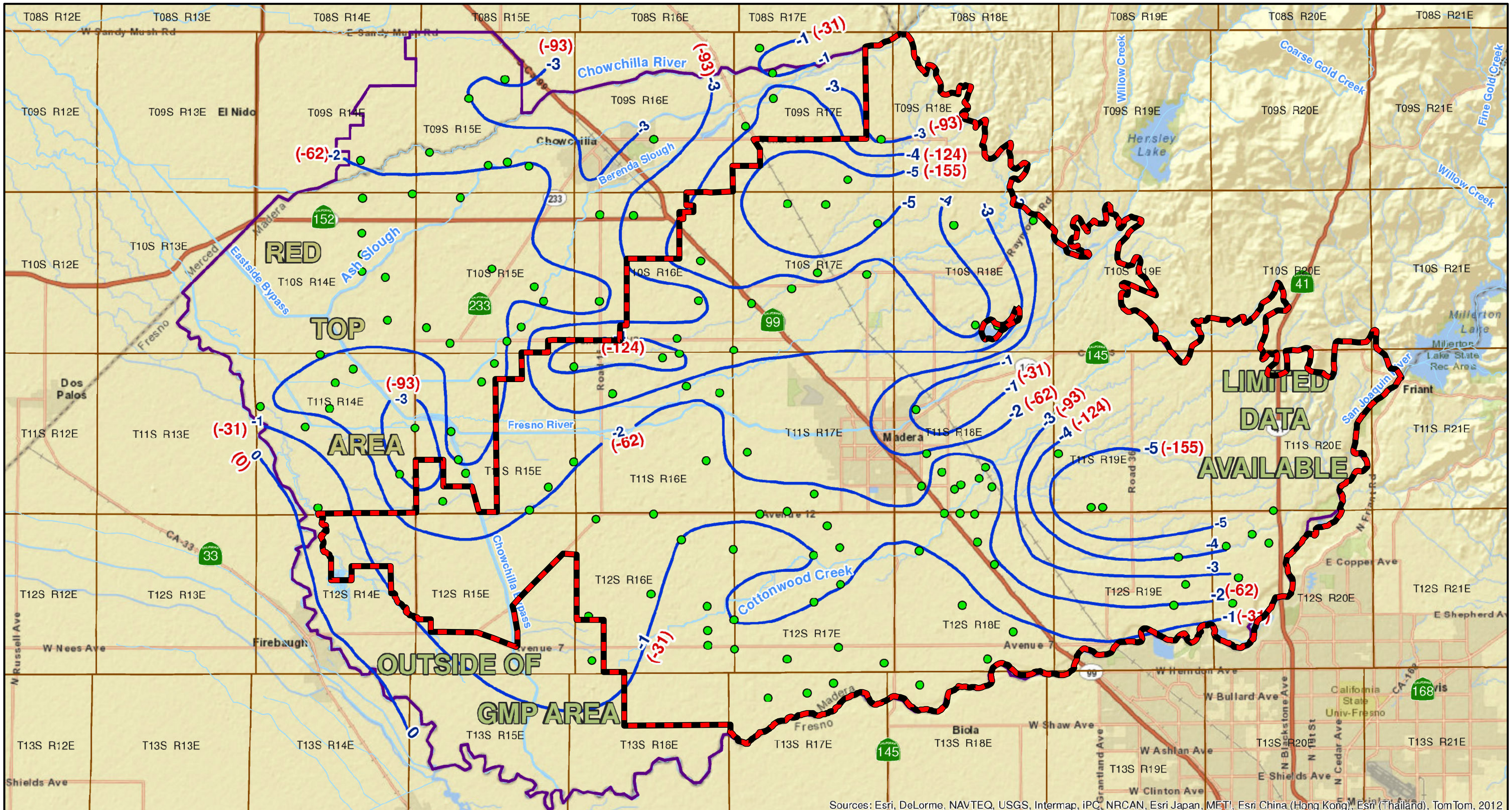
FIGURE 3-12
General Areas of Declining and Stable Water Levels

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



0 2.5 5 Miles

Legend

- Groundwater Management Plan Boundary
- Average Annual Rates of Water Level Decline (Ft), 1980- 2011
- (-155) Total Groundwater Level Decline, 1980-2011
- Wells Used for Analysis
- Madera Subbasin

Source: Madera County AB 3030 Update Report by Ken Schmidt and Associates, December 2013

Madera Regional Groundwater Management Plan

Average Annual Rates and Total Groundwater Level Declines (Ft) from 1980 to 2011

X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Figure 3-12 Madera Subbasin Groundwater Level Change from 1980 to 2011.mxd

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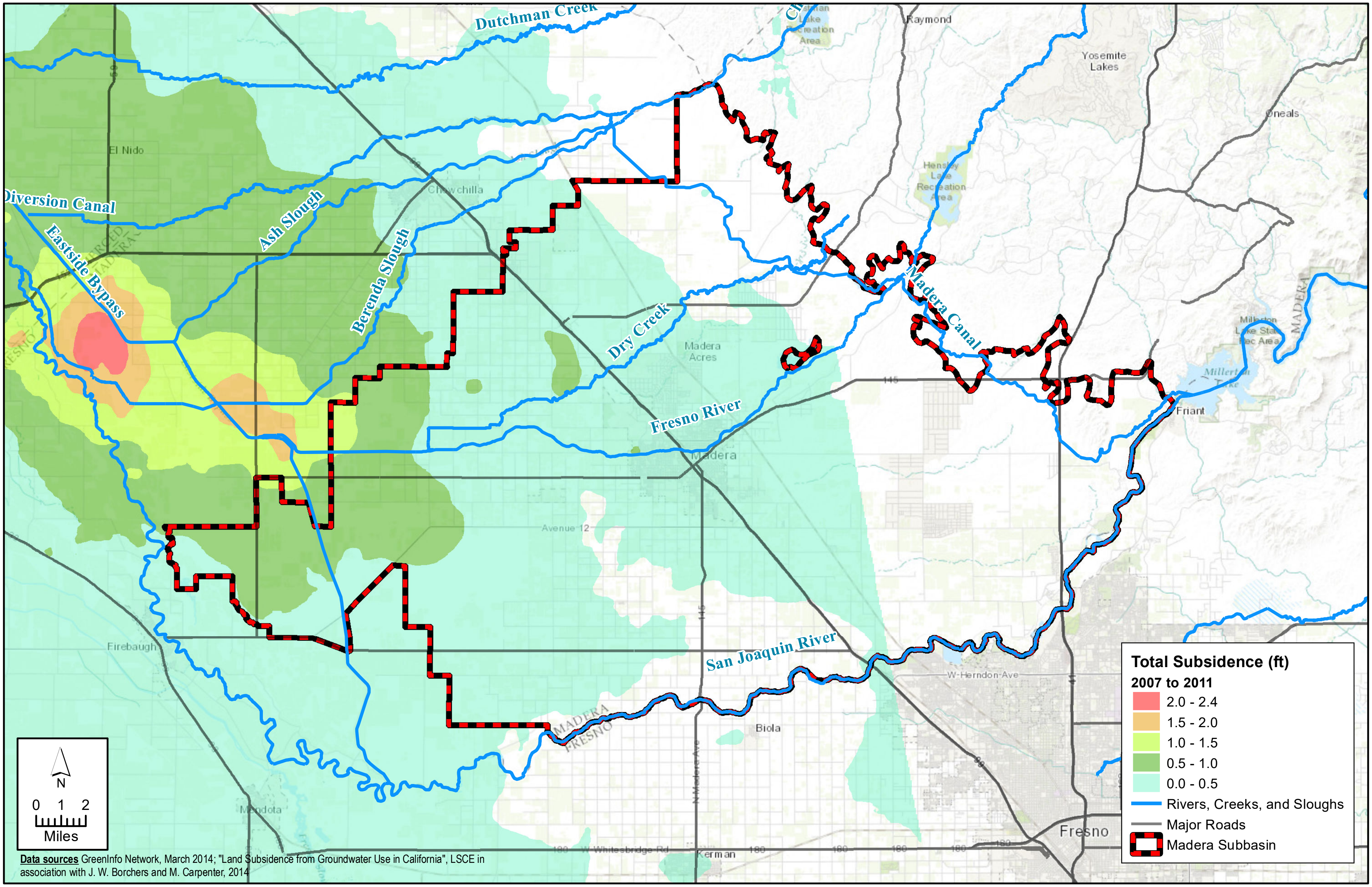
FIGURE 3-13
Groundwater Level Change from 1980 to 2011 (from 2014 Madera Regional GMP)

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Figure 3-14 Madera Subbasin Map of Land Subsidence.mxd

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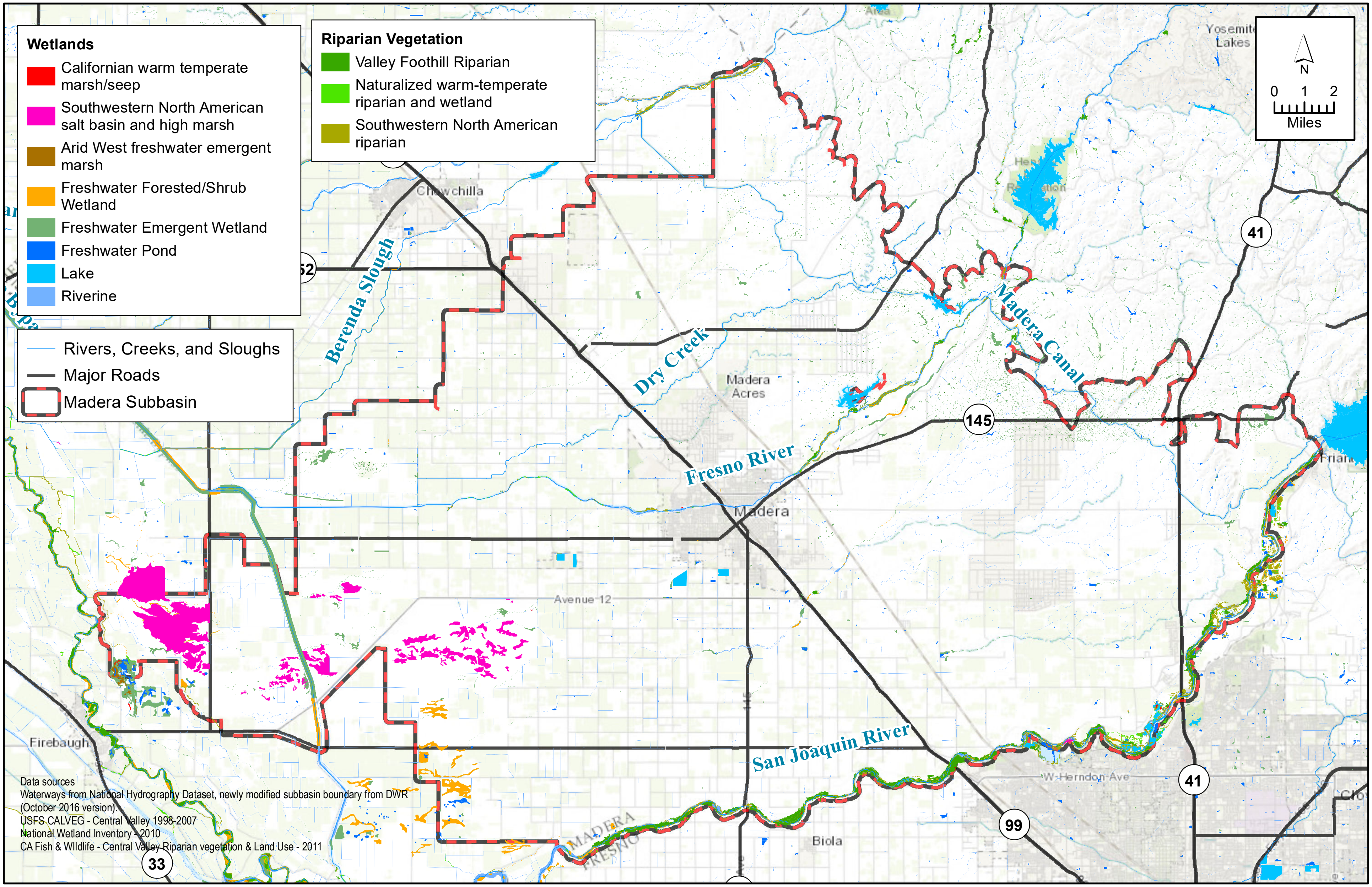
FIGURE 3-14
Map of Land Subsidence: 2007-2011

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



\\lsceexser\Clerical\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Figure 3-14 Madera Subbasin Map of Surface Water Features.mxd

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FIGURE 3-15

Map of Surface Water Features and Riparian Vegetation

Madera County: Madera Subbasin
SGMA Data Collection and Analysis

4 CONCEPTUAL WATER BUDGET MODEL

A water budget is defined as a complete accounting of all water flowing into and out of a defined area (e.g., a subbasin) over a specified period of time. The conceptual model for the Madera Subbasin water budget was developed to comply with the GSP Regulations and to adhere to sound water budget principles and practices (BMP, 2016). Additionally, the data required to develop the conceptual model were compared to the existing local and public information obtained through the data acquisition process described previously to identify and evaluate data gaps. Relevant accounting centers (land use categories or water use sectors) and flow paths (inflows and outflows to/from accounting centers) were identified based on the GSP regulations and DWR's water budget BMP (DWR, 2016) (**Figure 4-1**). The conceptual water budget model supports the required accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, and any changes in storage within the subbasin. The same conceptual water budget model (structure) is used for evaluating historical and current subbasin conditions as required by the GSP regulations. The conceptual water budget structure developed here for purposes of assessing data gaps may also be suitable for representing projected future conditions, or may need to be modified to include features associated with future projects or management actions. To the extent that any modifications are made, new data needs and data gaps may be revealed. A schematic representation of all the required water use sectors occurring in the Madera Subbasin was prepared (**Figure 4-2**) to illustrate the full complexity of the subbasin water budget resulting from the GSP regulations, and to serve as a basis for identifying all of the inflows and outflows (by water source type) that need to be quantified for the subbasin water budget. This serves as a comprehensive checklist for identifying data needs.

The lateral extent of the basin is consistent with that defined in **Section 3**, as described under the HCM (§354.14) portion of the GSP regulations. The conceptual model developed conforms to the lateral boundaries of the basin as provided in the recent DWR Bulletin 118 update (DWR, 2016). The vertical basin boundary, or definable bottom of the basin, was also defined in the HCM (**Section 3**). The vertical extent of the basin can be subdivided into a surface water system and groundwater system, with separate water budgets prepared for each; together these represent the overall subbasin water budget.

The surface water system is represented by water at the land surface and within the root zone within the lateral boundaries of the basin. Surface water systems include irrigated lands, lakes, streams, springs, and man-made conveyance systems and near-surface processes such as stream underflow, infiltration from surface water systems or outflow due to evapotranspiration from the root zone. The groundwater system is represented by that portion of the basin from the bottom of the root zone to the definable bottom of the basin and within the lateral boundary of the basin. The following sections focus on the surface water system and describe the basis for identifying accounting centers, flow paths, the preliminarily identified base period and time step and the data gap assessment.

4.1 Accounting Centers

Accounting centers represent subareas (volumes) within the larger water budget domain defined by water use sectors identified in the GSP regulations. In the GSP regulations, water use sectors are 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." Thus, comprising the overall water budget for each subbasin are subbudgets representing each water use sector.

Land uses based on the most recent DWR Madera County land use survey (2011) are summarized (**Table 4-1**) to identify which of the water use sectors cited in the GSP regulations occur within the Madera

Subbasin. Agriculture is by far the dominant land use in the Madera Subbasin covering nearly 207,100 acres of the approximately 347,600 acres comprising the subbasin. Native vegetation covers approximately 95,500 acres, followed by urban areas at about 30,900 acres. The semi-agricultural land use category defined by DWR includes dairies, farmsteads, feedlots, poultry farms, and small roads and ditches etc. (**Table 4-2**). These are generally small areas scattered across the subbasin supplied primarily by groundwater. The dairies, feedlots, poultry farms, farmsteads without a residence and small roads and ditches were included in the agricultural water use sector as a semi-agricultural land use type. Farmsteads with a residence were included with the agricultural water use sector as a rural residential land use. The native water surface class includes subclasses for natural streams and lakes and water channels used for conveyance (**Table 4-3**), which provide one estimate of the surface area for the rivers and streams system and conveyance system accounting centers, respectively.

4.2 Management Areas

Subdividing the agricultural land use area into subareas having access to surface water and groundwater versus areas with access only to groundwater is often useful for characterizing groundwater recharge and management. The recent land use surveys described above do not contain sufficient information to map subareas having access to surface water versus groundwater only. However, using the area served by Madera Irrigation District and other Water Districts in the subbasin and available information on water rights from the State Water Resources Control Board (SWRCB) these subareas can be mapped. This subdivision and any additional subdivision by management area should be made in consultation with the County and Coordinating Committee during development of the GSP. More information will be available then to define management areas that will best support characterization of baseline, historical, and current conditions and support the identification and evaluation of potential projects and management actions to achieve sustainability as part of GSP implementation.

4.3 Flow Paths

Subbasin boundary inflows and outflows must be quantified according to Section §354.18(b) of the GSP regulations. These water budget components are often referred to as flow paths. The surface water boundary inflows and outflows and infiltration within the subbasin flowing into the underlying groundwater system (often referred to as deep percolation) must be tracked by water source type.

A water source type is defined in the GSP regulations as: "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 the Central Valley Project (CVP), the State Water Project (SWP), the Colorado River Project (CRP), local supplies, and local imported supplies." Additionally, recycled water is defined in subdivision (n) of §13050 of the Water Code as "water that, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur, and is therefore considered a valuable resource." Reused water generally refers to water that has been applied to and subsequently runs off of agricultural fields that is of suitable quality to be reused on the same or other agricultural fields. The Madera Subbasin water budget includes the following water source types: surface water from the CVP (the Madera Canal and Hensley Lake), local supplies (San Joaquin River, Dry Creek, Cottonwood Creek, and Berenda Creek), and local imported supplies (occasional small volumes of water transfers), and groundwater. Reused water is not included because, although there is some reuse of agricultural supplies within the subbasin, there are no reused supplies coming from outside the subbasin. Additionally, based on information received from the City of Madera, all treated wastewater from the city is disposed in percolation ponds as groundwater recharge rather than being used as a recycled water supply.

In some years, winter precipitation exceeds reservoir storage and flood flows are released from Hensley Lake on the Fresno River and Millerton Lake on the San Joaquin River. These flood flows may be available for managed recharged by entities in the subbasin and are included in the water balance as a separate source type.

A total of about 60 flow paths are represented in the Madera Subbasin water budget (**Figure 4-2**) to account for the water use sectors and water source water types required by the GSP regulations. A schematic of the general water budget structure (representing all applicable land uses) is also presented in **Appendix G**, along with more easily readable individual water budget structures for each water use sector included in the GSP regulations and occurring in the subbasin.

4.4 Time Period and Time Step

The GSP regulations require that the most recent available information be used to characterize current conditions and that at least the most recent ten years of information be used to characterize historical (or baseline) conditions. Based on review of the local and public data collected, it is been determined that at least a 27-year historical water budget can be developed for the Madera Subbasin at the subbasin boundary level.

In accordance with GSP regulations, a base period must be selected so that the analysis of sustainable yield is performed for a representative period, with minimal bias that might result from the selection of an overly wet or dry period while recognizing changes in other conditions including land use and water demands. The base period should be selected considering the following criteria: long-term mean annual water supply; inclusion of both wet and dry stress periods, antecedent dry conditions, adequate data availability; and inclusion of current hydrologic, cultural, and water management conditions in the basin. To develop a preliminary base period to be used for sustainability analyses during GSP development, historical precipitation records for the area were evaluated.

Precipitation provides an indication of the long-term mean water supply and potential for natural groundwater recharge. Monthly precipitation records acquired from the Western Regional Climate Center for a station in Madera (Station 045233) were analyzed for the period 1928 through 2015. A plot with annual precipitation, mean annual precipitation, and cumulative departure[2] from mean annual precipitation were developed for the Madera station and is presented in **Figure 4-3**.

Notable on this plot is the long-term overall average period from the late 1920s through the late-1970s (overall flat cumulative departure curve), followed by a somewhat wet period during the late-1970s and early-1980s, dry late-1980s, wet 1990s, overall average from late 1990s to 2011, and recently a dry period from 2012 through 2015. The period of 1989 to 2015 is a relatively balanced climatic period with a similar number of wet and dry years and some prolonged periods of wet, dry, and average conditions and represents a reasonable base period for conducting sustainability analyses. Nevertheless, the net negative slope of the cumulative departure curve over this period suggests that precipitation inputs to the subbasin over the 1989 to 2015 period were on the whole a little below average (relative to the entire 1928-2015 period).

Antecedent (i.e., prior or left-over year) dry conditions minimize differences in groundwater in the unsaturated zone at the beginning and at the end of a study period. Given that the measure of water in

[2] Cumulative departure curves are useful to illustrate long-term rainfall characteristics and trends during drier or wetter periods relative to the mean annual precipitation. Downward slopes of the cumulative departure curve represent drier periods relative to the mean, while upward slopes represent a wetter period relative to the mean.

the unsaturated zone is nearly impossible to determine, particularly at the scale of a groundwater subbasin, selection of a base period with relatively dry conditions antecedent to the beginning and end of the period of record is preferable in that any water stored in the unsaturated zone is minimized. In this case, the proposed base period from 1989 to 2015 begins in a dry year with one additional prior dry year and ends in a dry year with several prior dry years.

The available hydrologic and land and water use data over the period are sufficient to calculate the various parameters used to analyze groundwater conditions as related to the groundwater budget and sustainability (e.g., precipitation, streamflow, land uses, groundwater pumping, groundwater levels, and imported water sources). Lastly, the proposed base period ends near the present time, so that the study period can be used to assess groundwater conditions as they currently exist. Given these criteria, the base period of 1989 to 2015, provides an appropriate base period for assessing groundwater conditions with minimal introduced bias from land use changes or imbalances due to wet or dry conditions. Although the evaluation of the precipitation data at Madera suggest that 1989 through 2015 represents a good base period of 27 years for conducting GSP analyses, additional consideration with respect to the base period should be given during the GSP development as additional data review is conducted. In particular, consideration should be given to the patterns of CVP supplies and to local supplies from Hensley Lake, which may or may not be strongly correlated with local precipitation. Ultimately, the base period may be selected based on some combination of these and/or other factors to define a period that is normal for the subbasin from a water budget perspective.

The GSP regulations require that evaluation of water budgets under projected future conditions utilize 50 years of historical hydrology (precipitation, evapotranspiration and streamflow) information. Review of available data indicates that at least a 75-year hydrologic record can be utilized for such analyses in the Madera Subbasin.

The GSP regulations also specify that sustainability analyses be conducted on at least an annual time step. A monthly time step is recommended to support evaluation of sustainability indicators, and potential projects and management actions. These sustainability evaluations, which may include analyses involving hydrologic modeling, will require data and analyses at a time step sufficient to assess conditions and trends within an annual interval in addition to longer-term trends.

4.5 Water Budget Data Gap Assessment

A data gap is defined in the GSP Regulations as: "a lack of information that significantly affects the understanding of the basin setting or evaluation of the efficacy of Plan implementation, and could limit the ability to assess whether a basin is being sustainably managed." As described in the previous sections, the data needed to complete the water budget have been identified through the process of reviewing the land use in the subbasin to identify water use sectors, reviewing the source water types available for use in the subbasin, and developing water budget schematics identifying all the relevant flow paths. Once all the flow paths were identified, the data types needed to support quantification of each flow path were reviewed. After compiling all the data collected from local and publicly available sources, the quantity and quality of the data were assessed to identify data gaps.

The primary data types required for the subbasin water budget include: (1) topography and boundaries; (2) surface soil properties; (3) land use; (4) water use; (5) meteorological data (primarily precipitation, air temperature and reference ET); (6) surface water inflows, including streamflows and identified water source types; (7) surface water outflows, including streamflows and identified water source types; (8) agricultural groundwater pumping; (9) applied water; (10) surface water diversions; (11) municipal and industrial pumping; and (12) rural residential pumping. Additional data types needed primarily for the

HCM and groundwater conditions are discussed in the HCM section. Local data and publicly available data for each of these twelve primary data types needed to develop the current, historical, and projected water budgets were reviewed and assessed for data gaps (**Table 4-4**). Generally, sufficient data exist for all of the necessary data types to complete the required water budget analyses. However, some degree of data quality control and data analysis will be required to develop estimates for relatively short, intermittent periods of missing data to produce complete, quality controlled, data sets. Meteorological data, surface water inflows and surface water outflows are discussed in more detail in the following paragraphs.

The locations of streamflow measurements and meteorological stations with respect to subbasin boundaries are shown in **Figure 4-4**. It is evident that the streamflow measurement sites are not always on the subbasin boundary, but they are generally close enough to boundaries to provide sufficiently representative information for the water budget. The Madera station has sufficient records to provide the necessary data for the Madera Subbasin water budget (**Table 4-5**).

The main surface water inflows into the subbasin are the Fresno River, San Joaquin River, and CVP water supplies in the Madera Canal. Local agency records for the last 43 years and 44 years are available for these two sources, respectively (**Table 4-6**). A longer record for the Fresno River has been developed for use in DWR's C2VSim model and is publicly available. A longer record for the CVP water supplies entering the subbasin is also available. The remaining surface water inflows in the table are minor, only flowing occasionally (like Cottonwood Creek), occurring along subbasin boundaries, or crossing only a short distance into the subbasin.

The main surface water outflows from the subbasin are the Fresno River, Chowchilla Bypass, Cottonwood Creek, Berenda Creek, Dry Creek, and San Joaquin River. Limited records of outflow are available in the DWR Water Data Library and California Data Exchange Center (CDEC) (**Table 4-7**). Madera Irrigation District has a recorder just outside the subbasin boundary where the Fresno River joins the Chowchilla Bypass. The outflows are often dry and additional research for flow records and analysis will be required to complete the record.

Table 4-1
DWR Land Use and Corresponding SGMA Water Use Sector and Accounting Center

SGMA Water Use Sector/Accounting Center	DWR Land Use Class	Area, acres
Agriculture	Agriculture*	207,109
Native Vegetation	Native Vegetation	95,482
Urban	Urban	30,906
Agriculture	Semi agricultural	5,639
Conveyance System/River & Stream System	Water Surface**	4,658
Industrial	Industrial	2,285
River & Stream System	Native Riparian	1,608
	Total**	347,686

*Native pasture NOT included
**The total land use area is slightly more than the Madera Subbasin because Madera Lake is included.

Table 4-2
DWR Semi-Agricultural Land Use Subclasses and Assigned Agricultural Land Use Types

CLASS1	SUBCLASS1	DWR Land Use Description	Assigned Land Use Type	Area, acres
S	1	Farmsteads (includes a farm residence)	Rural Residential	2,122
S	6	Miscellaneous semi-ag (small roads, ditches, non-planted areas of cropped fields	Semi-agricultural	1,120
S	3	Dairies	Semi-agricultural	1,071
S	4	Poultry Farms	Semi-agricultural	581
S	5	Farmsteads (without a farm residence)	Semi-agricultural	545
S	2	Livestock feed lot operations	Semi-agricultural	199
			Total:	5,639

Table 4-3
DWR Native Water Surface Subclasses and Assigned Agricultural Land Use Types

CLASS1	SUBCLASS1	DWR Land Use Description	Accounting Center	Area, acres
NW	2	Water channel (all sizes - ditches and canals - delivering water for irrigation and urban use – i.e., State Water Project, CVP, water district canals, etc.)	Conveyance System	2,284
NW	4	Freshwater lake, reservoir, or pond (all sizes, includes ponds for stock, recreation, groundwater recharge, managed wetlands, on-farm storage, etc.)	River & Stream System	1,239
NW	1	River or stream (natural fresh water channels)	River & Stream System	1,011
NW	6	Wastewater pond (dairy, sewage, cannery, winery, etc.)	Agricultural	124
			Total:	4,658

Table 4-4
Water Budget Data Gap Assessment

Data Type	Relevant GSP Regulation	Data Source	Data Use	Data Gap Assessment	Data Gap Assessment-Detailed Comments	Future Needs
Topography*	§ 354.18	USGS	Assign topography characteristics	NO GAPS		
Surface Soil Properties**	§ 354.18	NRCS, SSURGO	Assign soil characteristics	NO GAPS		
Land Use	§ 354.18	USDA, DWR, Counties, Local Agencies	Assign land use to each GW model element each year for 30-year historical run	Sufficient data with analysis	Spatial data available for 1995, 2001 (Madera County), 2007-2016 (Madera and Merced Counties), crops by area available 1980-2015 for use to develop annual spatial coverages for years without spatial data	Continue collecting spatial crop information
Water Use	§ 354.18	DWR, USGS	Estimates of water use	Sufficient data with analysis	Use standard, accepted ASCE Manual 70 methods to develop estimates of ET of applied water	
Meteorological	§ 354.18	CIMIS, NOAA, PRISM	Develop historical ET by crop and precipitation for 30-year historical run	Sufficient data with analysis	Use standard, accepted ASCE Manual 70 methods to develop ET_o and precipitation daily time series from available weather data	Continue support of Madera CIMIS station
Surface Water Inflows	§ 354.18	USGS, CDEC	Develop water budget for 30 years	Sufficient data with analysis	Use standard, accepted methods to estimate missing record	Continue support of stream gaging and water measurement
Surface Water Outflows	§ 354.18	USGS, CDEC	Develop water budget for 30 years	Sufficient data with analysis	Use standard, accepted methods to estimate missing record	Continue support of stream gaging and water measurement
Agricultural Groundwater Pumping	§ 354.18	Analysis and reports	Develop water budget for 30 years	Sufficient data with analysis	Use standard, accepted methods to estimate historical groundwater pumping	Continue to estimate using accepted method
Applied Water	§ 354.18	Local Agencies	Develop water budget for 30 years	Sufficient data with analysis	Use standard, accepted methods to estimate missing record	Continue collecting applied water data
Surface Water Diversions	§ 354.18	Local Agencies	Develop water budget for 30 years	Sufficient data with analysis	Use standard, accepted methods to estimate missing record	Continue collecting surface water diversion data
M&I Groundwater	§ 354.18	Local Agencies	Develop water budget for 30 years	Sufficient data with analysis	Use standard, accepted methods to estimate missing record	Continue collecting groundwater pumping data
Rural Residential Pumping	§ 354.18	DWR, State Dept. of Finance	Develop water budget for 30 years	Sufficient data with analysis	Use standard, accepted methods to estimate rural residential pumping	

*Also required for HCM and groundwater conditions

** Also required for HCM

Table 4-5
Climate Data Summary

Data Source*	Station Name	Station Number	Begin Date	End Date	Time step	Number of Years
CIMIS	Los Banos	56	6/28/1988	2/23/2017	Daily	29
CIMIS	Merced	148	1/4/1999	2/23/2017	Daily	18
CIMIS	Madera	145	5/13/1998	3/27/2013	Daily	15
CIMIS	Madera II**	188	4/2/2013	2/23/2017	Daily	4
NOAA	MADERA CA US	USC00045233	1/1/1928	2/20/2017	Daily	89
NOAA	CHOWCHILLA 0.3 E CA US	US1CAMA0008	1/1/2015	2/22/2017	Daily	2
PRISM	Raster (4 km resolution)		1/1/1981	12/31/2016	Daily	36
PRISM	Raster (4 km resolution)		1/1/1895	12/31/1980	Monthly	85

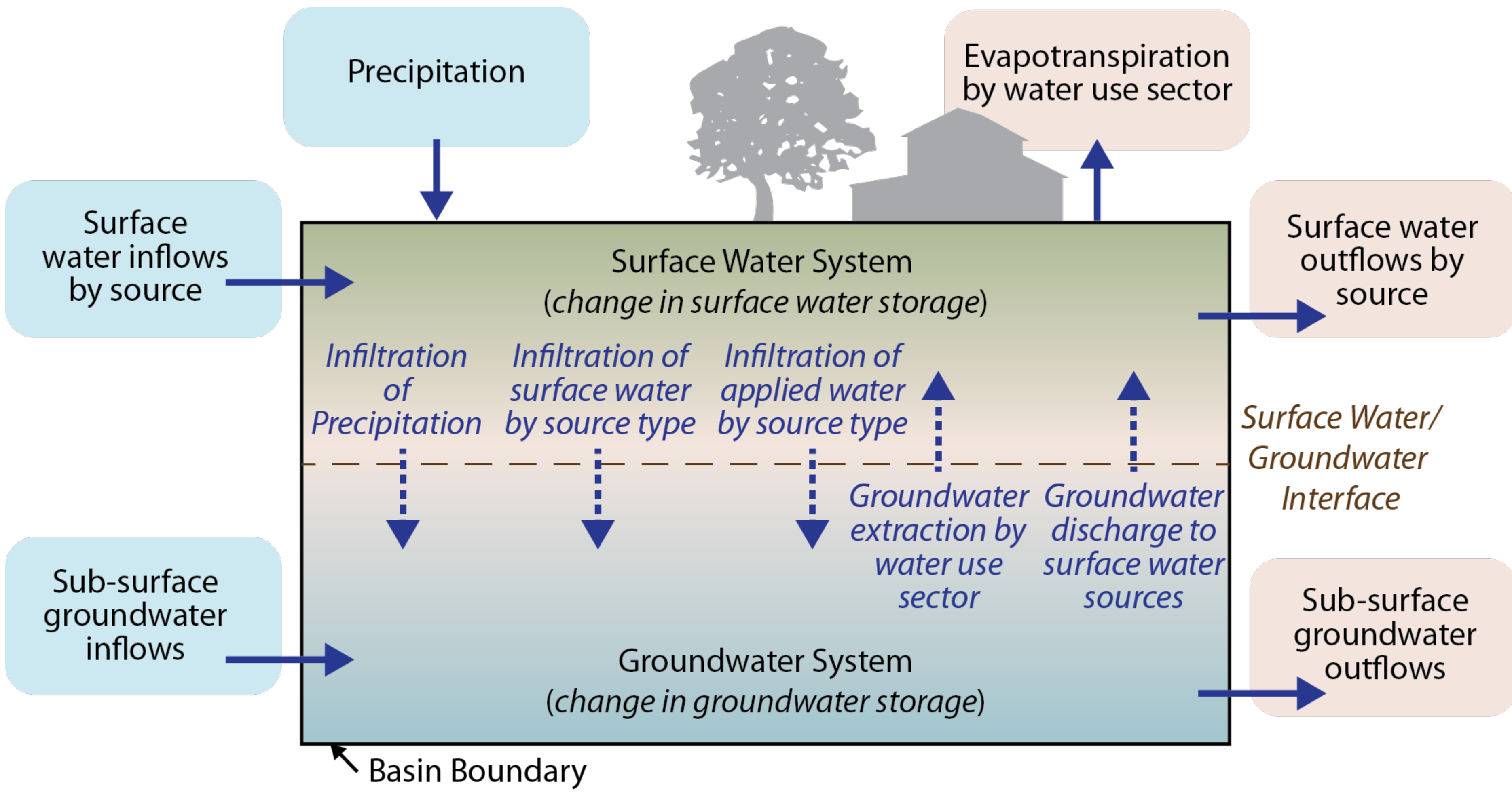
*CIMIS Includes reference ET, precipitation and required weather measurements to calculate reference ET.
**Madera Station was moved two miles from previous location in the spring of 2013
NOAA includes minimum, maximum and average temperature and precipitation unless noted otherwise.
PRISM includes precipitation, minimum, maximum and average temperature, mean dewpoint temp, minimum and maximum vapor pressure deficit, and elevation. Due to use of weather stations in non-agricultural settings, an aridity assessment is required before using this data.

Table 4-6
Surface Water Inflow Summary

Flowpath Name	Station Name	Source	Begin Date	End Date	Number of Years
Madera Canal	MADERA CN A FRIANT CA	USGS	1/1/1970	9/30/2016	47
Cottonwood Creek	Recorder 14: Cottonwood Creek Head	Madera Irrigation District	1/1/1998	2/20/2017	19
Fresno River	Fresno River below Hidden Dam/ Hidden Dam, Hensley Lake	USGS / CDEC	10/1/1941	5/24/2017	76
Dry Creek	Recorder 5: Dry Creek Head Flood Water	Madera Irrigation District	2/1/1966	2/20/2017	51
Chowchilla Bypass	Chowchilla Bypass at Head Below Control Structure (CBP)	DWR Water Data Library	11/14/1982	9/29/1991	9
Chowchilla Bypass	Chowchilla Bypass at Head Below Control Structure (CBP)	CDEC	6/20/1997	6/30/2017	20
Berenda Creek	Recorder 13: Berenda Creek Head	Madera Irrigation District	1/1/1970	12/31/2004	35
San Joaquin River	San Joaquin River Below Friant	USGS	1/1/1920	3/12/2017	97

Table 4-7
Surface Water Outflow Summary

Flowpath Name	Station Name	Data Source	Begin Date	End Date	Num. Years	Notes
Chowchilla Bypass	No Measurement					
Fresno River	Recorder 4 (Fresno River Rd. 16)	Madera Irrigation District	1/1/1951	3/27/2017	66	
Madera Canal	Class 1 and Class 2 Deliveries to Chowchilla Water District	Madera Irrigation District	1973	2016	43	
Berenda Creek	Recorder 2: Berenda Creek Spill	Madera Irrigation District	1/1/1966	7/12/2017	52	
Dry Creek	Recorder 4 (Fresno River Rd. 16)	Madera Irrigation District	1951	2004	53	
San Joaquin River	San Joaquin River at Gravelly Ford (GRF)	CDEC	6/27/1997	7/12/2017	20	
Chowchilla Bypass	Chowchilla Bypass near Subbasin Boundary	Proposed New Site				Improved and more complete information on surface water outflows
Fresno River	Fresno River near Subbasin Boundary	Proposed New Site				Improved and more complete information on surface water outflows
Berenda Creek	Berenda Creek near Subbasin Boundary	Proposed New Site				Improved and more complete information on surface water outflows



(Source: DWR SGMA Water Budget BMP, 2016)

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FIGURE 4-1

Required Water Budget Components

Madera County: Madera Subbasin
SGMA Data Collection and Analysis

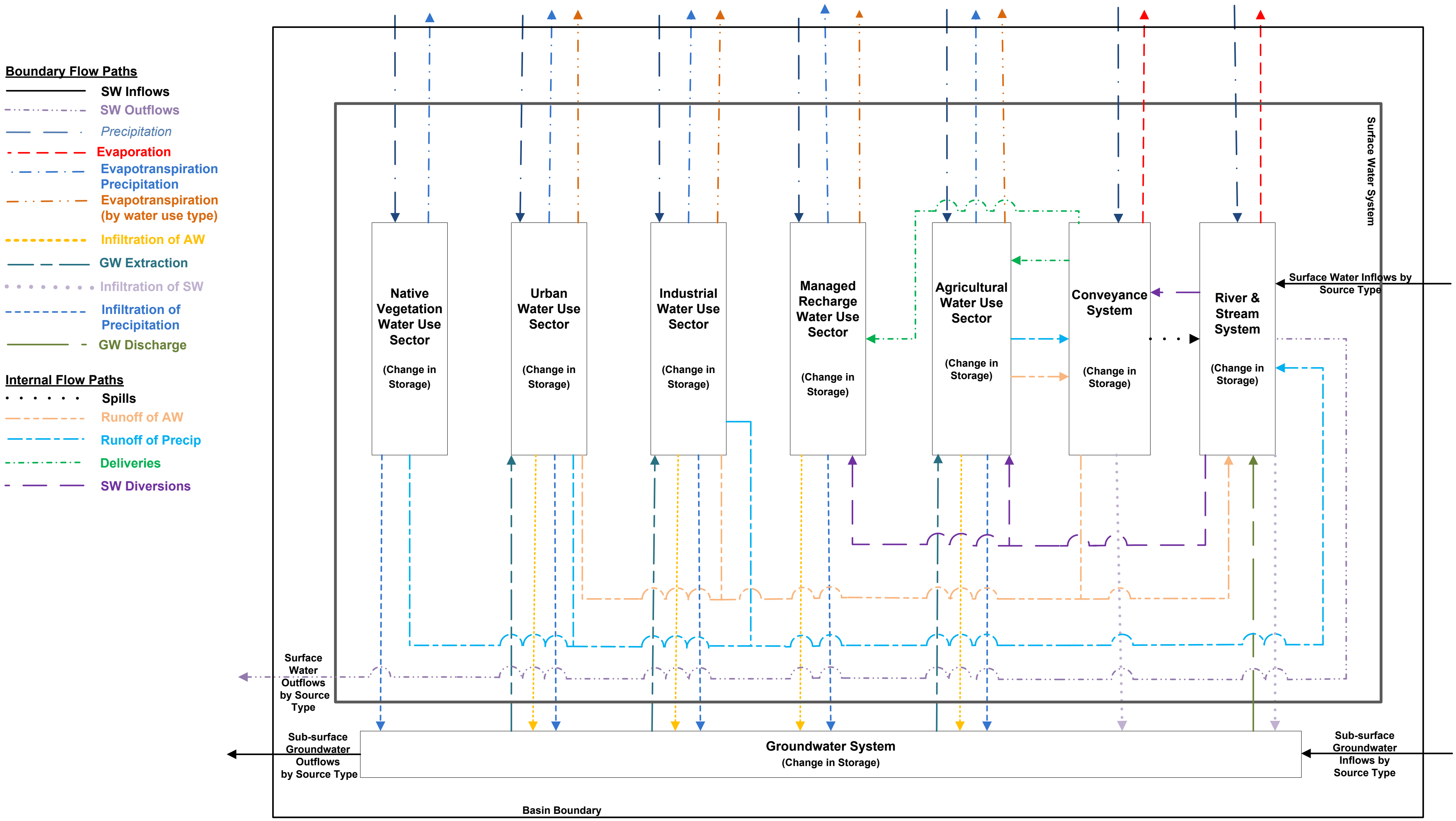

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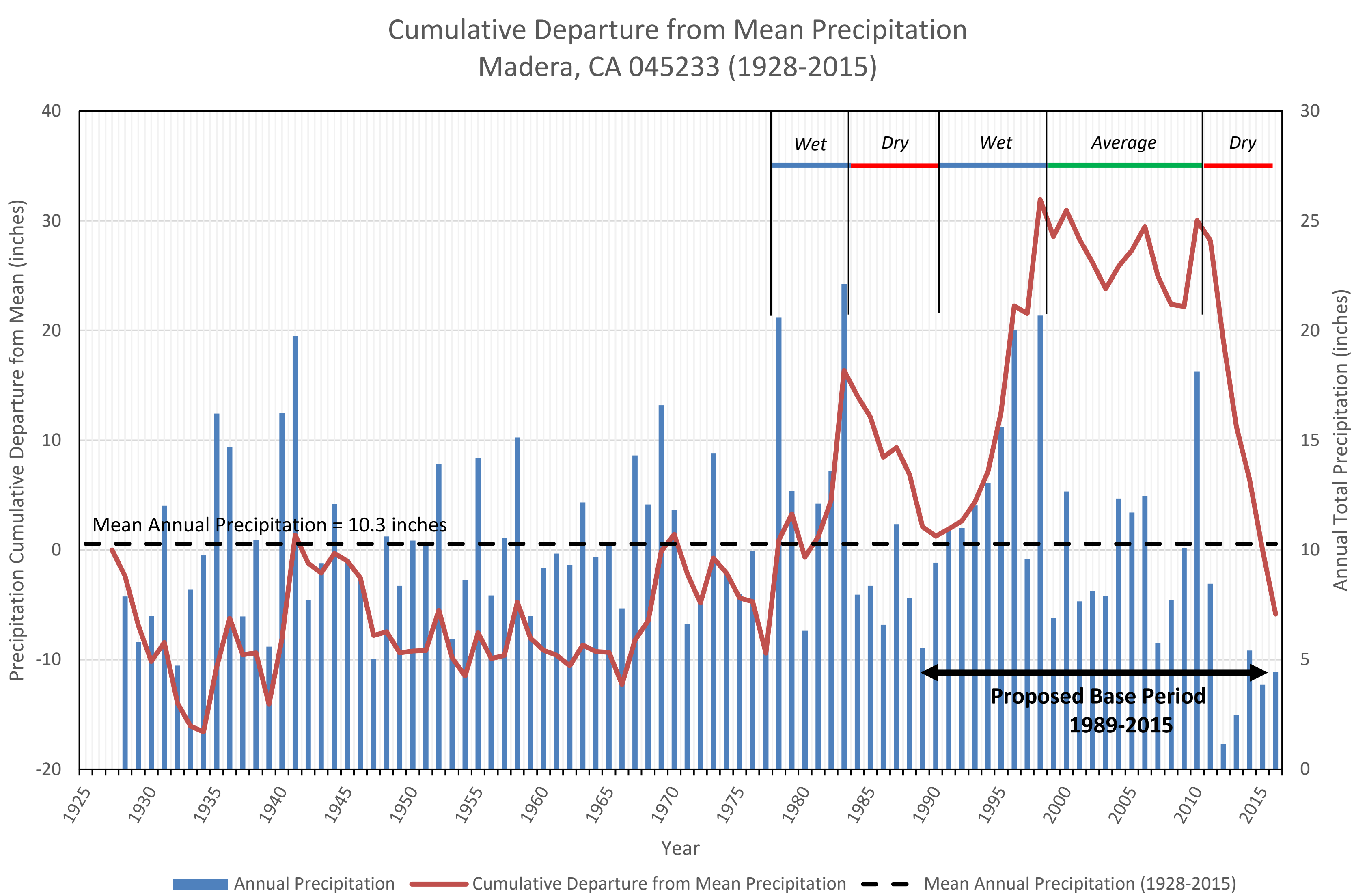
FIGURE 4-2
Complete Water Budget for the Madera Subbasin Including All Water Use Sectors Required by the GSP Regulations
Madera County: Madera Subbasin
SGMA Data Collection and Analysis



(Precipitation data from Western Regional Climate Center, 2017)

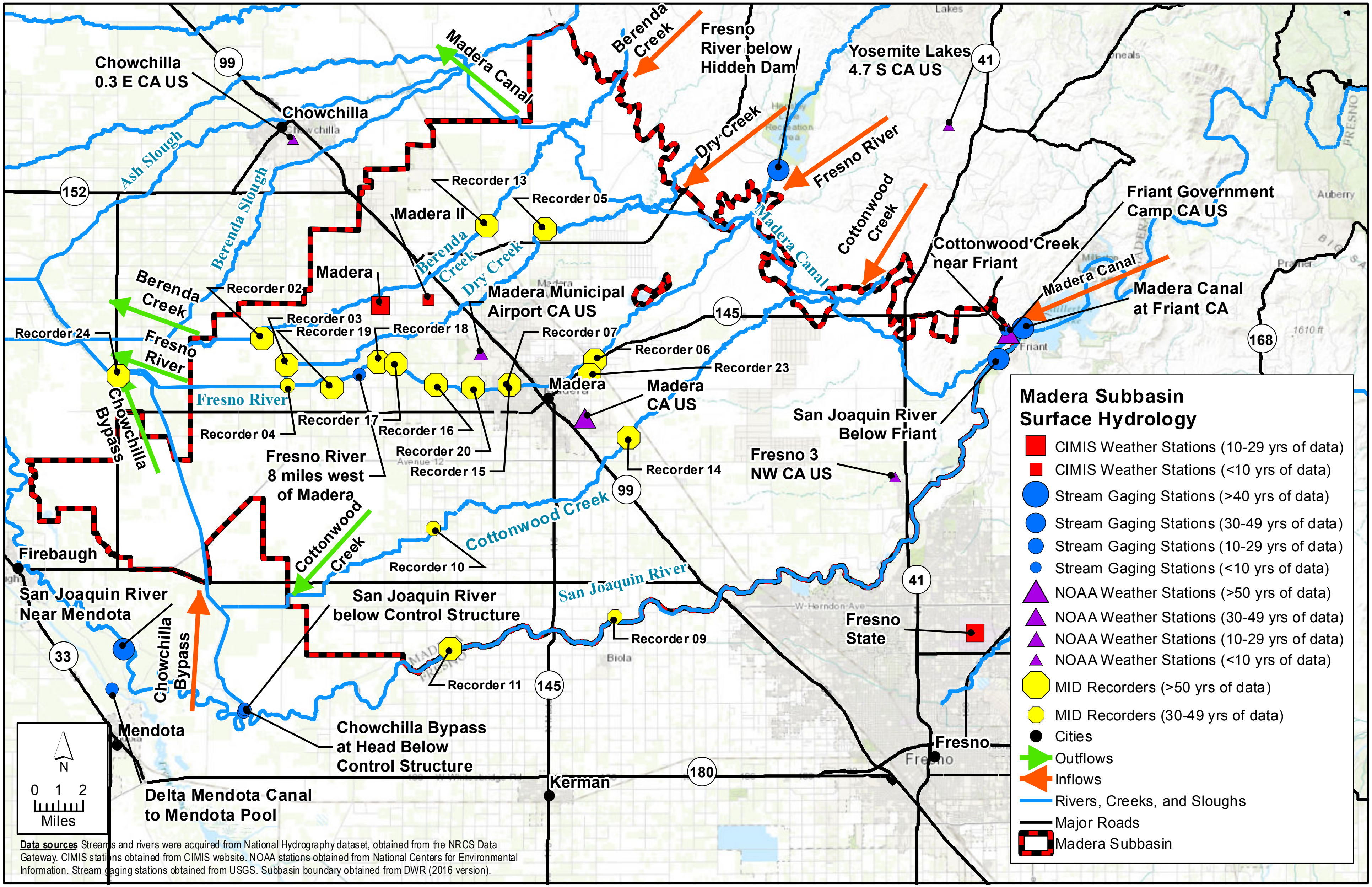


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FIGURE 4-4

Madera Subbasin Surface Hydrology Map

Madera County: Madera Subbasin
SGMA Data Collection and Analysis

5 DATA GAP SUMMARY AND RECOMMENDATIONS

5.1 Hydrogeology Data Gap Summary

Seven data types identified as needing some analysis were evaluated with respect to the importance of the data for developing the HCM (geologic and groundwater conditions) and a reconnaissance level cost estimate was assigned for filling each data gap (**Table 5-1**). These data gaps were identified based, in part, on review of GSP regulations and the GSP element guide for the HCM, groundwater conditions, and water budget (Subarticle 2) provided in **Appendix H**. Although not included in **Appendix H**, our review of GSP regulations and the GSP element guide for data gaps included review of other GSP sections on Sustainable Management Criteria (Subarticle 3) and Monitoring Networks (Subarticle 4), and the required data types for these GSP sections were similar to those required in Subarticle 2.

The actions necessary to fill the data gaps include analyses utilizing data compiled for this study, obtaining and evaluating data that will soon be available, and field work involving drilling and installation of new monitoring wells. Prioritization of data gaps was based on: (1) the overall importance of each identified gap, and (2) the timing sequence and importance of filling the data gap as soon as possible. A simple three level priority system of low, medium, and high was used to rank the data gaps.

As noted in **Table 5-1**, the highest data gap priority was assigned to groundwater levels and quality. Filling data gaps in the network for historical and future groundwater level and quality monitoring for the GSP can be accomplished with a combination of the following:

1) Identifying DWR well completion reports (with construction details) to match existing wells with historical data and unknown construction details that are currently in the monitoring network (this task can be conducted utilizing data in this TM);
2) Existing wells with no historical data and known construction details that can be added to the monitoring network (this task can be conducted utilizing data collected in this TM);
3) New dedicated monitoring wells can be installed to supplement the existing monitoring well network (additional discussion regarding recommendations for locations of potential new monitoring wells is provided below).

A more complete understanding of historical groundwater levels in the two major aquifers requires improvement in the dataset of existing wells with known well construction details. While new dedicated monitoring wells provide important benefits for the future GSP monitoring program, new monitoring wells will not help with characterization of historical groundwater levels. Historic groundwater levels specific to the upper and lower aquifers are critical in development of the hydrogeologic conceptual model and for groundwater flow model calibration. Furthermore, existing wells with historical water level data provide the baseline for comparison with future basin conditions to evaluate effects of changed management practices. In accordance with the above discussion, a combination of matching existing wells with unknown construction details to DWR WCRs and installation of new dedicated monitoring wells to fill gaps in the monitoring well network are essential for the development of the GSP and its future monitoring network. Identification of additional existing wells with known construction details may limit the number of new dedicated monitoring wells that will be needed.

A medium data gap priority was assigned to compilation and assessment of GDE data when it becomes available from The Nature Conservancy/DWR. A low data gap priority was assigned to additional work on geologic cross-sections and aquifer parameters primarily because this work can be accomplished using data compiled for this study during GSP groundwater model development. If groundwater modeling is ultimately to be conducted as part of the GSP process, it is recommended that the following tasks be completed at the beginning of the modeling effort: 1) preparation of additional geologic cross-sections utilizing data compiled for this study (e.g., well completion reports obtained from DWR and any logs provided by local entities) to help define model layering throughout the subbasin, 2) and review of well completion reports to supplement the database for aquifer testing data to help define aquifer parameter zones.

The data gap assessment included review of available groundwater level data with respect to well locations, known well construction details, period of record, and availability of recent measurements. The available historical water level data have been compiled for the work documented in this TM. As indicated in **Figure 5-1** (all wells with measurements), there are many wells throughout the subbasin with historical records of water level measurements. However, a significant portion of these wells have unknown construction details and/or lack recent measurements. A map of wells with recent water level data (i.e., after 2010) and known construction details is provided in **Figure 5-2**. Wells to be included in the GSP monitoring network will require known construction details to facilitate an understanding of groundwater elevations in the upper aquifer versus the lower aquifer. At present, a major data gap is the lack of a sufficient spatial and vertical distribution of water level monitoring wells with known construction details.

Available groundwater quality data were also reviewed with respect to well locations, known well construction details, and period of record – with particular emphasis on TDS and nitrate. The available historical water quality data have been compiled for the work documented in this TM. As indicated in **Figure 5-3** (all wells with water quality data), there are many wells throughout the subbasin with historical records of water quality measurements. However, the majority of these wells have unknown construction details. A map of wells with groundwater quality data (TDS and/or nitrate) and known construction details is provided in **Figure 5-4**. Wells to be included in the GSP monitoring network will require known construction details to facilitate an understanding of groundwater quality in the upper aquifer versus the lower aquifer. At present, a major data gap is the lack of a sufficient spatial and vertical distribution of water quality monitoring wells with known construction details.

Based on this preliminary evaluation, recommended general locations for new monitoring wells are shown in **Figure 5-5** and described in **Table 5-2**. The recommended new dedicated monitoring well locations would fill in spatial and vertical gaps in the existing distribution of wells across the subbasin. The new monitoring wells should be drilled using methods that allow for collection of good geologic information that can be used to enhance the preliminary hydrogeologic conceptual model. A prioritization is provided in **Table 5-2** with consideration of areas lacking monitoring wells, providing better definition of groundwater level depressions, providing data to assess boundary inflows/outflows, and areas of potential groundwater-surface water interaction. Based on these factors, a higher priority was assigned to wells at sites 5, 6, 9, and 13. A medium priority was assigned to other wells.

It is recommended that new dedicated monitoring wells be installed as dual or triple completions to monitor water level differences in upper versus lower aquifer zones. Furthermore, these wells should be installed in accordance with DWR's BMP guidelines (DWR, 2016) and utilizing detailed engineering specifications that specify drilling methods, geophysical logging, geologic sample collection methods, construction materials, details of the well design, and well development methods. Examples of a typical monitoring well design for this purpose and associated construction specifications are included in **Appendix I**. The drilling contractor should be experienced with deep dual/triple nested monitoring well construction, and field work should be conducted under supervision of a professional geologist or engineer. Anticipated drilling contractor costs for a double or triple completion monitoring well typically range from $80,000 to $100,000, and geologist/engineer costs typically range from $15,000 to $25,000.

5.1.1 Hydrogeology Data Gap Recommendations

In summary, the following steps are recommended to fill existing data gaps:

- Conduct detailed review of DWR well completion reports acquired for this study and comparison of DWR well completion report locations to wells with water level data but unknown construction details to further expand the database of wells with known construction details.
- Conduct outreach with existing well owners that have wells with known construction details but are not currently part of the groundwater monitoring network. If the well owner is willing to participate and has a well that is representative of either the upper or lower aquifer (but not both), the well could be added to the GSP monitoring network.
- The remaining data gaps in the existing monitoring network (of wells with known construction details and recent measurements) could be filled with installation of new dedicated monitoring wells at locations where existing wells with known construction details are lacking.
- When statewide GDE mapping is published by The Nature Conservancy and DWR, compile a map of potential GDEs in the subbasin and conduct further analyses to determine which potential GDEs need to be addressed in the GSP.
- In the preliminary phase of groundwater model development, prepare additional geologic cross-sections as input to model layering.
- In the preliminary phase of groundwater model development, review DWR well completion reports to extract specific capacity data for incorporation in the aquifer parameter database to be used for development of aquifer parameter zones in the model.

5.2 Water Budget Data Gap Summary

This study provides preliminary water budget schematics for use during GSP development and reveals that QA/QC analysis is required for ten of the twelve water budget data types to develop complete, monthly data sets for the historical water budget. Additionally, three new stream gages to measure subbasin outflow are recommended. Prioritization of data gaps was based on: (1) the need for future monitoring, (2) the importance of each identified gap to reduce the uncertainty in the water budget, and (3) the cost of filling the data gap. A simple three level priority system of low, medium, and high was used with priority assigned based primarily on the importance of the data analysis to developing the water budget.

The data gap assessment involved reviewing the data acquired from local agencies and public sources for twelve data types required to complete the water budget and related analyses described in the GSP regulations. The highest priority data gap noted was a lack of surface water outflow stream gages on, or sufficiently close to, the subbasin boundaries. A major reason for this data gap is that these surface water outflow points are dry much of the time. It is recommended to add outflow stream gage sites on or near (depending on site conditions) the subbasin boundary for the Chowchilla Bypass, Fresno River and Cottonwood Creek. The estimated reconnaissance level (+/- 30%) cost is $30,000 per site to install all equipment and set up remote logging of data (USGS, 2017). Site visits are necessary to select locations and refine costs. Additional annual costs including establishing and maintaining a rating curve, site maintenance and logging of data are estimated to be between $15,000 and $18,000 (USGS, 2017).

Ten data types identified as needing QA/QC analysis (data types with no gaps were not evaluated) were evaluated with respect to the importance of the data for developing the water budget and a reconnaissance level cost estimate assigned for each required analysis. The required analysis consists of applying procedures to develop estimates to fill short, intermittent periods of missing data within the overall record.

Groundwater pumping data for agricultural water supply in the Madera Basin are not publicly available. Accepted practice to estimate agricultural groundwater pumping is to estimate total crop irrigation consumptive use based on information describing land use, weather (reference ET and precipitation), agronomic practices (leaching, frost protection, pre-irrigation, etc.), and on-farm irrigation water consumptive use fraction. Then, groundwater pumping is estimated as the total consumptive use, minus measured or estimated surface water deliveries. Sufficient information is available to develop a reasonably accurate estimate of groundwater pumping for purposes of water budget development using this accepted methodology.

To complete the water budget, complete monthly data sets are required for the initial 27-year base period described in **Section 4** (as it may be refined based in further analysis). Initially it is advisable to complete the water budget for the subbasin overall. The basin boundary water budget will provide useful information on the existence and magnitude of historical overdraft, and the types and scales of projects potentially needed to achieve subbasin sustainability.

For each of the ten data types requiring analysis, the data use and required analysis are briefly described in **Table 5-3**. Additionally, a reconnaissance level estimate of cost (+/- 30 percent) to complete the analysis for each data type is provided. It is recommended to assemble all available data related to surface water outflows and complete an analysis to develop a complete, monthly 27-year record including a flood flow analysis to estimate flood flows potentially available for managed recharge. If all of these analyses are completed as recommended, a subbasin boundary water budget can be assembled at an estimated cost of $160,000. This cost includes development of a complete, monthly time step for a 27-year basin boundary balance and includes development of a 50-year precipitation and reference ET time series for use in simulating future subbasin water budgets.

The individual flow path analyses and development of the basin boundary water budget are a medium priority. These analyses provide useful information regarding the water available for recharge and an initial estimate of historical subbasin overdraft. Accordingly, this information should be developed during initial steps of the GSP development.

The quality control and analysis to develop and complete a 27-year record for each data type analysis could be completed individually. From this perspective, developing estimates for surface water outflows should be the highest priority with the objective of developing an improved estimate of water potentially available for recharge. Two methods are considered for developing an improved estimate of the water available for recharge. One method is to collect all available data on inflows and outflows assembling the best possible record and then estimate missing outflows based on the relationship between inflows and outflows when both records are available. The second method is to complete the full water budget at the basin boundary level. The inflow-outflow method is estimated to cost about $15,000 and the water balance method is estimated to cost $160,000. The full water budget method provides additional benefits both in improved confidence in the estimated surface water outflows and provides useful information on sustainability and possible sustainability measures and projects.

5.2.1 Water Budget Data Gap Recommendations

In summary, subject to funding availability and other considerations that the local agencies may elect to apply, the following recommendations are made for addressing identified water budget data gaps:

- Install three additional outflow measurement sites, subject to site visits and additional evaluation, one each at the Chowchilla Bypass, Fresno River and Cottonwood Creek.
- Analyze available surface water outflow records and each of the three subbasin outflow sites, to synthesize a complete record of subbasin outflow to use in the subbasin boundary water budget.
- Once the development of subbasin outflows is complete, develop an initial subbasin boundary water balance.

Table 5-1
HCM Data Gap Evaluation of Importance, Priority, and Cost

Data Type	Data Use	Required Action/Analysis	Priority*	Estimated Cost
Geologic Cross Sections	Groundwater Model	Utilize compiled data (e.g., DWR WCRs) to construct additional geologic cross-sections	Low	$50,000-$70,000
Aquifer Parameters	Groundwater Model	Utilize compiled data (e.g., DWR WCRs) to obtain specific capacity data	Low	$25,000-$35,000
Groundwater Levels	HCM, Groundwater Model, GSP Monitoring Network	Review DWR WCRs to match with existing wells with water level data; identify existing wells to add to monitoring network	High	$30,000-$50,000
		Install new dedicated monitoring wells	High	$95,000-$125,000 per nested well
Groundwater Quality	HCM, Groundwater Model, GSP Monitoring Network	Review DWR WCRs to match with existing wells with water quality data; identify existing wells to add to monitoring network	High	Included in groundwater level cost
		Install new dedicated monitoring wells	High	Included in groundwater level cost
Groundwater Levels and Quality	HCM, Groundwater Model, GSP Monitoring Network	Conduct outreach with existing well owners. Identify wells with known construction details that are not currently part of the groundwater monitoring network. If the well owner is willing to participate and has a well that is representative of either the upper or lower aquifer (but not both), consider adding the well to the GSP monitoring network	High	$15,000-$25,000
Groundwater Dependent Ecosystems	HCM, Groundwater Model, GSP Monitoring Network	Evaluate potential GDEs mapped by TNC/DWR to determine if could be impacted by regional pumping	Medium	$20,000-$35,000

*All identified data gaps will need addressing for the GSP. Data gap priority is assigned based on relative importance and timing sequence.

Table 5-2
Recommended New Monitoring Well Locations, Priority, and Cost

New Monitoring Well*	Approximate Location	Purpose	Priority**	Estimated Cost
1	Southeast basin boundary	Groundwater Levels/Quality; Upper/Lower Semi-Confined Aquifer; contours missing in this area due to lack of data	Medium	$95,000-$125,000
2	Southeast basin	Groundwater Levels/Quality; Upper/Lower Semi-Confined Aquifer; limited wells in area	Medium	$95,000-$125,000
3	East basin boundary	Groundwater Levels/Quality; Upper/Lower Semi-Confined Aquifer; contours missing in this area due to lack of data	Medium	$95,000-$125,000
4	East of City of Madera	Groundwater Levels/Quality; Upper/Lower Semi-Confined Aquifer; lack of wells in area	High	$95,000-$125,000
5	South central basin boundary	Groundwater Levels/Quality; Upper/Lower Semi-Confined Aquifer; near San Joaquin River; base boundary flow	High	$95,000-$125,000
6	Northeast basin boundary	Groundwater Levels/Quality; Upper/Lower Semi-Confined Aquifer; limited wells in area; basin boundary flows; 2016 groundwater depression	High	$95,000-$125,000
7	Central basin; in City of Madera	Groundwater Levels/Quality; Upper/Lower Semi-Confined Aquifer; lack of upper aquifer wells in area	Medium	$95,000-$125,000
8	North central basin	Groundwater Levels/Quality; Upper/Lower Semi-Confined Aquifer; lack upper aquifer wells in area; basin boundary flows; 2016 groundwater depression	Medium	$95,000-$125,000
9	Central basin; west of City of Madera	Groundwater Levels/Quality; Upper/Lower Semi-Confined Aquifer; limited wells in area	High	$95,000-$125,000
10	Northwest basin boundary	Groundwater Levels/Quality; Upper Unconfined/Lower Confined Aquifers; limited wells in area; basin boundary flows; 2016 groundwater depression	Medium	$95,000-$125,000
11	West basin boundary	Groundwater Levels/Quality; Upper Unconfined/Lower Confined Aquifers; limited wells in area	Medium	$95,000-$125,000
12	Southwest basin boundary	Groundwater Levels/Quality; Upper Unconfined/Lower Confined Aquifers; lack of lower aquifer wells in area; basin boundary flows	Medium	$95,000-$125,000
13	West basin boundary	Groundwater Levels/Quality; Upper Unconfined/Lower Confined Aquifers; lack of wells in area	High	$95,000-$125,000

* New monitoring well numbers are identified on Figure 5-5.

** New monitoring well priority is assigned according to existing hydrogeologic data need and importance for future monitoring.

Table 5-3
Water Budget Data Gap Evaluation of Importance, Priority, and Cost

Data Type	Data Use	Required Action/Analysis	Priority	Estimated Cost
Surface Water Outflows	Fill data gap for future monitoring of surface water outflows	Add and maintain stream gage records on Cottonwood Creek, Chowchilla Bypass, and Fresno River (3 separate sites)	High	$90,000
			Subtotal for new stream gages*	$90,000
Surface Water Outflows	Develop historical data for 50 year period for planning and water budget for 30 years	Review available records and use standard, accepted methods to estimate missing records	High	$15,000
Meteorological	Develop reference ET by crop and precipitation for 50 year period for planning projections	Use standard, accepted ASCE Manual 70 methods to develop ET_o and precipitation daily time series from available weather data	Medium	$10,000
Surface Water Inflows	Develop water budget for 30 years and 50 year hydrology for planning projections	Review available records and use standard, accepted methods to estimate missing records	Medium	$5,000
Land Use	Assign land use to each water balance area each year for 30 year historical period	Based on available spatial data and crop reports, assign crops to water balance areas	Medium	$15,000
Water Use (Evapotranspiration)	Outflow from subbasin and basis for estimate of agricultural groundwater pumping	Root zone water balance based on meteorological, remotely-sensed energy balance ET estimates, and land use data to estimate crop water use.	Medium	$20,000
Surface Water Diversions	Develop water budget for 30 years	Review available records and use standard, accepted methods to estimate missing records	Medium	$30,000
Agricultural Groundwater Pumping	Develop water budget for 30 years	Use standard, accepted methods to estimate historical groundwater pumping	Medium	$15,000
Applied Water	Develop water budget for 30 years	Review available records and use standard, accepted methods to estimate missing records	Medium	$15,000
M&I Groundwater Pumping	Develop water budget for 30 years	Review available records and use standard, accepted methods to estimate missing records	Low	$10,000
Rural Residential Pumping	Develop water budget for 30 years	Use standard, accepted methods to estimate historical groundwater pumping	Low	$10,000
		Cost to assemble and document water budget		$15,000
			Subtotal	$160,000
			Total	$250,000

*Estimate of $30,000 per site includes final site selection plus instrumentation. Establishing a rating and continuing annual costs are estimated to be between $15,000 to $20,000.

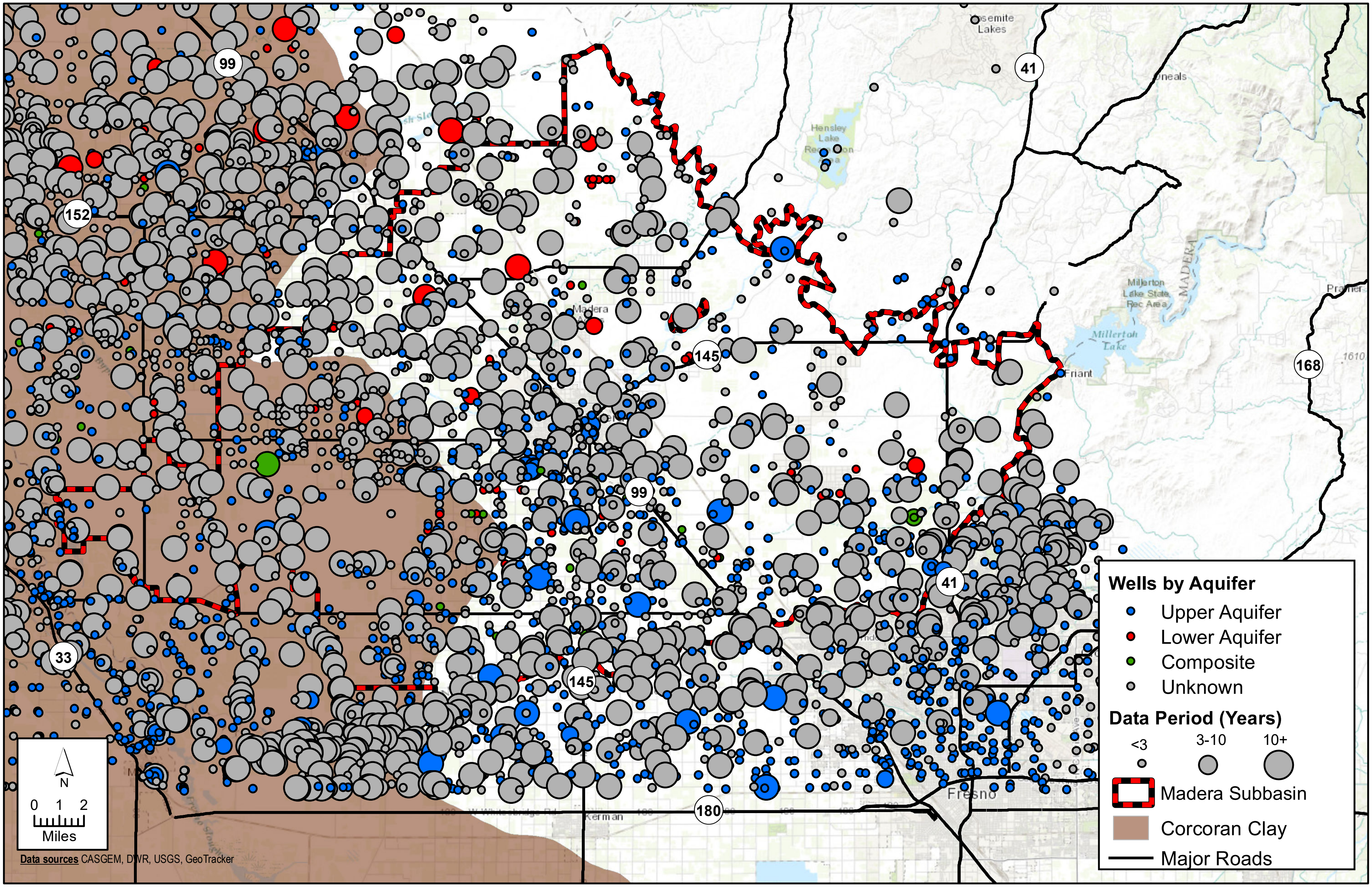

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FIGURE 5-1

Map of Known Wells with Water Level Data

Madera County: Madera Subbasin
SGMA Data Collection and Analysis

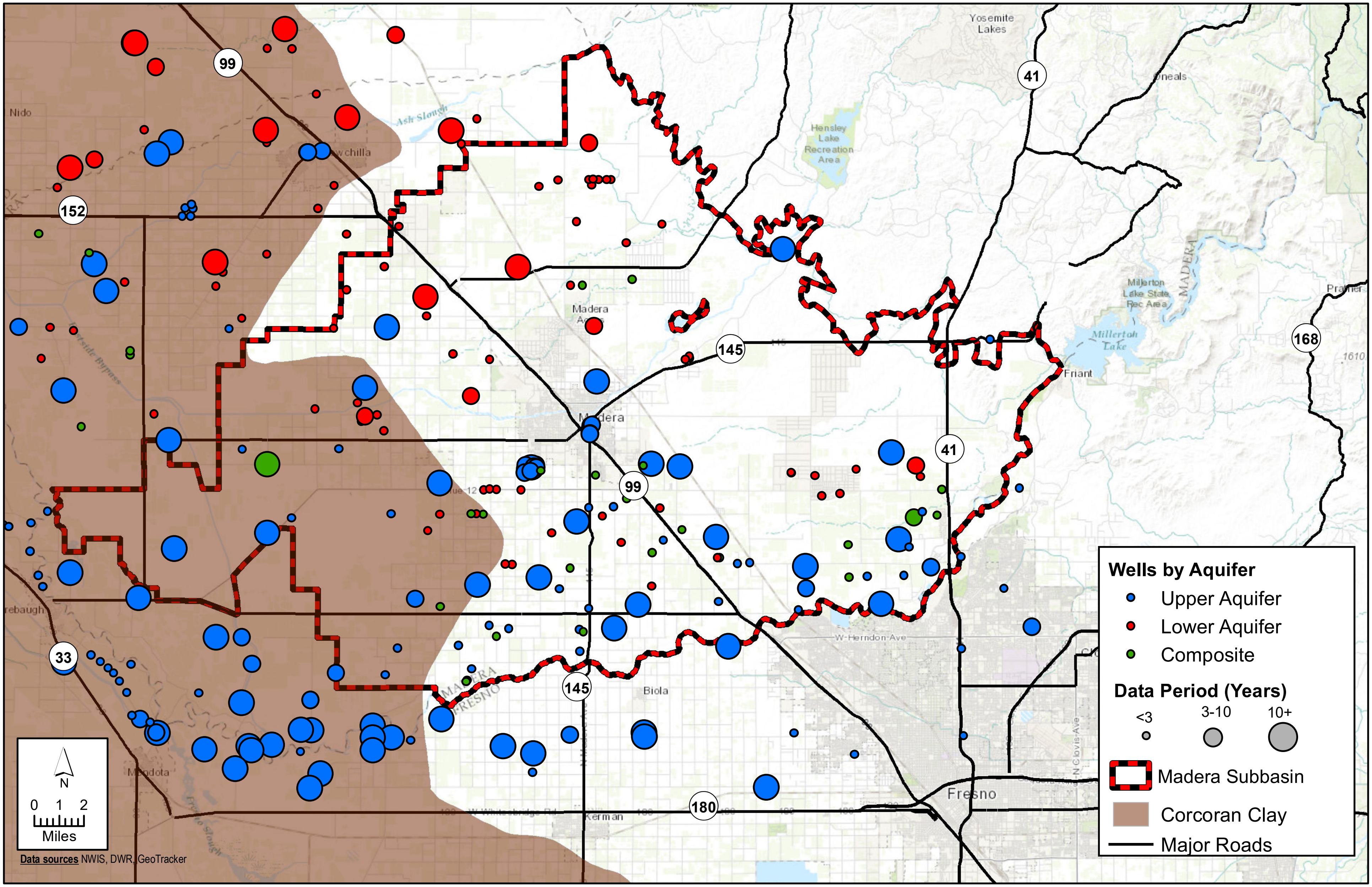

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FIGURE 5-2
Map of Known Wells with Recent Water Level Data and Construction Data

Madera County: Madera Subbasin
SGMA Data Collection and Analysis

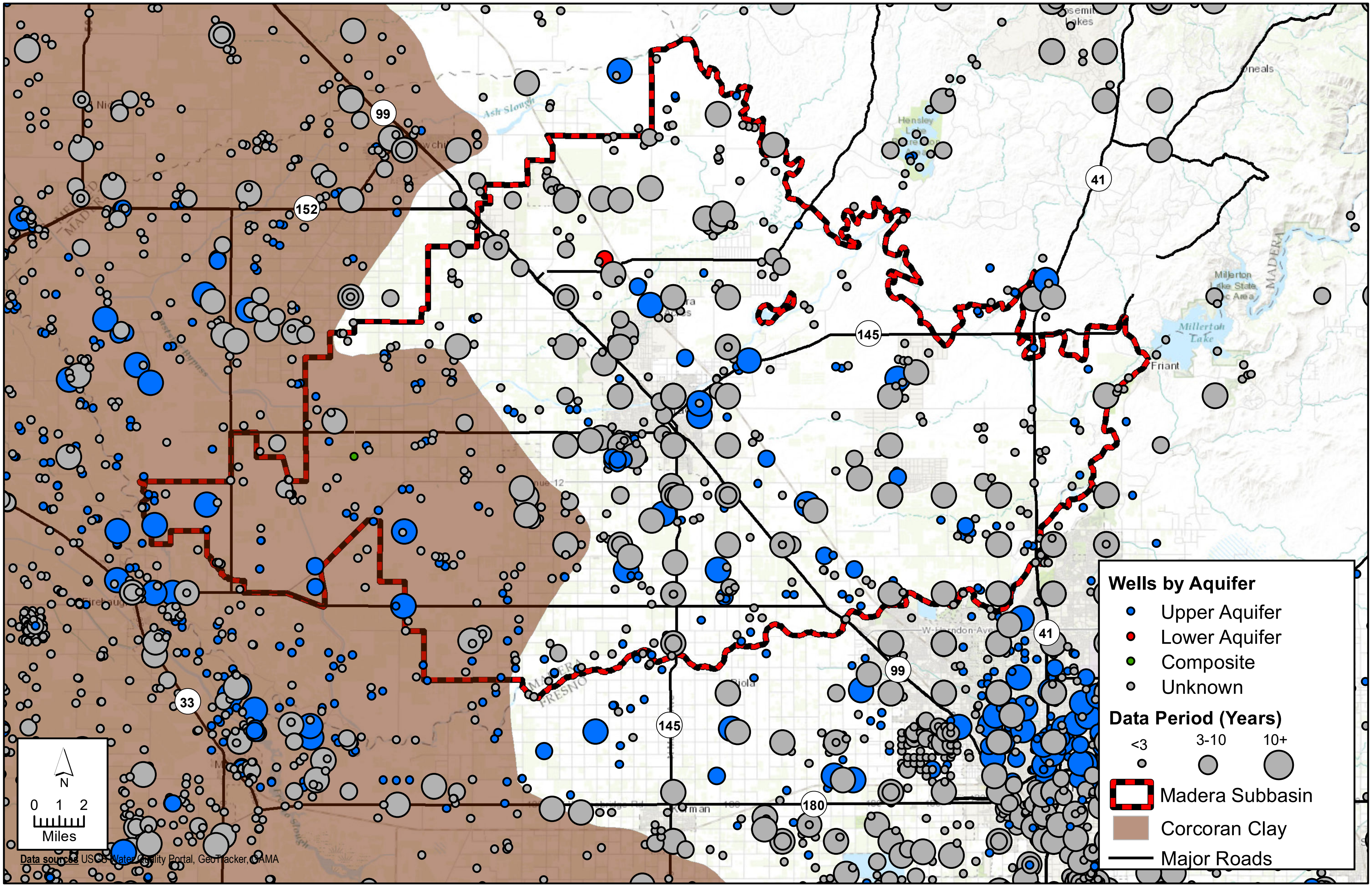

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FIGURE 5-3

Map of Known Wells with Water Quality Data

Madera County: Madera Subbasin
SGMA Data Collection and Analysis

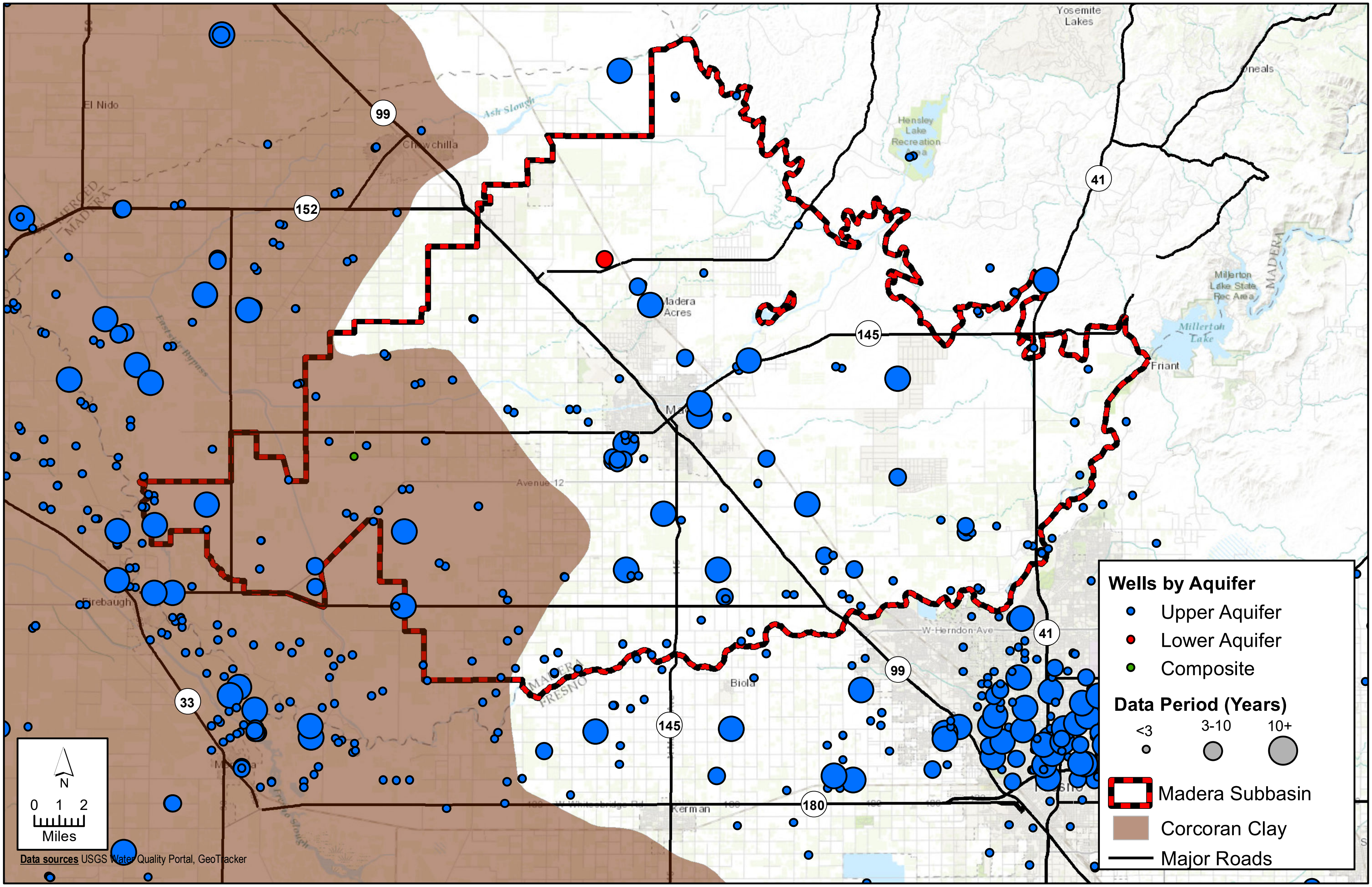

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FIGURE 5-4
Map of Known Wells with Water Quality Data and Construction Data

Madera County: Madera Subbasin
SGMA Data Collection and Analysis

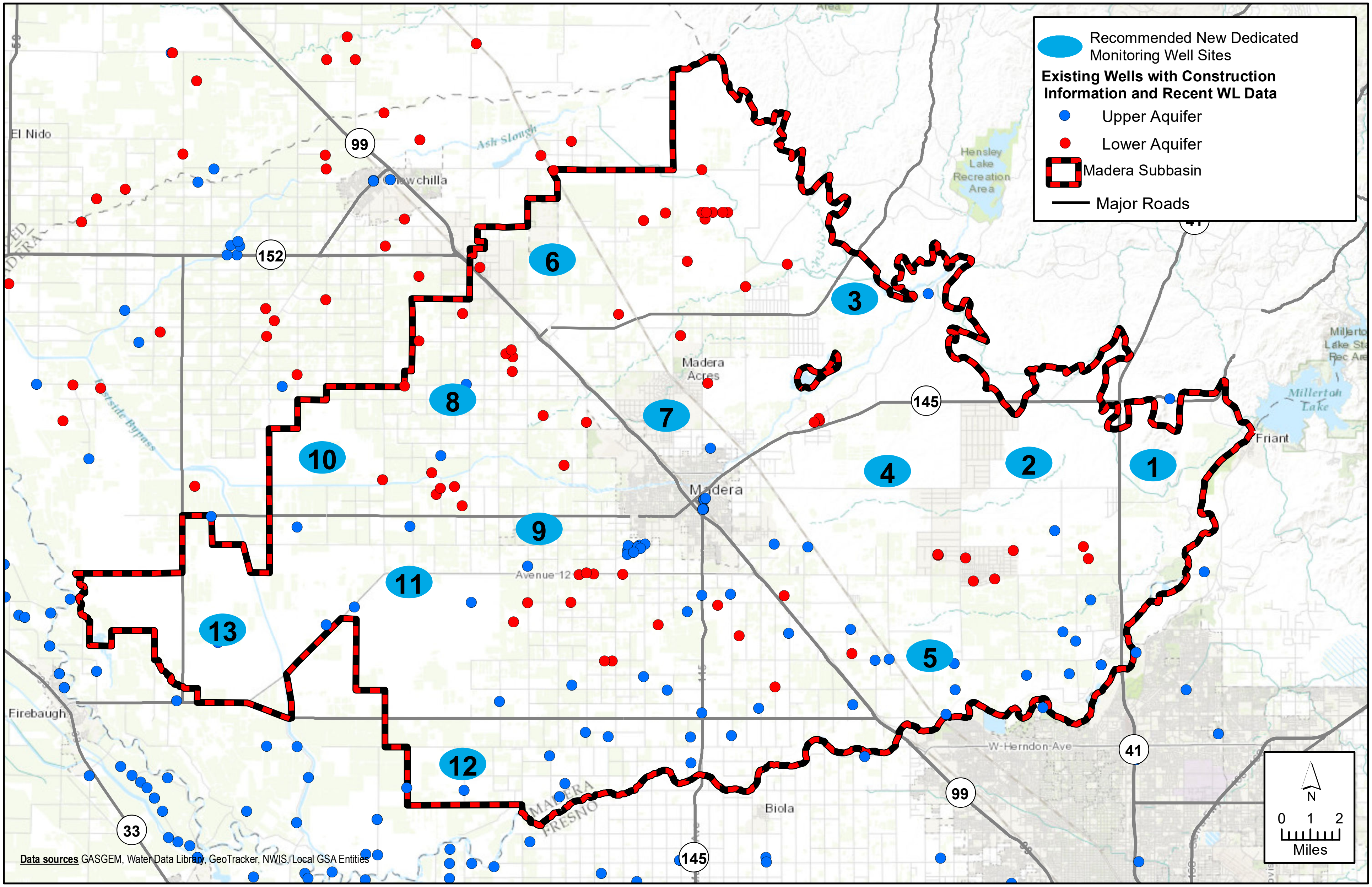

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FIGURE 5-5

Preliminary Recommendations for New Dedicated Monitoring Well Sites

Madera County: Madera Subbasin
SGMA Data Collection and Analysis

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APPENDIX A

DATA REQUEST AND DATA COMPILATION

Madera County

SGMA Data Collection and Analysis

Davids Engineering/Luhdorff & Scalmanini Team

Objective: Assemble existing data and data sources in support of data gap analysis.

Schedule: Please return before April 1, 2017.

Priorities: Local digital data that is not available through DWR, USBR or USGS for the items listed as a high priority in the attached data list. Scanned paper records if not digital. If not scanned, time period and data available with a sample page(s) scanned. If you have data that is not listed in this request but you think might be relevant, please include a sample and ask for clarification of whether or not it will be useful.

Time period of interest: Priority for 1985 through 2016. Desire for complete data inventory, assembly of all available digital data and a complete inventory of paper records for the data in the attached data list.

Instructions: Please complete the Local Entity Data Availability Form and return along with digital records and an inventory of paper records for the data items requested.

Transmittal: The preferred method of transmittal of data is via the data upload location link provided below.

Madera County SGMA data upload data link: http://info.lsce.com:500

Each local entity is being assigned a unique login username and password (login info to follow in separate correspondence) which will provide access to a unique upload location for each unique login; all data uploaded through this link will be maintained in confidence unless otherwise authorized.

This ftp location is password protected for access by users. Aside from the project team members and designated Madera County representatives, only those with the appropriate username and password are able to access information at this location.

Please contact either Bryan Thoreson with Davids Engineering with questions regarding data needs for the Surface Water System, or Nick Watterson with Luhdorff & Scalmanini with any questions regarding data needs for the Groundwater System and difficulties uploading information.

Bryan Thoreson; bryan@davidsengineering.com; 530-757-6107 x105

Nick Watterson; nwatterson@lsce.com; 530-661-0109

Madera County SGMA Data Needs and Acquisition--Please Transmit Data Before: April 1, 2017

Data Description	Potential Data Sources	Assessment of Acquisition	Priority	Relevant SGMA Element	Team Lead
General geographic data					
Topography	USGS	Have all	High	Hydrogeologic conceptualization, water balance, GW conditions, modeling, general GSP	DE
Water planning documents					
Groundwater Management Plans, Urban Water Management Plans	Local entities, adjacent districts	Need local assistance	High	Hydrogeologic conceptualization, water balance, GW conditions, modeling, general GSP	DE
District water infrastructure and basemap data					
Wells - location coordinates [or in other spatial form (GIS or CAD)], elevation, depth, perforated interval, seal depth, pumping capacity	Local entities, adjacent districts	Need local assistance	High	Hydrogeologic conceptualization, water balance, GW conditions, modeling, general GSP	LSCE
Canals and irrigation ditches - location [spatial format], depth/dimensions, lined/unlined, direction of flow	Local entities, adjacent districts	Need local assistance	Medium	Primarily modeling, conceptual water balance, general GSP	DE
	USGS, DWR, SWRCB, USBR	Have some locations			
Lakes/reservoirs (or managed surface water bodies) - location [spatial format], depth/dimensions, lined/unlined	Local entities, adjacent districts	Need local assistance	Medium	Primarily modeling, conceptual water balance, general GSP	DE
	USGS, DWR, SWRCB, USBR	Have some locations			
Water supply pipelines - location [spatial format], diameter, capacity (historical or design?)	Local entities, adjacent districts	Need local assistance	Medium	Primarily modeling, general GSP	DE
Tile drains - location [spatial format], depth, sump or discharge location, fate of discharge, direction of flow	Local entities, adjacent districts	Need local assistance	Medium	Primarily modeling, conceptual water balance, general GSP	LSCE
	USBR, DWR, USGS	Have some			
Parcel data	Madera County or local entity, local counties	Have most publicly available, need local assistance for any additional parcel info, especially where land use or water use is indicated	Medium	Primarily modeling	DE
Hydrogeology					
Borehole lithology in digital form from well completion reports (WCR) - location coordinates, depth interval, lithology	CVHM/CVHM2	Complete, have all	High	Primarily hydrogeologic conceptualization, GW conditions	LSCE
Other/additional borehole lithology information available - location coordinates, depth interval, lithology	Madera County or local entity/DWR	Have some, need local assistance providing data and with DWR WCR requests	High	Primarily hydrogeologic conceptualization, GW conditions	LSCE
Borehole geophysical logs	Local entities, adjacent districts	Need local assistance	High	Primarily hydrogeologic conceptualization, GW conditions	LSCE
	DWR	Have some			
Hydrogeologic investigation reports (and associated data)	Madera County or local entity	Need assistance acquiring local studies and associated data	High	Hydrogeologic conceptualization, water balance, GW conditions, modeling, general GSP	LSCE
	USGS, DWR, USBR, UC Extension, other	Have most			
Well pump test data/aquifer test data	Local entities, adjacent districts	Need local assistance	High	Hydrogeologic conceptualization, modeling, general GSP	LSCE
Surficial soils	NRCS	Have all	High	Hydrogeologic conceptualization, water balance, modeling, general GSP	DE

Madera County SGMA Data Needs and Acquisition--Please Transmit Data Before: April 1, 2017

Data Description	Potential Data Sources	Assessment of Acquisition	Priority	Relevant SGMA Element	Team Lead
Groundwater levels (time-series; depth to water, groundwater elevation)					
Historical groundwater level measurements from available digital data sources - location coordinates, well type, well depth, perforated interval, RP elevation, date, observation	Local entities, adjacent districts	Need local assistance	High	Hydrogeologic conceptualization, water balance, GW conditions, modeling, general GSP	LSCE
	DWR, SWRCB Geotracker, USGS, USBR, other	Have most, need to update			
Historical groundwater level measurements from non-tabular/non-digital data sources - PDF, hardcopy, or other available WL data	Local entities, adjacent districts	Need local assistance	Low	Supplement digitally available data as necessary	LSCE
	USGS, DWR, USBR, SWRCB	Have some			
Groundwater quality (time-series; all WQ data including TDS/EC, nitrate, general minerals, contaminants)					
Historical groundwater quality results from available digital data sources - observation location coordinates, well type, well depth, perforated interval, date, observation	Local entities, adjacent districts	Need local assistance	High	Hydrogeologic conceptualization, GW conditions, modeling (solute transport), general GSP	LSCE
	DWR, SWRCB Geotracker, USGS, USBR, other	Have most, need to update			
Historical groundwater quality results from non-tabular/non-digital data sources - PDF, hardcopy, or other available WL data	Local entities, adjacent districts	Need local assistance	Low	Supplement digitally available data as necessary	LSCE
	DWR, SWRCB Geotracker, USGS, USBR, other	Have most			
Drainage water quality (time-series; all WQ data including TDS/EC, nitrate, general minerals, contaminants)					
Historical water quality results from tile drains - observation location coordinates, observation location type, drainage source area, depth, date, observation	Local entities, adjacent districts	Need local assistance	Low	Hydrogeologic conceptualization, GW conditions, modeling (solute transport), general GSP	LSCE
	DWR, USGS, USBR, other	Have most available, need to update as appropriate			
Groundwater pumping (time-series)					
Historical agricultural groundwater pumping by well - well location coordinates, well depth, perforated interval, date, quantity	Local entities, adjacent districts, other pumpers in subbasin	Need local assistance	High	Hydrogeologic conceptualization, water balance, GW conditions, modeling, general GSP	LSCE
Historical non-agricultural pumping by well - well location coordinates, well depth, perforated interval, date, quantity	Local entities, adjacent districts, other pumpers in subbasin	Need local assistance	High	Hydrogeologic conceptualization, water balance, GW conditions, modeling, general GSP	LSCE
Surface water diversions and deliveries (time-series)					
Historical agricultural surface water deliveries - location where delivered, date, quantity, conveyance method, location applied, use	Local entities, adjacent districts, other surface water users in subbasin	Need local assistance	High	Water balance, modeling, general GSP	DE
	DWR, USGS, USBR, other	Have some			
Historical municipal surface water deliveries - location where delivered, date, quantity, conveyance method, location applied, use	Local entities, adjacent districts, other surface water users in subbasin	Need local assistance	High	Water balance, modeling, general GSP	DE
	DWR, USGS, USBR, other	Have some			
Historical actual surface water diversions (including riparian diversions) - location where diversion occurs and/or where measured, date, quantity, conveyance method, intended use	Local entities, adjacent districts, other water diverters in subbasin	Need local assistance	High	Water balance, modeling, general GSP	DE
	DWR, USGS, USBR, other	Have some			
Total surface water available (including all allocated and other surface water available including water available, but not diverted) - location of diversion, dates/time period, allocated quantity/flow rate, conveyance method, intended use	Local entities, adjacent districts, other water diverters in subbasin	Need local assistance	Medium	Water balance, modeling, general GSP	DE
	SWRCB, USBR, DWR, other	Have some			

Madera County SGMA Data Needs and Acquisition--Please Transmit Data Before: April 1, 2017

Data Description	Potential Data Sources	Assessment of Acquisition	Priority	Relevant SGMA Element	Team Lead
Surface water quality (time-series; all WQ data including TDS/EC, nitrate, general minerals, contaminants)					
Historical surface water quality results from available digital data sources - measurement location coordinates, date, observation	Local entities, adjacent districts	Need local assistance	Medium	Modeling (solute transport), general GSP	DE
	DWR, USGS, USBR, other	Have some			
Historical surface water quality results from available non-digital sources	Local entities, adjacent districts	Need local assistance	Low	Supplement digitally available data as necessary	DE
	DWR, USGS, USBR, other	Have some			
Surface water flows (time-series)					
Historical surface water discharge measurements (includes both inflows and outflows, drains/drainage, in local entity conveyance network, and other canals) - measurement location coordinates, type of flow measurement (e.g., streamflow, canal, drainage), date, quantity/flow rate	Local entities, adjacent districts	Need local assistance	High	Hydrogeologic conceptualization, water balance, modeling, general GSP	DE
	DWR, USGS, USBR, other	Have some			
Land use/water demand (time-series)					
Spatial historical land use data (annual or at other interval as available) - spatial data with land use code	Local entities, adjacent districts	Need local assistance	High	Water balance, modeling, general GSP	DE
	DWR, USDA, NRCS, USGS, other	Have most			
Non-spatial historical land use data (annual or at other interval as available) - non-spatially located with land use code	Local entities, adjacent districts	Need local assistance	Medium	Supplement spatial data as necessary	DE
	DWR, USDA, NRCS, USGS, other	Have some			
Spatial irrigation method (annual or at other interval as available) - spatial data with irrigation method indicated	Local entities, adjacent districts	Need local assistance	High	Water balance, modeling, general GSP	DE
	DWR, USDA, NRCS, USGS, other	Have some			
Non-spatial irrigation method (annual or at other interval as available) - non-spatially located	Local entities, adjacent districts	Need local assistance	Medium	Supplement spatial data as necessary	DE
	DWR, USDA, NRCS, USGS, other	Have some			
Water demand calculations	Local entities, adjacent districts	Need local assistance	High	Supplement other data and inform on local practices	DE
Subsidence data (time-series)					
Historical subsidence monitoring data - station location coordinates, date, elevation	Local entities, adjacent districts	Need local assistance	Medium	Hydrogeologic conceptualization, water balance, GW conditions, modeling, general GSP	LSCE
	USGS, DWR, USBR, other	Have some			
Climate (time-series)					
Historical precipitation - station location coordinates or other spatial info, date (time period), observation	CIMIS, PRISM, NOAA, other sources	Have some	High	Water balance, modeling, general GSP	DE
Historical evapotranspiration (reference) - station location coordinates, date (daily), observation	CIMIS, NOAA, other sources	Have some	High	Water balance, modeling, general GSP	DE

Madera County SGMA Data Needs and Acquisition--Please Transmit Data Before: April 1, 2017

Data Description	Potential Data Sources	Assessment of Acquisition	Priority	Relevant SGMA Element	Team Lead
Other data					
GW-Dependent Ecosystems	Nature Conservancy, others	Need	Medium	General GSP	LSCE
CVHM data sources	USGS	Have all	High	Hydrogeologic conceptualization, water balance, GW conditions, modeling, general GSP	LSCE
C2VSIM data sources	DWR	Have all	High	Hydrogeologic conceptualization, water balance, GW conditions, modeling, general GSP	LSCE
Future conditions (e.g., population, land use planning, climate)	Madera County, local entities	Need local assistance	Medium	Water balance, groundwater conditions, modeling, general GSP	DE
	DWR, NOAA, USGS (BCM), USBR, UWMPs, Census, CA Dept. Finance, others	Have some			

Madera County SGMA Local Entity Data Availability Form

<u>Please Return Before: April 1, 2017</u>

Local Entity Name:

Contact Email:

Contact Name:

Contact Phone Number:

Data Description	Information Availability for Entity Area						
	Not relevant *(no such features/processes exist within entity area; indicate where value = "0")*	**Available and provided**		**Available, but not provided**		**Relevant, but not available**	**Comments/ Description of information available and/or provided**
		Digital	Hardcopy	Digital	Hardcopy		
Water planning documents							
Groundwater Management Plans, Urban Water Management Plans							
District water infrastructure and basemap data							
Wells - location coordinates [or in other spatial form (GIS or CAD)], elevation, depth, perforated interval, seal depth, pumping capacity							
Canals and irrigation ditches- location [spatial format], depth/dimensions, lined/unlined, direction of flow							
Lakes/reservoirs (or managed surface water bodies) - location [spatial format], depth/dimensions, lined/unlined Water supply pipelines - location [spatial format], diameter, capacity (historical or design?)							
Tile drains - location [spatial format], depth, sump or discharge location, fate of discharge, direction of flow							
Parcel data							
Hydrogeology							
Borehole lithology in digital form from well completion reports (WCR) - location coordinates, depth interval, lithology							
Other/additional borehole lithology information available - location coordinates, depth interval, lithology							
Borehole geophysical logs							
Hydrogeologic investigation reports (and associated data)							
Well pump test data/aquifer test data							
Groundwater levels (time-series; depth to water, groundwater elevation)							
Historical groundwater level measurements from available digital data sources - location coordinates, well type, well depth, perforated interval, RP elevation, date, observation							
Historical groundwater level measurements from non-tabular/non-digital data sources - PDF, hardcopy, or other available WL data							
Groundwater quality (time-series; all WQ data including TDS/EC, nitrate, general minerals, contaminants)							
Historical groundwater quality results from available digital data sources - observation location coordinates, well type, well depth, perforated interval, date, observation							
Historical groundwater quality results from non-tabular/non-digital data sources - PDF, hardcopy, or other available WL data							
Drainage water quality (time-series; all WQ data including TDS/EC, nitrate, general minerals, contaminants)							
Historical water quality results from tile drains - observation location coordinates, observation location type, drainage source area, depth, date, observation							
Groundwater pumping (time-series)							
Historical agricultural groundwater pumping by well - well location coordinates, well depth, perforated interval, date, quantity							
Historical non-agricultural pumping by well - well location coordinates, well depth, perforated interval, date, quantity							

Madera County SGMA Local Entity Data Availability Form

Data Description	Information Availability for Entity Area						
	Not relevant *(no such features/processes exist within entity area; indicate where value = "0")*	**Available and provided**		**Available, but not provided**		**Relevant, but not available**	**Comments/ Description of information available and/or provided**
		Digital	Hardcopy	Digital	Hardcopy		
Surface water diversions and deliveries (time-series)							
Historical agricultural surface water deliveries - location where delivered, date, quantity, conveyance method, location applied, use							
Historical municipal surface water deliveries - location where delivered, date, quantity, conveyance method, location applied, use							
Historical actual surface water diversions (including riparian diversions) - location where diversion occurs and/or where measured, date, quantity, conveyance method, intended use							
Total surface water available (including all allocated and other surface water available including water available, but not diverted) - location of diversion, dates/time period, allocated quantity/flow rate, conveyance method, intended use							
Surface water quality (time-series; all WQ data including TDS/EC, nitrate, general minerals, contaminants)							
Historical surface water quality results from available digital data sources - measurement location coordinates, date, observation							
Historical surface water quality results from available non-digital sources							
Surface water flows (time-series)							
Historical surface water discharge measurements (includes both inflows and outflows, drains/drainage, in local entity conveyance network, and other canals) - measurement location coordinates, type of flow measurement (e.g., streamflow, canal, drainage), date, quantity/flow rate							
Land use/water demand (time-series)							
Spatial historical land use data (annual or at other interval as available) - spatial data with land use code							
Non-spatial historical land use data (annual or at other interval as available) - non-spatially located with land use code							
Spatial irrigation method (annual or at other interval as available) - spatial data with irrigation method indicated							
Non-spatial irrigation method (annual or at other interval as available) - non-spatially located							
Water demand calculations							
Subsidence data (time-series)							
Historical subsidence monitoring data - station location coordinates, date, elevation							
Climate (time-series)							
Historical precipitation - station location coordinates or other spatial info, date (time period), observation							
Historical evapotranspiration (reference) - station location coordinates, date (daily), observation							
Other data							
Future conditions (e.g., population, land use planning, climate)							

List of Compiled Local Entity Data

Local Entity	Data Description	Data Type	File Type	Original File Name	Period of Record
City of Madera	Well completion reports; Well #15 through #34	Well construction data	PDF (Scanned)	"BoreholeGeoLogs" folder	
	Pumping well locations	Well locations	GIS	W_wells.shp in "CNVSHAPE.mdb"	
	City Water system layout	Area boundary and/or Location	GIS	CNVSHAPE.mdb	
	Daily pumping of each production well; 2013 to 2016	Groundwater Pumping	Excel	in "SCADA" folder	2013-2016
	City of Madera water system master plan, 2014 (includes chapters on water demand and supply)		PDF	2014_Water_System_Master_Plan_Final_092314_signed	
	Water quality data of production wells (?); 9 wells, tested at different times, not annually	Water quality	Excel	All CCR Results	2004 - 2014
	Total monthly and annual production from all wells; 1999-2016	Groundwater Pumping	Excel	AnFysProd.xls	1999-2016
	Destroyed production wells and CDPH water codes		Excel	CDPH Source Codes	
	Well construction info, historical water level data (pumping and static) at random intervals (?)	Groundwater level	Excel	Hist Well Yield and Water Levels	Water level data from 1968 to present
	Madera water distribution system map with well locations	Well locations	PDF	Madera Water System	
	Madera basin, spring 2010 groundwater contours; unconfined aquifer	Groundwater Level - Contours	PDF (Scanned)	Well Field Analysis_Recommendations and Conclusions	2010
	Well field analysis report	Well performance data	PDF	Well Field Analysis_Recommendations and Conclusions	2014
City of Madera - Submitted by P&P	City of Madera annual water usage 2004-2012 in AF; Doesn't specify surface water or groundwater	Water use	Excel	City of Madera GW Usage.xls	2004-2012
	Annual inflow to waste water treatment plant, 2006-2013	Water use	PDF	WWTP Inflow 2006-2013.pdf	2006-2013
	City of Madera annual public water supply statistics, 2011 and 2012	water use	Excel	CityofMadera_PWS Statistics 2011a.xls CityofMadera_PWS Statistics 2012.xls	2011, 2012
	2013 Pumping tests at ~15 wells in City of Madera; reports by Well #	Well test data	Scanned PDF	Pump Test Reports.pdf	2013
	City of Madera ~ 18 well construction info (table)	Well Construction	Scanned PDF	Water Well Information.pdf	
Madera County	Madera County general plan, canals, streams, lakes	Area boundary and/or Location	GIS	shape files	
	MC groundwater elevtion change: shape file, DOESN'T SPECIFY TIME RANGE	Groundwater level	GIS	MC_GroundwaterElevationChange.shp	time range not given
	Well locations with drilled year, but no other construction details	Well locations	GIS	Wells_basin_91_2002.shp Wells_basin_2003_2016.dbf	
Madera County - Submitted by P&P	CASGEM wells - groundwater levels 2010-2012	Water level	Excel	GroundwaterElevations - 2011 to 2012.xls	2010-2012
	Madera County Groundwater management plan - 2002	Report	Scanned PDF	Madera County GMP.pdf	
	Groundwater elevation surface, fall 2013- raster file	Water level	GIS - raster	fall13wse	Fall 2013
	GW levels, fall 2013 at 200 wells in Madera County. State well number and coordinates of wells given with water level. This data has been used to create water elevation sueface.	Water level	GIS	WellsUsedInAnalysis.shp	Fall 2013
	Locations of 126 wells in Madera County with state well numbers. Few wells have water level data for fall 2013, but not used to create water elevation surface raster.	Well locations	GIS	WellsNotUsedInAnalysis.shp	
	Groundwater elevation contours, fall 2013	Water level - contours	GIS	Fall2013_WellWaterElevations.shp	Fall 2013
	Groundwater elevation contours, upper aquifer spring 2013	Water level - contours	GIS	groundwate_elevation_contours_wse_spring_2013_upperaquifer.shp	spring 2013
	Groundwater elevation point values, upper aquifer spring 2013. Point name does not include well name or well ID	Water level	GIS	well_waterelevation_spring2013_upperaquifer.shp	spring 2013
	Groundwater elevation contours, lower aquifer spring 2013	Water level - contours	GIS	groundwate_elevation_contours_wse_spring_2013.shp	spring 2013
	Groundwater elevation point values, lower aquifer spring 2013. Point name does not include well name or well ID	Water level	GIS	well_waterelevation_spring2013.shp	spring 2013
	Average annual rates of groundwater level decline and total decline from 1980 to 2011 - contours	Water level	GIS	average_annual_rates_of_water_level_declne1980_2011.shp	2011
	List of wells used to calculate GWL decline from 1980 to 2011. State well ID and coordinates are given, but no water level data.	Well locations	GIS	wells_used_for_analysis.shp	
	Ground surface elevation change from 2008 to 2010, contours	subsidence	GIS	ground_surface_change_in_elevation2008_2010.shp	2010
	Irrigation water requirements for Madera County, 1998-2003. Irrigated crop acreages and estimated water use	Water use	Excel	Table 4-1 IRWMP 2008.xls	1998-2003
Madera ID	Madera ID boundary and facilities	Area boundary and/or Location	GIS	shape files	
	Chowchilla WD and Madera ID annual surface water supplies 1973-2015	Water use	PDF	MCWPA_Surface_Water_Supply_Summary.pdf	1973-2015
	Annual water deliveries by category (by type of water users)	Water use	Excel	Water_Deliveries_By_Category_County Submittal.xls	1999-2017
	MID CASGEM wells; 65 wells with state well ID; no construction details	Well locations	GIS	MID_CASGEM_wells.shp	
	Historical water levels: monthly or semi-annual data of monitoring wells; Wells are primarily identified by a descriptive location (like cross-streets) with or without State well ID, so these wells should be linked to CASGEM or other well IDs	Groundwater level	Excel	MID_Well_Run (Historical)	2004 - 2014
	Recent bi-annual water level data; about 57 CASGEM and 5 non-CASGEM wells: Fall 2015 - Spring 2017	Groundwater level	Excel	Recent Well Data	Fall 2015 - Spring 2017
	Lat/Long of ~ 90 wells; some wells have construction details	Well locations / Well construction data	Excel	Recent Well Data	
	Recorder (stream flow recorders?); locations	Flow recorder locations	GIS	recorders.shp	
	Bi-annual water levels; Fall 2006 to Fall 2014; Wells are primarily identified by a descriptive location with or without State well ID, so these wells should be linked to CASGEM or other well IDs	Groundwater level	Excel	USBR Well Run (Historical)	Fall 2006 - Fall 2014
	Recorder data (stream flow recorders?); about 20 recorders with monthly data in various years ranging from 1964 to present	stream flow?	Excel	"MID Recorders" folder	1964-2017
Madera ID - Submitted by P&P	Madera Ranch groundwater and surface water quality from 2009 to 2012. About 40 wells, some with state well ID; surface water at canal and creek	Water quality	Excel	2013-03-05 Revised Analytical Results Summary.xls	2009-2012
	Madera Ranch surface and groundwater quality - 2006; about 50 measurements (~40-45 wells + creek + canal)	Water quality	Excel	Data Table 2006.xls	2006
	Madera ID annual water deliveries, 1993-2013	Water use	Excel	MID Surface Water Supplies.xls	1993-2013
Madera Valley WC	Drillers logs; 7 wells	Well construction data	PDF (Scanned)		
	MVWCo service area map; image	Area boundary and/or Location	JPEG	MVWCo Service Area	
	Total annual water delivery; 1996-2016	Water use	Excel	WELL AND WATER DATA.xls	1996-2016
	Standing water levels at production wells; one value per year, but it is not described (minimum or average ?) 1996-2017	Groundwater level	Excel	WELL AND WATER DATA.xls	1996-2016

List of Compiled Local Entity Data

Local Entity	Data Description	Data Type	File Type	Original File Name	Period of Record
Madera WD	MWD Groundwater management plan - 2014 Update		PDF & Word	Madera WD GMP Final 12-30-2014	
	Summarized pumping test results; gives flow rate and efficiency: 1994, 2003 and 2014	Well efficiency / Well construction data	Excel	Madera WD pump test summary	1994, 2003, 2014
	Attributes of production wells (drilled year, depth, screen depths)	Well construction data	Excel	Madera WD well attributes	
	MWD total annual water deliveries, 1993-2015; surface water and groundwater separately	Water use	Excel	MWD water supplies	1993-2015
	MWD Groundwater management plan - 1997, text only		Word	MWD-GWMP Dec 1997.doc MWD-GWMP.doc	
	MWD annual groundwater pumping by pump number; 1993-1997 and 2004-2014 (is pump number = well number??)	Groundwater Pumping	Excel	Pumping Records.xls	1993-1997 and 2004-2014
	Standing water levels of production wells; bi-annual Spring 2011 to Spring 2016; Oct 1994, July 2003; about 30 wells, not all wells have data	Groundwater level	Excel	MWD water levels.xls	2011-2016
New Stone WD	2016 estimated irrigation totals; acreage of crops and water demand of 47 "blocks"	Land use / Water use	PDF (Scanned)	2016 Estimated Irrigation Totals per Acre.pdf	2015
	Various pump test results (to assess pumping efficiency?) from 1997 to 2016 at many wells; Customer name, date and well/pump number are available in most reports	well test data	PDF (Scanned)	Well Information.pdf	1997-2016
Root Creek WD	Facility map showing (proposed?) main and lateral lines (for groundwater recharge project?)	Area boundary and/or Location	PDF (Scanned)	01_Facility Diagram.pdf	
	Well logs - 9 wells	Well construction data	PDF (Scanned)		
	Water level hydrographs at five wells; earliest data from 1975, latest 2014	Groundwater level	PDF (Scanned)		1975 - 2014
	Well logs; well #1, 2, 4, 68	Well construction data	PDF (Scanned)		
	A letter describing water quality and lithology of a well (TW #2?)	Water quality	PDF (Scanned)		
	Groundwater condition report around Root Creek WD, 2003. Contains well logs, water quality data		PDF (Scanned)	AB303 Project Summary Report.pdf	
	Crop acreage and water demand changes between 2001 and 2011	Land use / Water use	PDF (Scanned)	Comparison 2001 to 2011 crop demand.pdf	
	Root Creek WD facility map; shows conveyance pipeline	Area boundary and/or Location	PDF (Scanned)	facilities_rcwd.pdf	
	Root Creek WD holdings map; shows conveyance pipeline	Area boundary and/or Location		facilities_rcwd_holdings.pdf	
	Groundwater management plan - Root Creek WD; adopted 1997, revised 2012. contains GWL data, well logs, soils, recharge, geologic cross-sections		PDF	Final RCWD GMP.pdf	
	Southeastern Madera County hydrogeologic investigation for Root Creek WD; 1998. Evaluates groundwater impacts from on-going development activities		PDF	Hydrogeologic Investigation Southeastern Madera.pdf	
	Riverstone Well #1 pumping test report; 2014: specific capacity is given	well test data	PDF	Riverstone Well 1 Pump Test letter (2)	
	Gateway Village TW-1 pump test data and water quality ; 2014 (a letter)	well test data	PDF	TW-1 letter geologic log and wq table	
	Root Creek WD, approximate well location map	Well locations	PDF	Well location map.pdf	
	Water levels of 9 CASGEM well (2015-2016)	Groundwater level	Excel	CASGEM_Well_Data.xls	Spring 2015-Fall 2016
	Water levels of about 30 wells; mostly bi-annual, some data data from 1974, newest data 2017	Groundwater level	Excel	Root Creek All Wells hydrographs.xls	1974-2017
	Calculations of change of water levels at monitored wells between different time periods	Groundwater level	Excel	RtCWD WL Analysis.xls	2004-2013; random intervals
Gravelly Ford WD - Submitted by P&P	GFWD water management plan - 2009	Report	PDF	Gravelly Ford Water Management Plan 2009-Final.pdf	
	GFWD Total annual surface water deliveries; 2000-2013	Water use	Excel	GF Surface Water.xls	2000-2013

List of Compiled Public Data (Page 1 of 3)

Entity	Data Description	Data Type	File Type	File Name	Data source	Period of Record	Timestep
CASGEM	966 Wells. 903 Wells with one or more measurements for Madera County.	Ground water elevations: Point data	Excel	Madera_1900_1925, Madera_1925_1955, Madera_1955_1965, Madera_1965_1975, Madera_1975_1985, Madera_1985_1986, Madera_1986_1996, Madera_2007_2017	Bureau of Reclamation, Department of Water Resources, Madera-Chowchilla CASGEM Group, Madera Irrigation District, Central California Irrigation District & Firebaugh Canal Water District, CHOWCHILLA WATER DISTRICT	1920-2016	
CASGEM	2168 Wells. 1934 wells with one or more measurement	Ground water elevations: Point data	Excel	Merced_1900_1945, Merced_1945_1955, Merced_1955_1965, Merced_1965_1975, Merced_1975_1985, Merced_1985_1996, Merced_1996_2007, Merced_2007_2017	Bureau of Reclamation, San Luis & Delta-Mendota Water Authority, Central California Irrigation District & Firebaugh Canal Water District, POSO RESOURCE CONSERVATION DISTRICT, SAN LUIS CANAL COMPANY, CHOWCHILLA WATER DISTRICT, EL NIDO IRRIGATION DISTRICT, Merced Area Groundwater Pool Interests (MAGPI), Merced Irrigation District, US Geological Survey, TURLOCK IRRIGATION DISTRICT, Turlock Groundwater Basin Association	1922-2017	
CASGEM	5916 Wells. 5511 wells with one or more ground water elevation measurements.	Ground water elevations: Point data	Excel	Fresno_1900_1925, Fresno_1925_1945, Fresno_1945_1955, Fresno_1955_1965, Fresno_1965_1975, Fresno_1975_1985, Fresno_1985_1996, Fresno_1996_2007, Fresno_2007_2017	US Geological Survey, Department of Water Resources, Westlands Water District, Bureau of Reclamation, Kings River Conservation District, Central California Irrigation District & Firebaugh Canal Water District, RIVERDALE PUBLIC UTILITY DISTRICT, LIBERTY WATER DISTRICT, KINGS COUNTY WATER DISTRICT, RIVERDALE IRRIGATION DISTRICT, Alta Irrigation District, Consolidated Irrigation District, TRANQUILLITY RESOURCE CONSERVATION DISTRICT, JAMES IRRIGATION DISTRICT, Orange Cove Irrigation District, Fresno Irrigation District, City of Fresno, UNKNOWN AGENCY, Panoche Water District, RECLAMATION DISTRICT NO 1606, San Luis & Delta-Mendota Water Authority, POSO RESOURCE CONSERVATION DISTRICT, LEWIS CREEK WATER DISTRICT, GARFIELD WATER DISTRICT, CHOWCHILLA WATER DISTRICT	1921-2017	
CASGEM	8 wells with one or more measurements for Mariposa County. Only have measurements for one year	Ground water elevations: Point data	Excel	Mariposa	DWR	1971-1971	
CDFA	Contains information for crops in all CA counties, including harvested acres, yield, price, production, and value	Land Use	CSV	1980cropyear, 1981cropyear, 1982cropyear, 1983cropyear, 1984cropyear, 1985cropyear, 1986cropyear, 1987cropyear, 1988cropyear, 1989cropyear, 1990cropyear, 1991cropyear, 1992cropyear, 1993cropyear, 1994cropyear, 1995cropyear, 1996cropyear, 1997cropyear, 1998cropyear, 1999cropyear, 2000cropyear, 2001cropyear, 2002cropyear, 2003cropyear, 2004cropyear, 2005cropyear, 2006cropyear, 2007cropyear, 2008cropyear, 2009cropyear, 2010cropyear, 2011cropyear, 2012cropyear, 2013cropyear, 2014cropyear, 2015cropyear	California Department of Food and Agriculture (CDFA), and County Agricultural Commissioner	1980-2015	Yearly
CIMIS	CIMIS stations record weather data. Parameters included are Eto, Precip., Solar Radiation, Avg. Vap. Pressure, Min./Max./Avg. air Temp., Min./Max./Avg. Relative Humidity, Dew Point, Avg. Wind speed, Wind run, Avg. soil Temp.	Weather Data	Excel	Madera_Daily_Station_Data_CIMIS	CIMIS	1998-2013	Daily
CIMIS	CIMIS stations record weather data. Parameters included are Eto, Precip., Solar Radiation, Avg. Vap. Pressure, Min./Max./Avg. air Temp., Min./Max./Avg. Relative Humidity, Dew Point, Avg. Wind speed, Wind run, Avg. soil Temp.	Weather Data	Excel	Madera_II_Daily_Station_Data_CIMIS	CIMIS	2013-2017	Daily
DWR	Land Use surveys for Madera County	Land Use	GIS, shapefile	Map: Madera_County_SGMA_Data Shapefiles: 95ma.shp, 01ma_v2.shp, 11ma.shp	DWR Land Use Surveys	1995-2011	Yearly
DWR	Land Use surveys for Merced County	Land Use	GIS, shapefile	Map: Madera_County_SGMA_Data Shapefiles: 95me.shp, 02me.shp	DWR Land Use Surveys	1995-2002	Yearly
DWR	Map of Subsidense values in the Central Valley	Estimated Subsidence Map	PDF	Estimated Subsidence in the SCV	DWR	1949-2005	
DWR	Streamflow data for station at Chowchilla River below Buchanan Dam	Surface Water Diversions and Deliveries	Excel	chowchilla_river_fifteenmin_stage.xlsx	DWR Water Data Library	2011-2017	15-minute
DWR	Streamflow data for station at San Joaquin River near Dos Palos	Surface Water Diversions and Deliveries	Excel	SJR_near_Dos_Palos_FLOW_DAILY_MEAN_DATA.xlsx, SJR_near_Dos_Palos_STAGE_DAILY_MEAN_DATA.xlsx	DWR Water Data Library	1980-2013	Daily
DWR	Streamflow data for station at Fresno River 8 miles west of Madera	Surface Water Diversions and Deliveries	Excel	Fresno_River_FLOW_DAILY_MEAN_DATA.xlsx	DWR Water Data Library	1980-1990	Daily
DWR	Streamflow data for station at San Joaquin River near Washingotn Road	Surface Water Diversions and Deliveries	Excel	SJR_Near_Washington_Road_FLOW_DAILY_MEAN_DATA.xlsx	DWR Water Data Library	2009-2017	Daily
GeoTracker: GAMA	796 wells with one or more TDS measurements for Madera county	Ground water quality	Excel	gama_all_madera	DDW, DPR, DWR, EDF, USGS, and USGSNWIS	1928-2016	
GeoTracker: GAMA	977 wells with one or more NO3 measurements for Madera county	Ground water quality	Excel	gama_all_madera	DDW, DPR, DWR, EDF, USGS, and USGSNWIS	1946-2016	
GeoTracker: GAMA	1239 wells with one or more TDS measurements for Merced county	Ground water quality	Excel	gama_all_merced	DDW, DPR, DWR, EDF, USGS, and USGSNWIS	1954-2016	
GeoTracker: GAMA	1328 wells with one or more NO3 measurements for Merced county	Ground water quality	Excel	gama_all_merced	DDW, DPR, DWR, EDF, USGS, and USGSNWIS	1948-2016	
GeoTracker: GAMA	2657 wells with one or more TDS measurements for Fresno county	Ground water quality	Excel	gama_all_fresno	DDW, DPR, DWR, EDF, GAMA DOMESTIC, LLNL, USGS, USGSNWIS	1950-2016	
GeoTracker: GAMA	2989 wells with one or more NO3 measurements for Fresno county	Ground water quality	Excel	gama_all_fresno	DDW, DPR, DWR, EDF, GAMA DOMESTIC, LLNL, USGS, USGSNWIS	1950-2016	
GeoTracker: GAMA	163 wells with one or more TDS measurements for Mariposa county	Ground water quality	Excel	gama_all_mariposa	DDW, DWR, EDF, USGS, and USGSNWIS	1968-2016	
GeoTracker: GAMA	168 wells with one or more NO3 measurements for Mariposa county	Ground water quality	Excel	gama_all_mariposa	DDW, DWR, EDF, USGS, and USGSNWIS	1965-2016	
GeoTracker: GAMA	Groundwater elevations and locations for entire state of California	Groundwater Elevation: point data	Excel	gama_all_dtw_elev	DWR	1915-2014	
GeoTracker: GAMA	Groundwater elevations and location of 7435 wells with one or more measurements for Madera, Merced, Fresno, and Mariposa	Groundwater Elevations: point data	Excel	Gama_MaderaSurrounding_elev	DWR	1920-2014	
NOAA	Precip and snowfall data from the weather station CHOWCHILLA 0.3 E CA US within Madera County	Weather Data	Excel	Madera_County_Weather_Data_1904_to_Present	National Centers for Environmental Information (NCEI), National Oceanic and Atmospheric Administration (NOAA)	2015-2017	Daily
NOAA	Precip, snow depth, snowfall, min/max temp from the weather station MADERA CA US within Madera County. Location data also contained here	Weather Data	Excel	Madera_County_Weather_Data_1904_to_Present	National Centers for Environmental Information (NCEI), National Oceanic and Atmospheric Administration (NOAA)	1928-2017	Daily
NOAA	Precip, snow depth, snowfall, min/max/average temp data from the weather station MADERA MUNICIPAL AIRPORT CA US within Madera County	Weather Data	Excel	Madera_County_Weather_Data_1904_to_Present	National Centers for Environmental Information (NCEI), National Oceanic and Atmospheric Administration (NOAA)	1998-2017	Daily
NOAA	Precip data from the weather station RAYMOND CA US within Madera County	Weather Data	Excel	Madera_County_Weather_Data_1904_to_Present	National Centers for Environmental Information (NCEI), National Oceanic and Atmospheric Administration (NOAA)	2012-2016	Daily
PRISM	30-year normals for Precip, mean/min/max temp, mean dewpoint temp, min/max vapor pressure deficit, and elevation	Weather Data	Raster	No File yet	PRISM, Northwest Alliance for Computational Science and Engineering	1981-2010	30-year Average
PRISM	National values for Precip, mean/min/max temp, mean dewpoint temp, min/max vapor pressure deficit, and elevation	Weather Data	Raster	No File yet	PRISM, Northwest Alliance for Computational Science and Engineering	January 1981-July 2016	Monthly
PRISM	National values for Precip, mean/min/max temp, mean dewpoint temp, min/max vapor pressure deficit, and elevation	Weather Data	Raster	No File yet	PRISM, Northwest Alliance for Computational Science and Engineering	January 1981-July 2016	Daily
PRISM	National values for Precip, mean/min/max temp, mean dewpoint temp, min/max vapor pressure deficit, and elevation	Weather Data	Raster	No File yet	PRISM, Northwest Alliance for Computational Science and Engineering	1895-1980	Yearly
SSURGO	Mapped soil characteristics for Madera County	Soils	GIS, shapefile	Map: Madera_County_SGMA_Data Shapefiles: soilmu_p_ca_651, soilsf_p_ca651, soilmu_l_ca651, soilsf_l_ca651, soilmu_a_ca651, soilsa_a_ca651	National Resource Conservation Service (NRCS), Soil Survey Geographic Database (SSURGO), United states Department of Agriculture (USDA)		
SSURGO	Mapped soil characteristics for Merced County	Soils	GIS, shapefile	Map: Madera_County_SGMA_Data Shapefiles: soilmu_p_ca_648, soilsf_p_ca648, soilmu_l_ca648, soilsf_l_ca648, soilmu_a_ca648, soilsa_a_ca648	National Resource Conservation Service (NRCS), Soil Survey Geographic Database (SSURGO), United states Department of Agriculture (USDA)		
STATSGO	Mapped soil characteristics for California	Soils	GIS, shapefile	Map: Madera_County_SGMA_Data Shapefiles: gsmsoilmu_a_ca.shp	National Resource Conservation Service (NRCS), State Soil Geographic Database (STATSGO), United states Department of Agriculture (USDA)		
UNAVCO	Change in horizontal and vertical locations. NAM08 and IGS08 reference frames for stations near Madera County	Subsidence Station data	Excel	p300.pbo.igs08, p300.pbo.nam08	Plate Boundary Observatory (PBO) Network Monitoring	2004-2017	
UNAVCO	Change in horizontal and vertical locations. NAM08 and IGS08 reference frames for stations near Madera County	Subsidence Station data	Excel	p303.pbo.igs08, p303.pbo.nam08	Plate Boundary Observatory (PBO) Network Monitoring	2005-2017	
UNAVCO	Change in horizontal and vertical locations. NAM08 and IGS08 reference frames for stations near Madera County	Subsidence Station data	Excel	p304.pbo.igs08, p304.pbo.nam08	Plate Boundary Observatory (PBO) Network Monitoring	2004-2017	

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Entity	Data Description	Data Type	File Type	File Name	Data source	Period of Record	Timestep
UNAVCO	Change in horizontal and vertical locations. NAM08 and IGS08 reference frames for stations near Madera County	Subsidence Station data	Excel	p305.pbo.igs08, p305.pbo.nam08	Plate Boundary Observatory (PBO) Network Monitoring	2005-2017	
UNAVCO	Change in horizontal and vertical locations. NAM08 and IGS08 reference frames for stations near Madera County	Subsidence Station data	Excel	p307.pbo.igs08, p307.pbo.nam08	Plate Boundary Observatory (PBO) Network Monitoring	2005-2017	
UNAVCO	Change in horizontal and vertical locations. NAM08 and IGS08 reference frames for stations near Madera County	Subsidence Station data	Excel	p566.pbo.igs08, p566.pbo.nam08	Plate Boundary Observatory (PBO) Network Monitoring	2005-2017	
UNAVCO	Change in horizontal and vertical locations. NAM08 and IGS08 reference frames for stations near Madera County	Subsidence Station data	Excel	p572.pbo.igs08, p572.pbo.nam08	Plate Boundary Observatory (PBO) Network Monitoring	2006-2017	
UNAVCO	Change in horizontal and vertical locations. NAM08 and IGS08 reference frames for stations near Madera County	Subsidence Station data	Excel	p725.pbo.igs08, p725.pbo.nam08	Plate Boundary Observatory (PBO) Network Monitoring	2006-2017	
USBR	Central California Irrigation District Water Management Plan, some data also located within the Westside San Joaquin Integrated Water Resources Plan	Water Planning Documents	PDF	Westside_San_Joaquin_2014_IWRP_Draft-July2014.pdf, CCID - 2011 WMP - FINAL - 6-2014.pdf	United States Bureau of Reclamation (USBR)	2014	
USBR	Chowchilla Water District Water Management Plan	Water Planning Documents	PDF	Chowchilla Attachment A-B.pdf, Chowchilla Attachment G.pdf, Chowchilla WMP Five Year Update 2009.pdf	United States Bureau of Reclamation (USBR)	2009	
USBR	Chowchilla Water District Water Management Plan Update	Water Planning Documents	PDF	Chowchilla WD 2015 Update.pdf	United States Bureau of Reclamation (USBR)	2015	
USBR	Columbia Canal Company Water Management Plan, some data also located within the Westside San Joaquin Integrated Water Resources Plan	Water Planning Documents	PDF	Westside_San_Joaquin_2014_IWRP_Draft-July2014.pdf, CCC WMP FINAL 6-2014.pdf	United States Bureau of Reclamation (USBR)	2014	
USDA Cropscape	Land usage data with crop delineations	Land use	Raster	CDL_2007_Chowchilla_buff_20mi_clip, CDL_2008_Chowchilla_buff_20mi_clip, CDL_2009_Chowchilla_buff_20mi_clip, CDL_2010_Chowchilla_buff_20mi_clip, CDL_2011_Chowchilla_buff_20mi_clip, CDL_2012_Chowchilla_buff_20mi_clip, CDL_2013_Chowchilla_buff_20mi_clip, CDL_2014_Chowchilla_buff_20mi_clip, CDL_2015_Chowchilla_buff_20mi_clip, CDL_2016_Chowchilla_buff_20mi_clip	United States Department of Agriculture (USDA), National Agricultural Statistics Service (NASS)	2007-2016	Yearly
USDA Cropscape	Crop-pixel linkages	Land use	CSV	cdl_2007_crop_stat, cdl_2008_crop_stat, cdl_2009_crop_stat, cdl_2010_crop_stat, cdl_2011_crop_stat, cdl_2012_crop_stat, cdl_2013_crop_stat, cdl_2014_crop_stat, cdl_2015_crop_stat, cdl_2016_crop_stat	United States Department of Agriculture (USDA), National Agricultural Statistics Service (NASS)	2007-2016	Yearly
USGS	Streamflow data for station at San Joaquin River near Mendota	Surface Water Diversions and Deliveries	Excel	Daily_Discharge.xlsx	United States Geological Survey (USGS)	1939-2017	Daily
USGS	Streamflow data for station at the Fresno River below hidden Dam	Surface Water Diversions and Deliveries	Excel	Daily_Discharge.xlsx	United States Geological Survey (USGS)	1995-2002	Daily
USGS CIDA	Monthly Eta values for Chowchilla Subbasin area and 20-mile buffer	Land Use	Raster	012000_clip, 022000_clip, 032000_clip, 042000_clip, 052000_clip, 062000_clip, 072000_clip, 082000_clip, 092000_clip, 102000_clip, 112000_clip, 122000_clip	United States Geological Survey (USGS), Center for Integrated Data Analytics (CIDA)	2000	Monthly
USGS CIDA	Monthly Eta values for Chowchilla Subbasin area and 20-mile buffer	Land Use	Raster	012001_clip, 022001_clip, 032001_clip, 042001_clip, 052001_clip, 062001_clip, 072001_clip, 082001_clip, 092001_clip, 102001_clip, 112001_clip, 122001_clip	United States Geological Survey (USGS), Center for Integrated Data Analytics (CIDA)	2001	Monthly
USGS CIDA	Monthly Eta values for Chowchilla Subbasin area and 20-mile buffer	Land Use	Raster	012002_clip, 022002_clip, 032002_clip, 042002_clip, 052002_clip, 062002_clip, 072002_clip, 082002_clip, 092002_clip, 102002_clip, 112002_clip, 122002_clip	United States Geological Survey (USGS), Center for Integrated Data Analytics (CIDA)	2002	Monthly
USGS CIDA	Monthly Eta values for Chowchilla Subbasin area and 20-mile buffer	Land Use	Raster	012003_clip, 022003_clip, 032003_clip, 042003_clip, 052003_clip, 062003_clip, 072003_clip, 082003_clip, 092003_clip, 102003_clip, 112003_clip, 122003_clip	United States Geological Survey (USGS), Center for Integrated Data Analytics (CIDA)	2003	Monthly
USGS CIDA	Monthly Eta values for Chowchilla Subbasin area and 20-mile buffer	Land Use	Raster	012004_clip, 022004_clip, 032004_clip, 042004_clip, 052004_clip, 062004_clip, 072004_clip, 082004_clip, 092004_clip, 102004_clip, 112004_clip, 122004_clip	United States Geological Survey (USGS), Center for Integrated Data Analytics (CIDA)	2004	Monthly
USGS CIDA	Monthly Eta values for Chowchilla Subbasin area and 20-mile buffer	Land Use	Raster	012005_clip, 022005_clip, 032005_clip, 042005_clip, 052005_clip, 062005_clip, 072005_clip, 082005_clip, 092005_clip, 102005_clip, 112005_clip, 122005_clip	United States Geological Survey (USGS), Center for Integrated Data Analytics (CIDA)	2005	Monthly
USGS CIDA	Monthly Eta values for Chowchilla Subbasin area and 20-mile buffer	Land Use	Raster	012006_clip, 022006_clip, 032006_clip, 042006_clip, 052006_clip, 062006_clip, 072006_clip, 082006_clip, 092006_clip, 102006_clip, 112006_clip, 122006_clip	United States Geological Survey (USGS), Center for Integrated Data Analytics (CIDA)	2006	Monthly
USGS CIDA	Monthly Eta values for Chowchilla Subbasin area and 20-mile buffer	Land Use	Raster	012007_clip, 022007_clip, 032007_clip, 042007_clip, 052007_clip, 062007_clip, 072007_clip, 082007_clip, 092007_clip, 102007_clip, 112007_clip, 122007_clip	United States Geological Survey (USGS), Center for Integrated Data Analytics (CIDA)	2007	Monthly
USGS CIDA	Monthly Eta values for Chowchilla Subbasin area and 20-mile buffer	Land Use	Raster	012008_clip, 022008_clip, 032008_clip, 042008_clip, 052008_clip, 062008_clip, 072008_clip, 082008_clip, 092008_clip, 102008_clip, 112008_clip, 122008_clip	United States Geological Survey (USGS), Center for Integrated Data Analytics (CIDA)	2008	Monthly
USGS CIDA	Monthly Eta values for Chowchilla Subbasin area and 20-mile buffer	Land Use	Raster	012009_clip, 022009_clip, 032009_clip, 042009_clip, 052009_clip, 062009_clip, 072009_clip, 082009_clip, 092009_clip, 102009_clip, 112009_clip, 122009_clip	United States Geological Survey (USGS), Center for Integrated Data Analytics (CIDA)	2009	Monthly
USGS CIDA	Monthly Eta values for Chowchilla Subbasin area and 20-mile buffer	Land Use	Raster	012010_clip, 022010_clip, 032010_clip, 042010_clip, 052010_clip, 062010_clip, 072010_clip, 082010_clip, 092010_clip, 102010_clip, 112010_clip, 122010_clip	United States Geological Survey (USGS), Center for Integrated Data Analytics (CIDA)	2010	Monthly
USGS CIDA	Monthly Eta values for Chowchilla Subbasin area and 20-mile buffer	Land Use	Raster	012011_clip, 022011_clip, 032011_clip, 042011_clip, 052011_clip, 062011_clip, 072011_clip, 082011_clip, 092011_clip, 102011_clip, 112011_clip, 122011_clip	United States Geological Survey (USGS), Center for Integrated Data Analytics (CIDA)	2011	Monthly
USGS CIDA	Monthly Eta values for Chowchilla Subbasin area and 20-mile buffer	Land Use	Raster	012012_clip, 022012_clip, 032012_clip, 042012_clip, 052012_clip, 062012_clip, 072012_clip, 082012_clip, 092012_clip, 102012_clip, 112012_clip, 122012_clip	United States Geological Survey (USGS), Center for Integrated Data Analytics (CIDA)	2012	Monthly
USGS CIDA	Monthly Eta values for Chowchilla Subbasin area and 20-mile buffer	Land Use	Raster	012013_clip, 022013_clip, 032013_clip, 042013_clip, 052013_clip, 062013_clip, 072013_clip, 082013_clip, 092013_clip, 102013_clip, 112013_clip, 122013_clip	United States Geological Survey (USGS), Center for Integrated Data Analytics (CIDA)	2013	Monthly
USGS CIDA	Monthly Eta values for Chowchilla Subbasin area and 20-mile buffer	Land Use	Raster	012014_clip, 022014_clip, 032014_clip, 042014_clip, 052014_clip, 062014_clip, 072014_clip, 082014_clip, 092014_clip, 102014_clip, 112014_clip, 122014_clip	United States Geological Survey (USGS), Center for Integrated Data Analytics (CIDA)	2014	Monthly
USGS CIDA	Monthly Eta values for Chowchilla Subbasin area and 20-mile buffer	Land Use	Raster	012015_clip, 022015_clip, 032015_clip, 042015_clip, 052015_clip, 062015_clip, 072015_clip, 082015_clip, 092015_clip, 102015_clip, 112015_clip, 122015_clip	United States Geological Survey (USGS), Center for Integrated Data Analytics (CIDA)	2015	Monthly
USGS NLCD	California coverage of land usage by crop	Land use	GIS, shapefile	Map: Madera_County_SGMA Shapefiles: NLCD2001_LC_California.tif, NLCD2006_LC_California.tif, NLCD2011_LC_California.tif	United States Geological Survey (USGS), National Land Cover Data (NLCD)	2001, 2006, 2011	Yearly
USGS Water Quality Portal	Location of sample site and site description for gw (e.g. well depth, aquifer name and type) and sw (e.g. drainage area). The WQP a c coopertive service sponsered by the USGS, EPA, and the National Water Quality Monitoring Council that integrates publically available water quality data.	Surface and Ground water quality sites	Excel	USGS_Madera_Sites	Water Quality Portal (WQP): a coopertive service sponsered by the USGS, EPA, and the National Water Quality Monitoring Council that integrates publically available water quality data.	n/a	
USGS Water Quality Portal	Location of sample site and site description for gw (e.g. well depth, aquifer name and type) and sw (e.g. drainage area). The WQP a c coopertive service sponsered by the USGS, EPA, and the National Water Quality Monitoring Council that integrates publically available water quality data.	Surface and Ground water quality sites	Excel	USGS_Merced_Sites	Water Quality Portal (WQP): a coopertive service sponsered by the USGS, EPA, and the National Water Quality Monitoring Council that integrates publically available water quality data.	n/a	
USGS Water Quality Portal	Location of sample site and site description for gw (e.g. well depth, aquifer name and type) and sw (e.g. drainage area). The WQP a c coopertive service sponsered by the USGS, EPA, and the National Water Quality Monitoring Council that integrates publically available water quality data.	Surface and Ground water quality sites	Excel	USGS_Fresno_Sites	Water Quality Portal (WQP): a coopertive service sponsered by the USGS, EPA, and the National Water Quality Monitoring Council that integrates publically available water quality data.	n/a	
USGS Water Quality Portal	Location of sample site and site description for gw (e.g. well depth, aquifer name and type) and sw (e.g. drainage area). The WQP a c coopertive service sponsered by the USGS, EPA, and the National Water Quality Monitoring Council that integrates publically available water quality data.	Surface and Ground water quality sites	Excel	USGS_Mariposa_Sites	Water Quality Portal (WQP): a coopertive service sponsered by the USGS, EPA, and the National Water Quality Monitoring Council that integrates publically available water quality data.	n/a	
USGS Water Quality Portal	Surface water and ground water quality	Surface and Ground water quality results	Excel	USGS_Madera_Results	Water Quality Portal (WQP): a coopertive service sponsered by the USGS, EPA, and the National Water Quality Monitoring Council that integrates publically available water quality data.	1950-2015	
USGS Water Quality Portal	Surface water and ground water quality	Surface and Ground water quality results	Excel	USGS_Merced_Results	Water Quality Portal (WQP): a coopertive service sponsered by the USGS, EPA, and the National Water Quality Monitoring Council that integrates publically available water quality data.	1943-2016	

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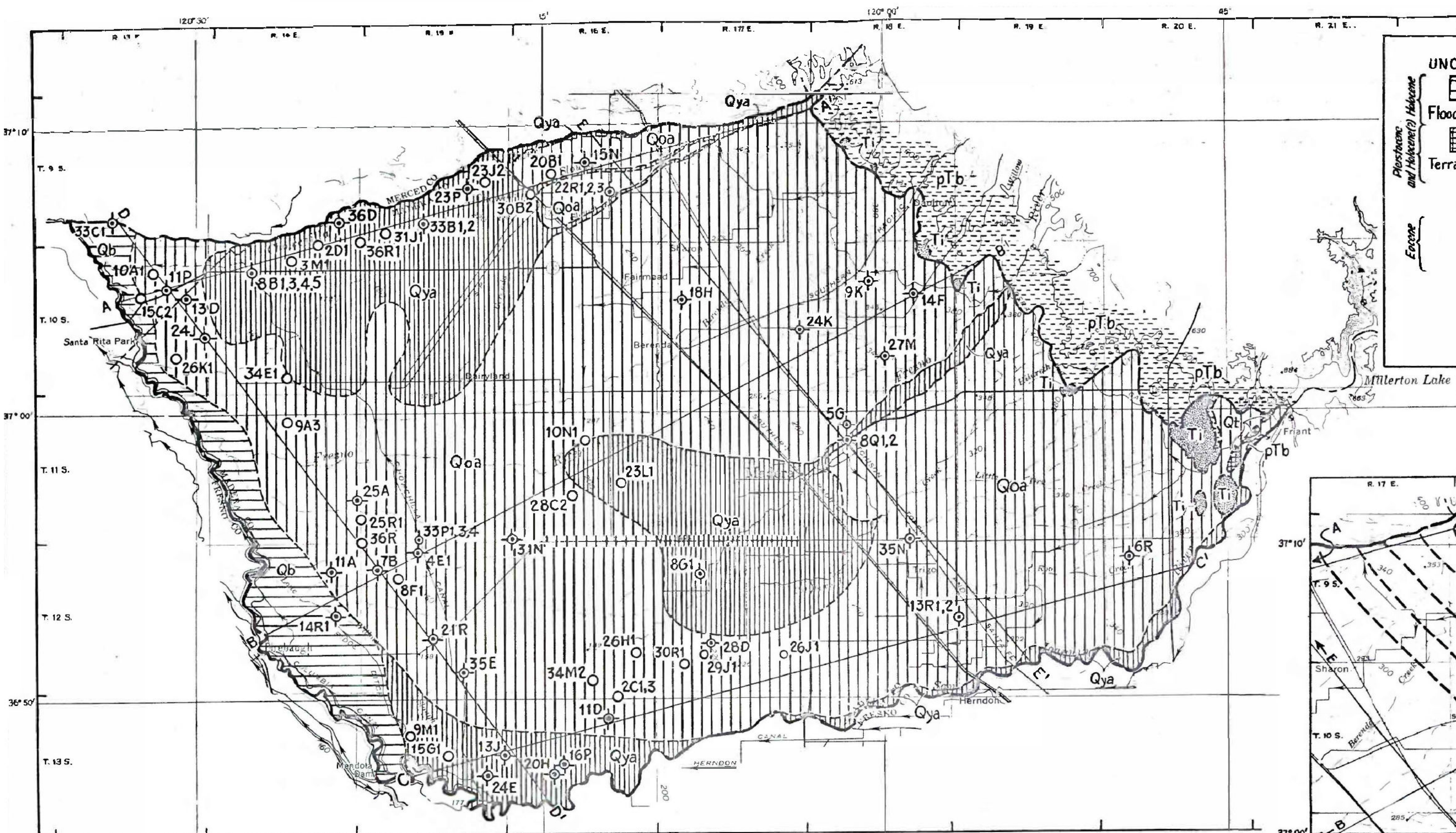
Entity	Data Description	Data Type	File Type	File Name	Data source	Period of Record	Timestep
USGS Water Quality Portal	Surface water and ground water quality	Surface and Ground water quality results	Excel	USGS_Fresno_Results	Water Quality Portal (WQP): a coopertive service sponsered by the USGS, EPA, and the National Water Quality Monitoring Council that integrates publically available water quality data.	1937-2017	
USGS Water Quality Portal	Surface water and ground water quality	Surface and Ground water quality results	Excel	USGS_Mariposa_Results	Water Quality Portal (WQP): a coopertive service sponsered by the USGS, EPA, and the National Water Quality Monitoring Council that integrates publically available water quality data.	1930-2017	
Jet Propulsion Laboratory	Report on subsidence in the Central Valley	Subsidence Data	PDF	JPL subsidence report final for public dec 2016	Jet Propulsion Laboratory	2015-2016	
GeoTracker SWRCB	Water Quality data for Madera, Merced, Fresno Counties	Water Quality	Excel	MaderaEDF, Merced EDF, FresnoEDF	SWRCB	2003-2016	
GeoTracker SWRCB	Screen intervals for wells	Well Construction	Excel	MaderaFieldPoints, MercedFieldPoints, FresnoField Points	SWRCB	n/a	
GeoTracker SWRCB	Locations of wells and sampling sites	Well List	Excel	MaderaGeoXY, MercedGeoXY, FresnoGeoXY	SWRCB	n/a	
GeoTracker SWRCB	Groundwater elevation for Madera, Fresno, and Merced counties	Groundwater Elevations: point data	Excel	MaderaGeoWell, MercedGeoWell, FresnoGeoWell	SWRCB	1993-2017	
GeoTracker SWRCB	Elevations of wells and sampling locations	Well List	Excel	MaderaGeoZ, MercedGeoZ, FresnoGeoZ	SWRCB	n/a	
DWR Water Data Library	Walter Level measurements for California. Includes information on groundwater levels, well construction, groundwater basin, and other measurement information.	Groundwater Elevations: point data, well construction	CSV	gst_file, perf_file, gwl_file, elevation_accuracy_type, elevation_measure_method_type, measurement_accuracy_type,measurement_issue_type, measurement_method_type, ReadMe.txt	DWR	1900-2017	
GeoTracker SWRCB	Water Quality data for Madera, Merced, Fresno Counties	Water Quality	Excel	MaderaEDF, Merced EDF, FresnoEDF	SWRCB	2003-2016	
GeoTracker SWRCB	Screen intervals for wells	Well Construction	Excel	MaderaFieldPoints, MercedFieldPoints, FresnoField Points	SWRCB	n/a	
GeoTracker SWRCB	Locations of wells and sampling sites	Well List	Excel	MaderaGeoXY, MercedGeoXY, FresnoGeoXY	SWRCB	n/a	
GeoTracker SWRCB	Groundwater elevation for Madera, Fresno, and Merced counties	Groundwater Elevations: point data	Excel	MaderaGeoWell, MercedGeoWell, FresnoGeoWell	SWRCB	1993-2017	
GeoTracker SWRCB	Elevations of wells and sampling locations	Well List	Excel	MaderaGeoZ, MercedGeoZ, FresnoGeoZ	SWRCB	n/a	
DWR	Spring groundwater Level Countours for Chowchilla County	Groundwater Elevations	PDF	PDFs_Chowchilla_1958_2011	DWR	1958-2011	
NRCS SSURGO	Soil Maps	Soils	zip	gssurgo_g_ca.zip	NRCS	n/a	
DWR	Spring and Fall groundwater level contour data	Groundwater Elevations	GIS, shapefile	Folder: Shapefiles_2011_2016	DWR	2011-2016	
USGS NWIS	Groundwater Elevation data	Groundwater Elevations: point data	Excel	NWIS_measurements_rawdata	USGS	1903-2016	
USGS NWIS	Coordinats and total depths of wells	Well List, Well Construction	Excel	NWIS_Wells	USGS	n/a	
GeoTracker: GAMA	Nitrate Measurements for entire state of California	Groundwater quality	Excel	UCDAVIS_Nitrate	UC Davis	1946-2011	
California Data Exchange Network	Surface Water Quality for state of California	Surface Water Quality	Excel, pdf	Excel: ceden_data_retriveal_201742110321, Environmental_Data_Exchage_Network_-_Chemistry_Data_2005-2015, PDF: Environmental_Data_Exchage_Network_-_Chemistry_Data_2005-2015	CEDEN	2005-2015	
USGS	Locations of InSAR Measurements	Subsidence	Excel	central-valley_insar-timeseries	USGS California Water Science Center	2003-2010	
USGS	Locations of extensometer measurements	Subsidence	Excel	central-valley_extesometer-data	USGS California Water Science Center	1958-2015	

Water Management Plans Available for the Subbasin and Nearby Area

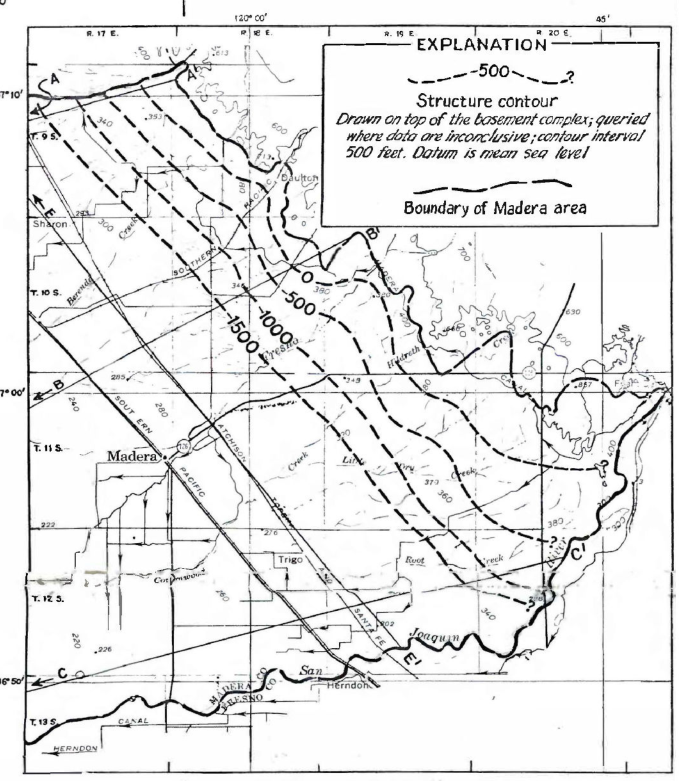
Entity	Plan	Year (of criteria)	Year (of submittal)	County
Central California Irrigation District (San Joaquin River Exchange Contractors)	5-Year Update Water Management Plan	2011	2014	Merced
Chowchilla Water District	5-Year Update Water Management Plan	2008	2011	Madera
Chowchilla Water District	SBx7-7 Supplement Report	2015	2015	Madera
City of Fresno	USBR Water Management Plan	2011	2013	Fresno
City of Los Banos	Urban Water Management Plan	2015	2016	Merced
Columbia Canal Company	Agricultural Water Management Plan	2011	2014	Fresno
Fresno Irrigation District	Agricultural Water Management Plan	2011	2016	Fresno
Gravelly Ford water District	Agricultural Water Management Plan	2008	2012	Madera
Madera County	Integrated Regional Water Management Plan		2008	Madera
Madera Irrigation District	SBx7-7 Supplement Report		2013	Madera
Madera Irrigation District	USBR Water Management Plan	2011	2013	Madera
Merced Irrigation District	Agricultural Water Management Plan	2009	2013	Merced
Merced Irrigation District	Agricultural Water Management Plan (drought and groundwater plans included here too)	2009	2016	Merced

APPENDIX B

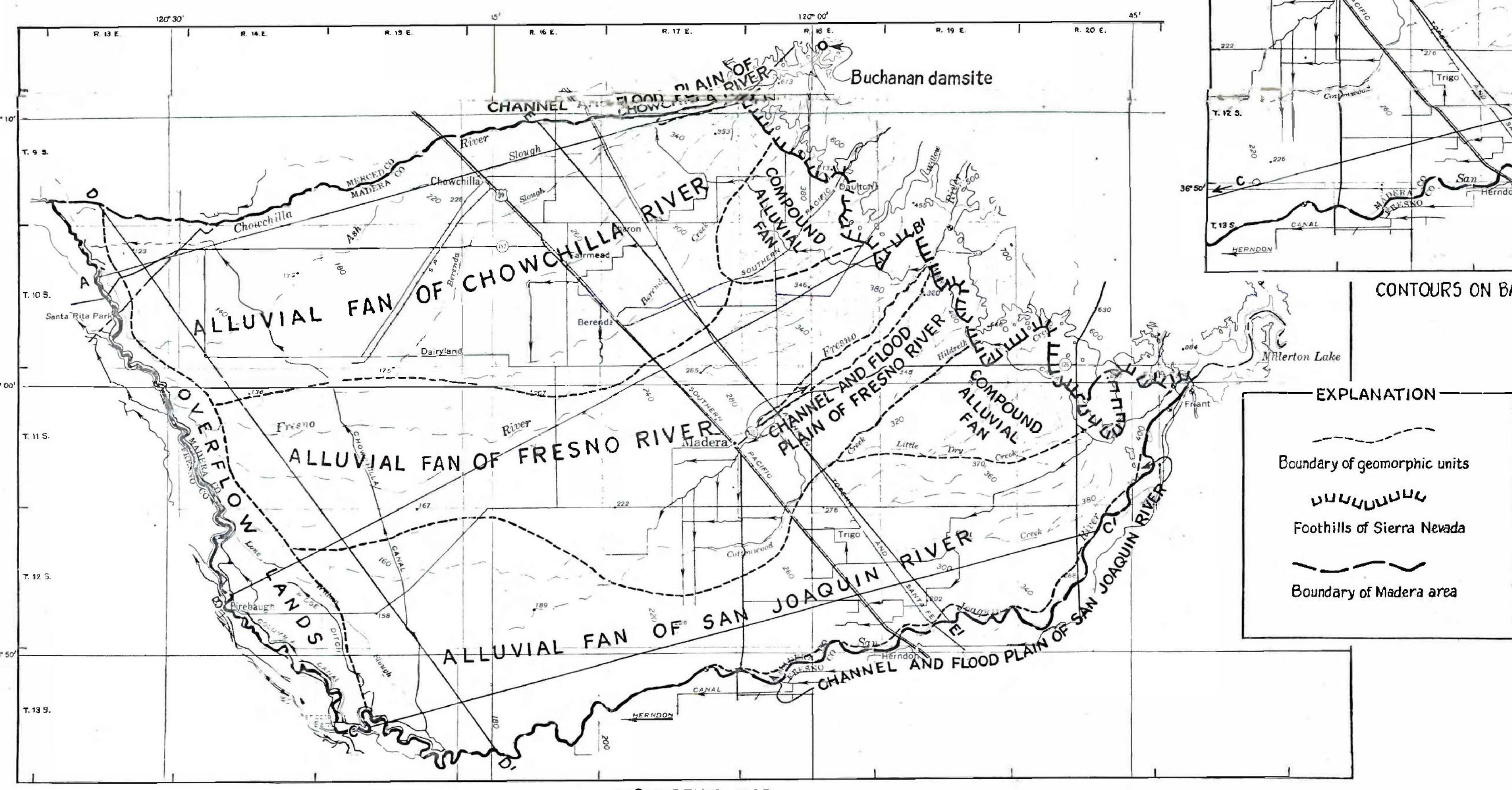
GEOLOGIC MAPS AND CROSS-SECTIONS



GEOLOGIC MAP



CONTOURS ON BASEMENT COMPLEX



GEOMORPHIC MAP

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

Data sources: Plate 1 of USGS Open-File Report 70-228

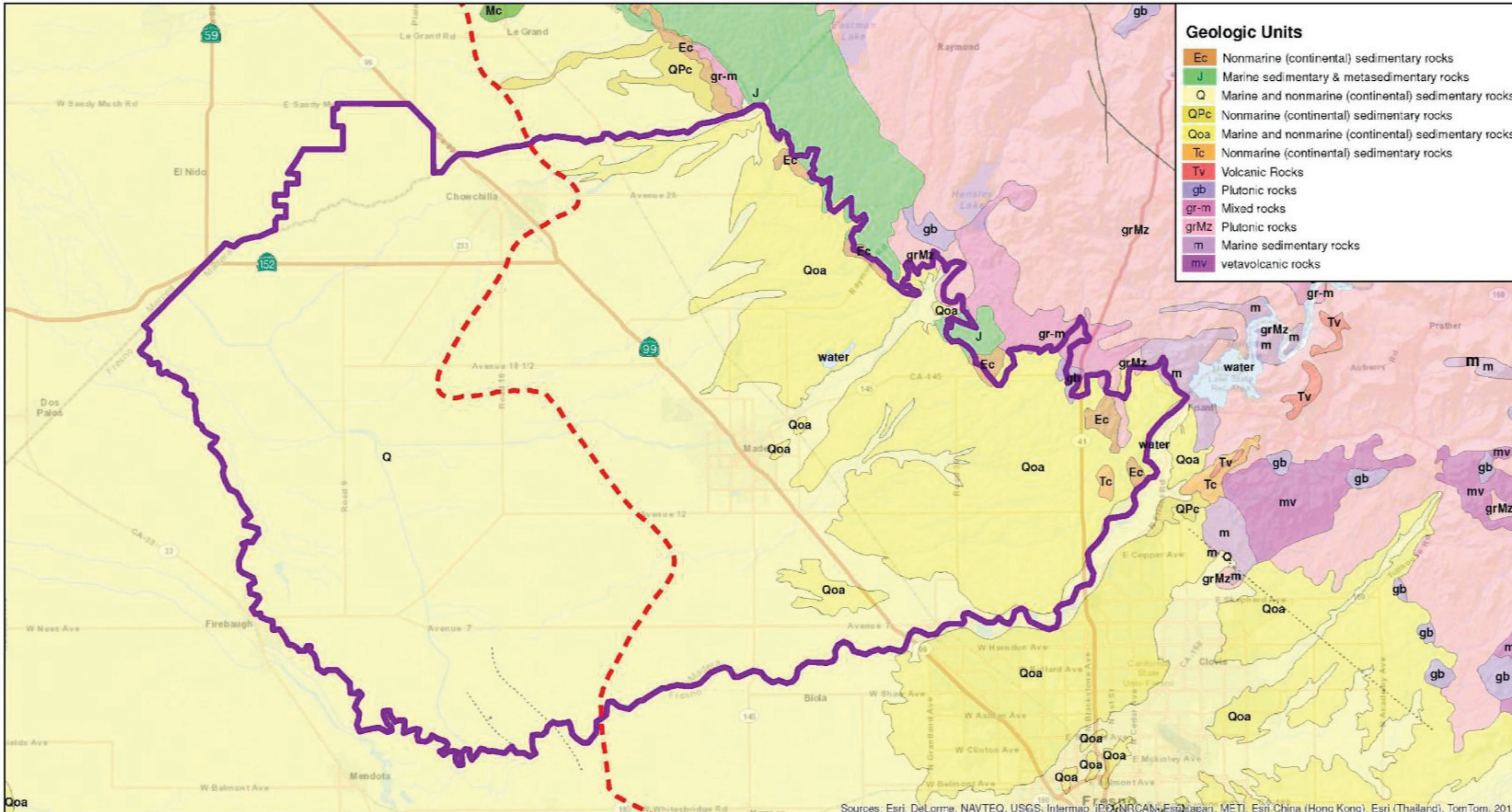
X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\ChowchillaSubbasinGeologyMap_fromUSGS_OFR70-228_11x17.mxd

DAVIDS ENGINEERING, INC

LUHDORFF & SCALMANINI CONSULTING ENGINEERS

Geologic and Geomorphic Maps from USGS OFR-70-228

Madera County - Chowchilla Subbasin
SGMA Data Collection and Analysis



0 2.5 5 Miles

PROVOST& PRITCHARD CONSULTING GROUP EST. 1968 An Employee Owned Company
2505 Alluvial Avenue
Clovis, CA 93611
(559) 326-1100

Legend

Groundwater Management Plan Boundary

Corcoran Clay Extent modified from Page (1986) for the Central Valley Hydrologic Model (2012)

Geologic Map of California, 2010

Madera Regional Groundwater Management Plan

Simplified Geologic Map
Groundwater Management Plan Area

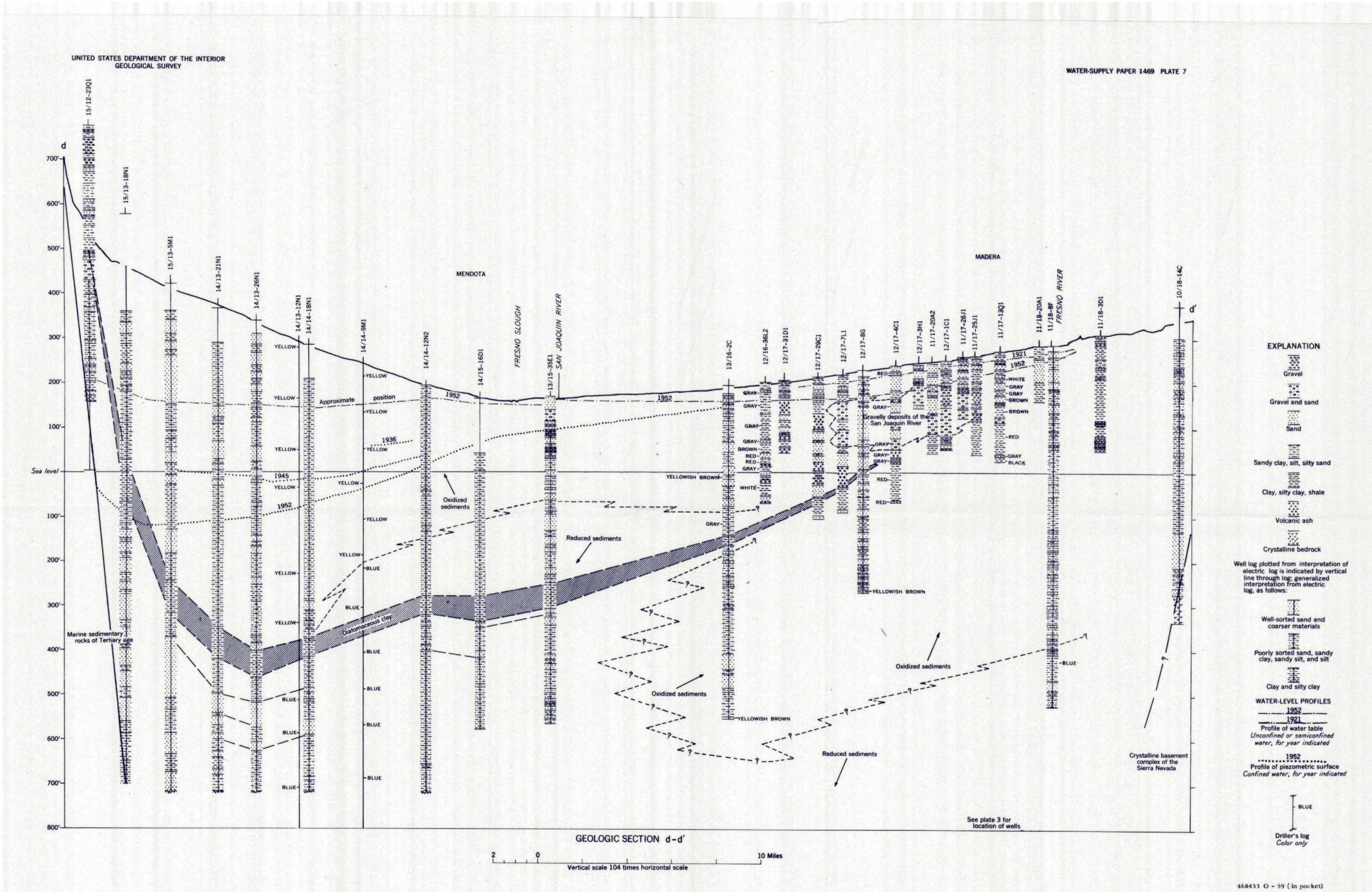
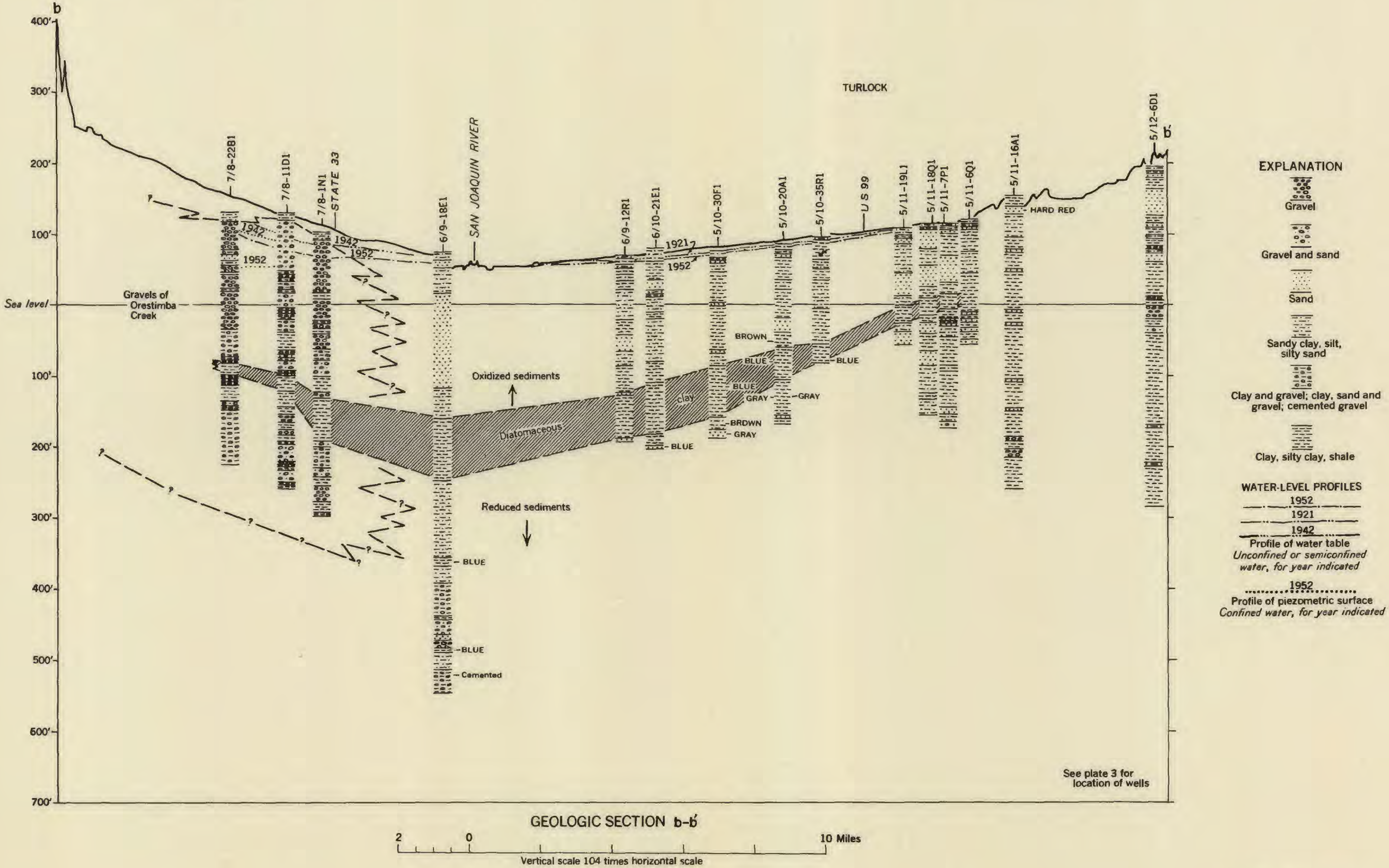


Figure 3-14 Geologic Cross Section

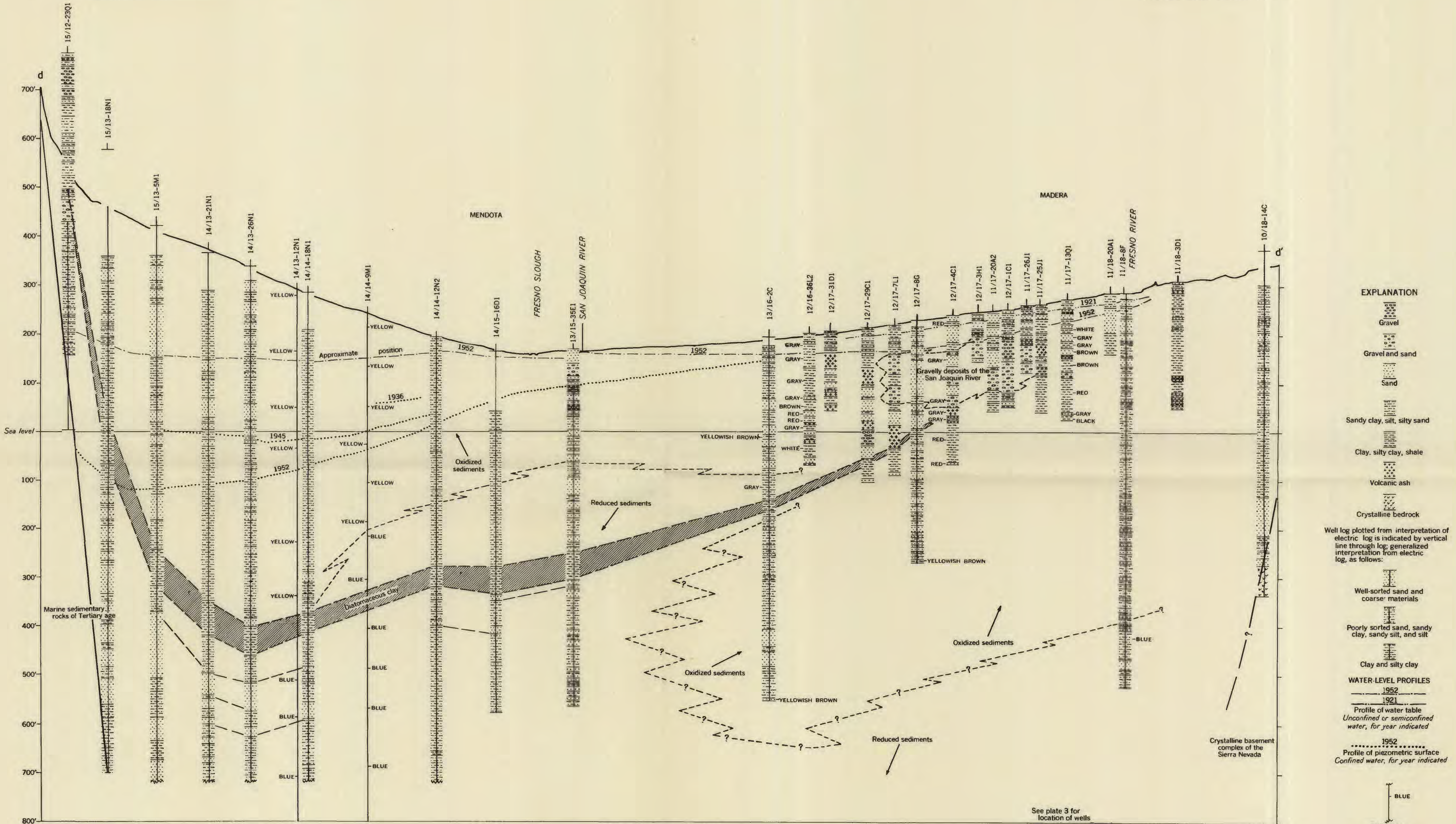
Davis et al., 1959



GEOLOGIC SECTION b-b'

468433 O - 59 (In pocket)

Davis et al., 1959



GEOLOGIC SECTION d–d'

2 0 10 Miles

Vertical scale 104 times horizontal scale

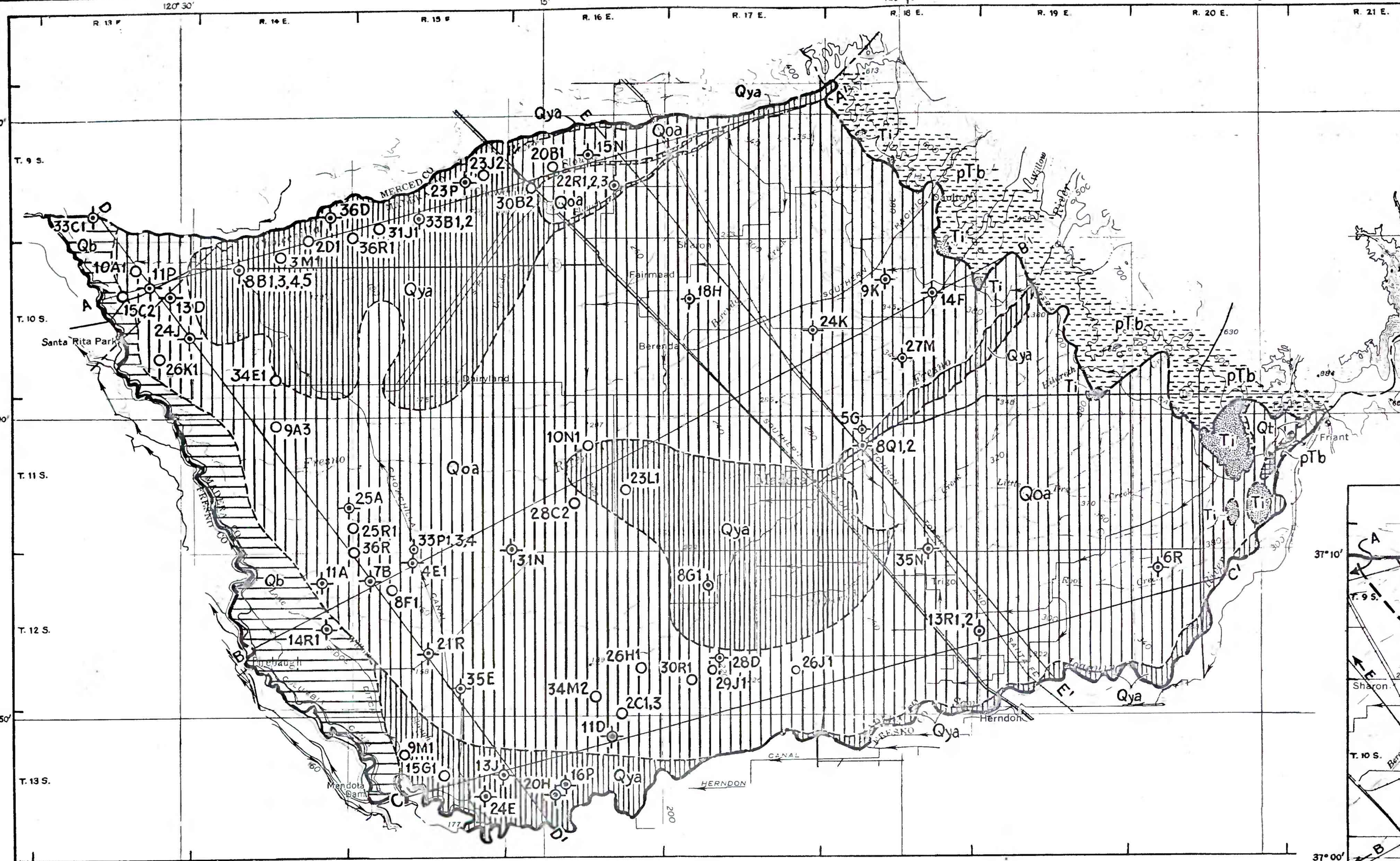
Mitten et al., 1970

70-228

U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE CALIFORNIA DEPARTMENT OF WATER RESOURCES

PLATE 1



EXPLANATION

UNCONSOLIDATED DEPOSITS

Pleistocene and Holocene(?) Holocene — QUATERNARY

Qb — Flood-basin deposits

Qya — Younger alluvium

Qt — Terrace deposits

Qoa — Older alluvium

UNCONFORMITY

CONSOLIDATED ROCKS

Eocene — TERTIARY

Ti — Ione Formation

UNCONFORMITY

PRE-TERTIARY

pTb — Basement complex

Geologic contact

13D1 — Water well and number

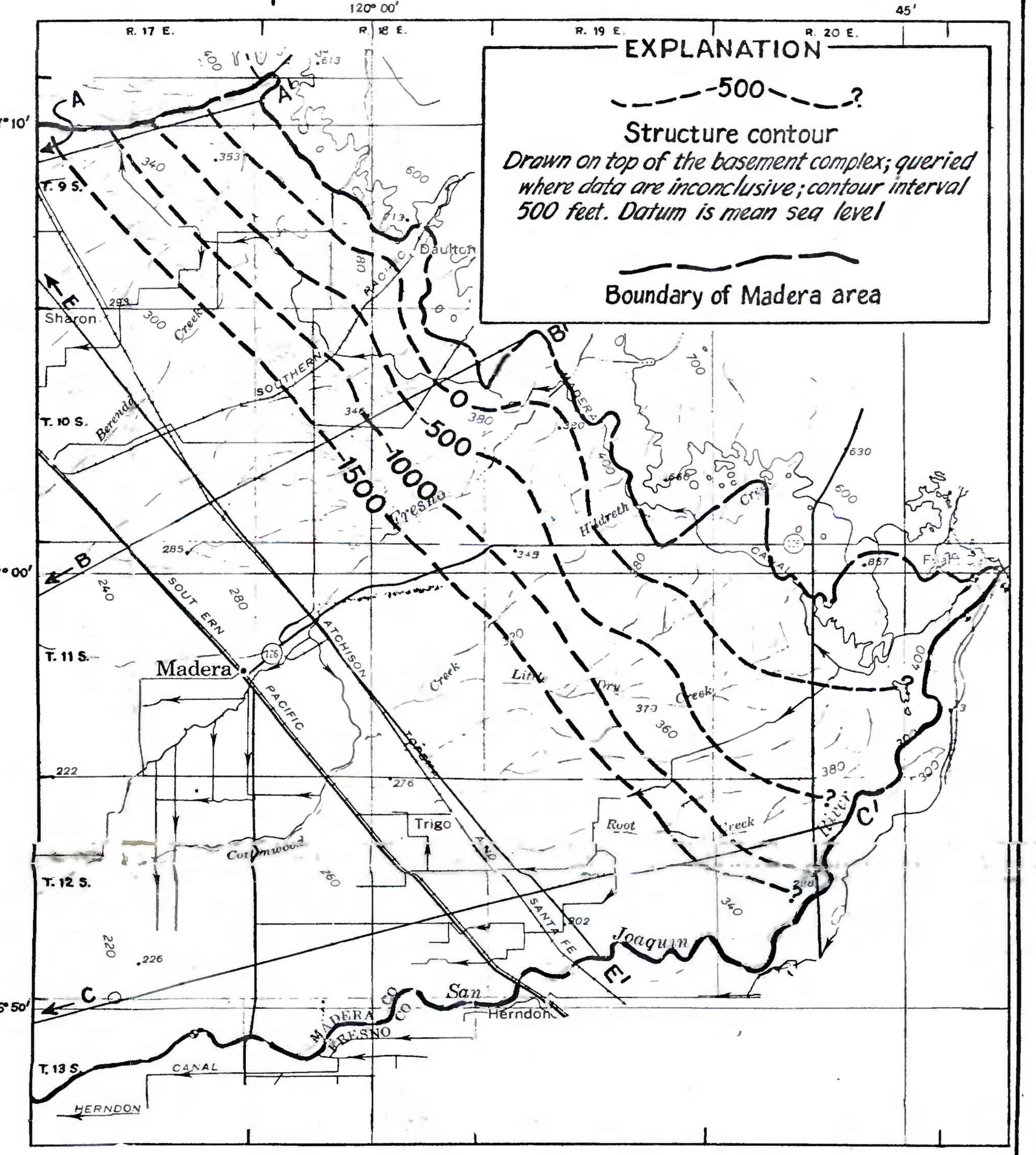
33B1 — Test well and number

Oil well or oil-test well and number

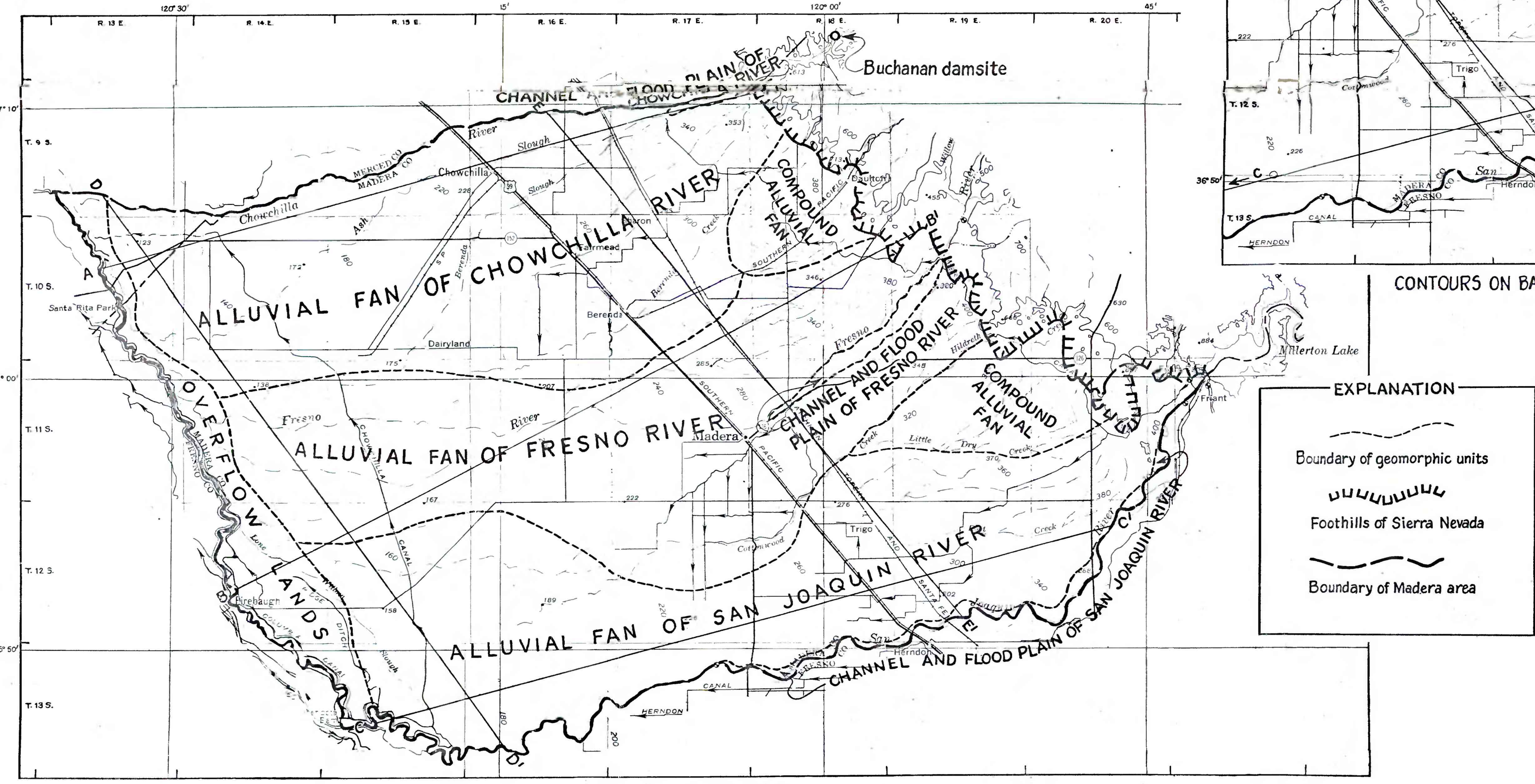
A—A' Line of geologic section

Boundary of Madera area

GEOLOGIC MAP



CONTOURS ON BASEMENT COMPLEX



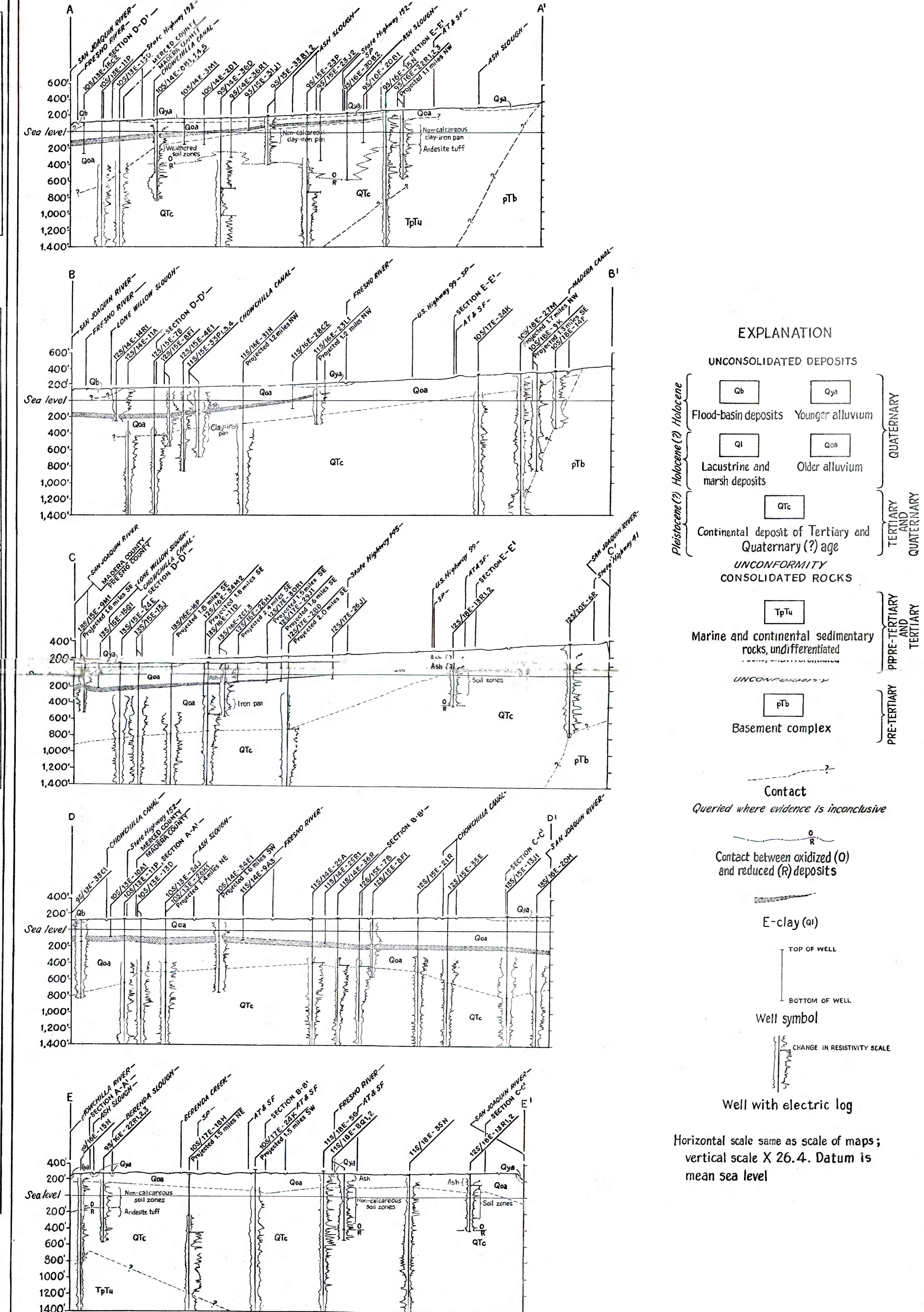
GEOMORPHIC MAP

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

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

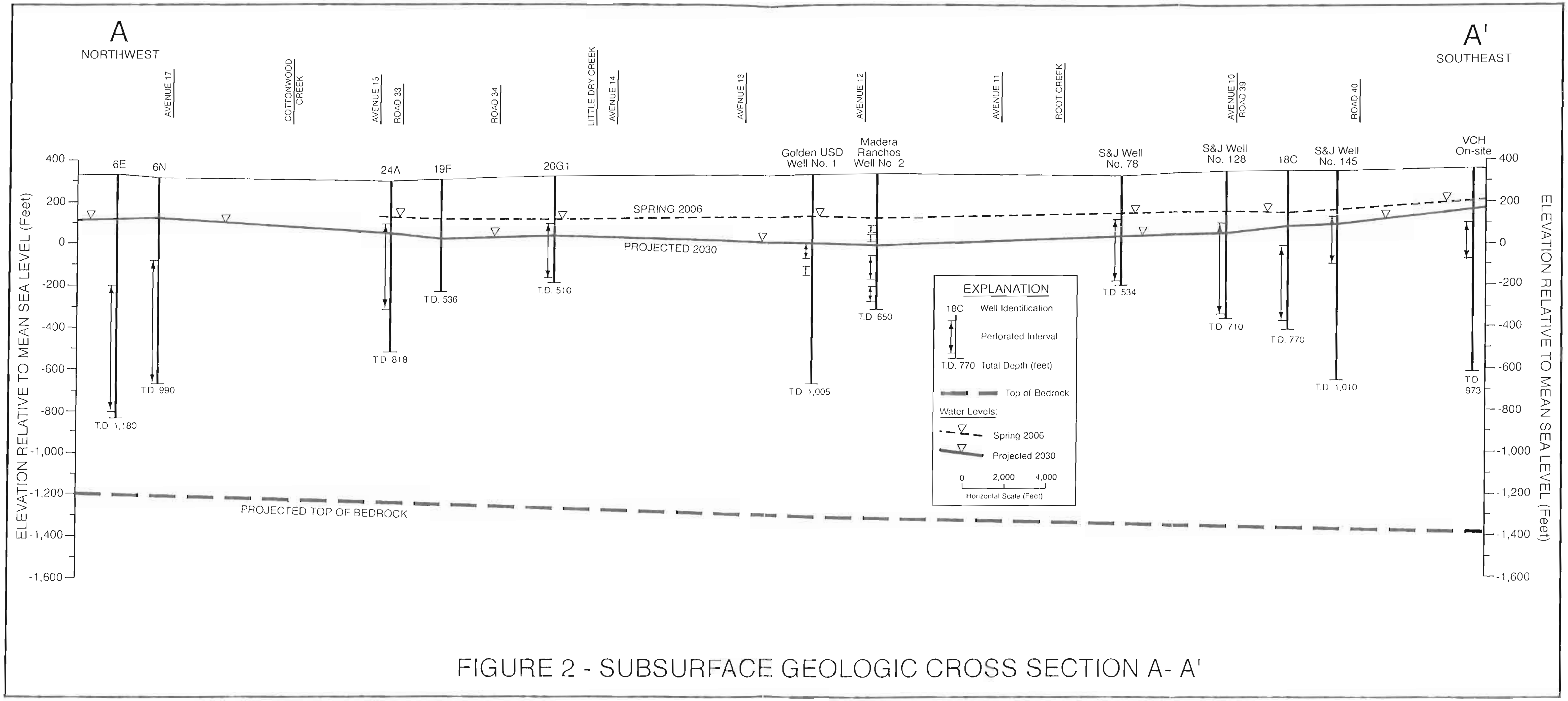


FIGURE 2 - SUBSURFACE GEOLOGIC CROSS SECTION A- A'

Gunner Ranch TM 3, 2006

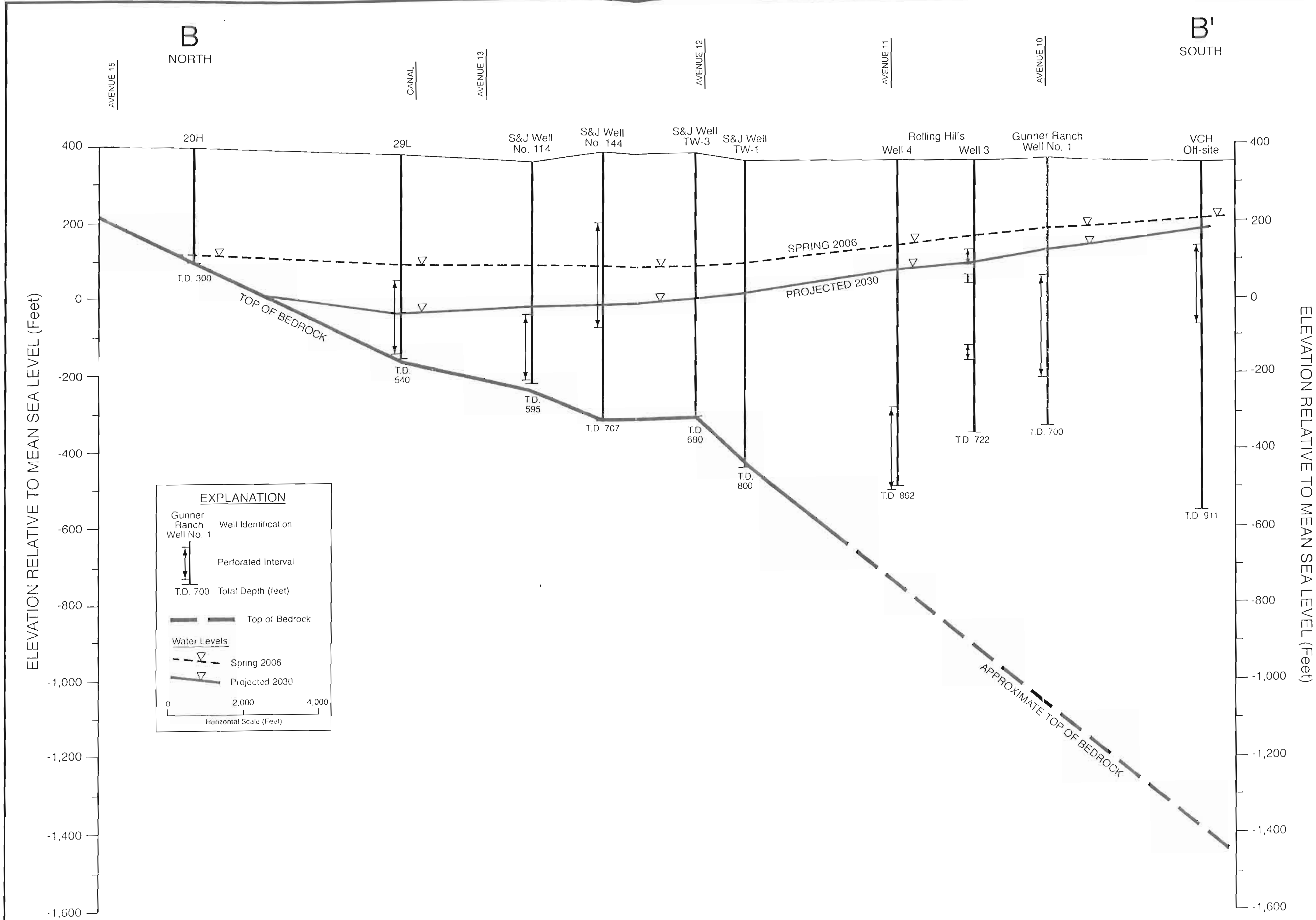


FIGURE 3 - SUBSURFACE GEOLOGIC CROSS SECTION B - B'

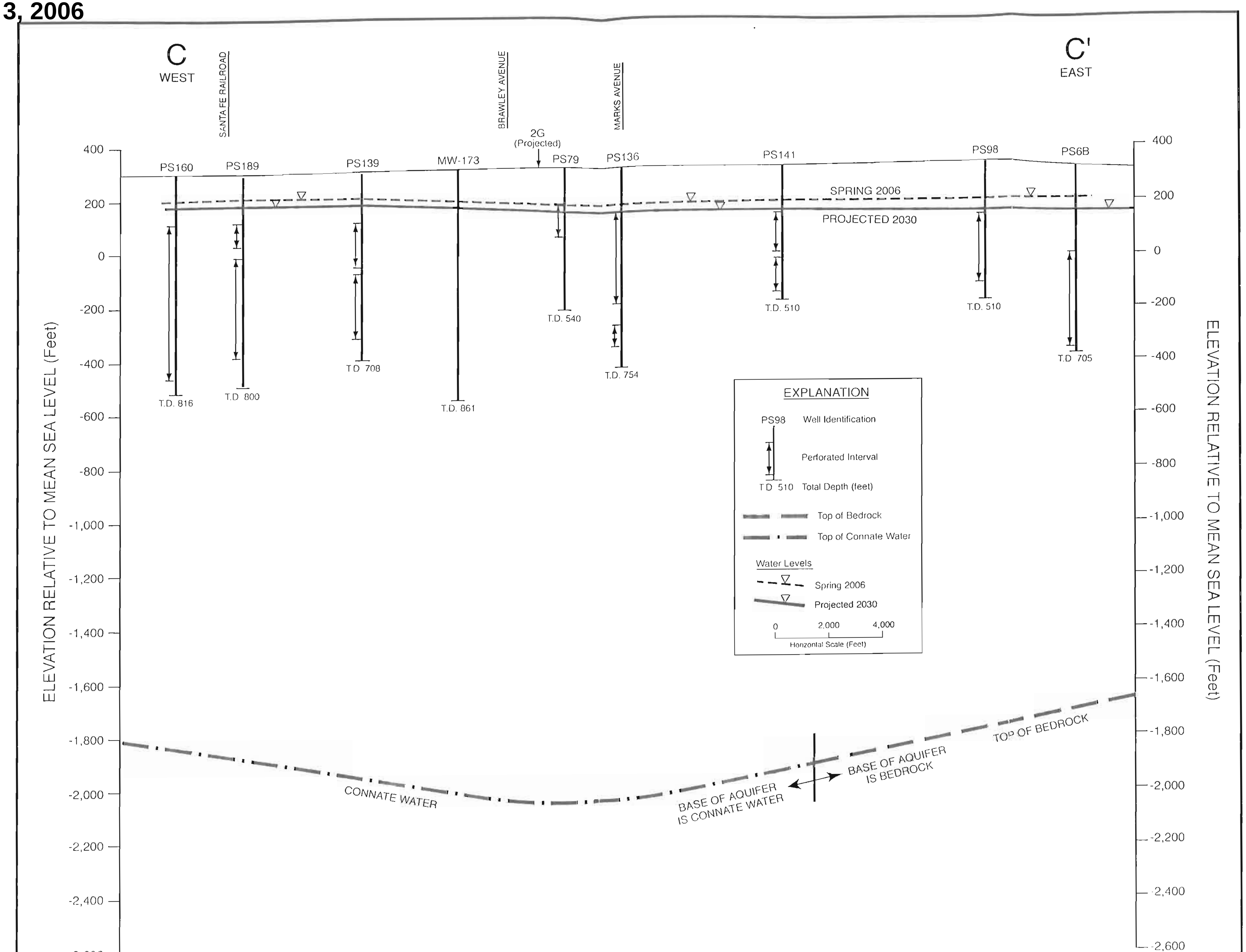
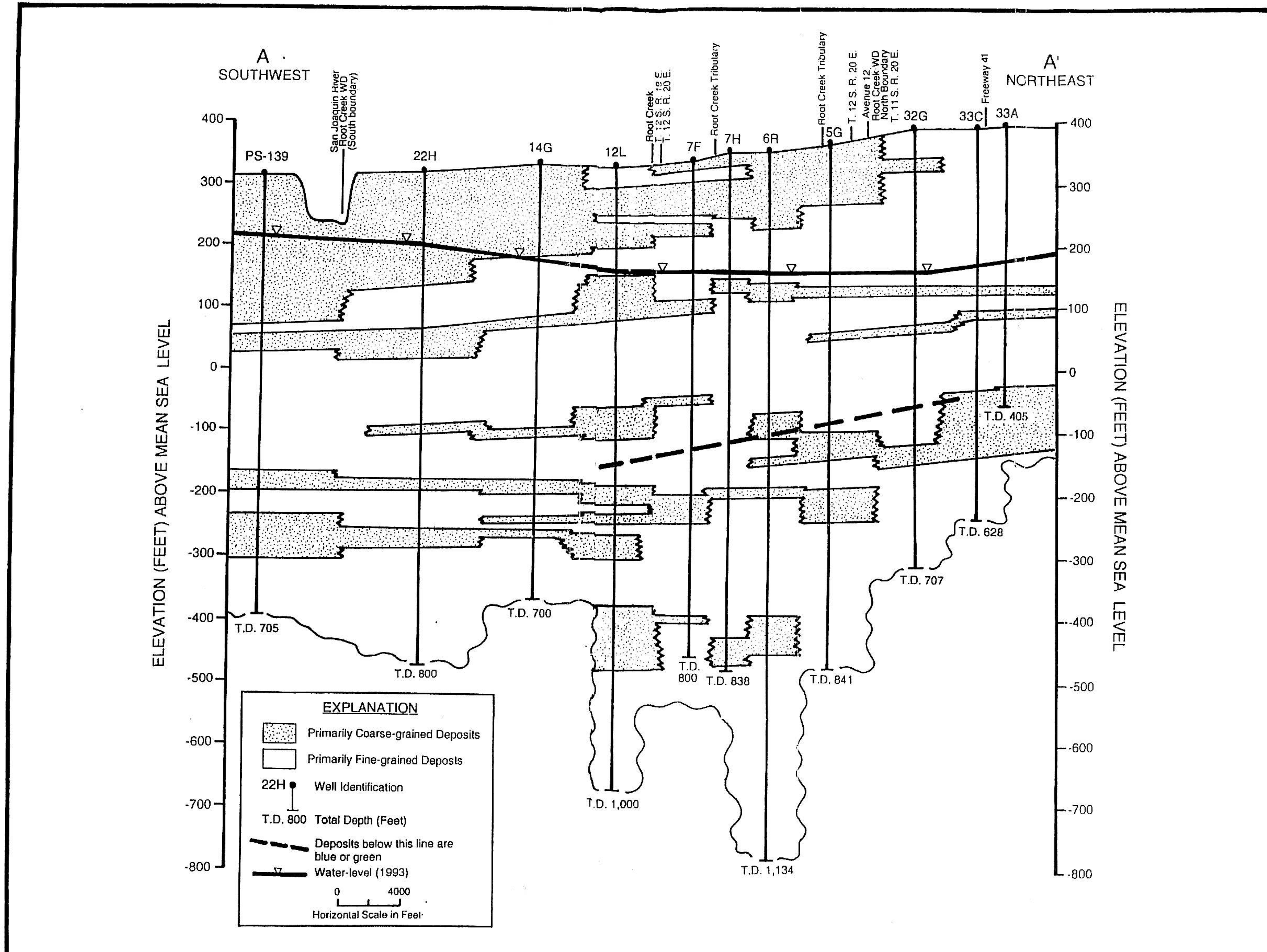


FIGURE 4 - SUBSURFACE GEOLOGIC CROSS SECTION C - C'

PLATE 10



SUBSURFACE GEOLOGIC CROSS SECTION A - A'

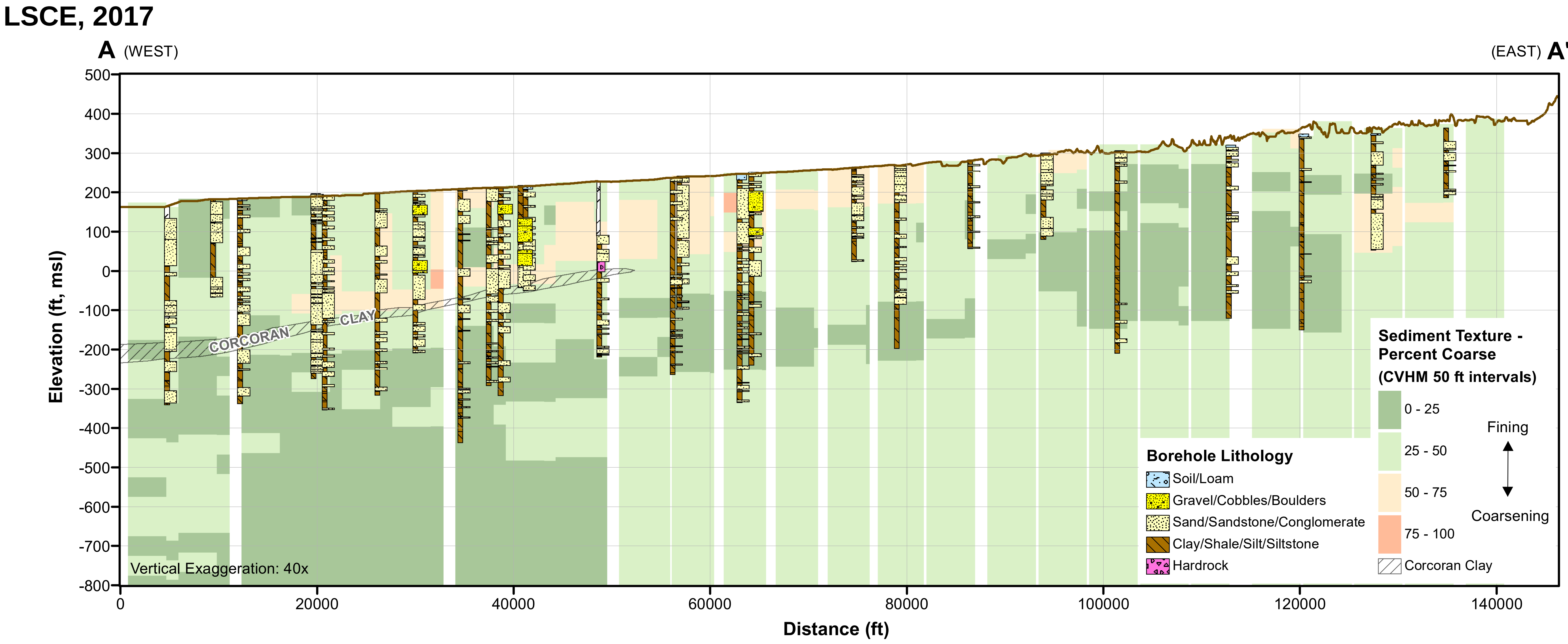
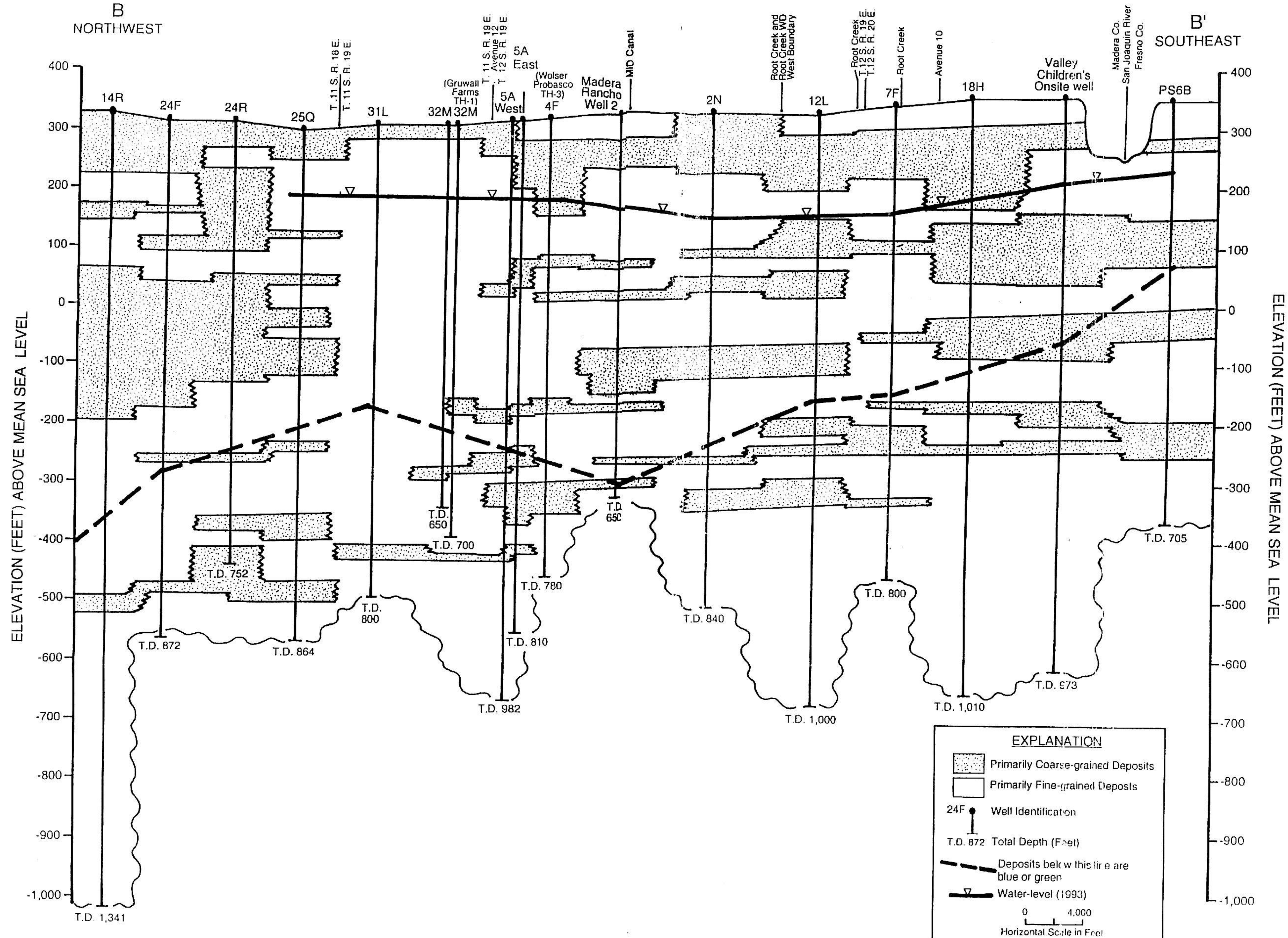

LSCE, 2017
A (WEST)
(EAST) A'
Elevation (ft, msl)
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
-700
-800
0
20000
40000
60000
80000
100000
120000
140000
Distance (ft)
CORCORAN CLAY
Vertical Exaggeration: 40x
Borehole Lithology
Soil/Loam
Gravel/Cobbles/Boulders
Sand/Sandstone/Conglomerate
Clay/Shale/Silt/Siltstone
Hardrock
Sediment Texture - Percent Coarse
(CVHM 50 ft intervals)
0 - 25
25 - 50
50 - 75
75 - 100
Corcoran Clay
Fining
Coarsening

PLATE 11



SUBSURFACE GEOLOGIC CROSS SECTION B - B'

APPENDIX C

GROUNDWATER LEVEL MAPS AND HYDROGRAPHS

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 500,000

5 0 5 10 15 20 Miles

10 0 10 20 Kilometers

1915

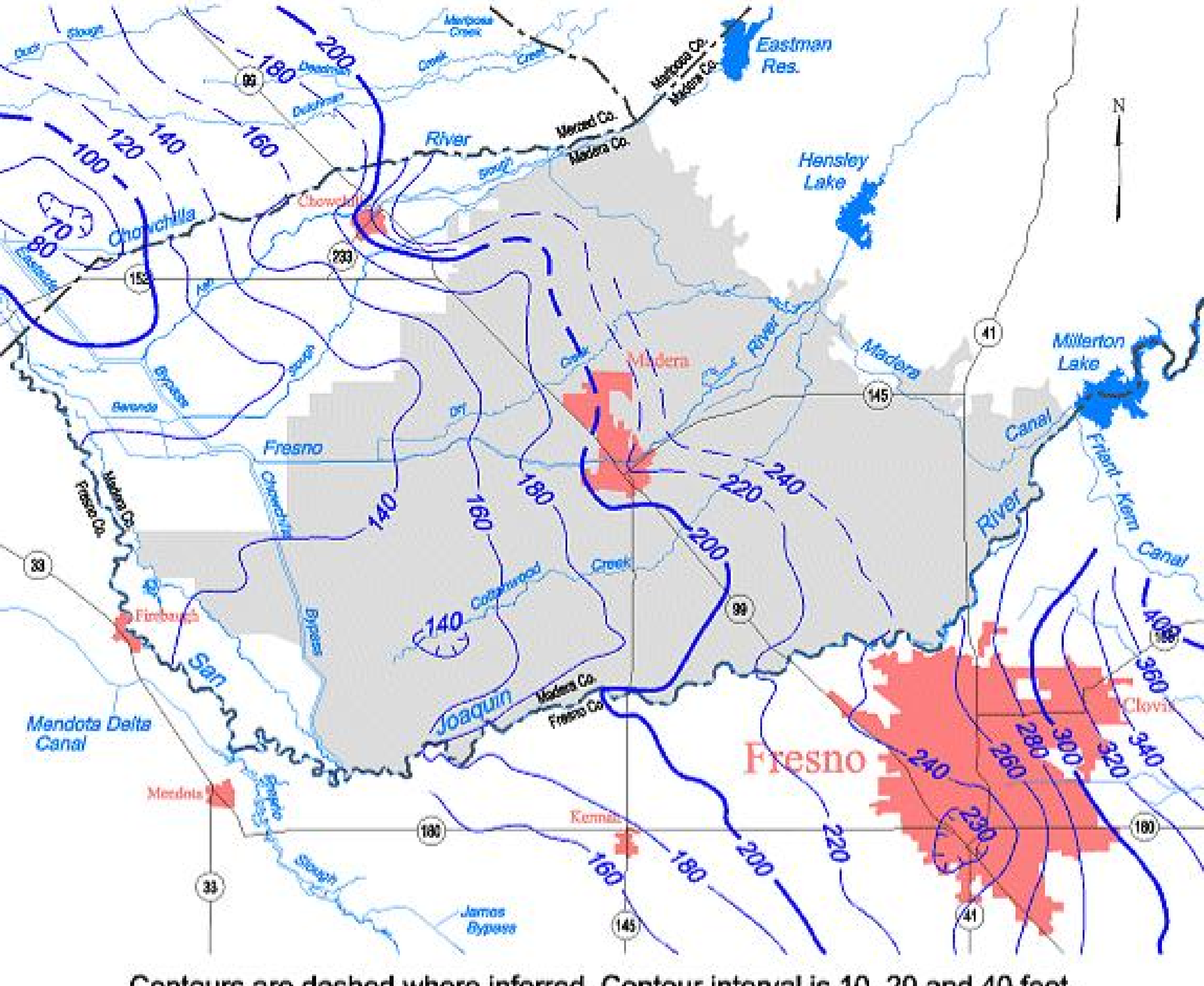
Madera Groundwater Basin

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

Scale of Miles

2 0 2 4 6 8

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.



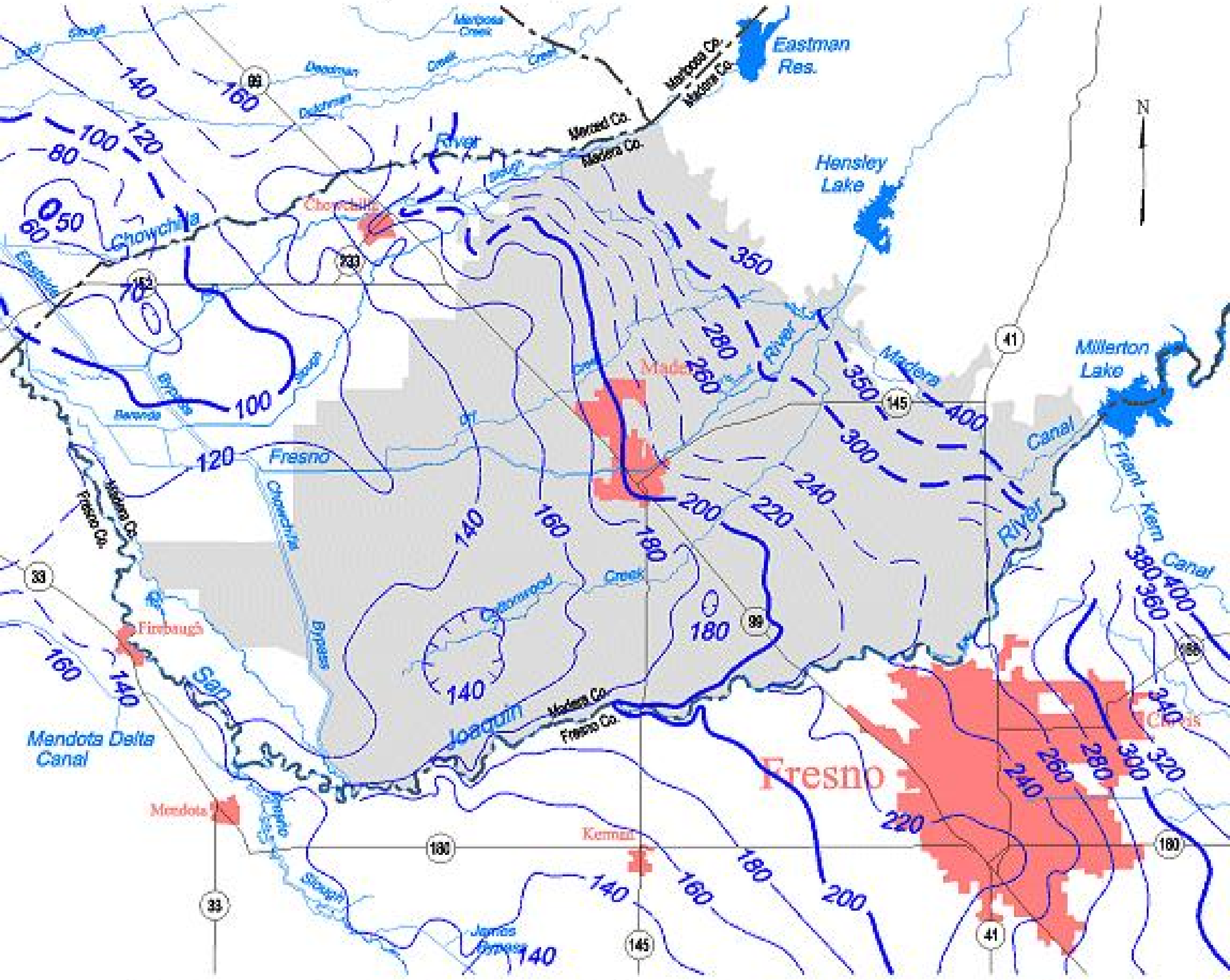
Contours are dashed where inferred. Contour interval is 10, 20 and 40 feet.

Madera Groundwater Basin

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

Scale of Miles
2 0 2 4 6 8

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.

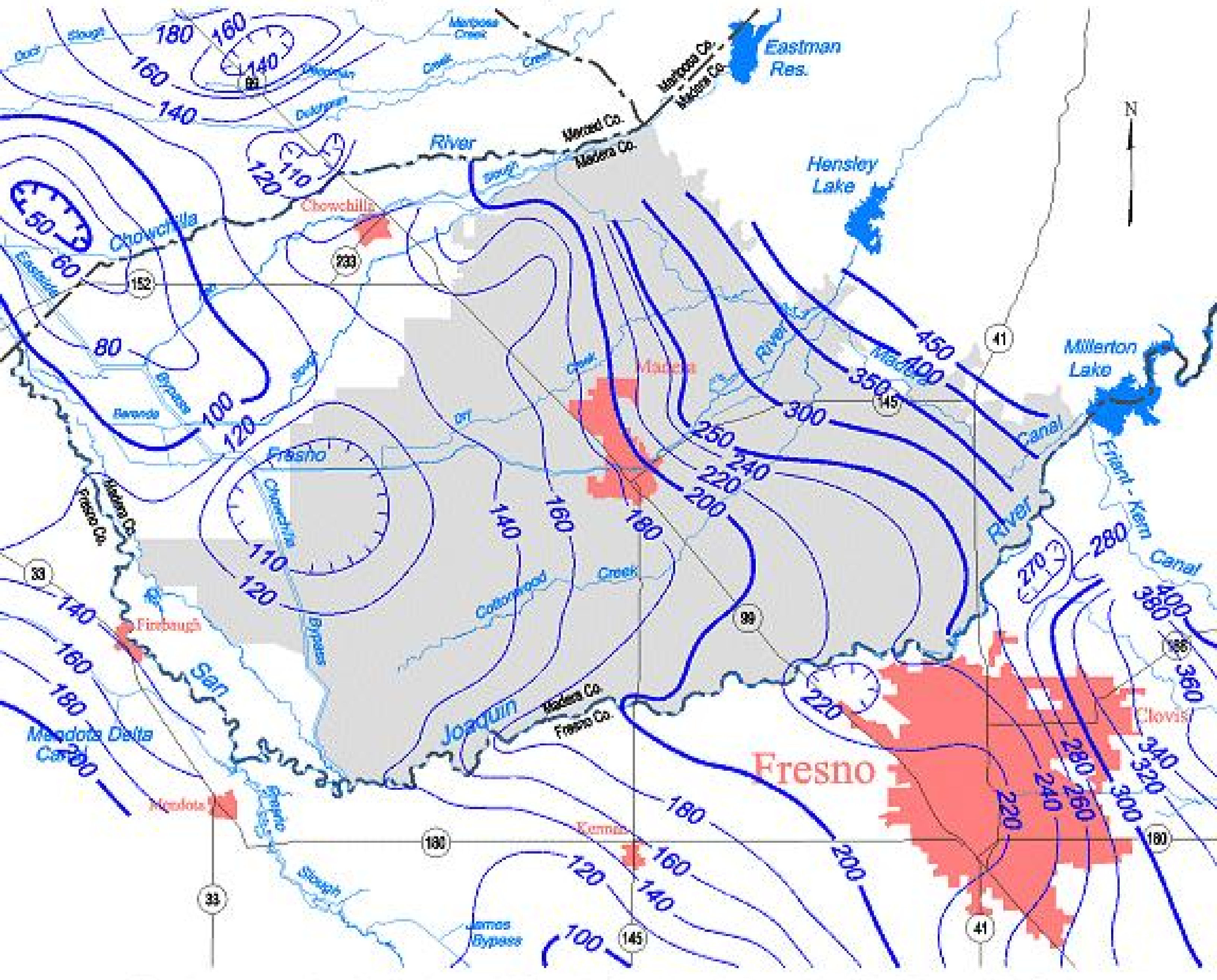
Madera Groundwater Basin

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

Scale of Miles

2 0 2 4 6 8

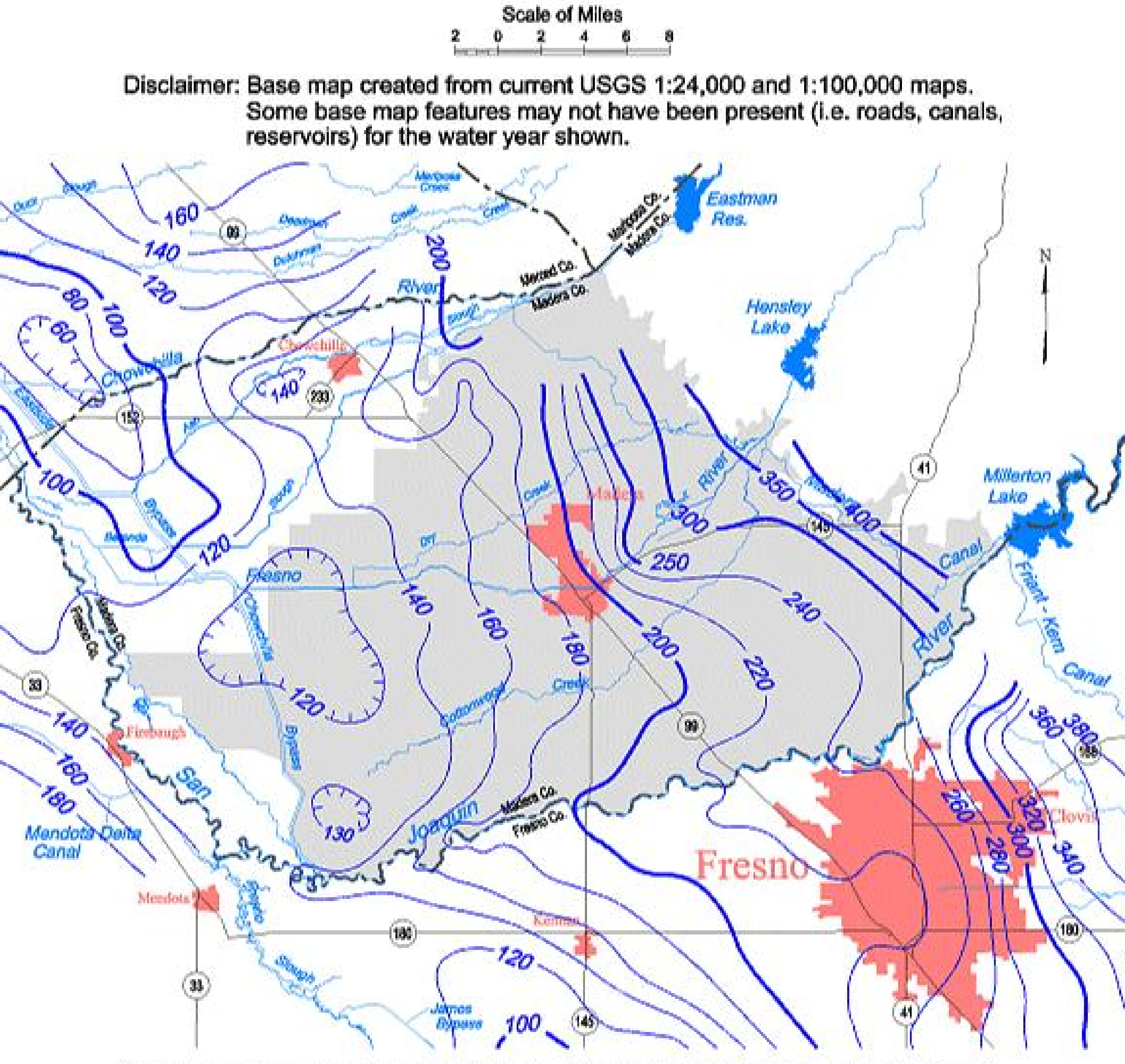
Disclaimer: Base map created from current USGS 1:24,000 and 1:100,000 maps. Some base map features may not have been present (i.e. roads, canals, reservoirs) for the water year shown.



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

Madera Groundwater Basin

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



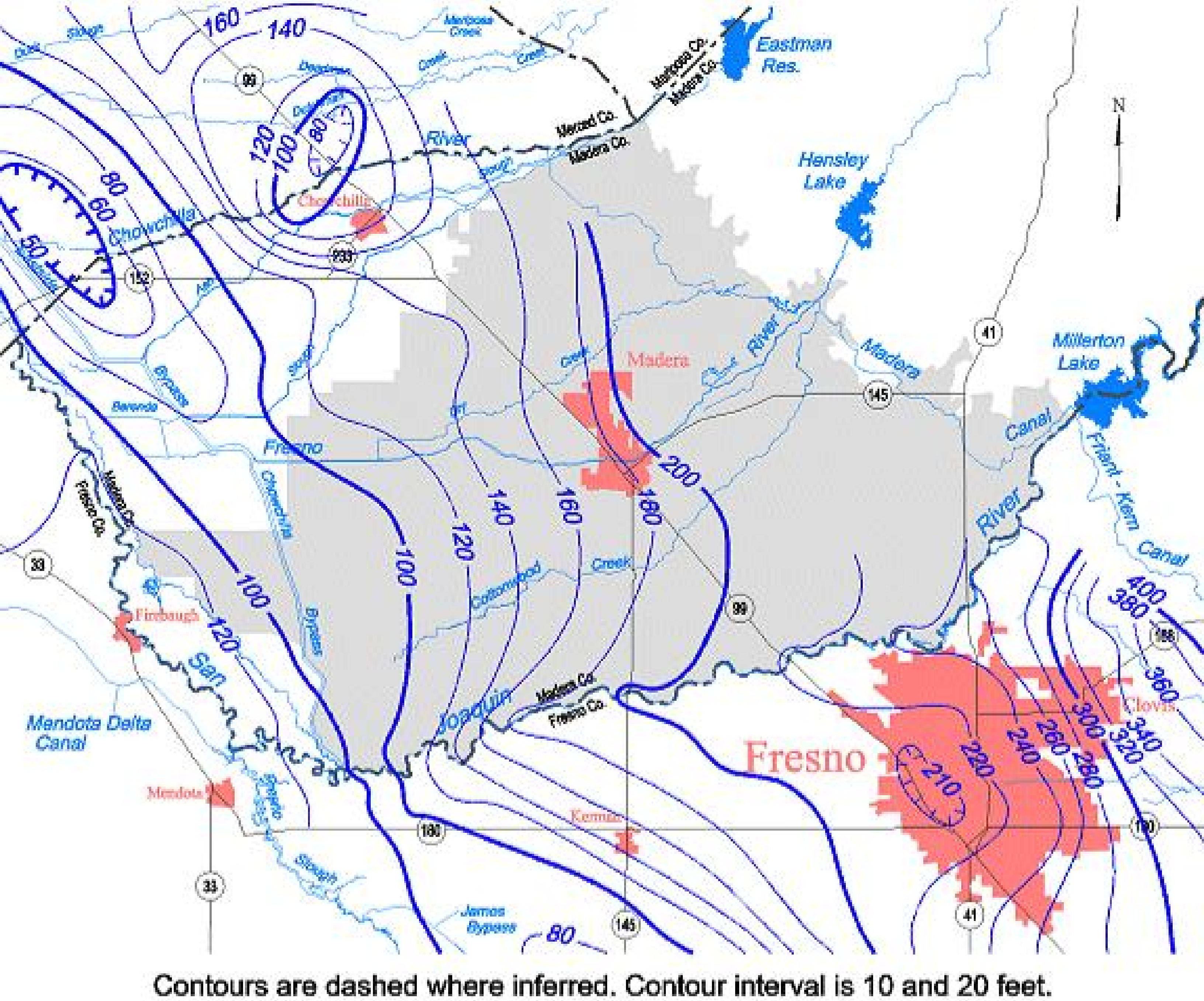
Contours are dashed where inferred. Contour interval is 10, 20 and 50 feet.

Madera Groundwater Basin

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

Scale of Miles
2 0 2 4 6 8

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 20 feet.

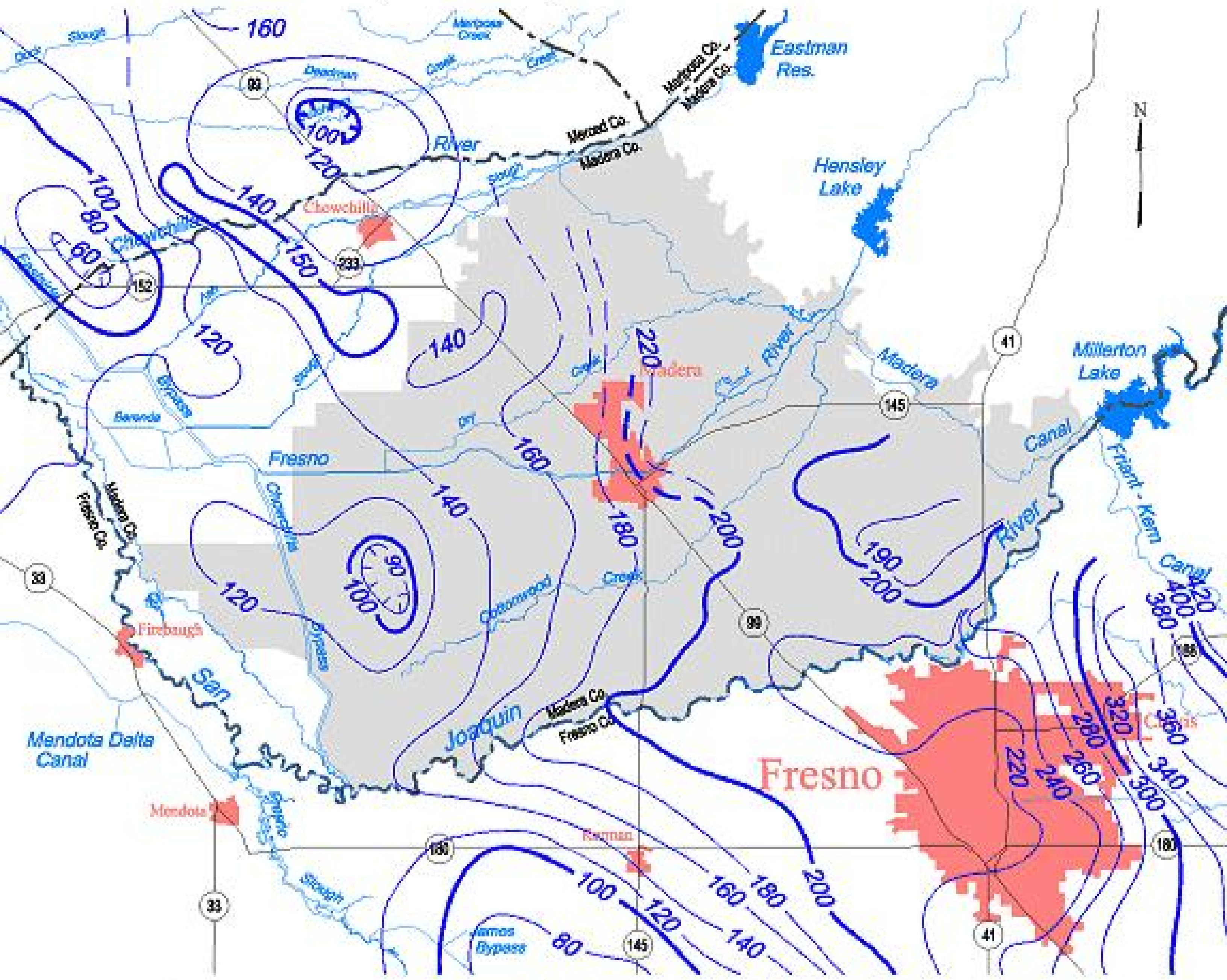
Madera Groundwater Basin

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

Scale of Miles

2 0 2 4 6 8

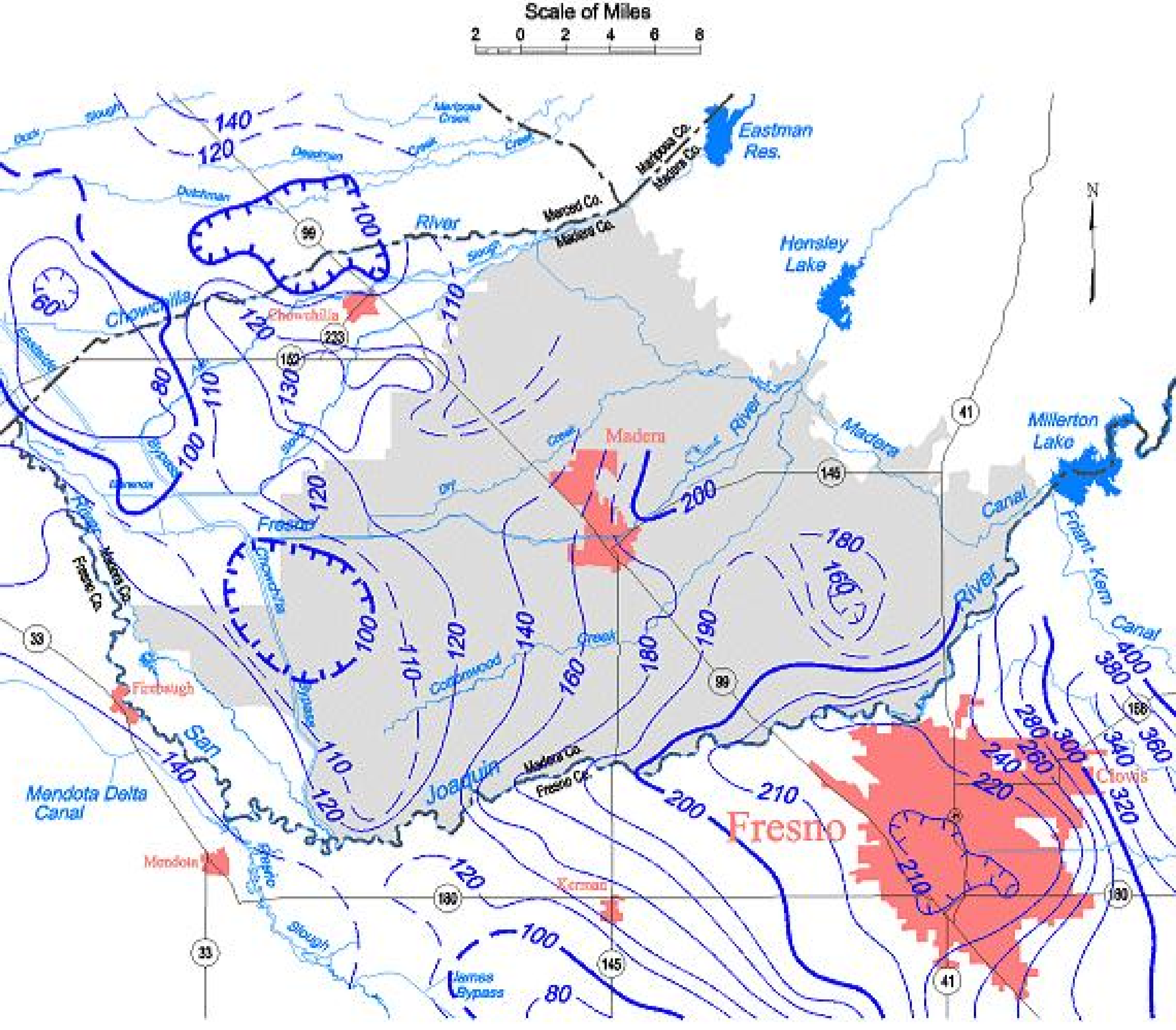
Disclaimer: Base map created from current USGS 1:24,000 and 1:100,000 maps. Some base map features may not have been present (i.e. roads, canals, reservoirs) for the water year shown.



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

Madera Groundwater Basin

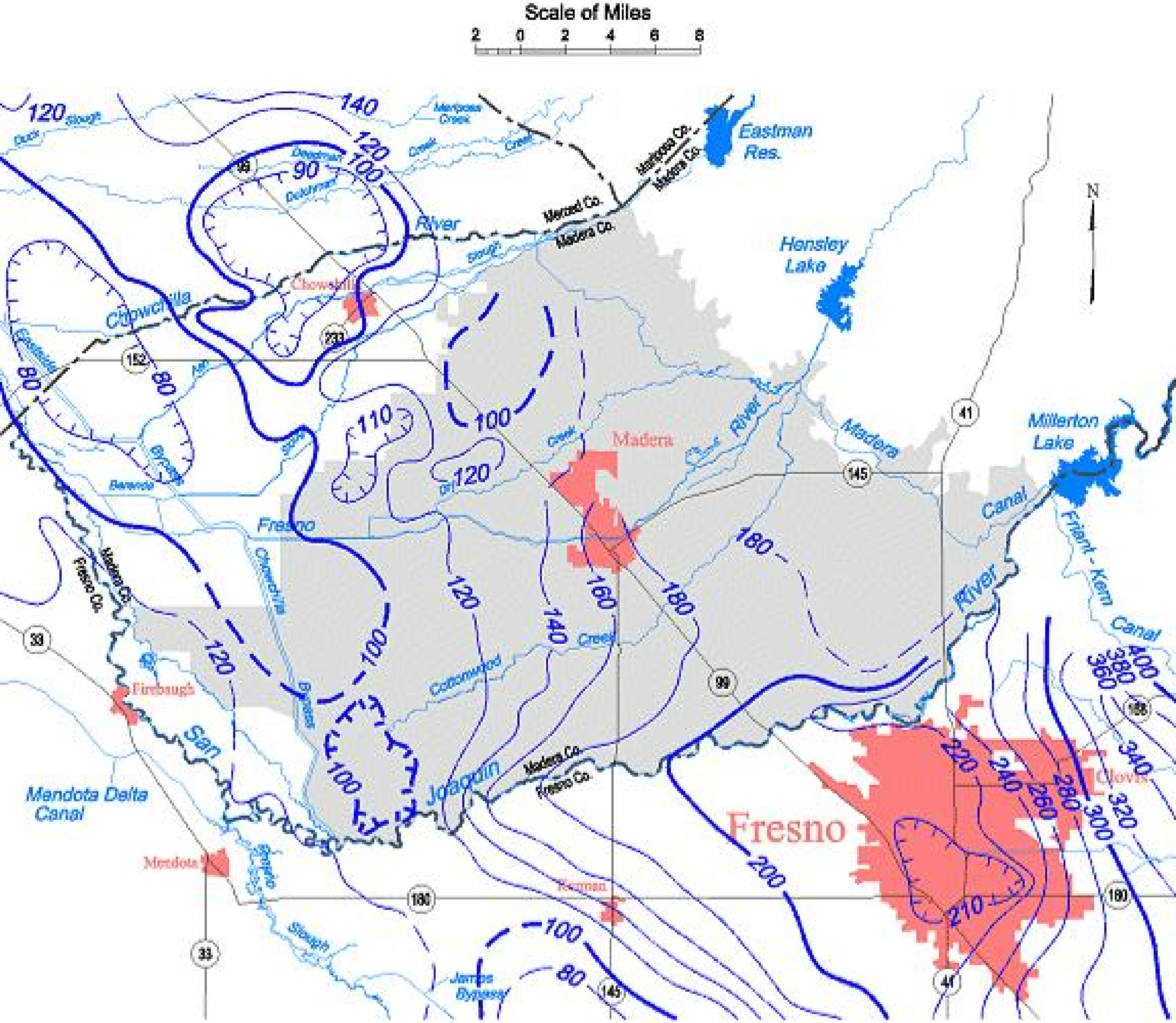
Spring 1989, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



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

Madera Groundwater Basin

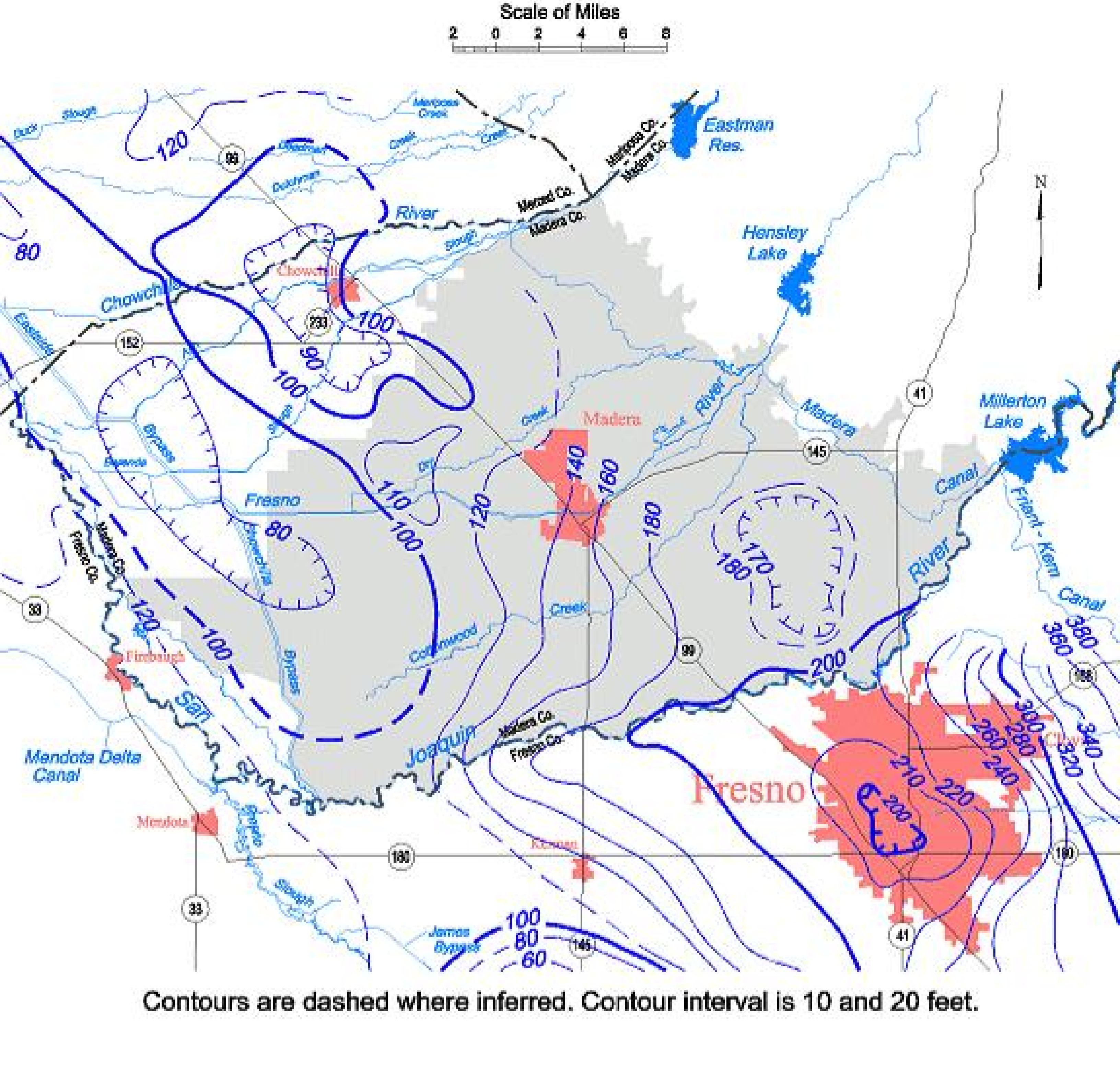
Spring 1990, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



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

Madera Groundwater Basin

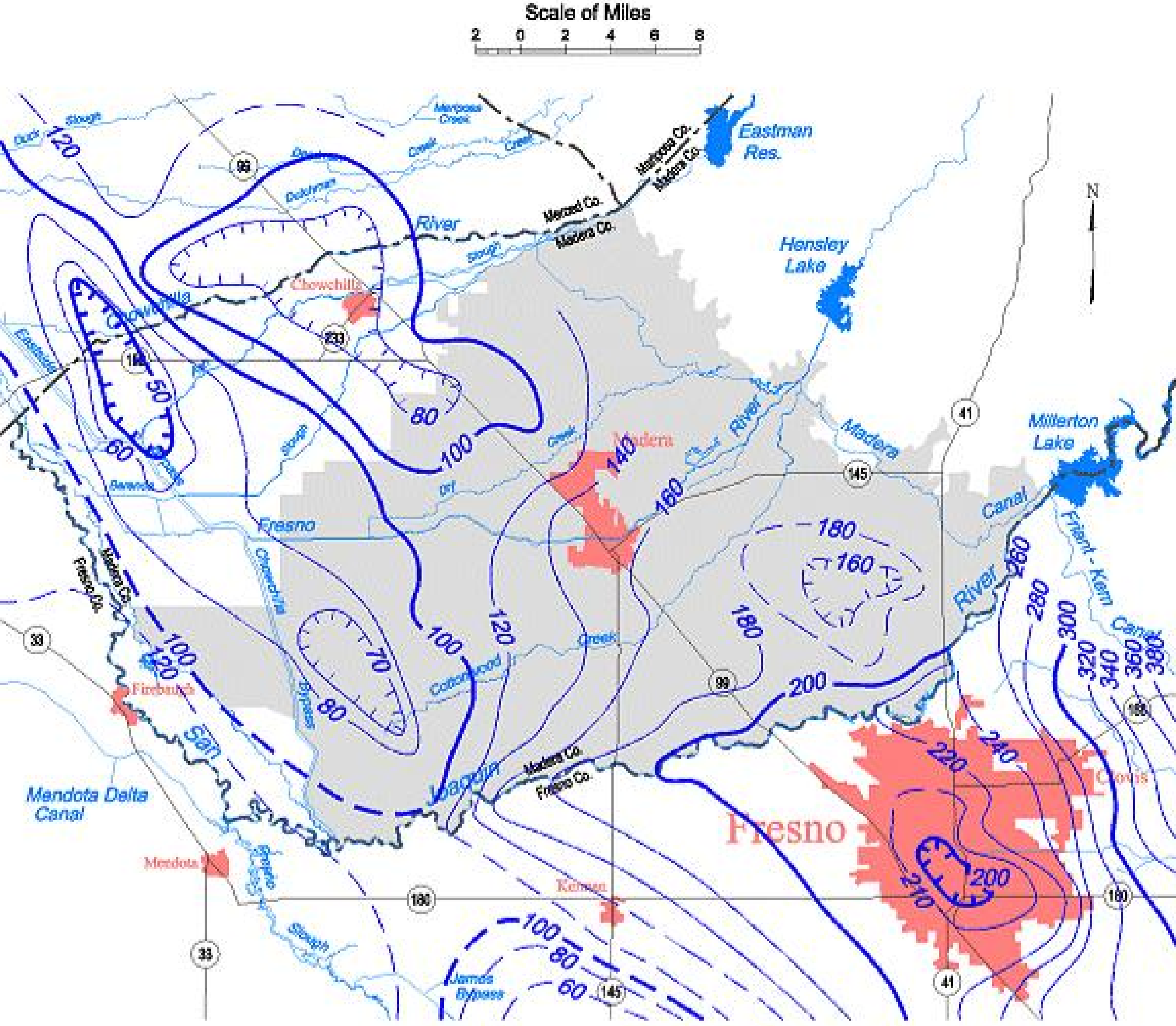
Spring 1991, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



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

Madera Groundwater Basin

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



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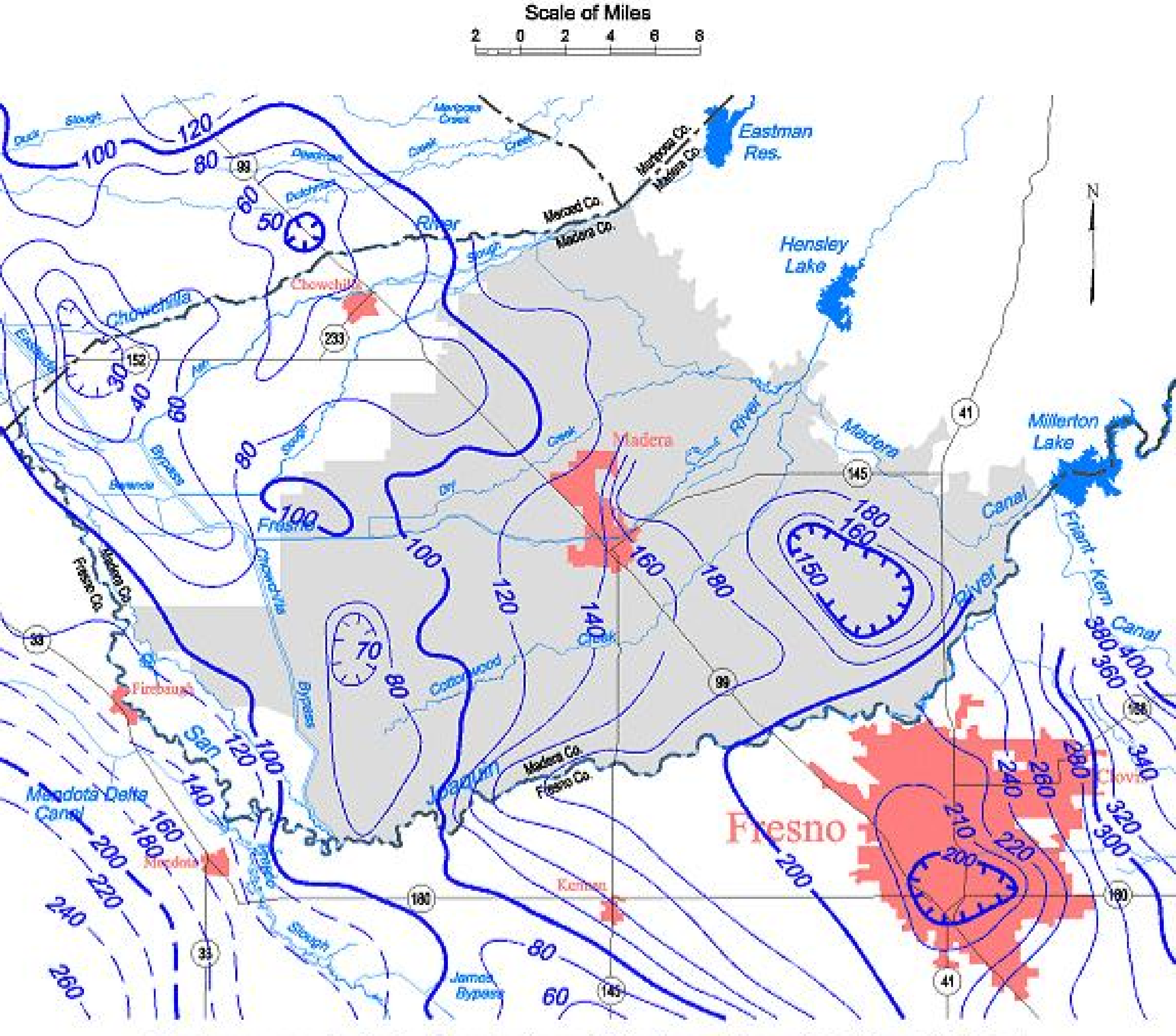
Madera Groundwater Basin

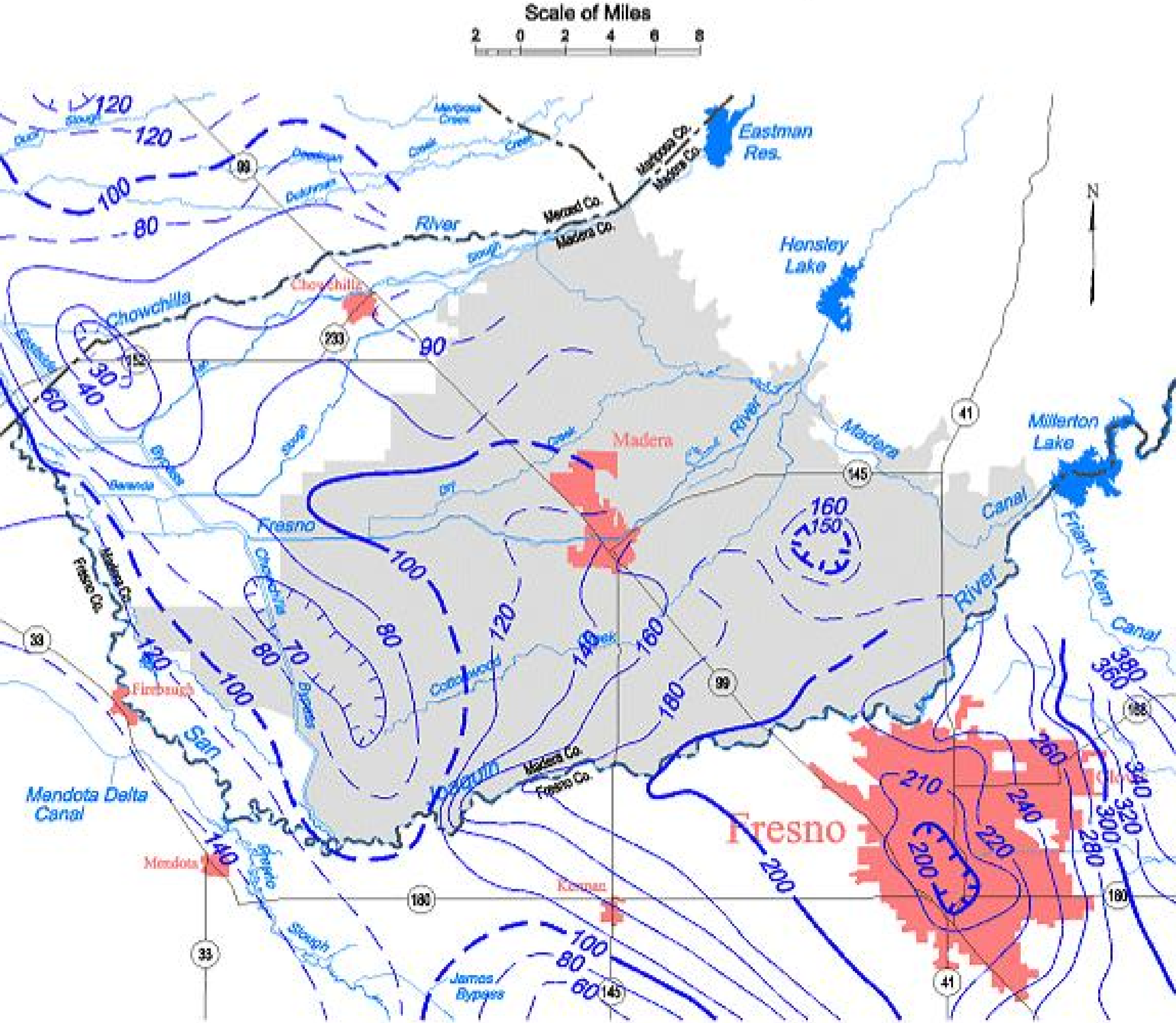
Spring 1993, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



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

Madera Groundwater Basin

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



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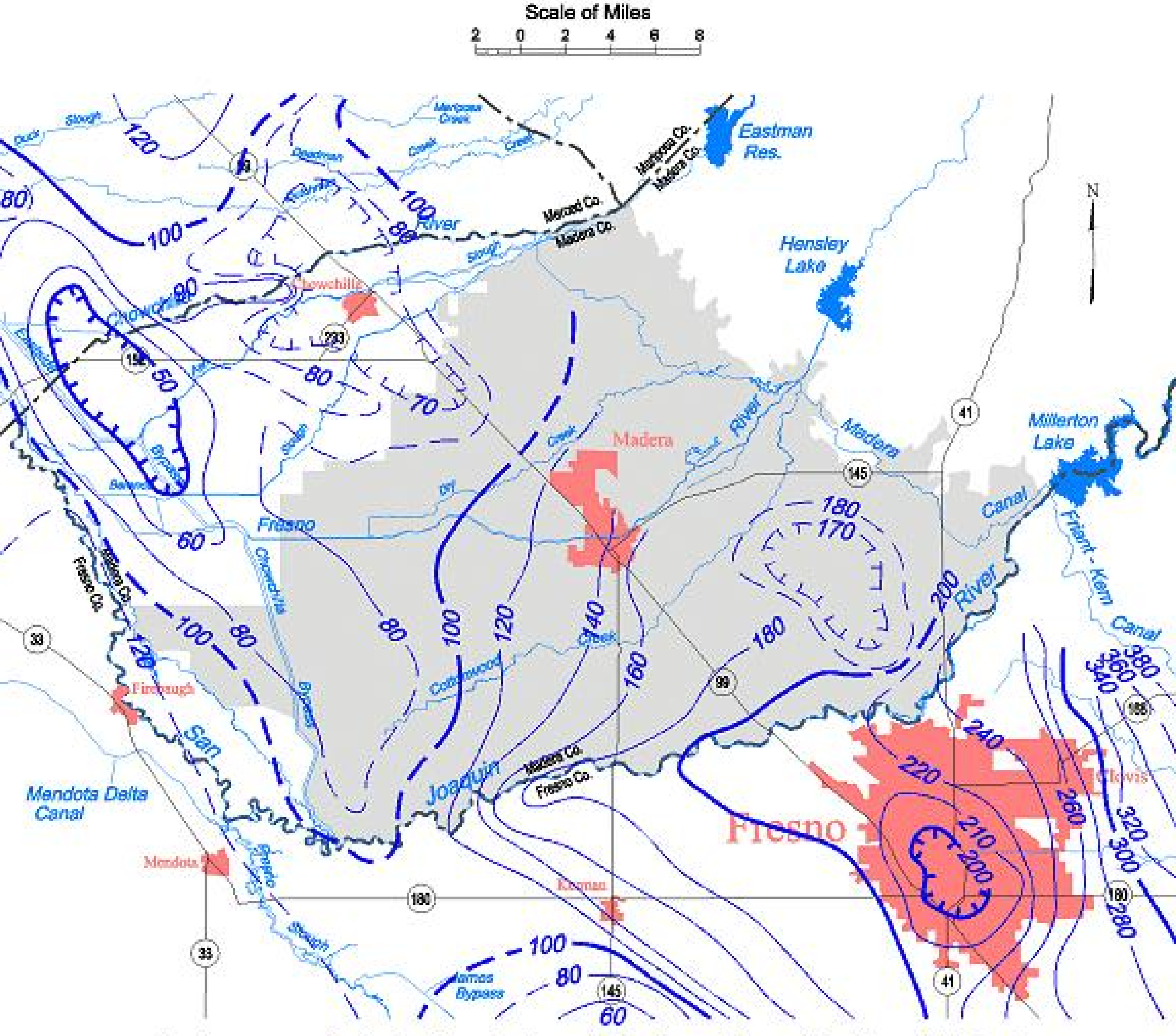
Madera Groundwater Basin

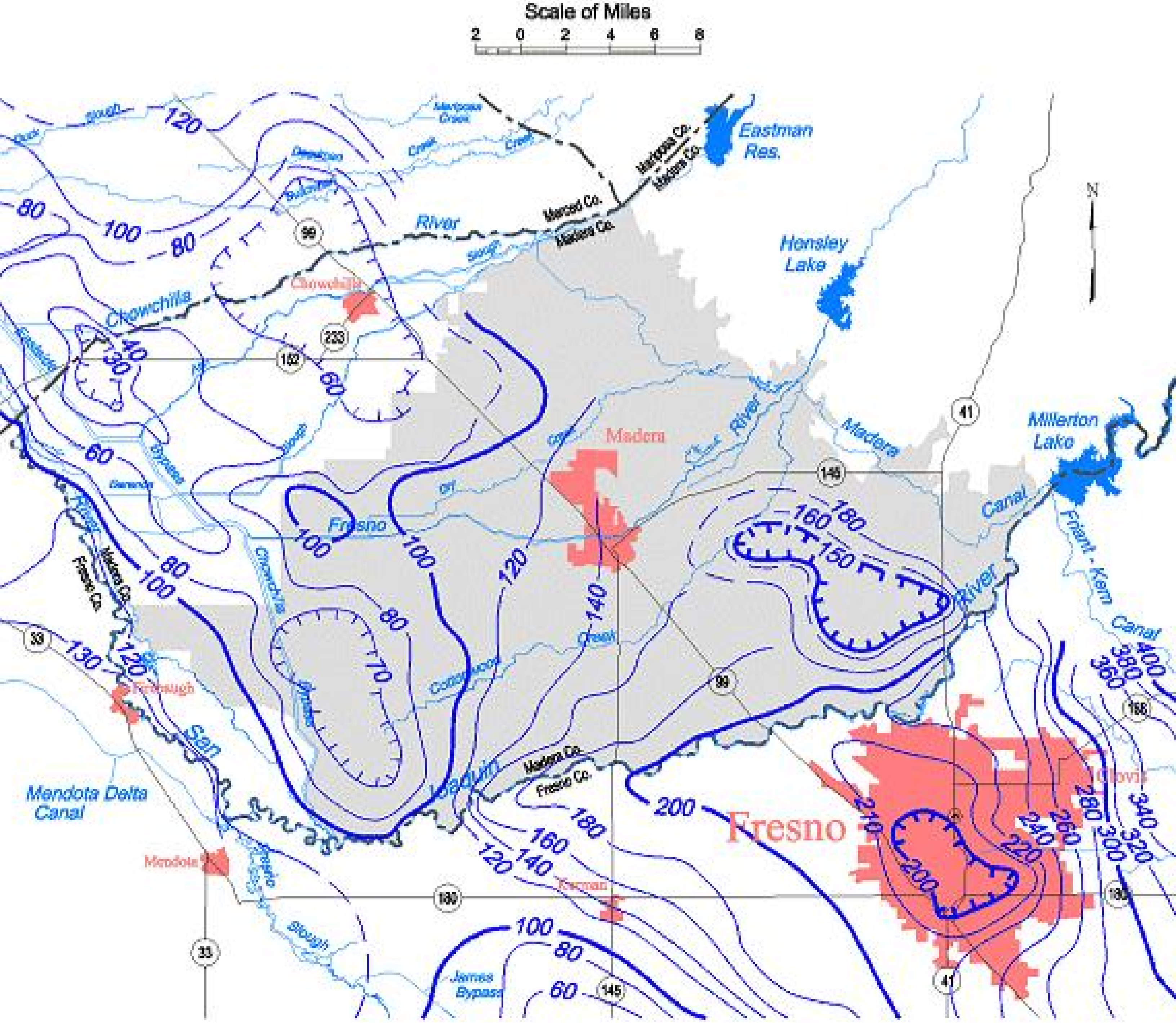
Spring 1995, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



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

Madera Groundwater Basin

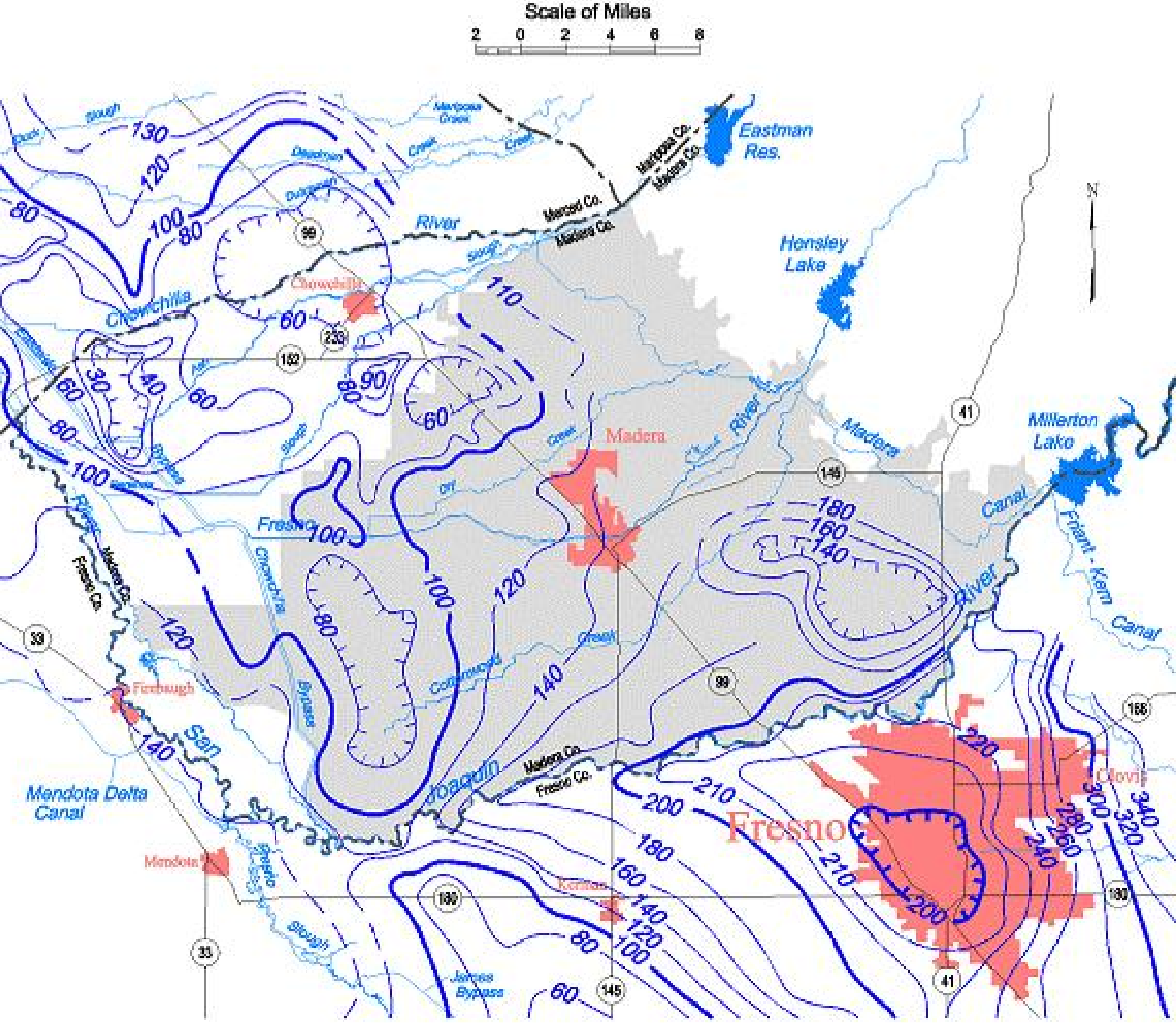
Spring 1996, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



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

Madera Groundwater Basin

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



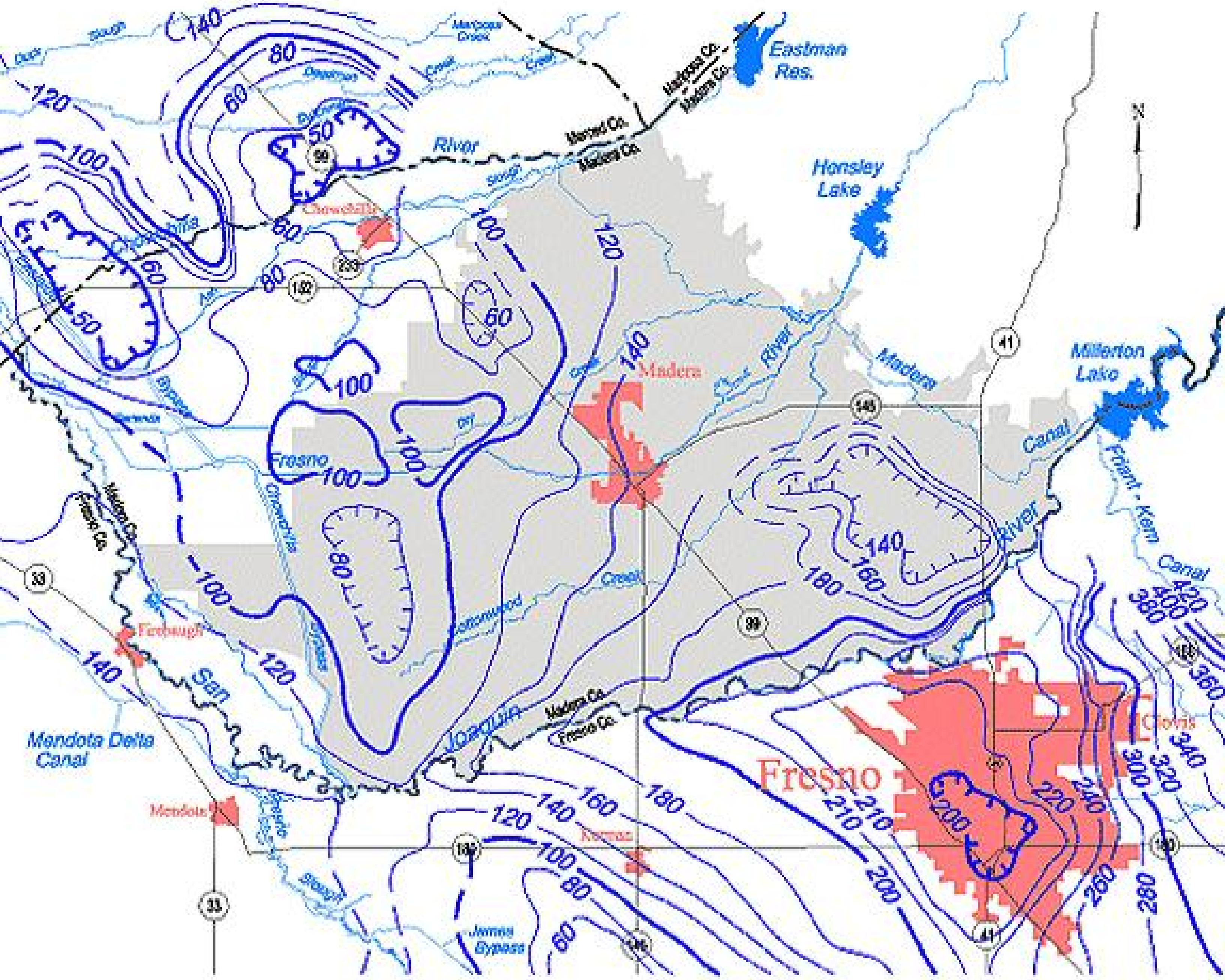
Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Madera Groundwater Basin

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

Scale of Miles

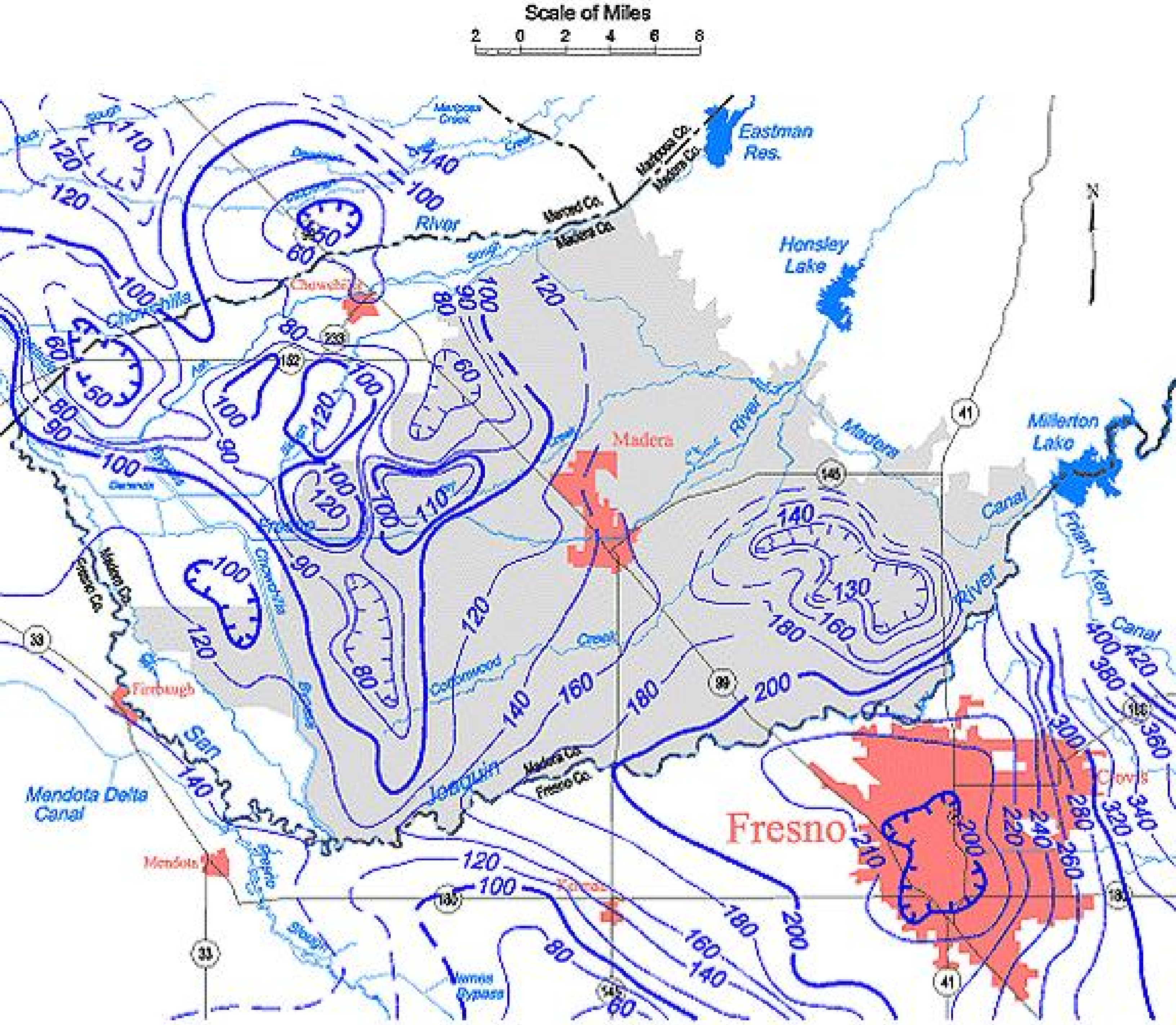
2 0 2 4 6 8



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

Madera Groundwater Basin

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



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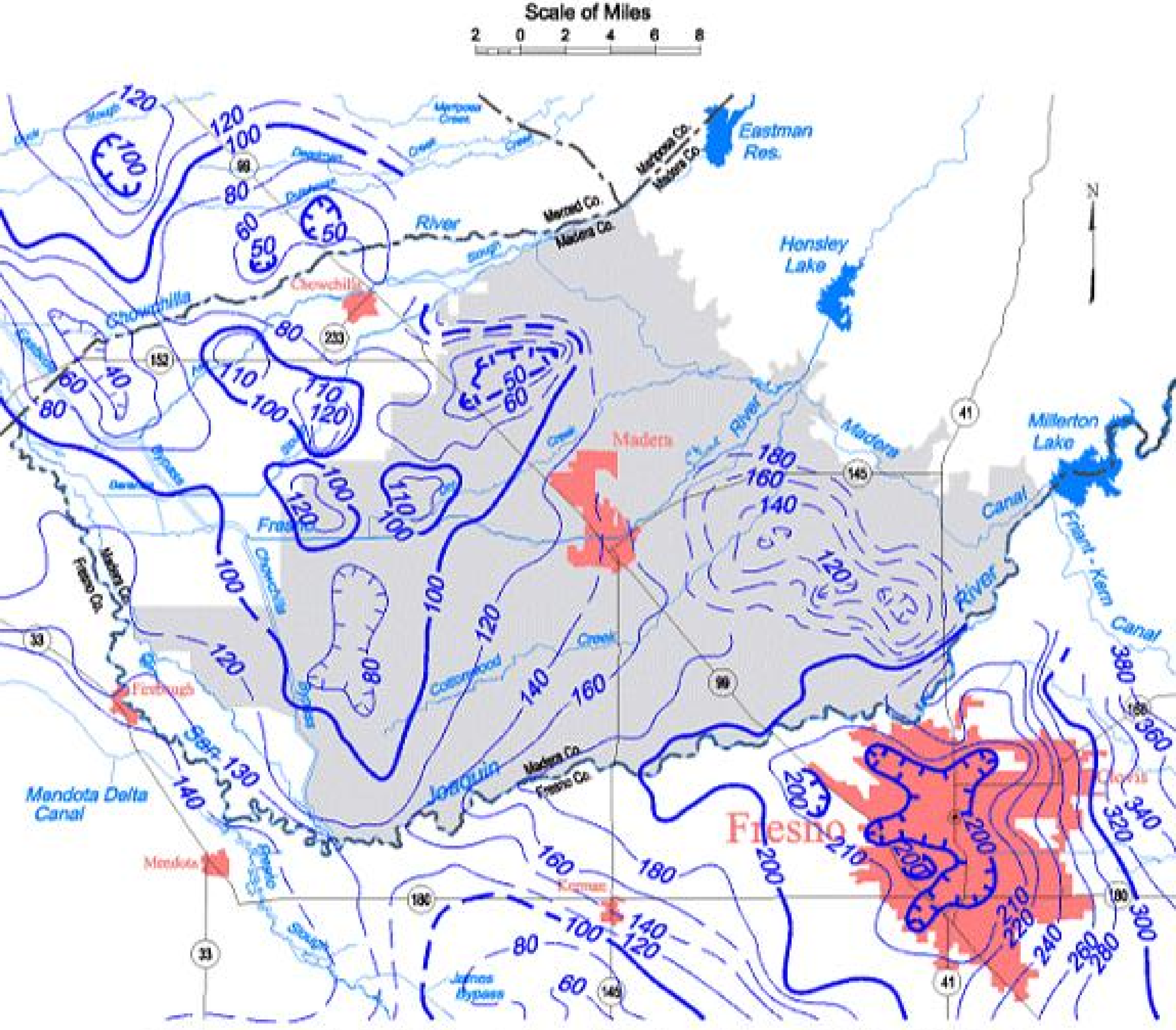
Madera Groundwater Basin

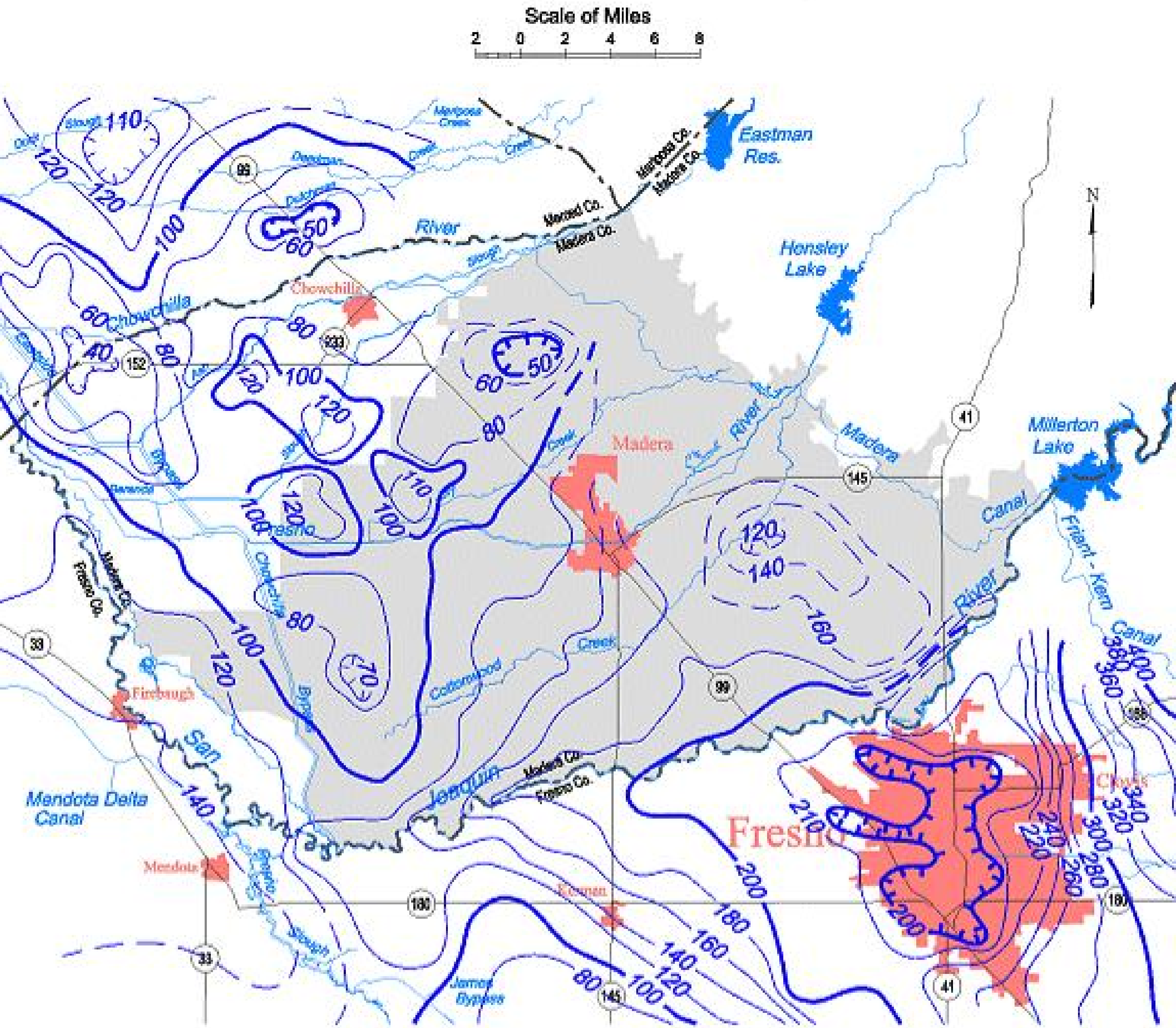
Spring 2000, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



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

Madera Groundwater Basin

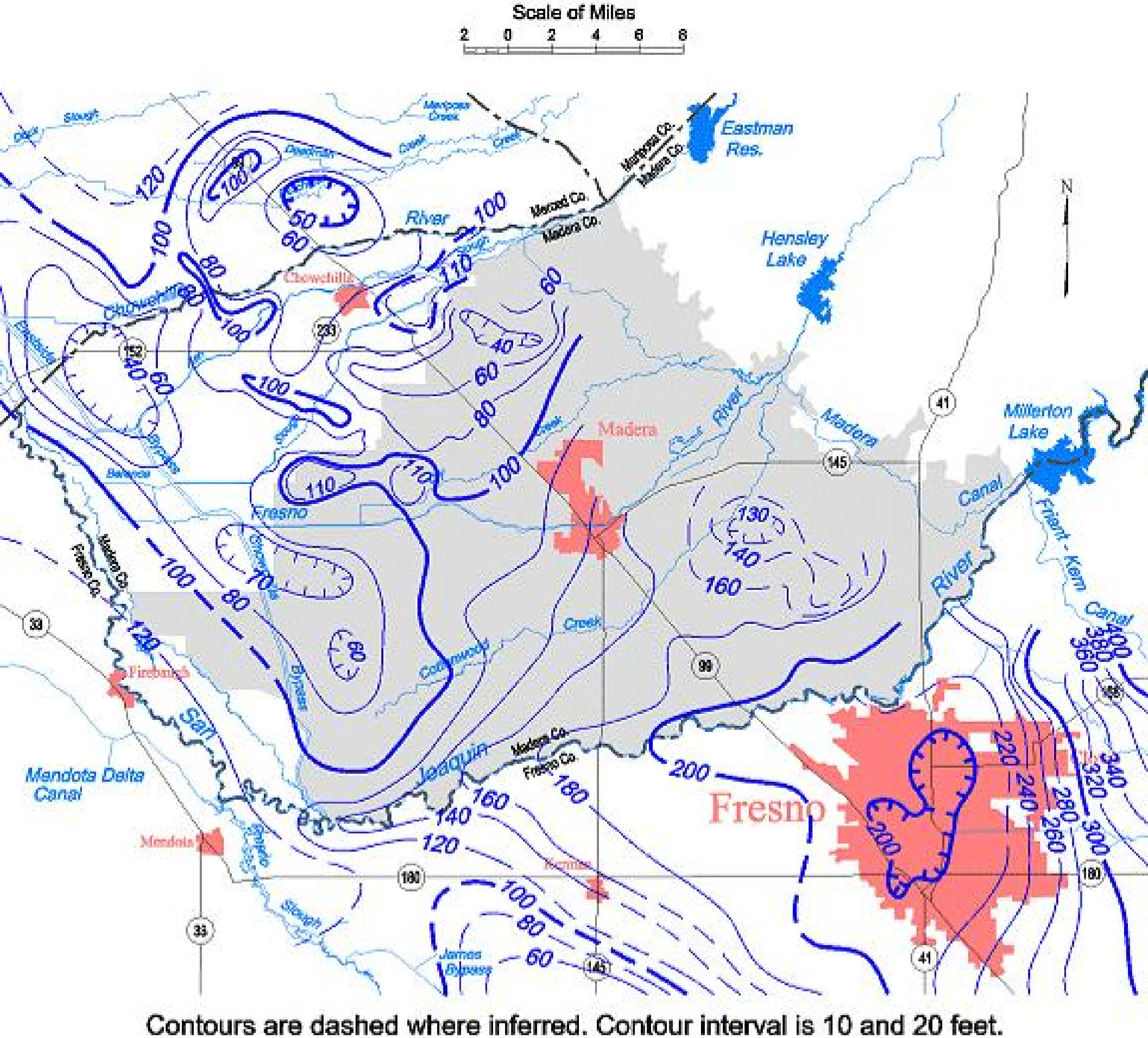
Spring 2001, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



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

Madera Groundwater Basin

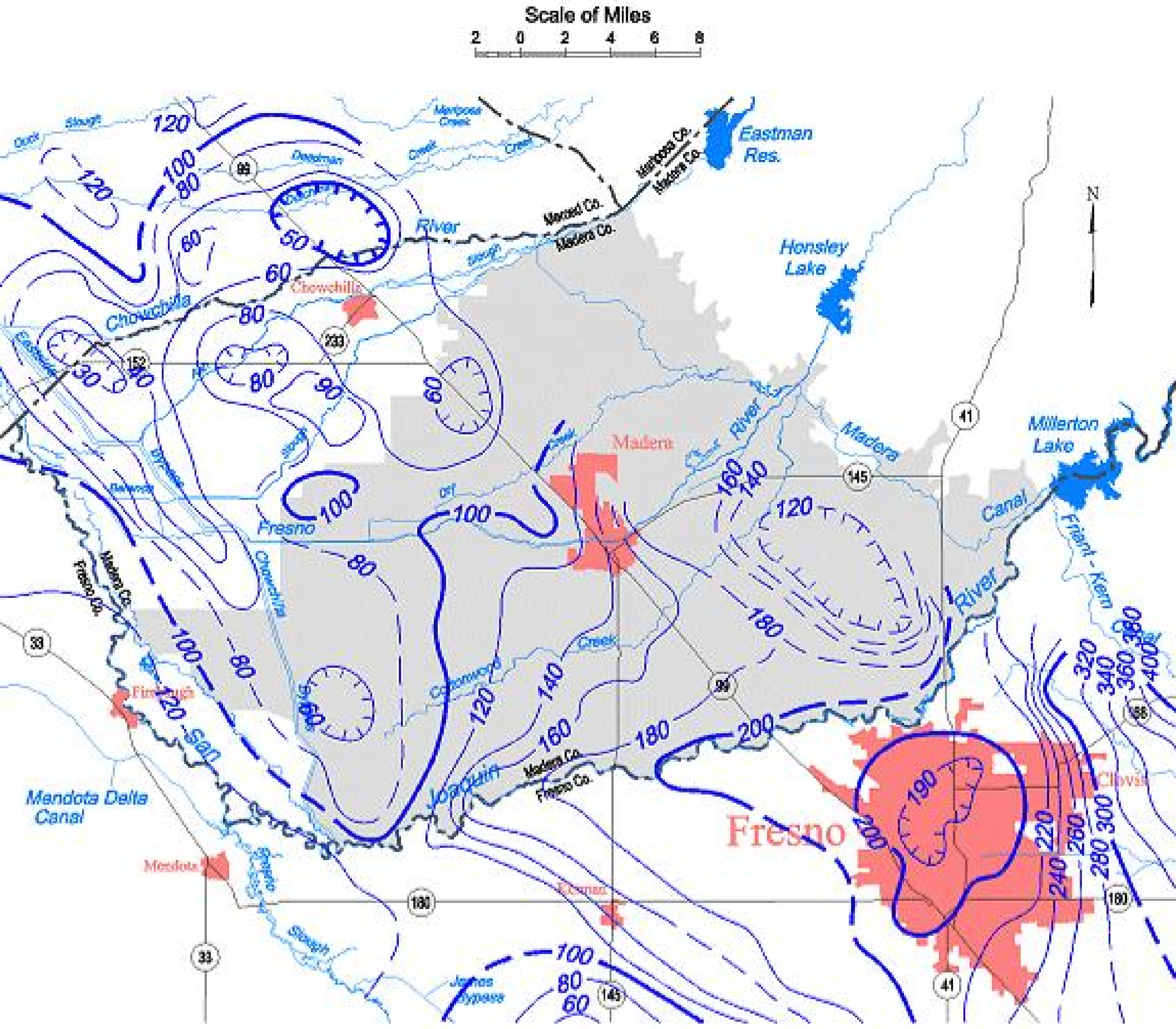
Spring 2002, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



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

Madera Groundwater Basin

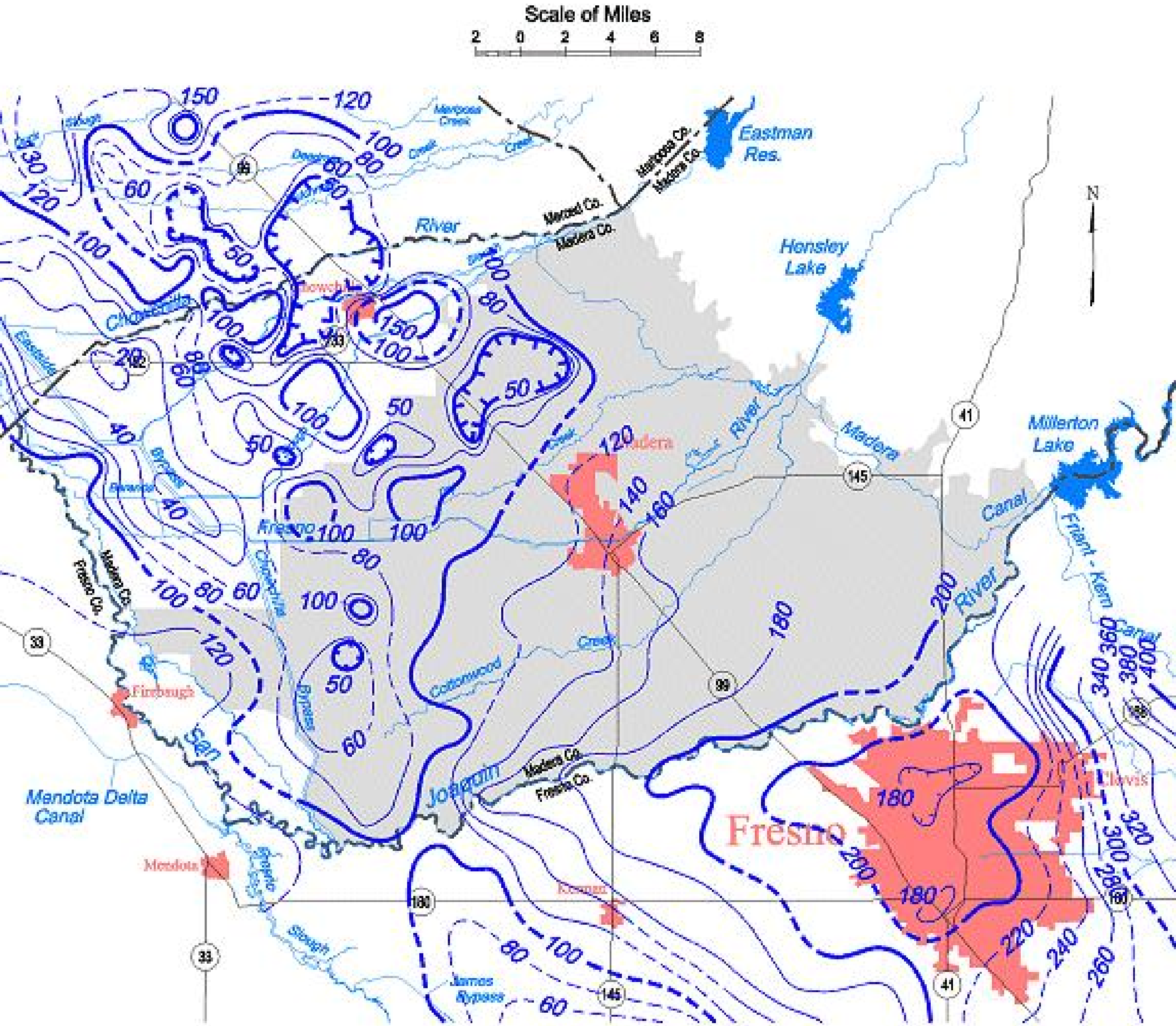
Spring 2003, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



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

Madera Groundwater Basin

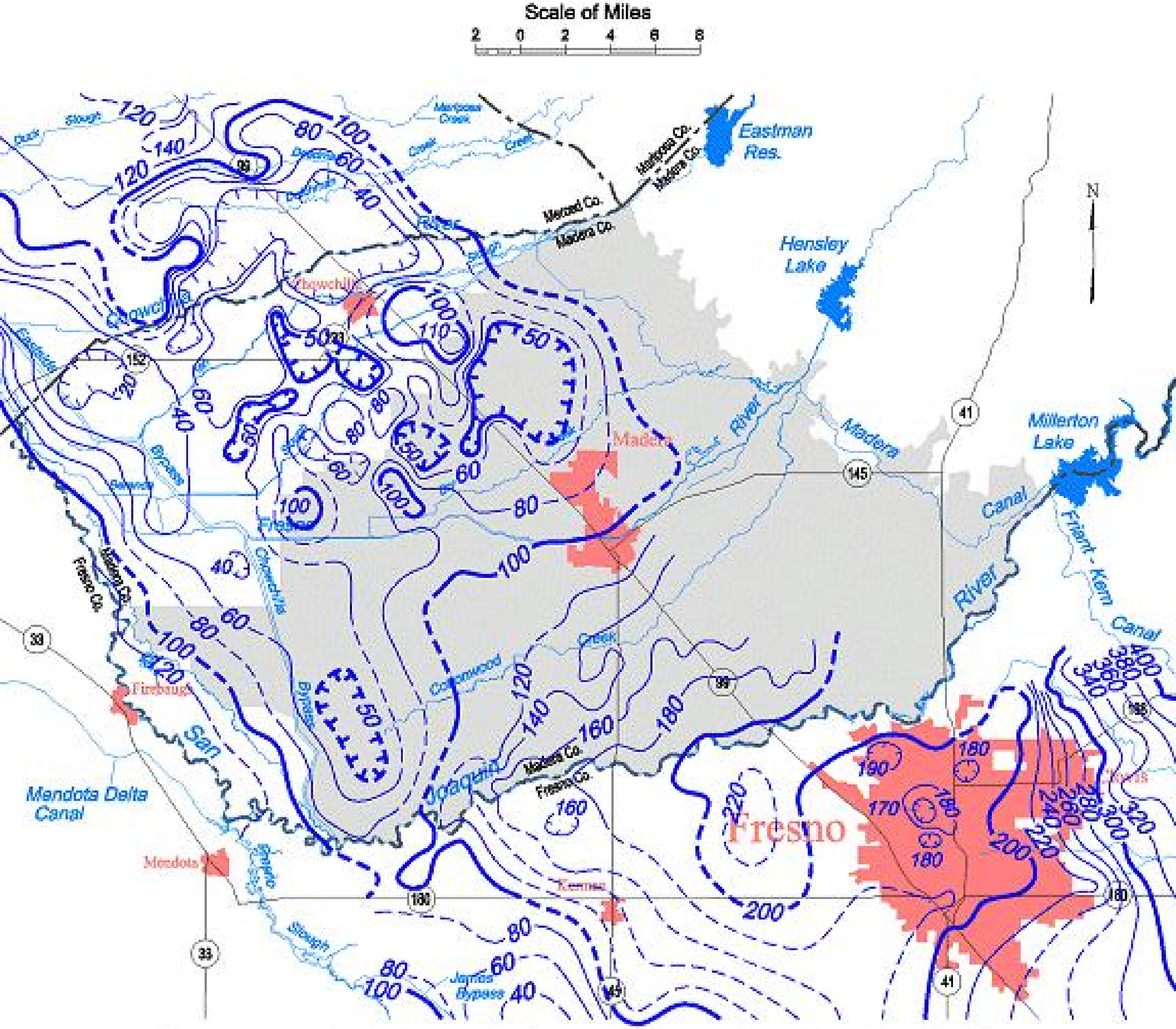
Spring 2004, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



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

Madera Groundwater Basin

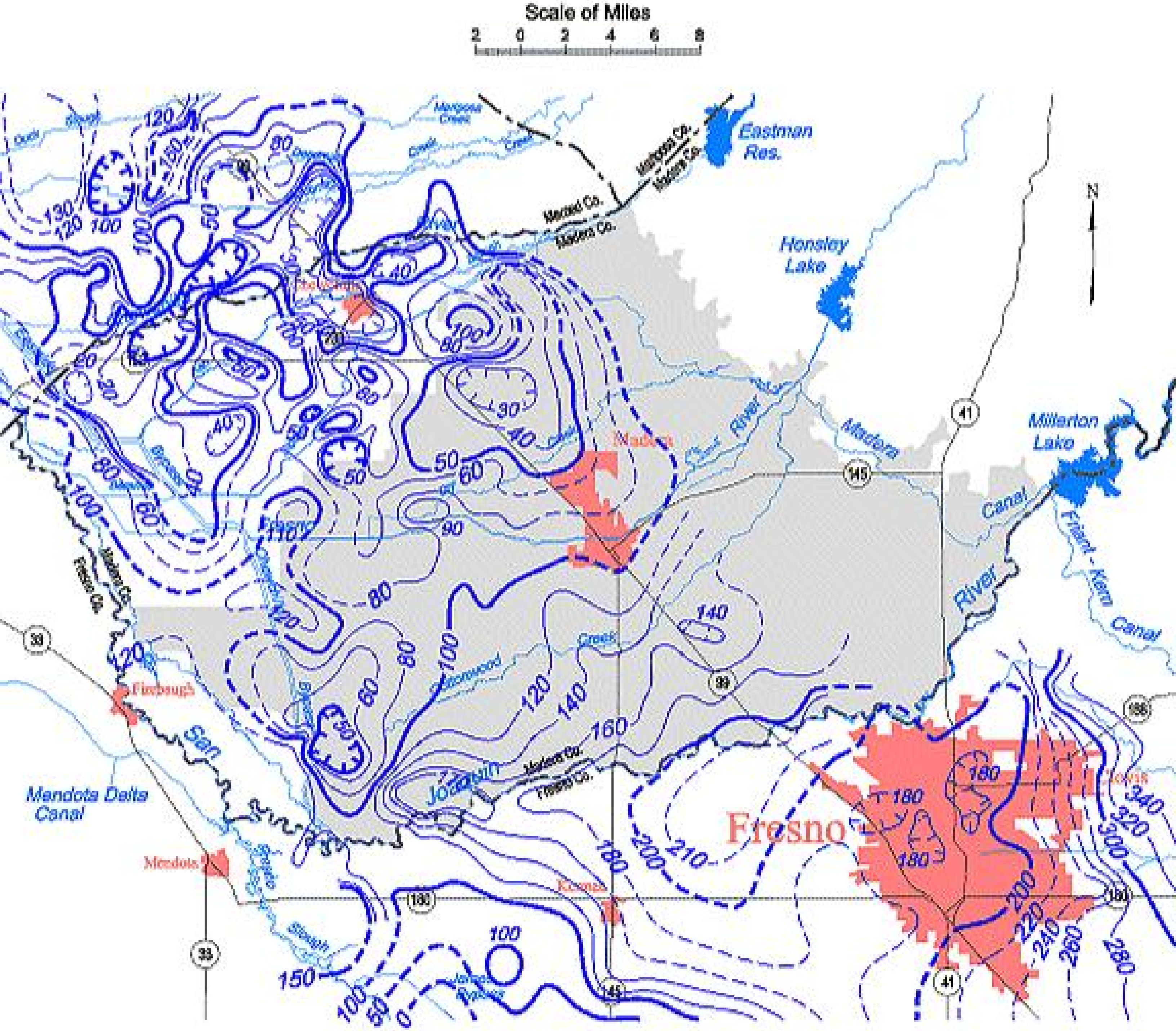
Spring 2005, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



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

Madera Groundwater Basin

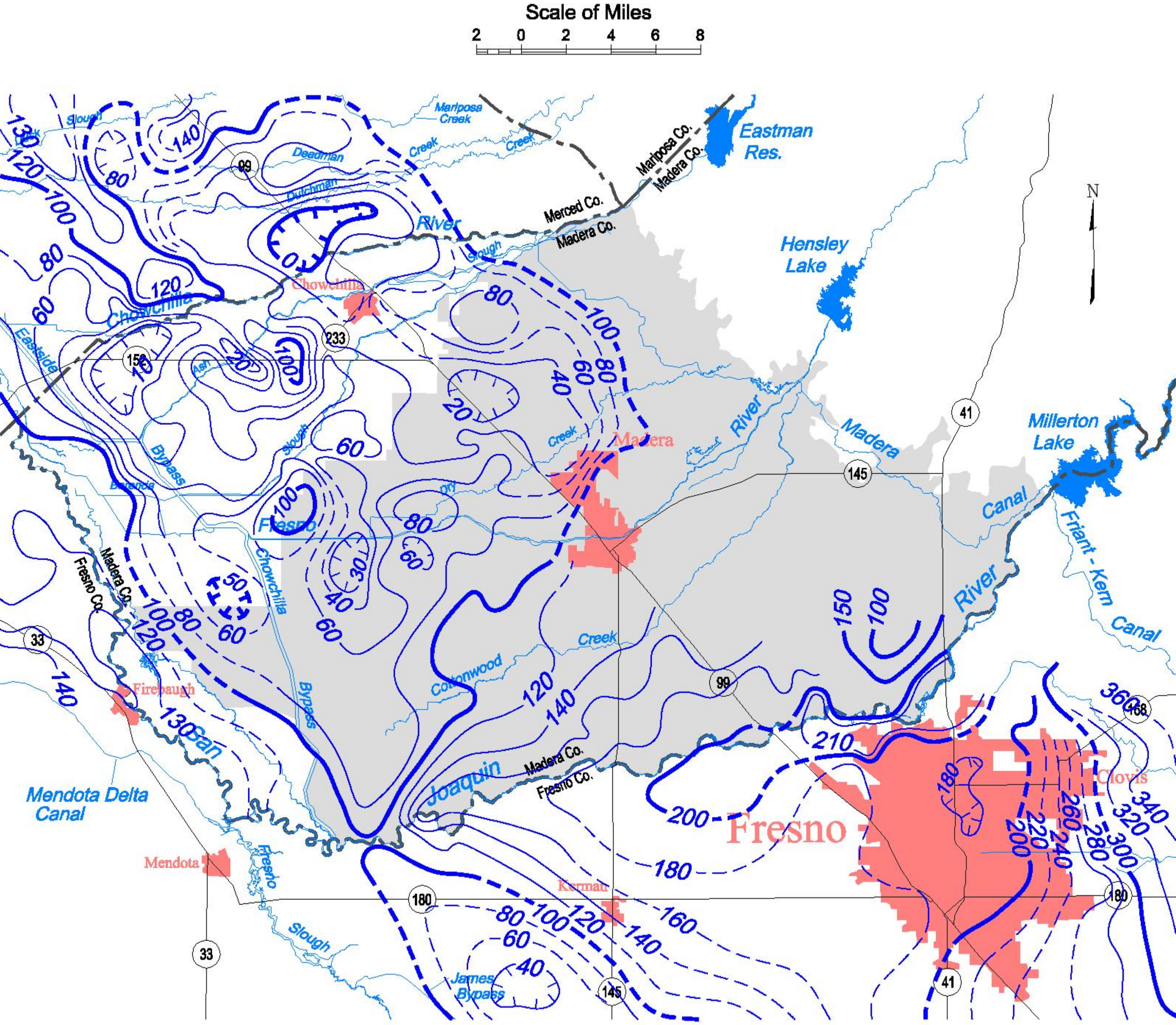
Spring 2006, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



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

Madera Groundwater Basin

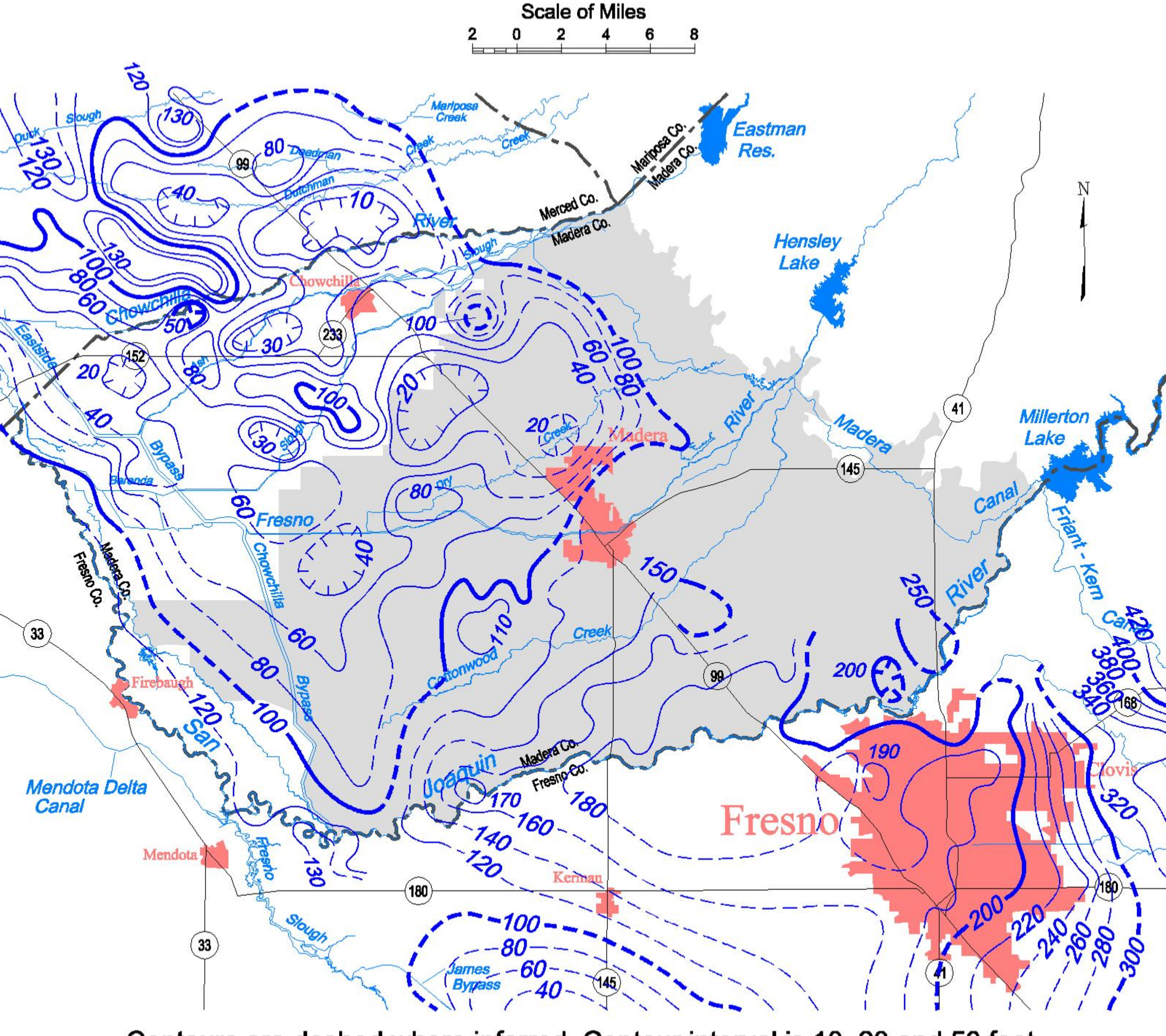
Spring 2007, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



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

Madera Groundwater Basin

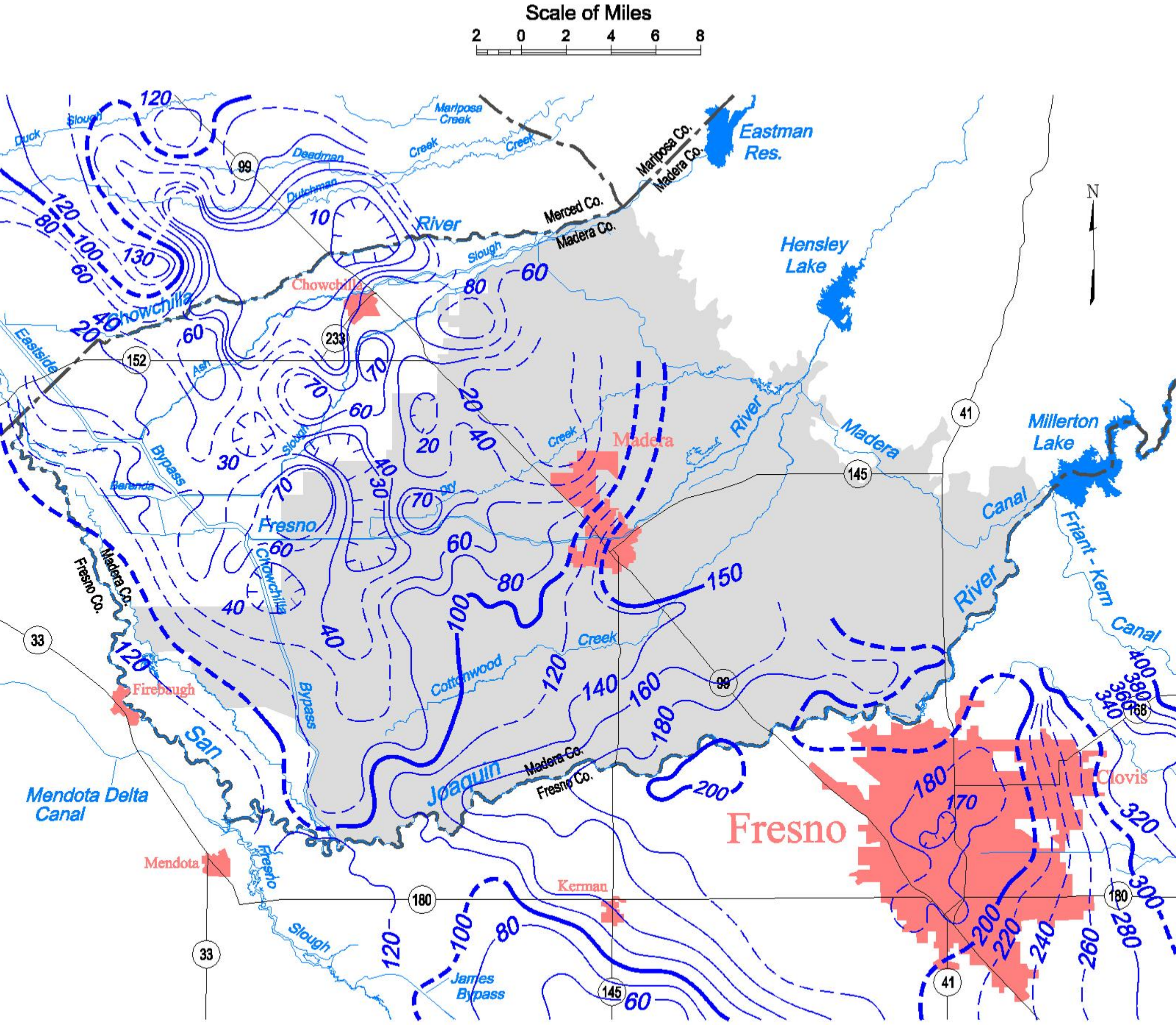
Spring 2008, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



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

Madera Groundwater Basin

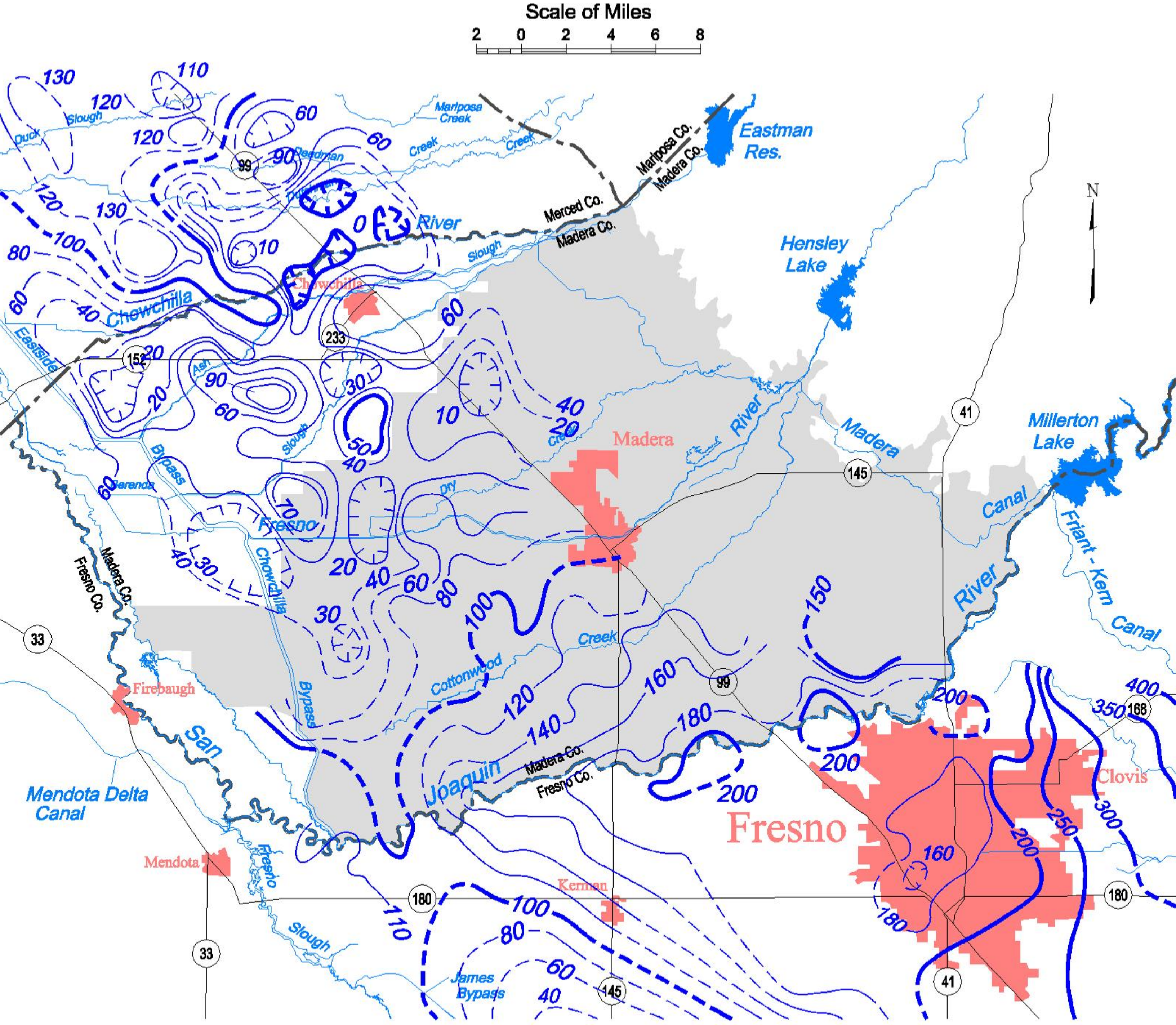
Spring 2009, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



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

Madera Groundwater Basin

Spring 2010, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

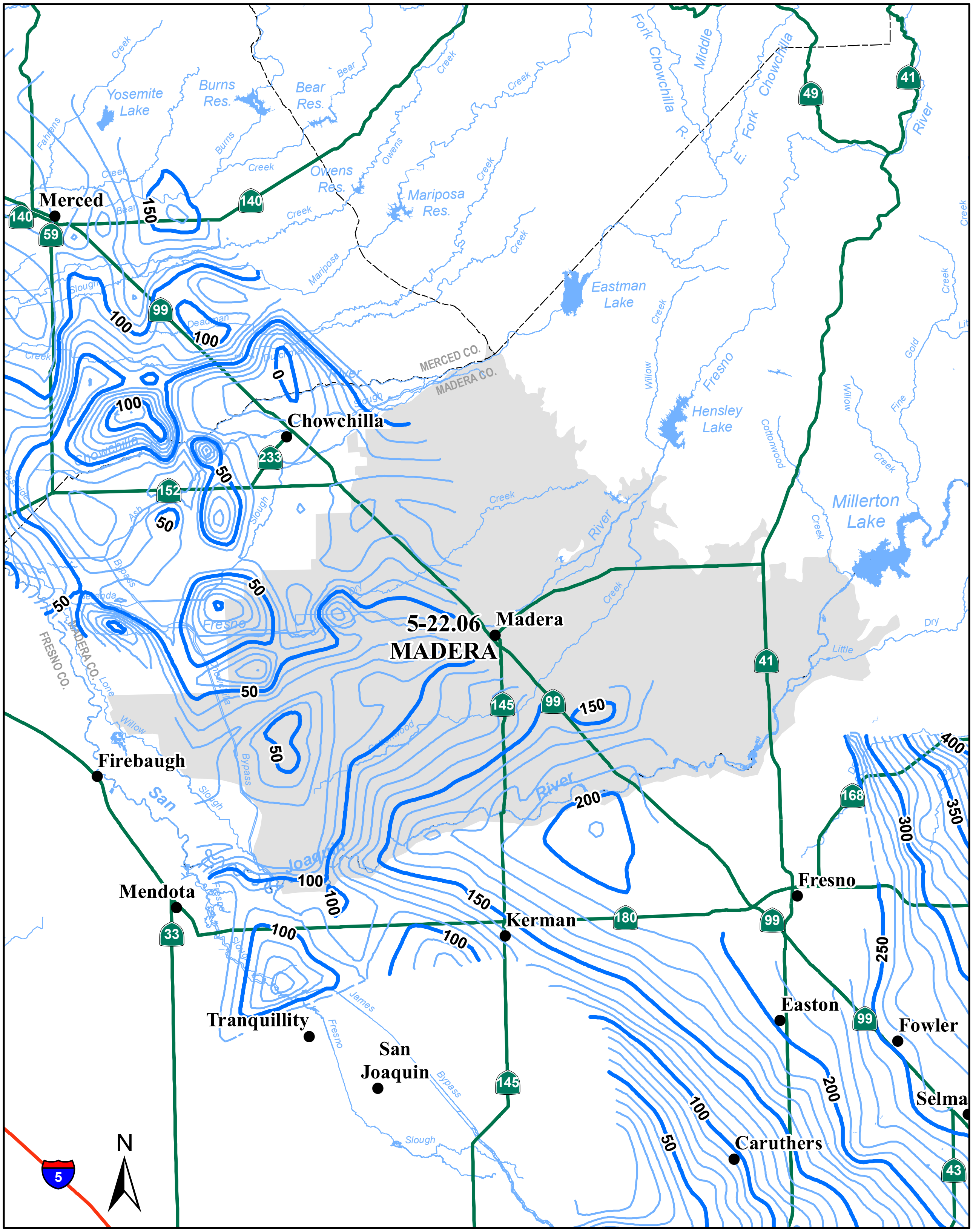


Contours are dashed where inferred. Contour interval is 10, 20 and 50 feet.

Madera Groundwater Basin 5-22.06

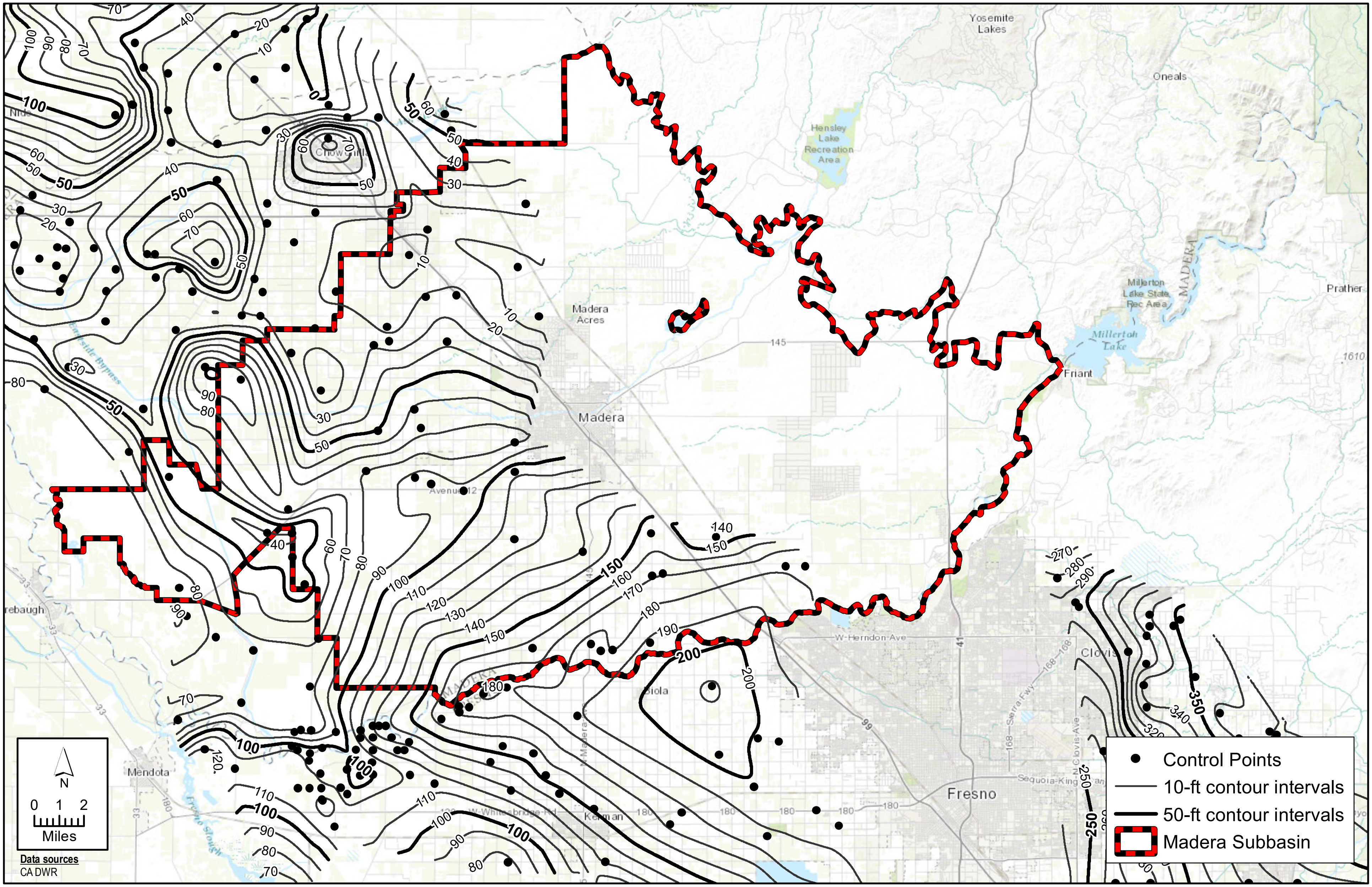
Groundwater Elevation Contours - Spring 2011

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.

South Central Region Office



X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Appendix B Madera Subbasin GWE Contours Spring 2011.mxd

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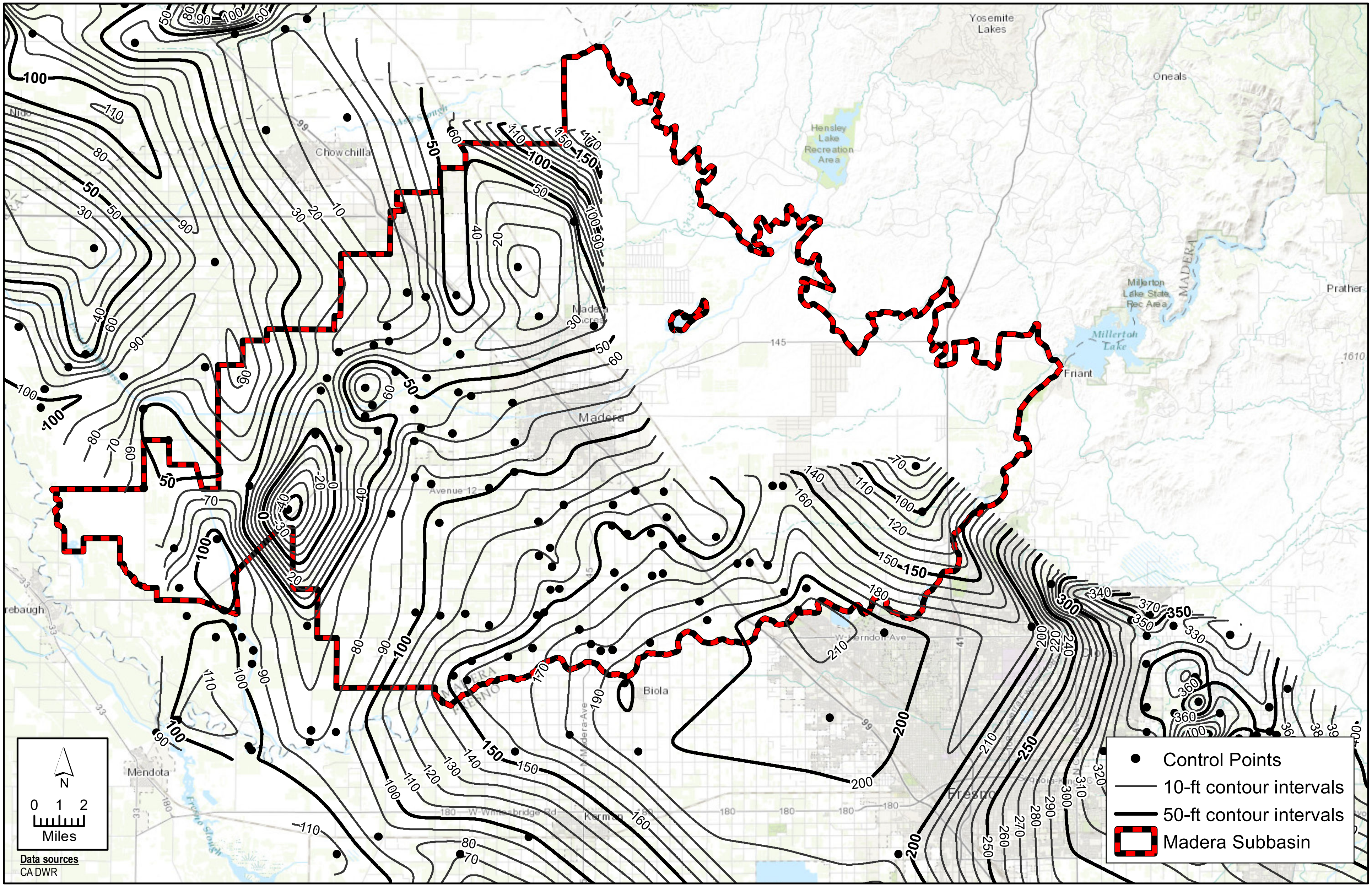
APPENDIX C
Contours of Equal Groundwater Elevation
Spring 2011

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



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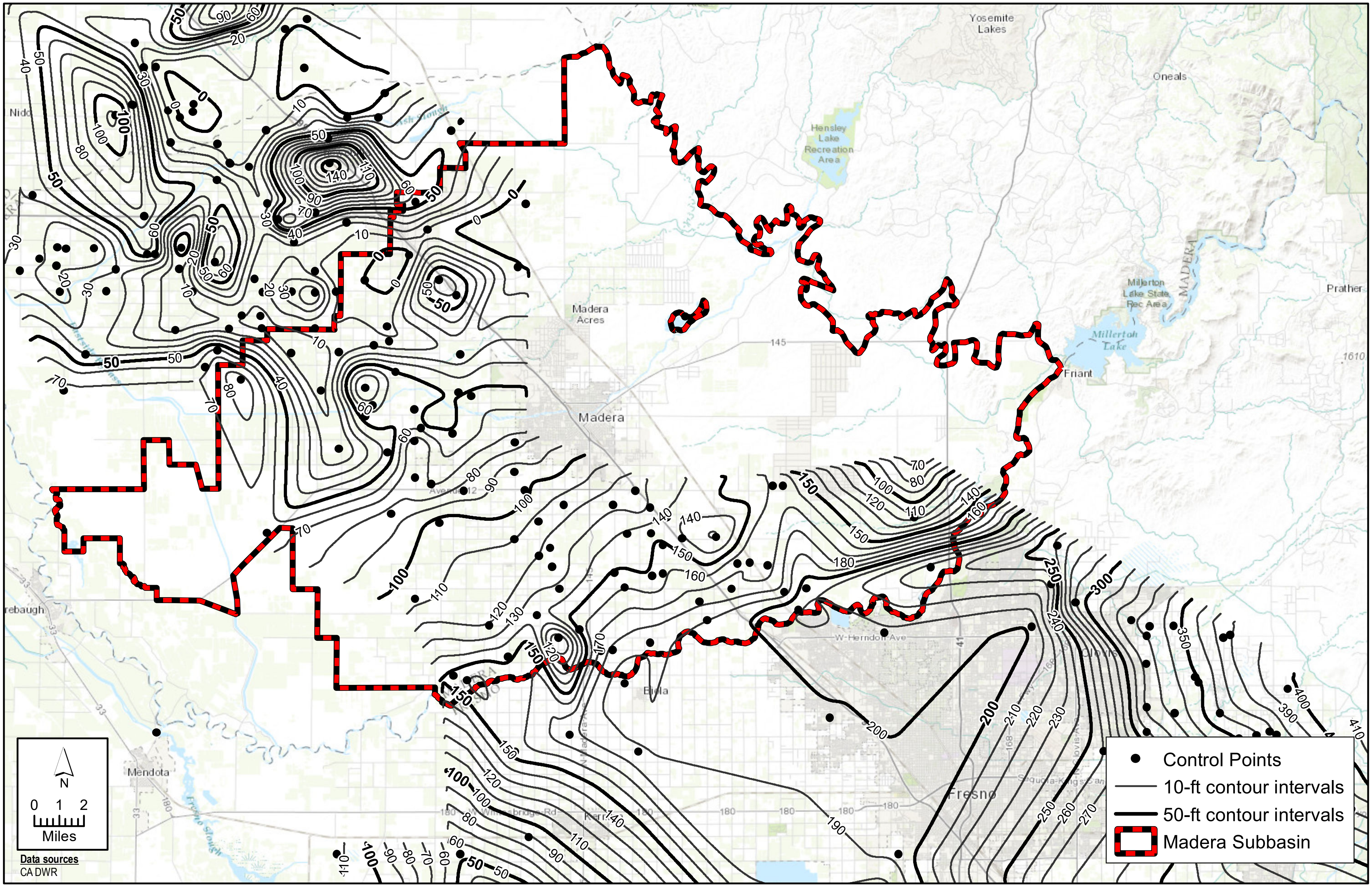
Contours of Equal Groundwater Elevation
Spring 2012

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



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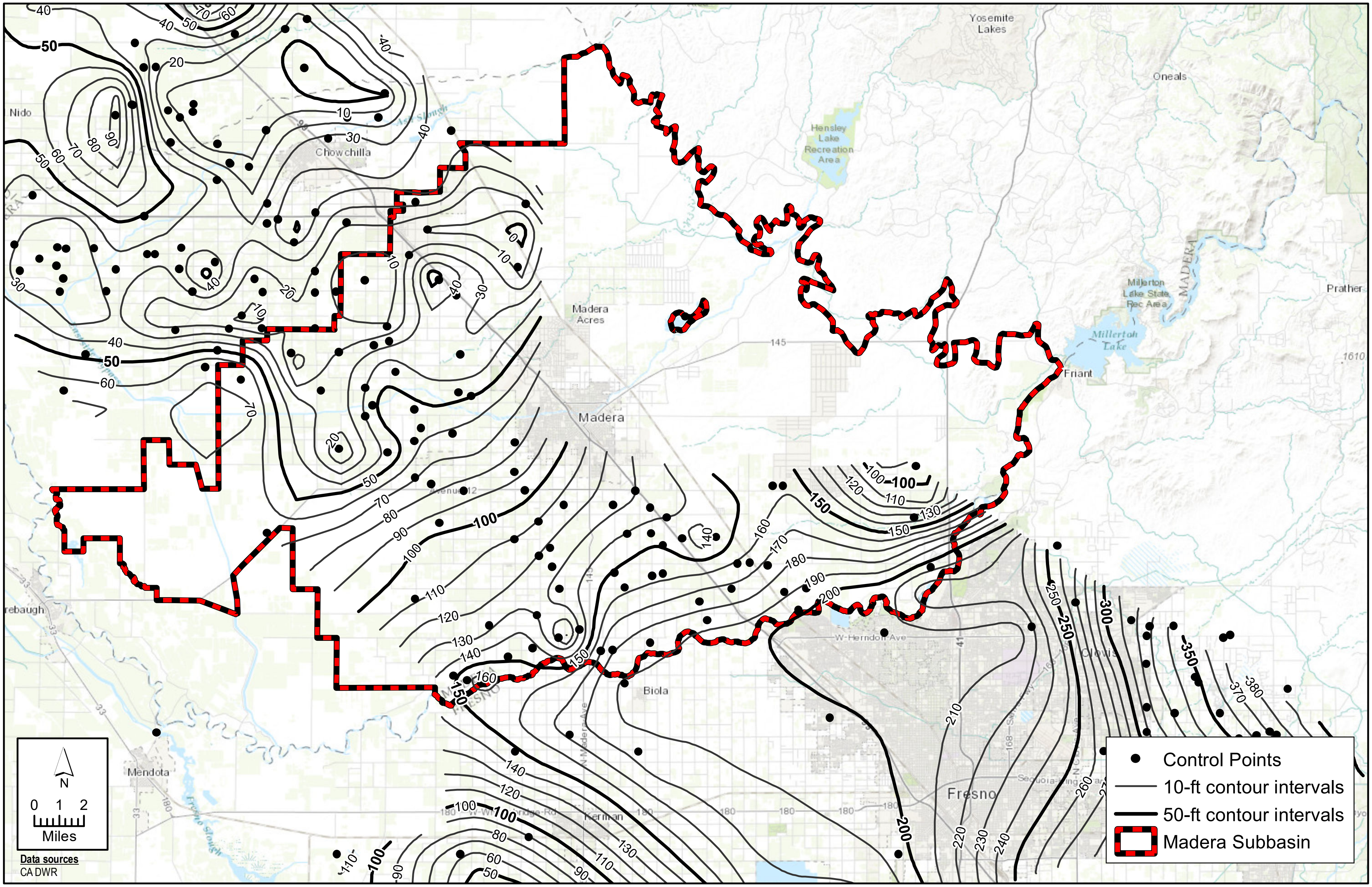
Contours of Equal Groundwater Elevation Spring 2013

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



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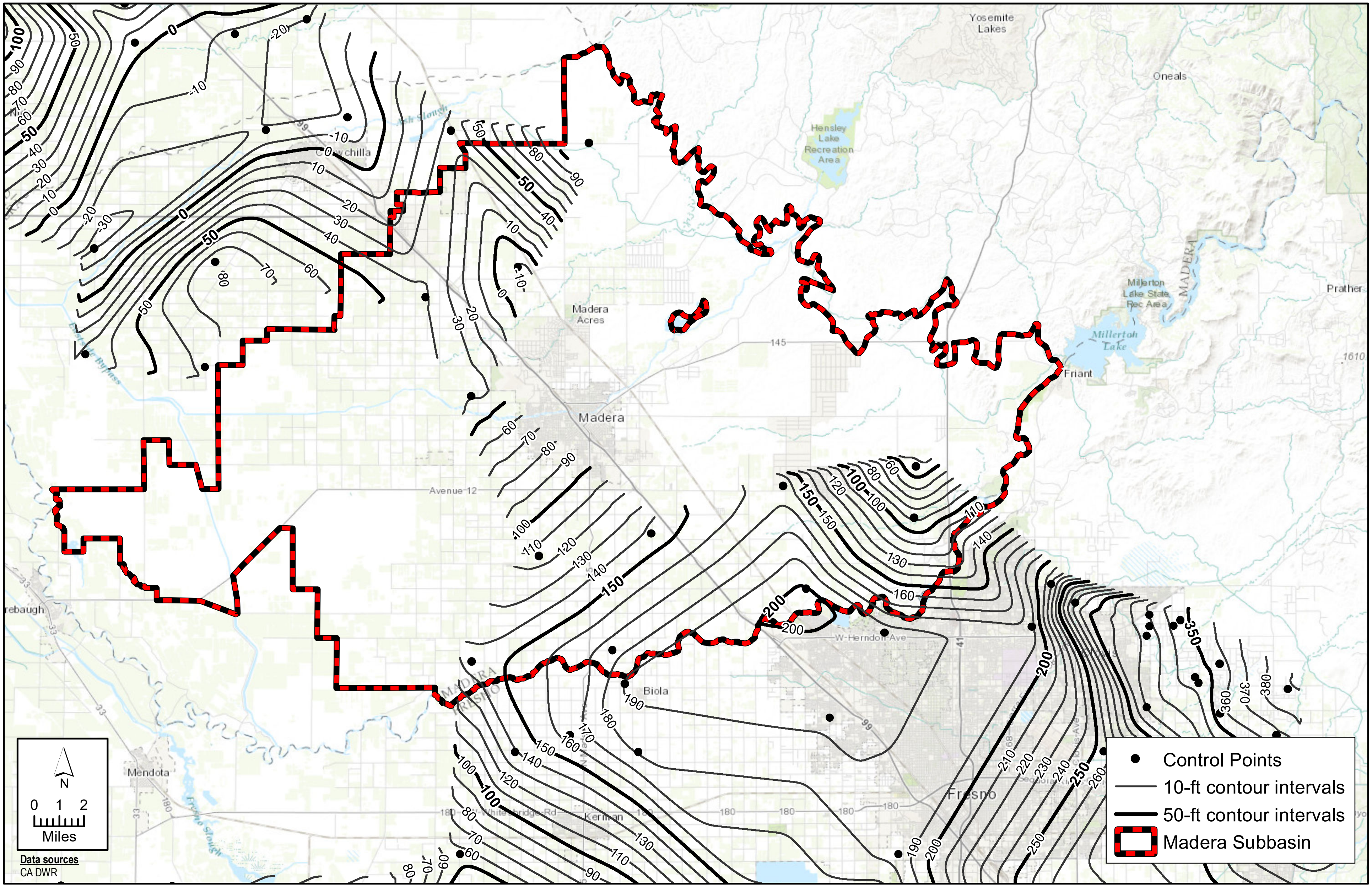
Contours of Equal Groundwater Elevation
Spring 2013 (EDIT)

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



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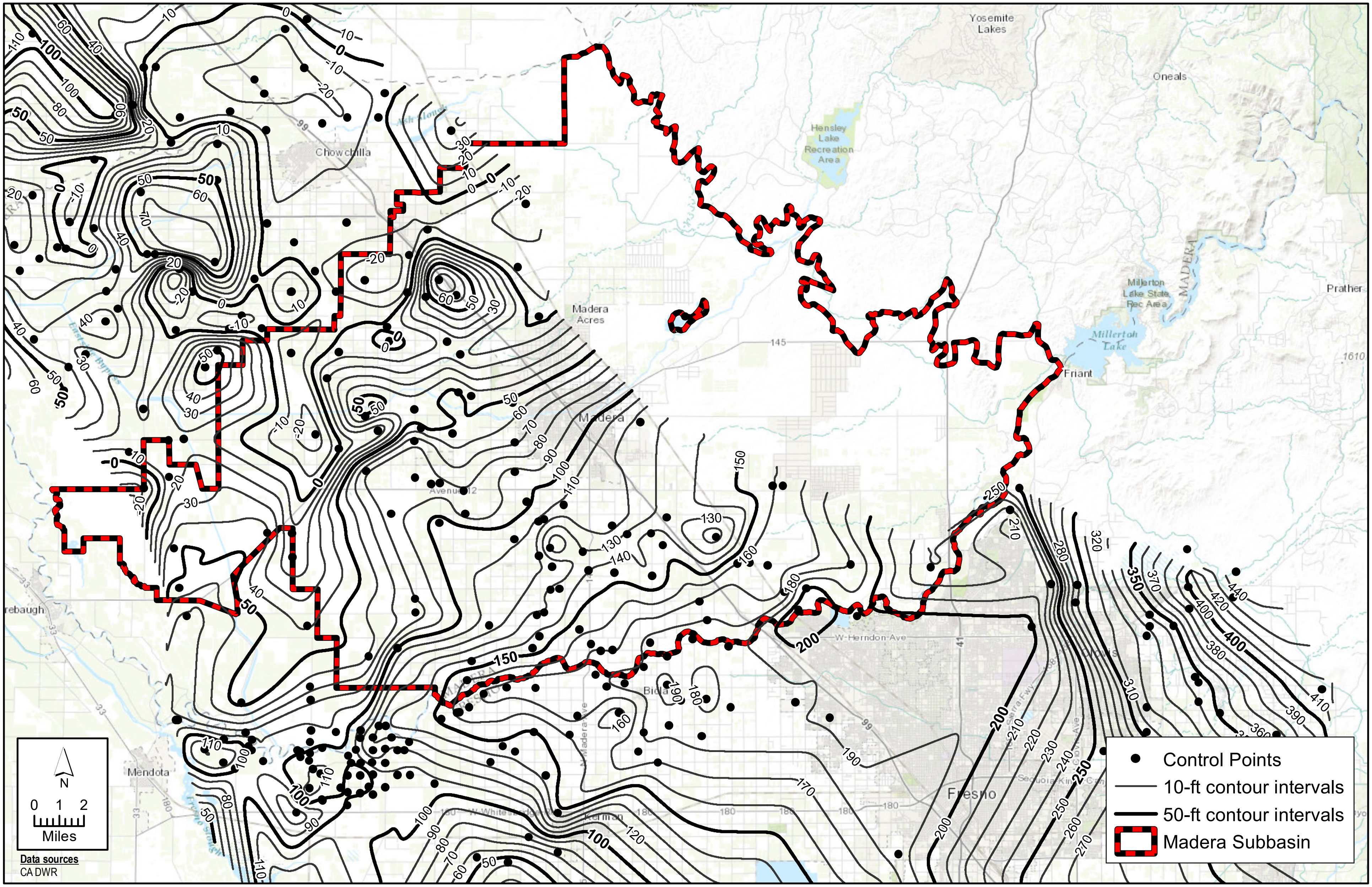
Contours of Equal Groundwater Elevation
Fall 2013

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



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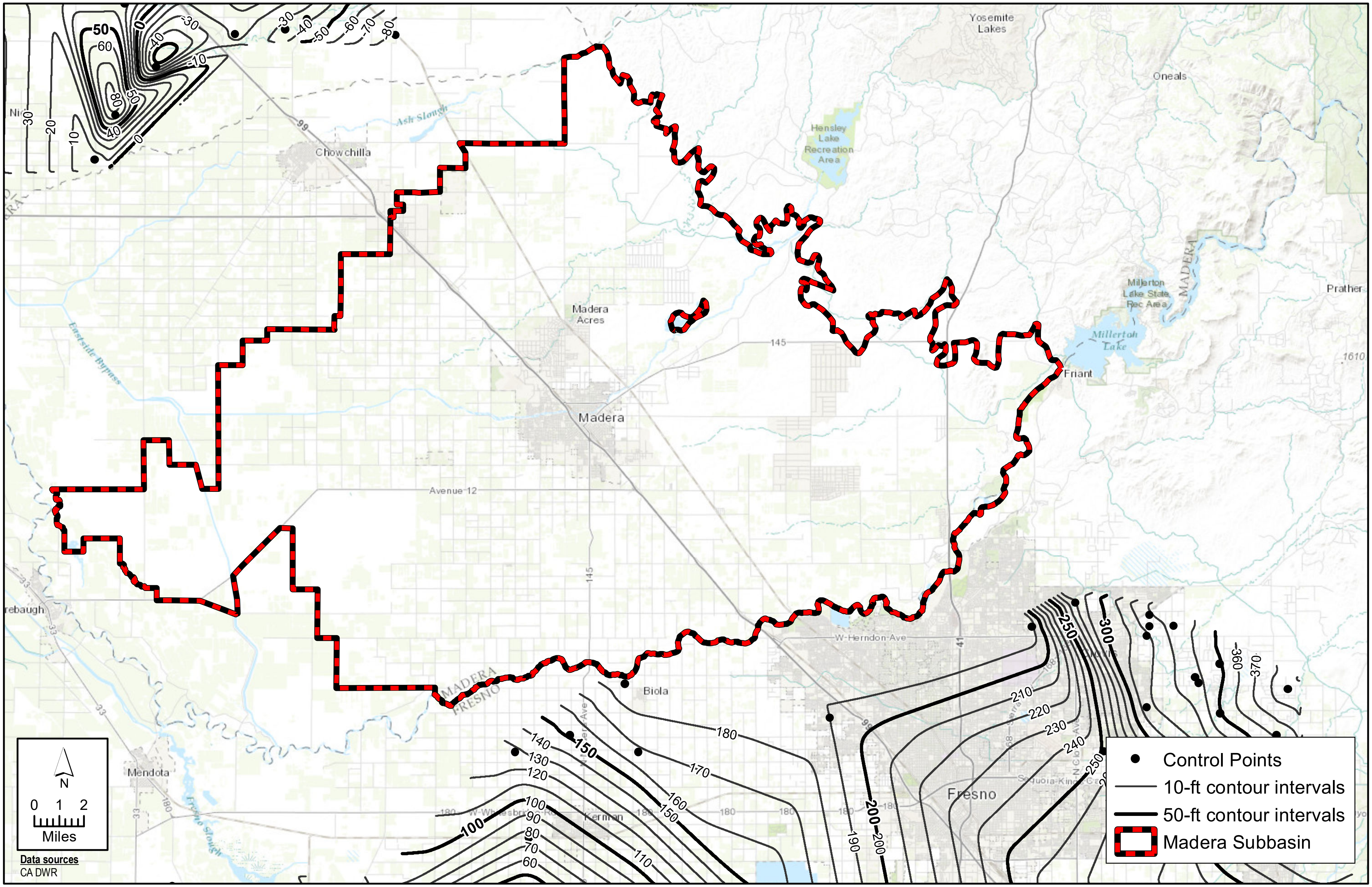
Contours of Equal Groundwater Elevation
Spring 2014

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



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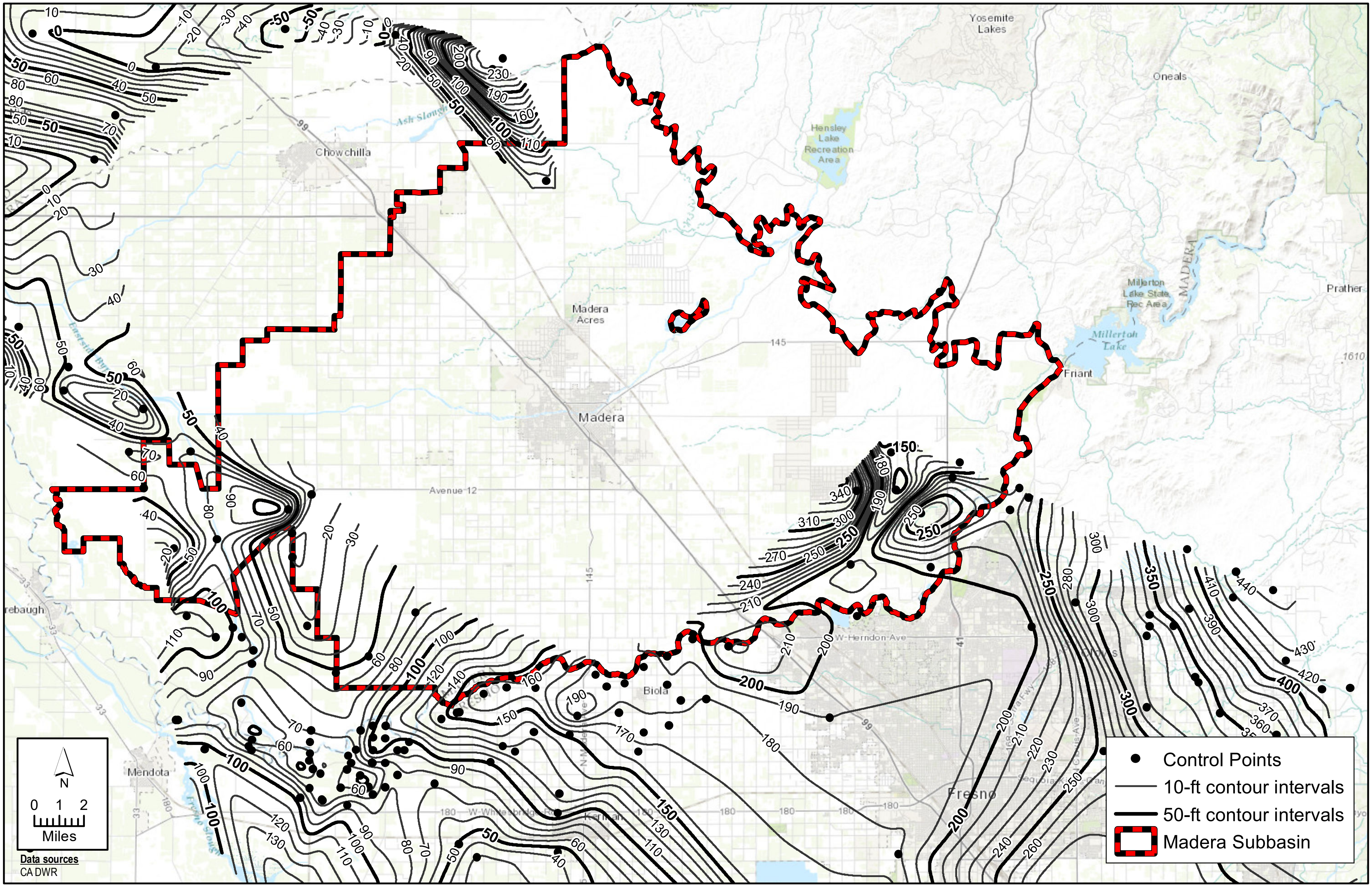
Contours of Equal Groundwater Elevation
Fall 2014

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



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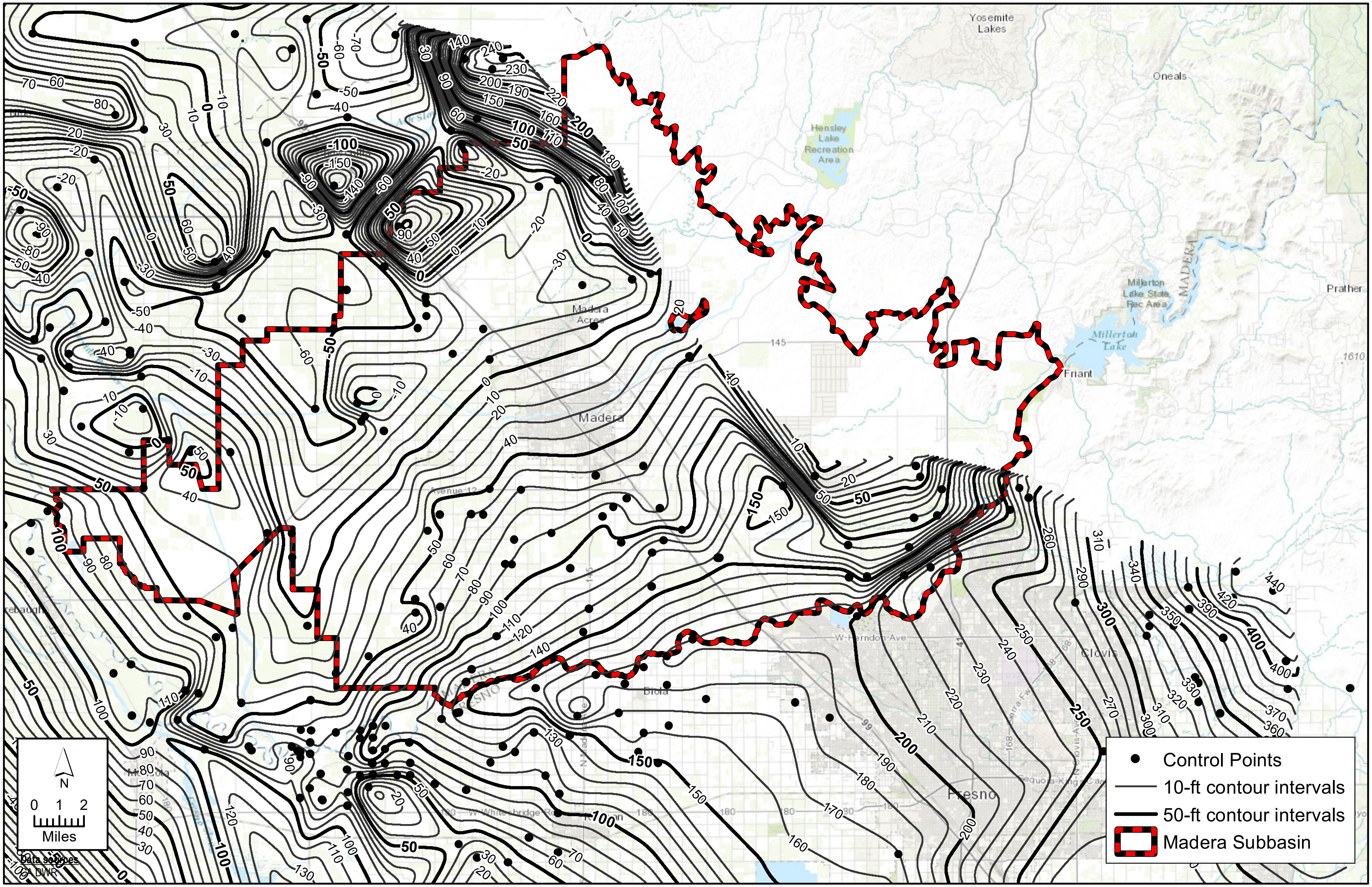
Contours of Equal Groundwater Elevation
Spring 2015

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



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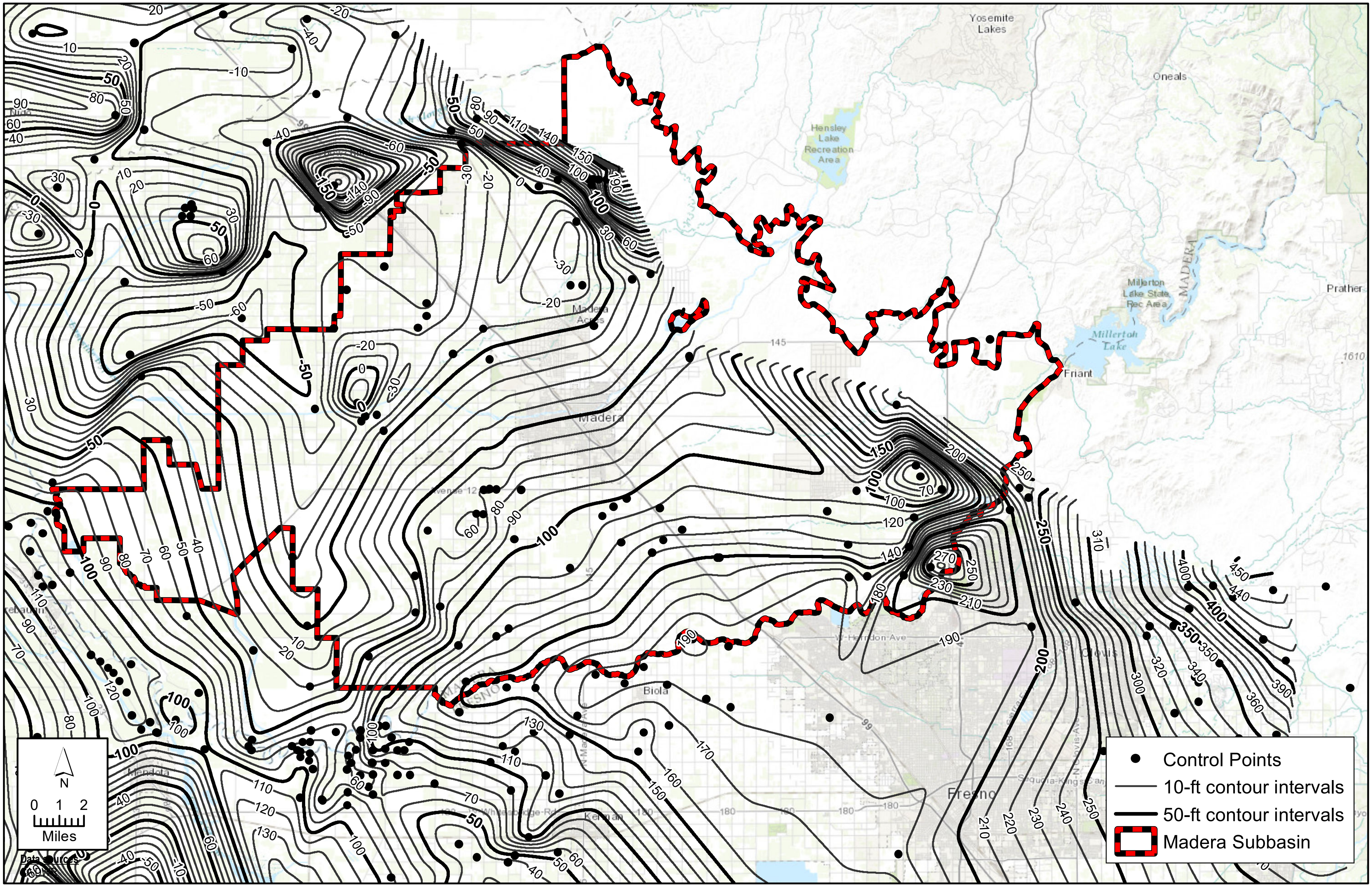
Contours of Equal Groundwater Elevation
Fall 2015

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



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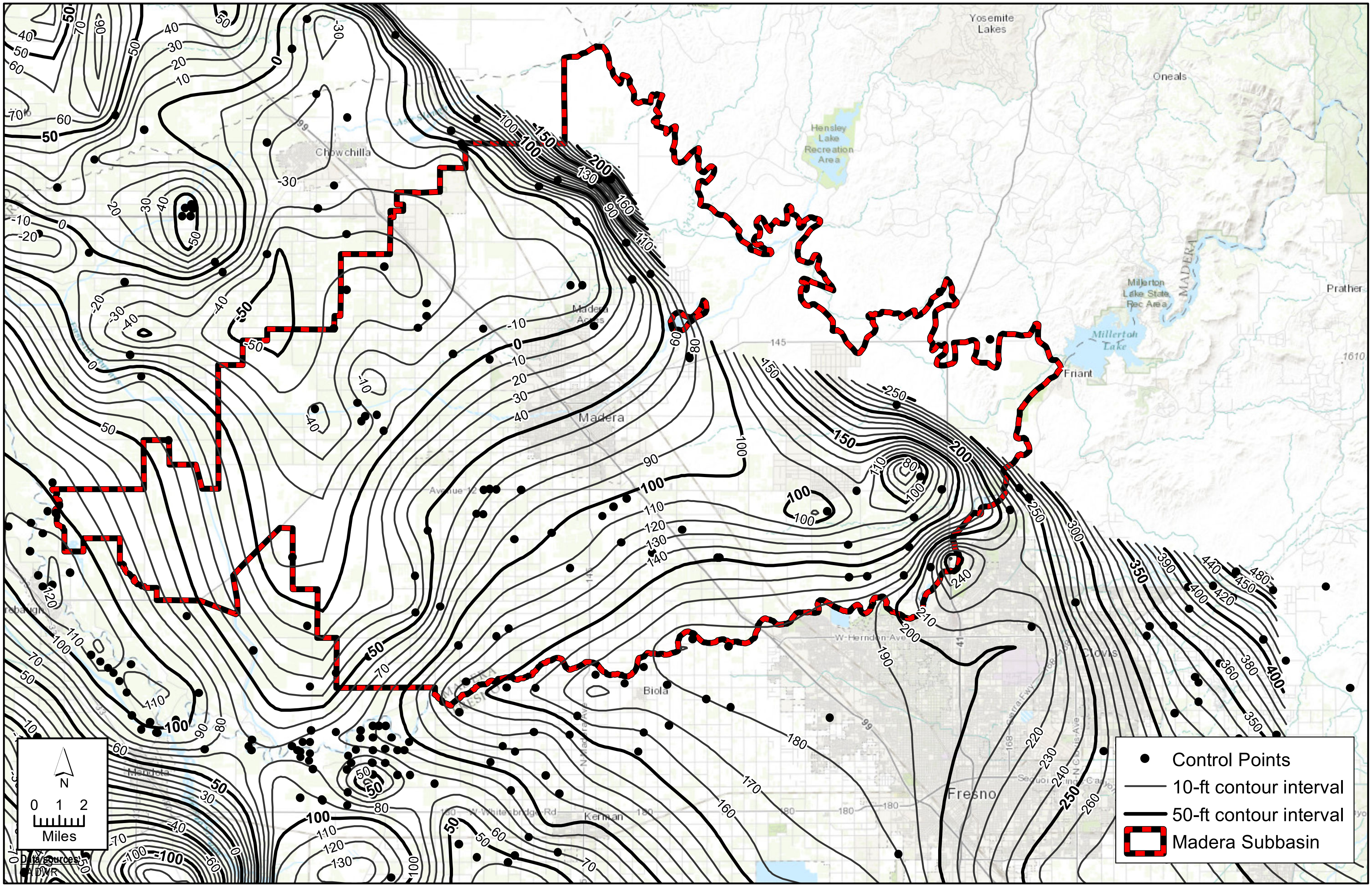
APPENDIX C
Contours of Equal Groundwater Elevation
Spring 2016

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



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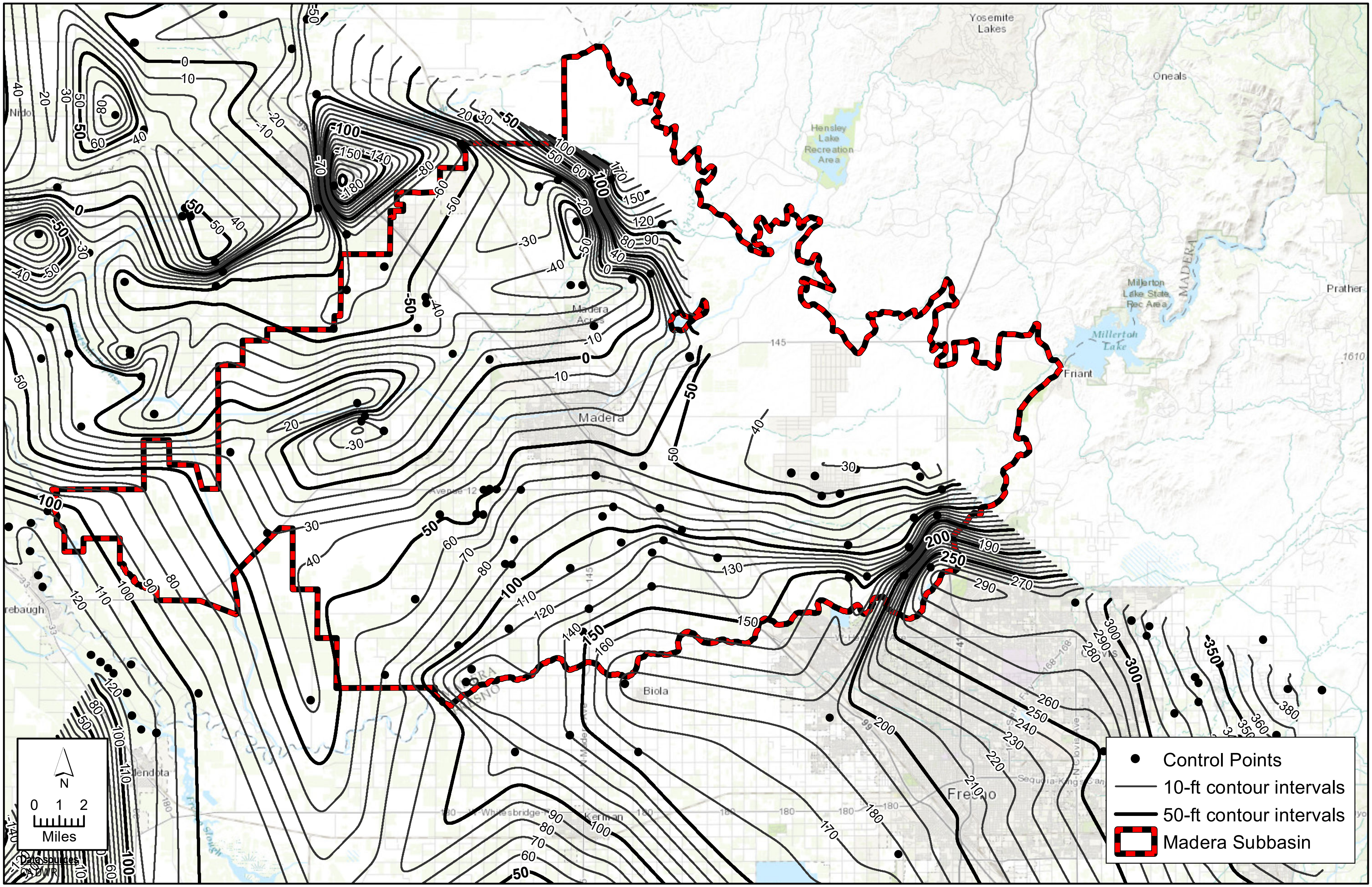
Contours of Equal Groundwater Elevation
Spring 2016 (EDIT)

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



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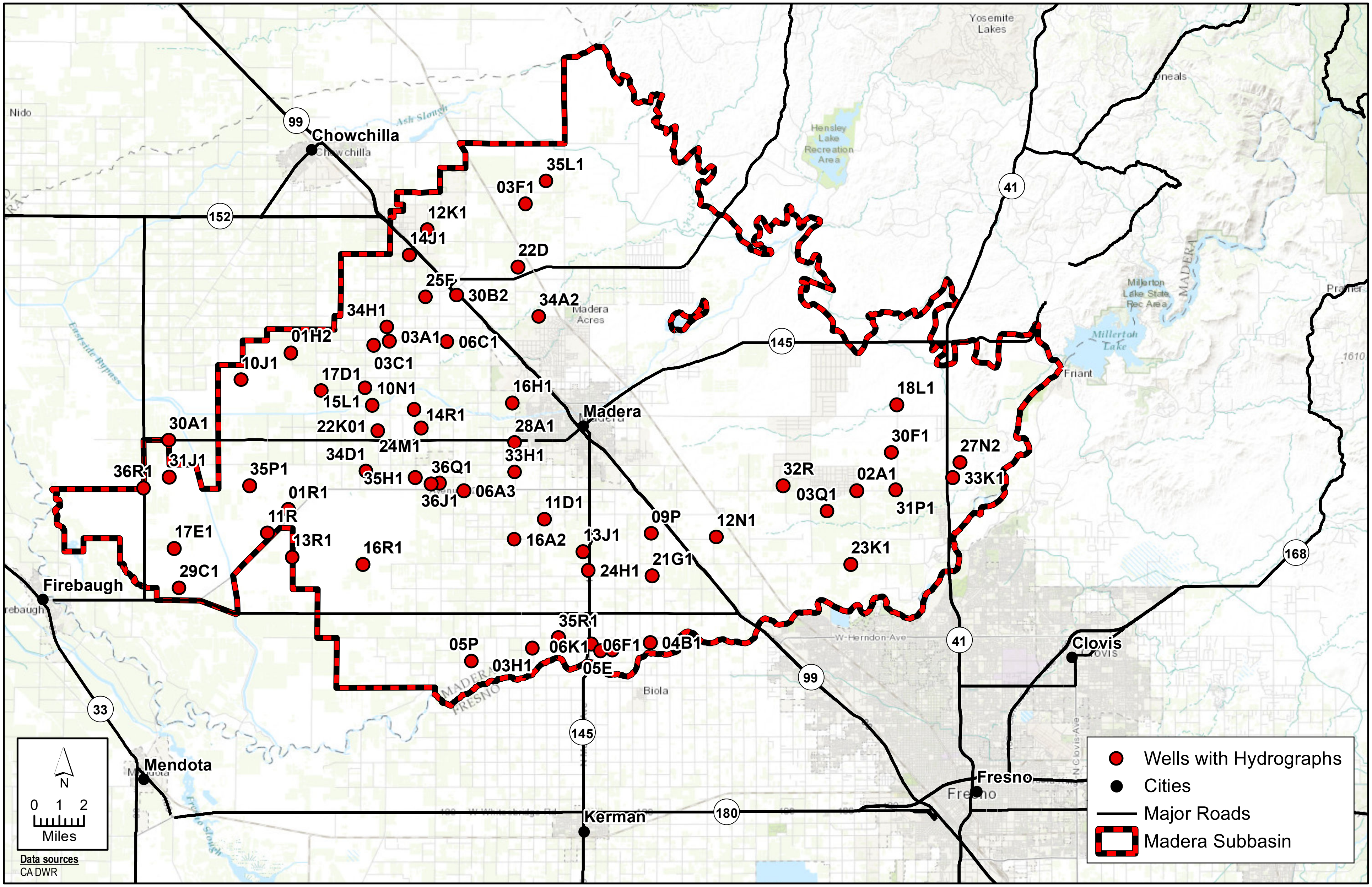
APPENDIX C
Contours of Equal Groundwater Elevation
Fall 2016

Madera County: Madera Subbasin
SGMA Data Collection and Analysis

Groundwater Elevation

Hydrographs



X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Appendix B Madera Subbasin Wells with Hydrographs.mxd

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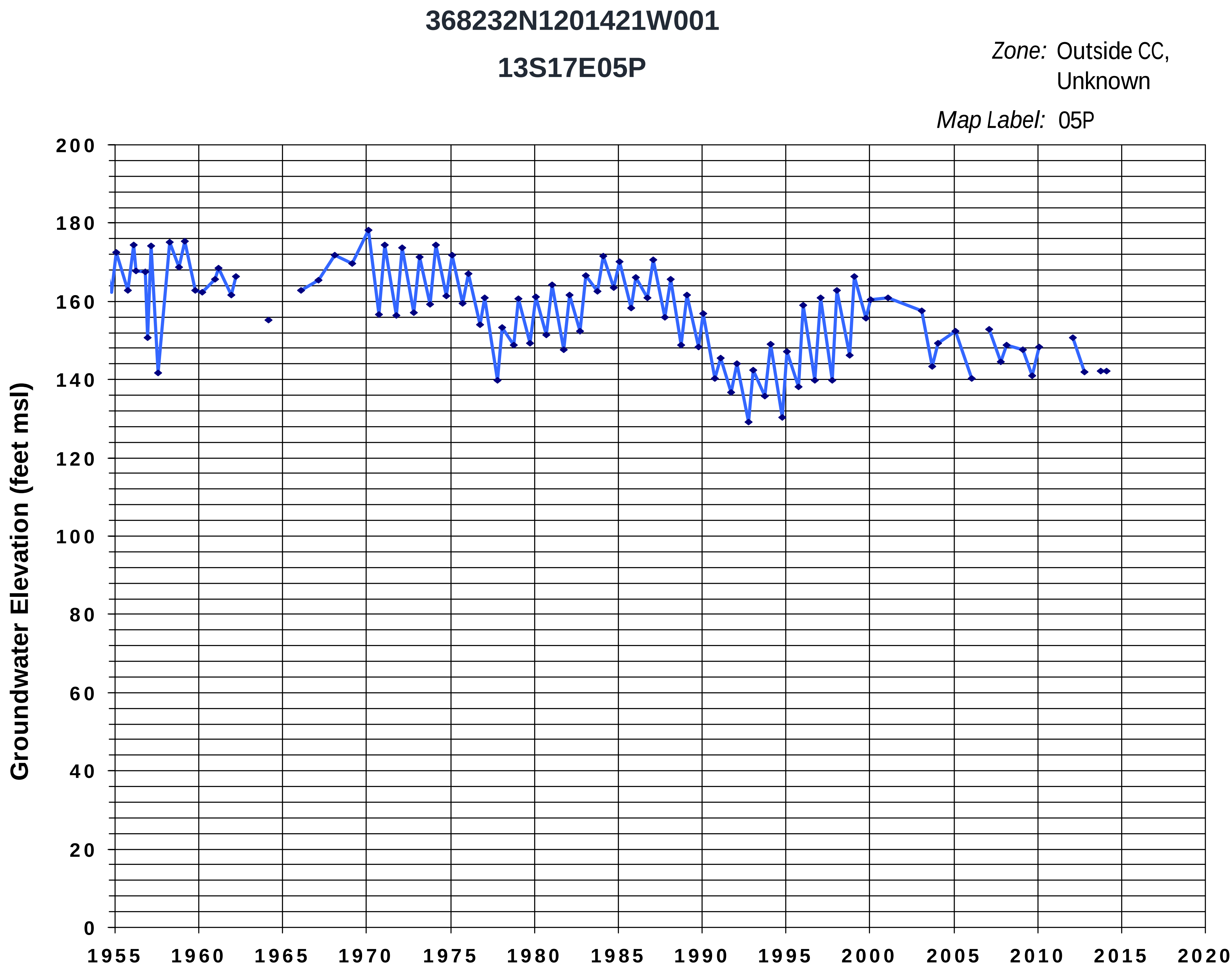
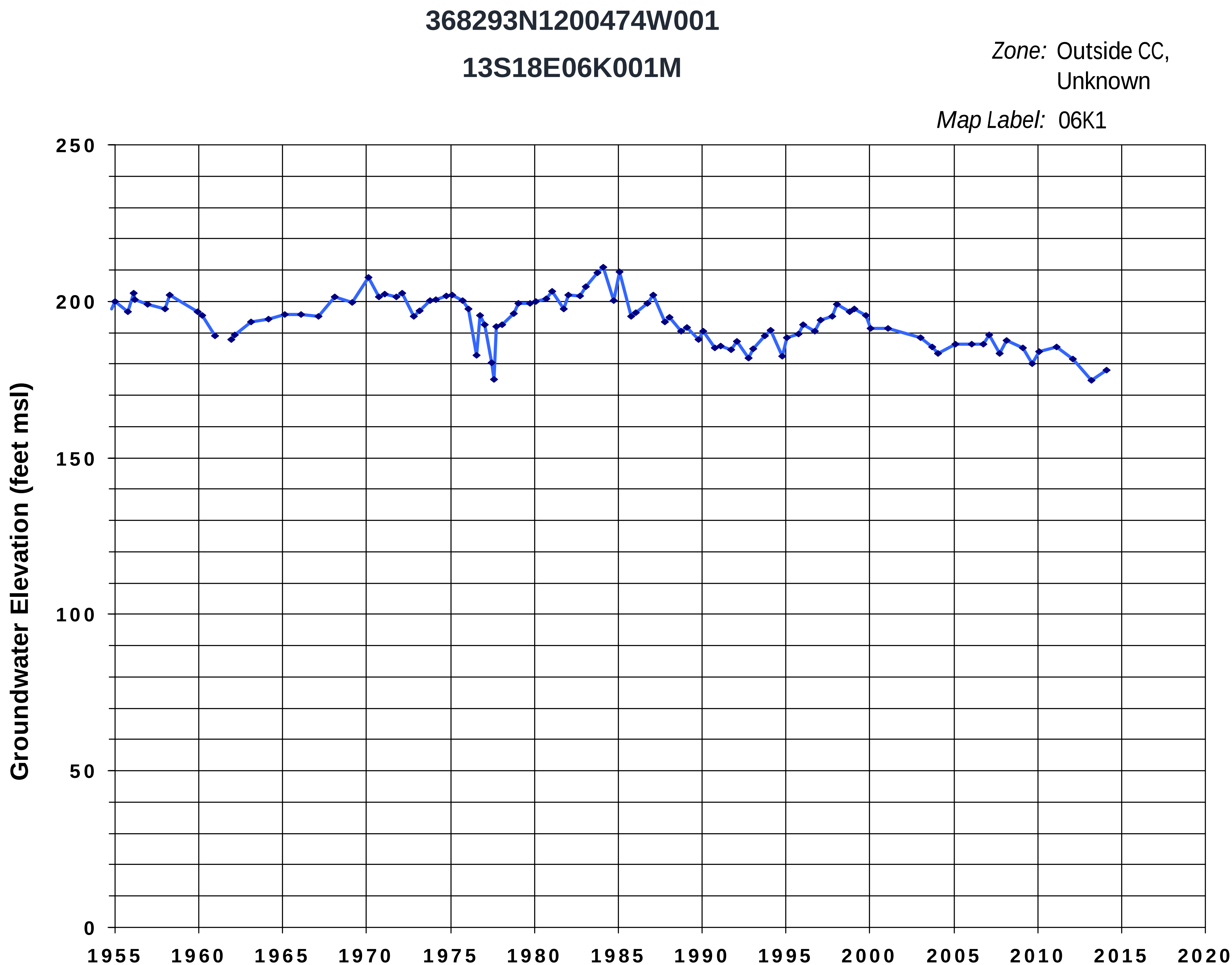
APPENDIX C

Locations of Wells with Hydrographs

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



368232N1201421W001
13S17E05P
Zone: Outside CC, Unknown
Map Label: 05P
Groundwater Elevation (feet msl)
200
180
160
140
120
100
80
60
40
20
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

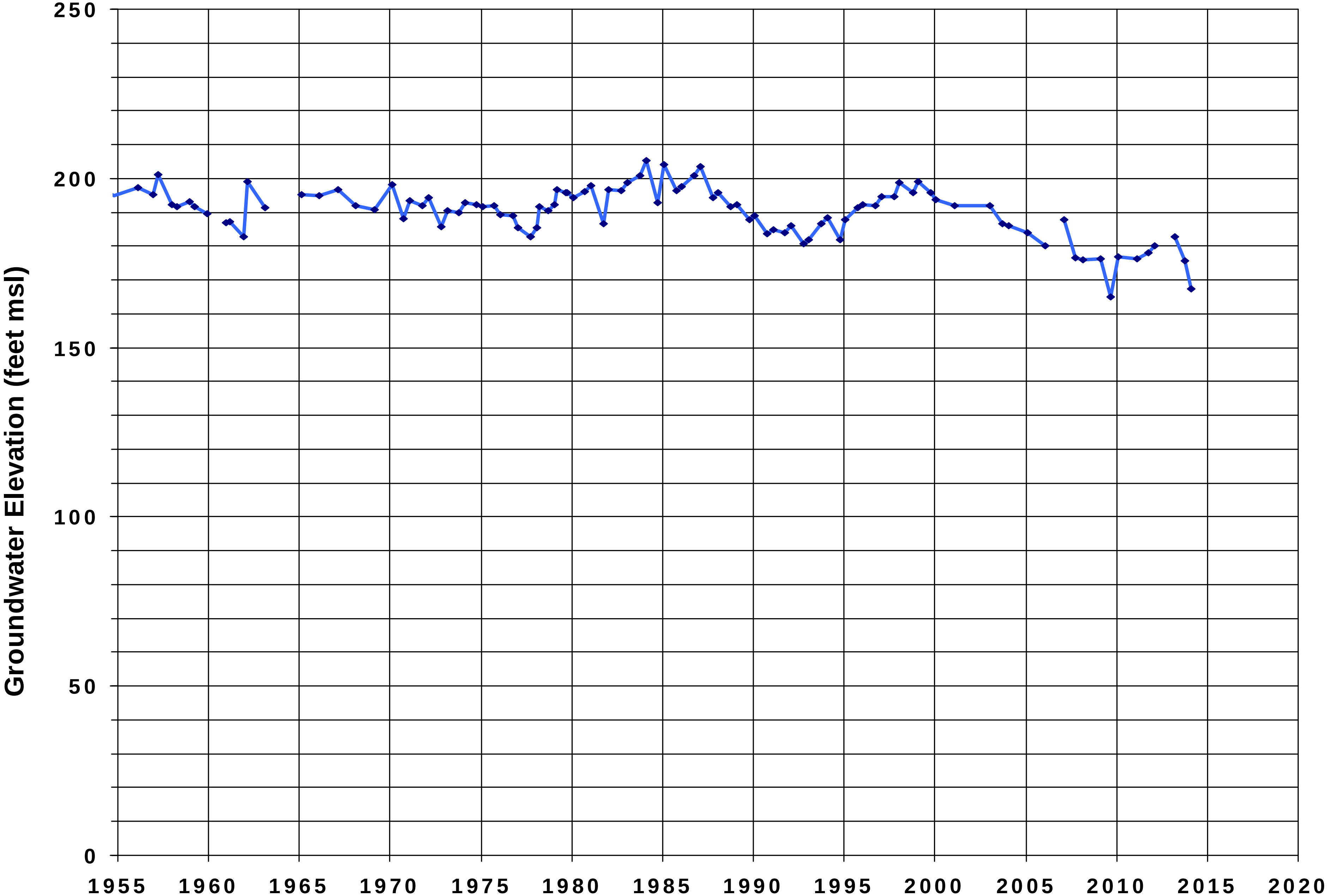

368293N1200474W001
13S18E06K001M
Zone: Outside CC, Unknown
Map Label: 06K1
Groundwater Elevation (feet msl)
250
200
150
100
50
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

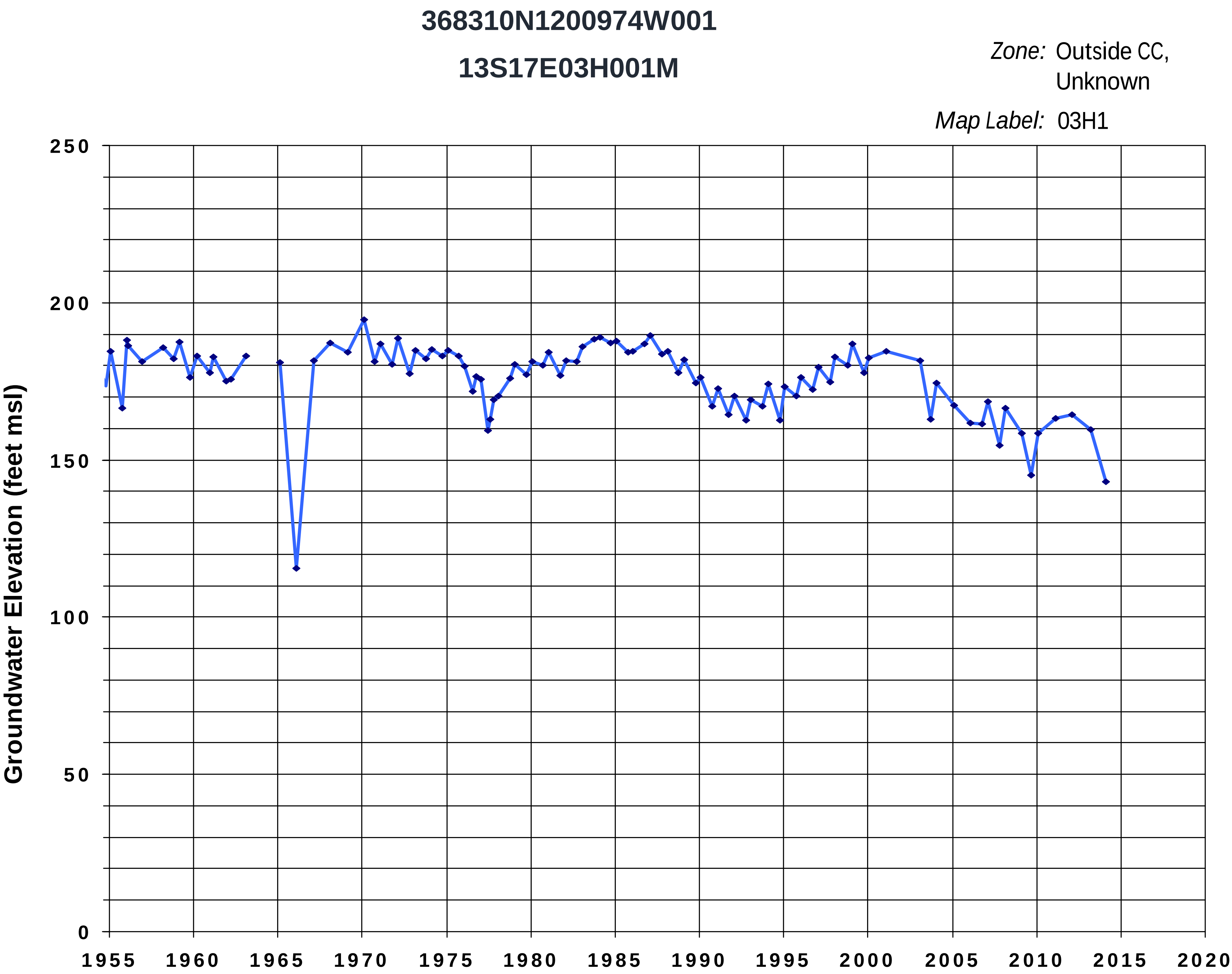
368299N1200388W001

13S18E05E

Zone: Outside CC, Unknown

Map Label: 05E



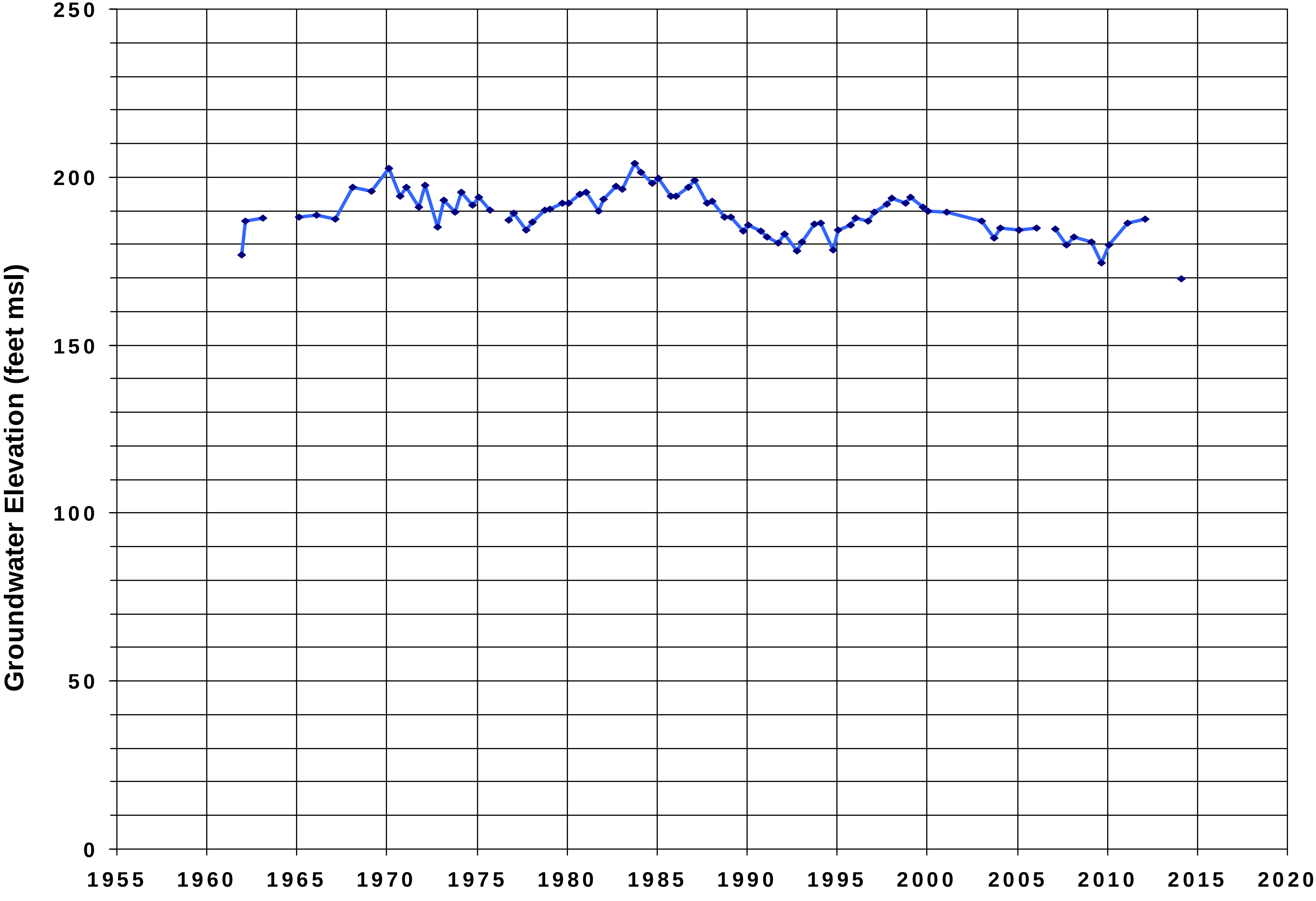

368310N1200974W001
13S17E03H001M
Zone: Outside CC, Unknown
Map Label: 03H1
Groundwater Elevation (feet msl)
0
50
100
150
200
250
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

368332N1200546W001

13S18E06F001M

Zone: Outside CC, Unknown

Map Label: 06F1

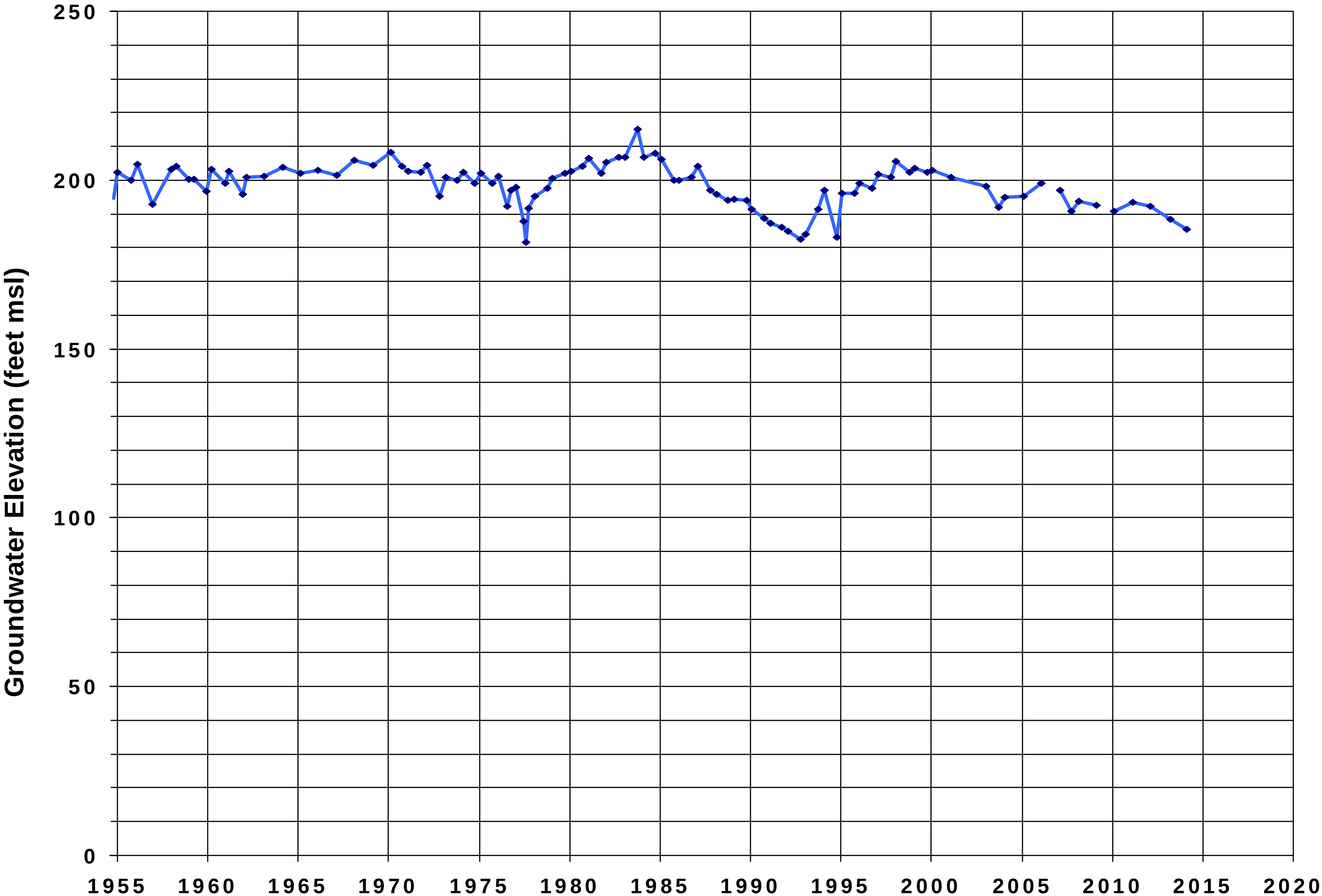


368341N1200113W001

13S18E04B001M

Zone: Outside CC, Unknown

Map Label: 04B1

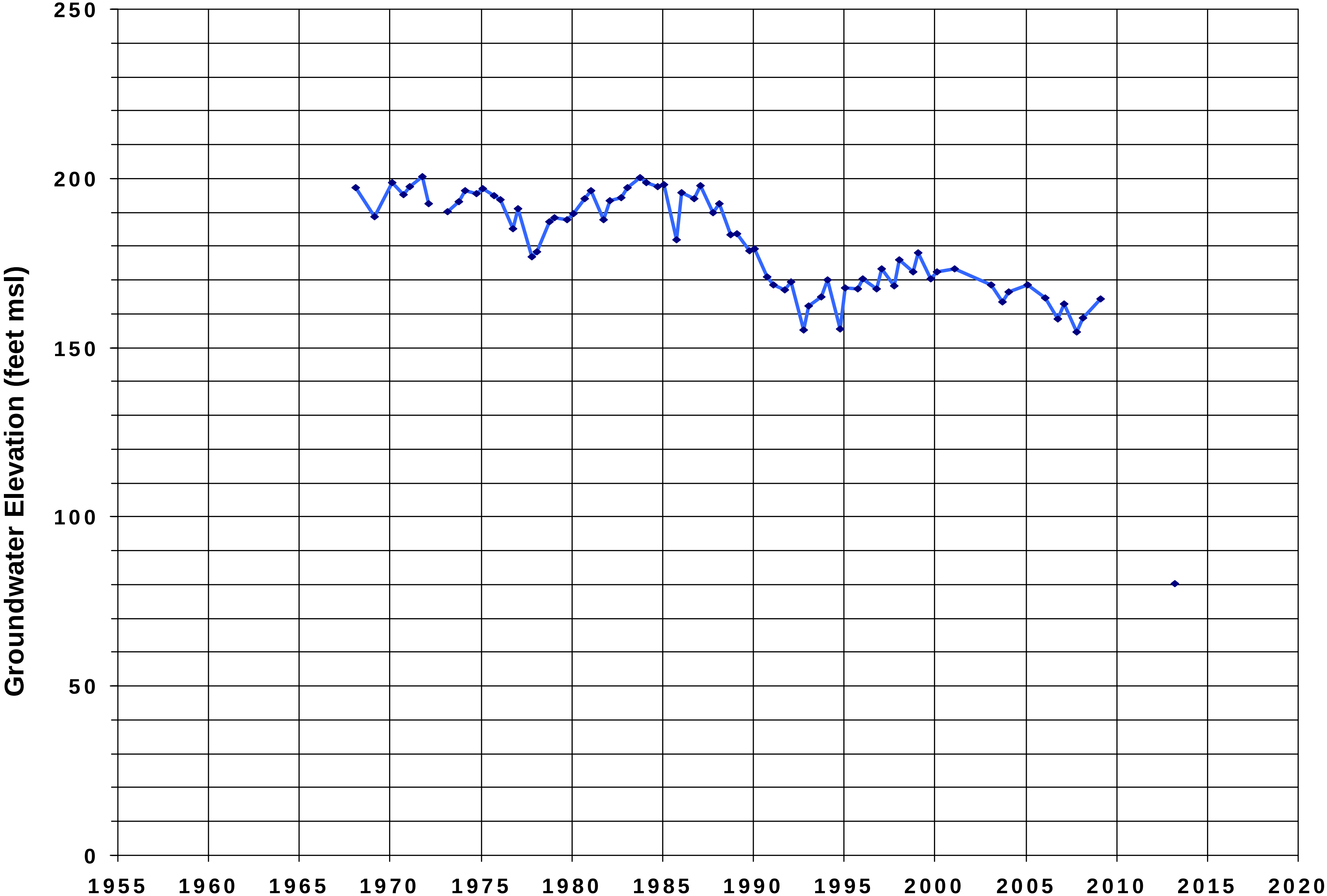


368371N1200785W001

12S17E35R001M

Zone: Outside CC, Unknown

Map Label: 35R1



368655N1203560W001

12S15E29C001M

Zone: Unknown

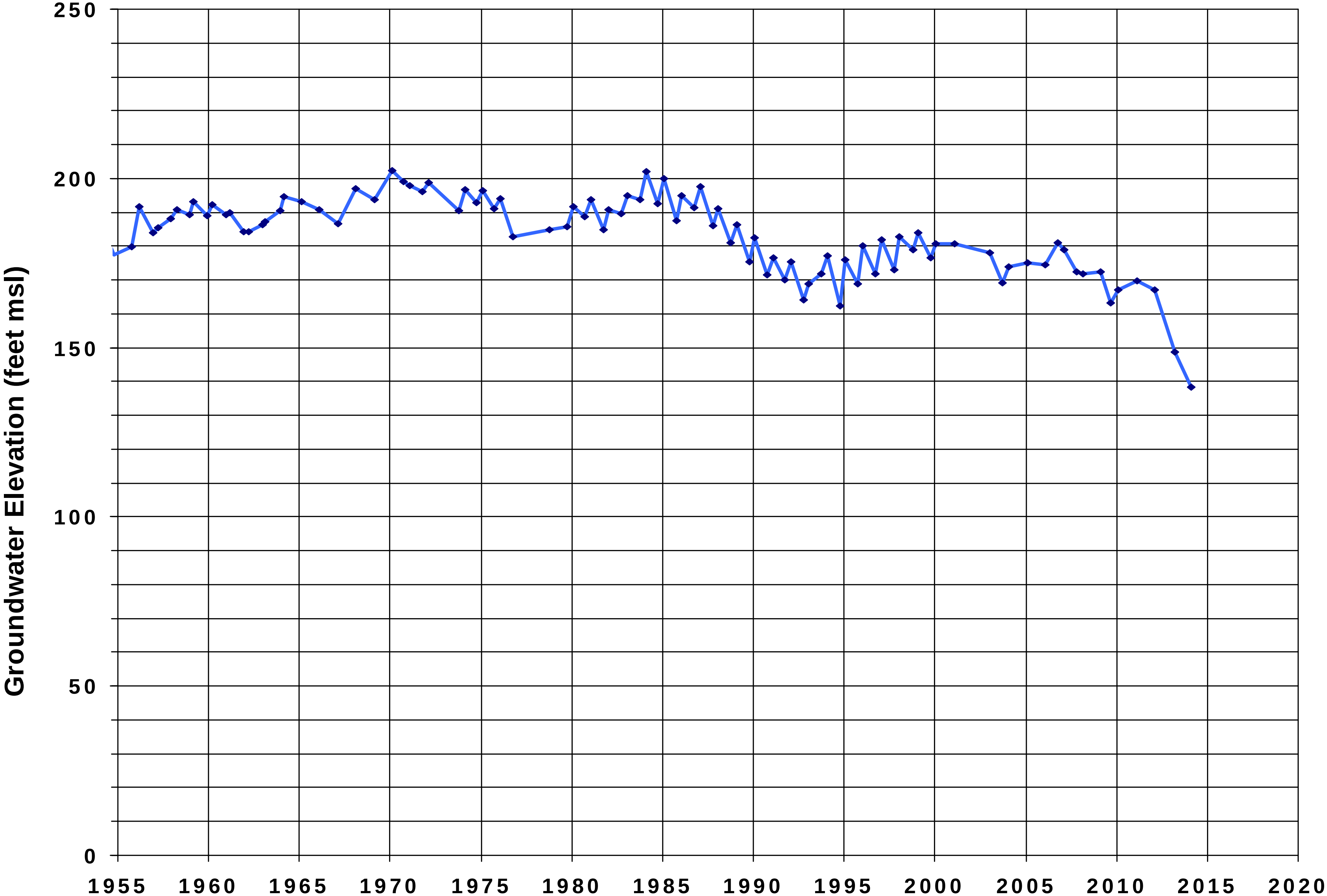
Map Label: 29C1

368732N1200099W001

12S18E21G001M

Zone: Outside CC, Unknown

Map Label: 21G1

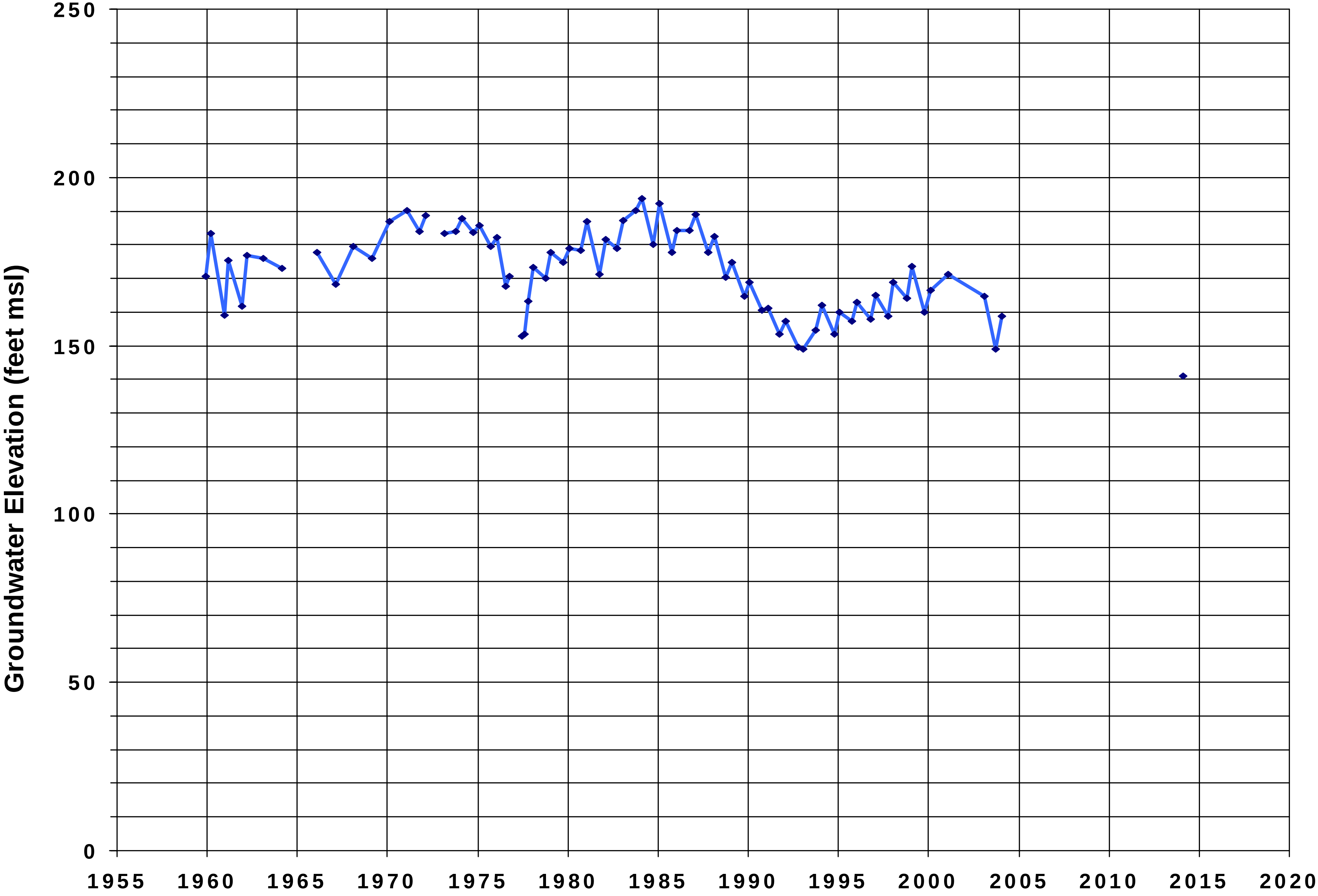


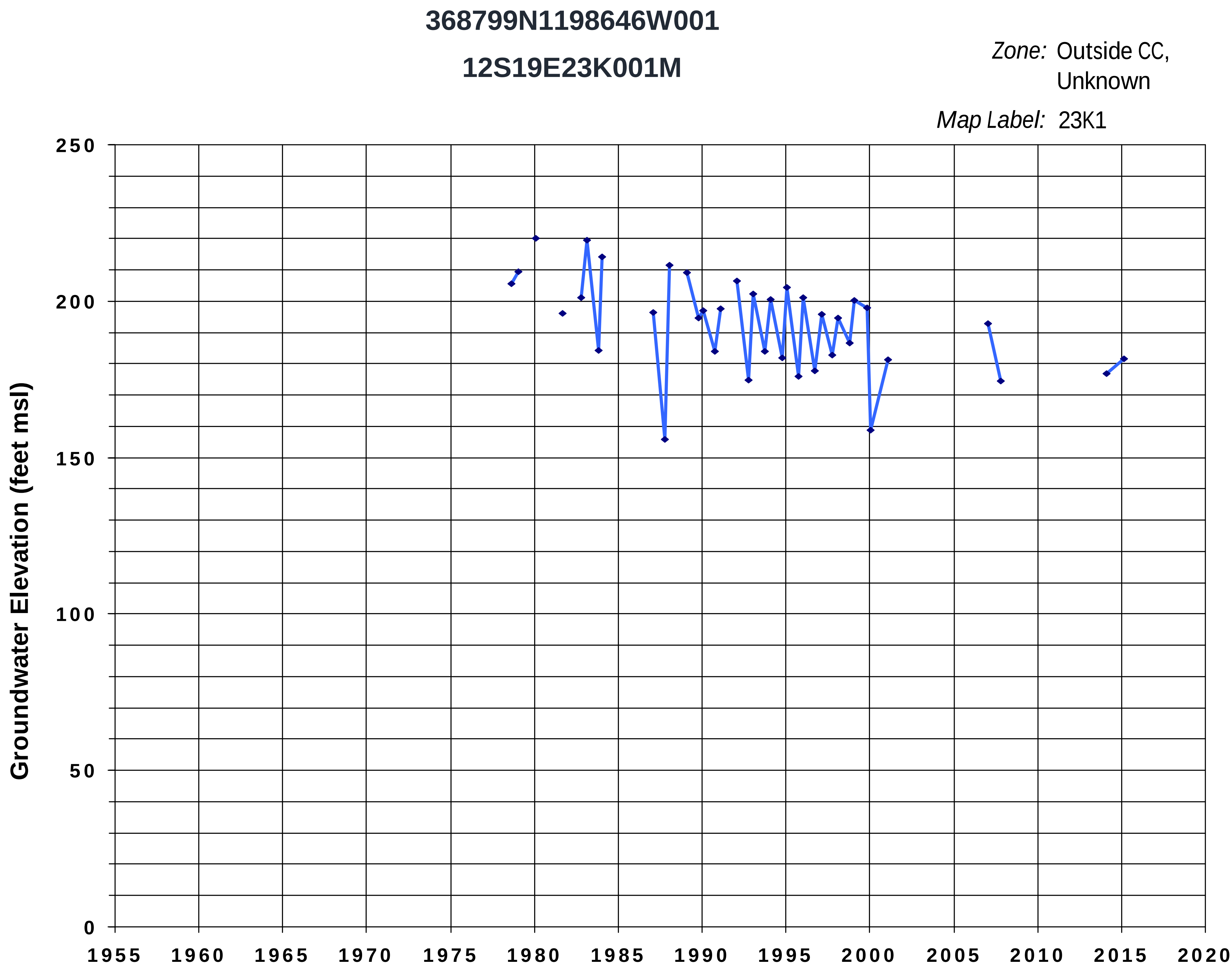
368766N1200566W001

12S17E24H001M

Zone: Outside CC, Unknown

Map Label: 24H1



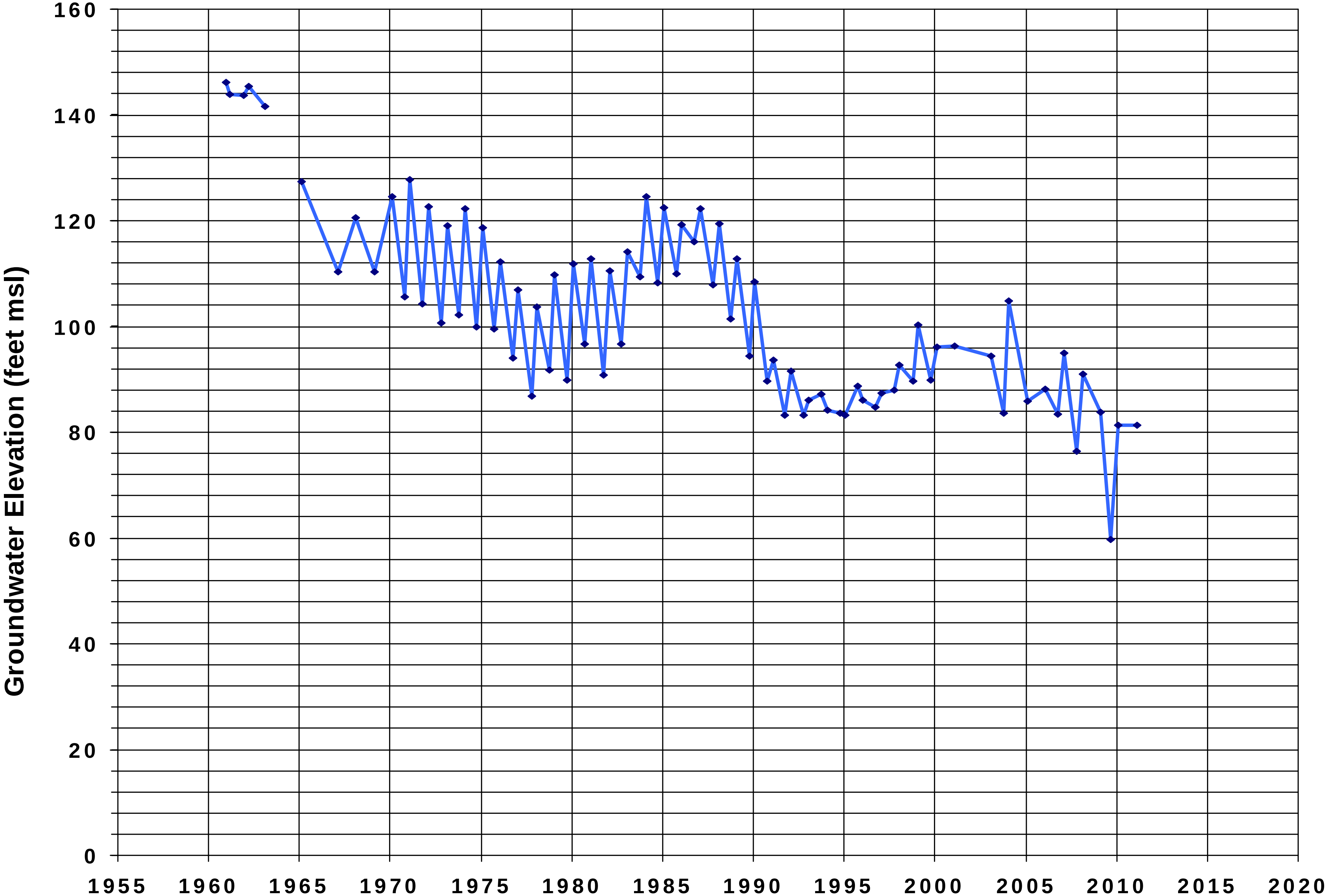

368799N1198646W001
12S19E23K001M
Zone: Outside CC, Unknown
Map Label: 23K1
Groundwater Elevation (feet msl)
250
200
150
100
50
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

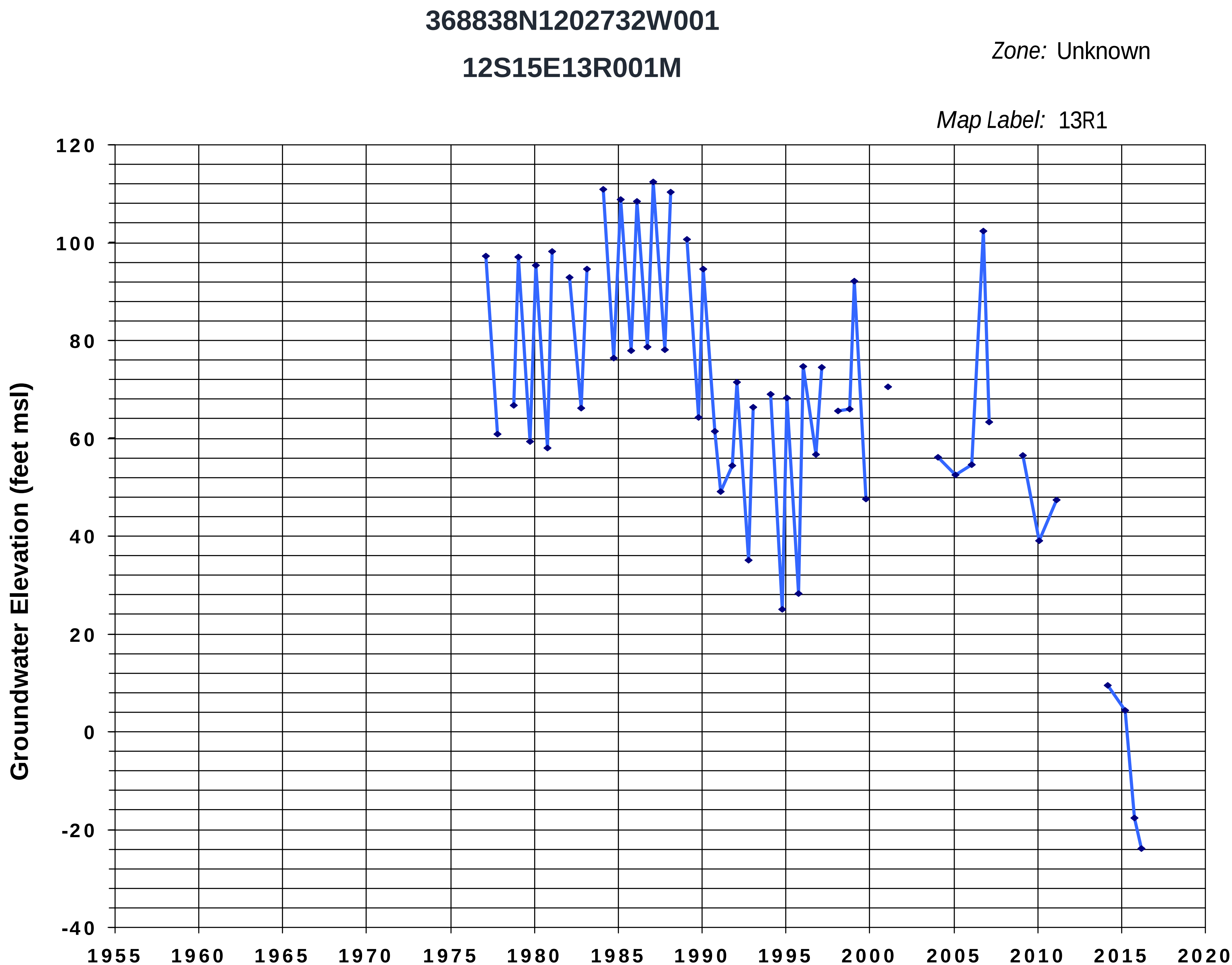
368799N1202216W001

12S16E16R001M

Zone: Unknown

Map Label: 16R1



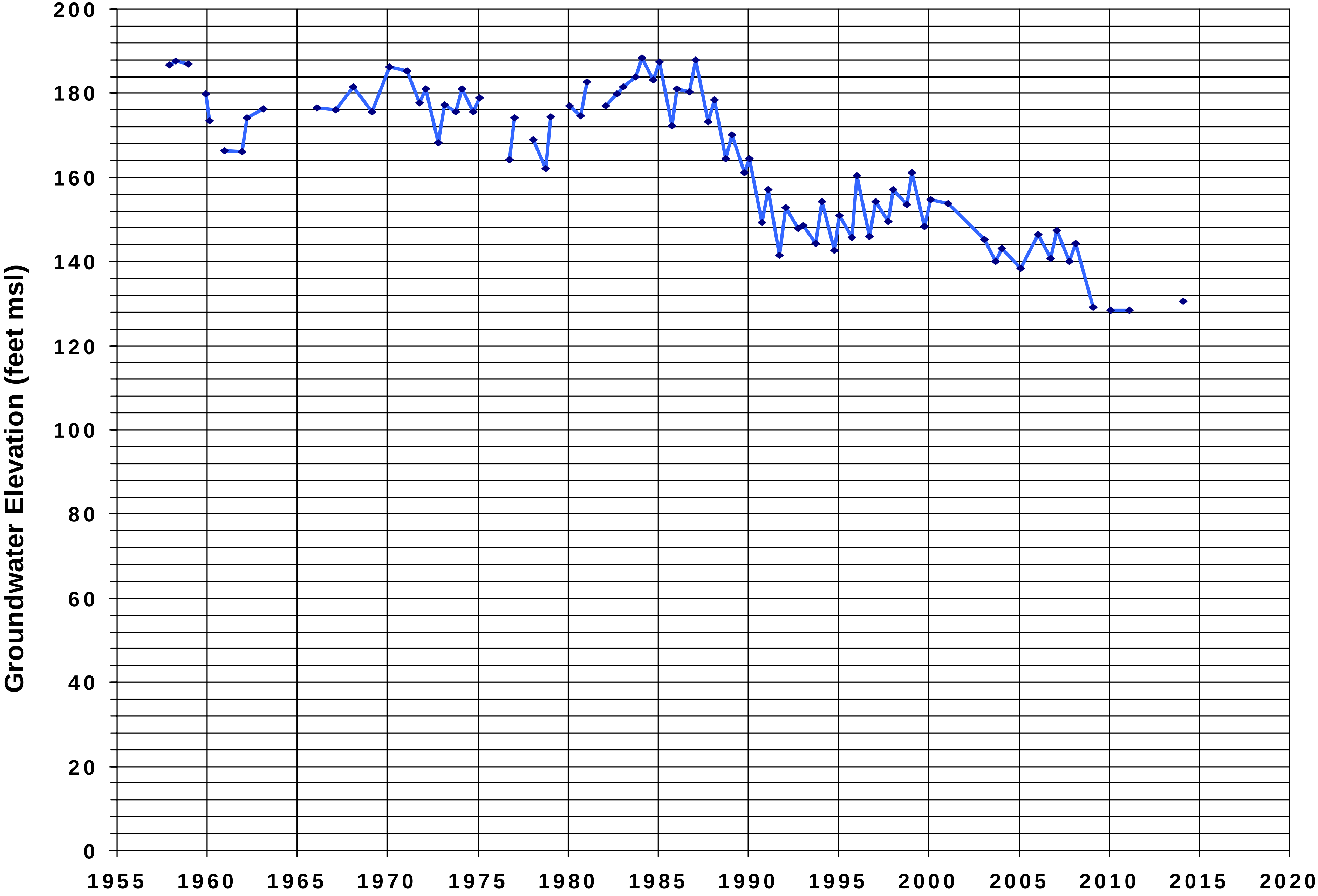

368838N1202732W001
12S15E13R001M
Zone: Unknown
Map Label: 13R1
Groundwater Elevation (feet msl)
120
100
80
60
40
20
0
-20
-40
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

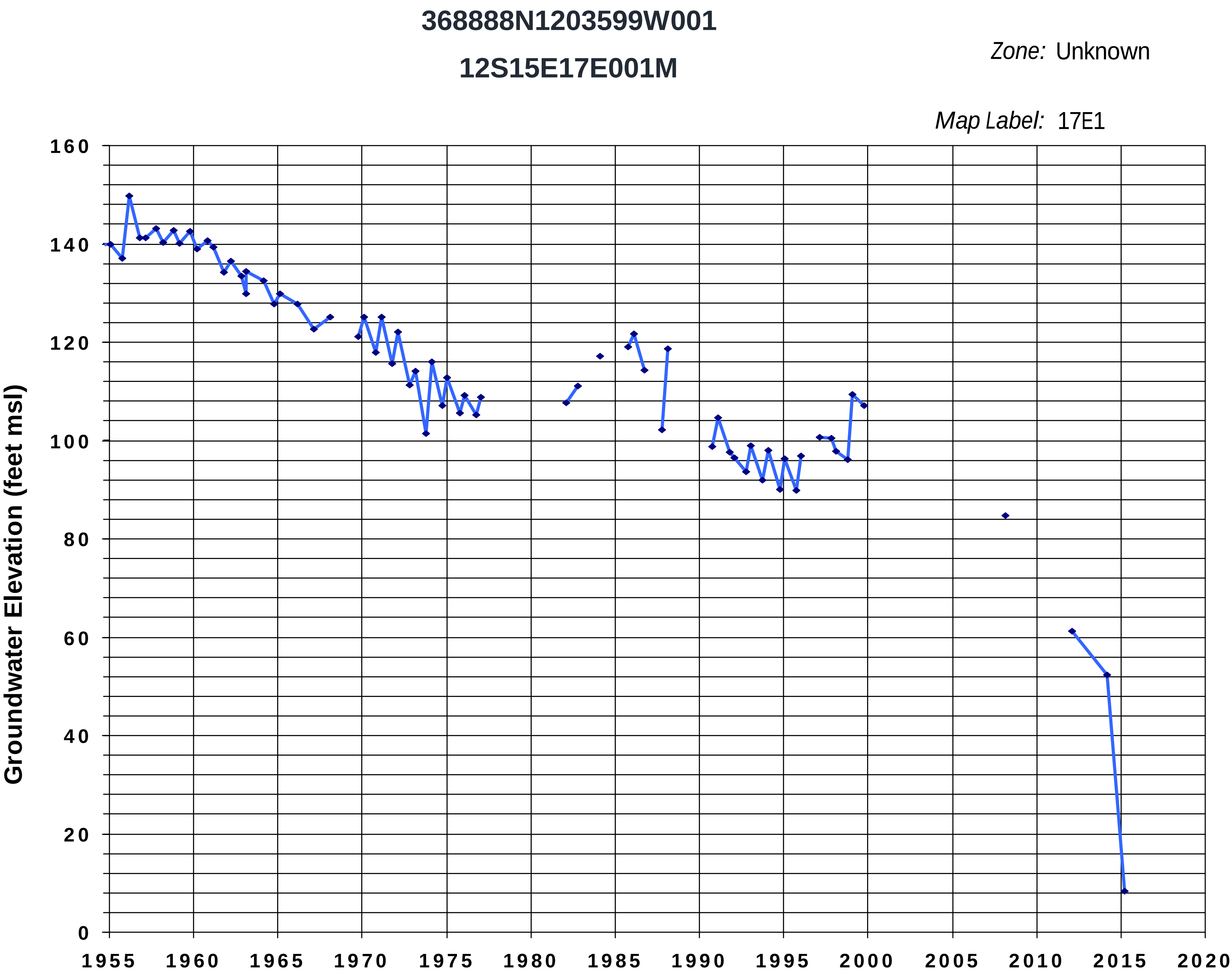
368874N1200604W001

12S17E13J001M

Zone: Outside CC, Unknown

Map Label: 13J1





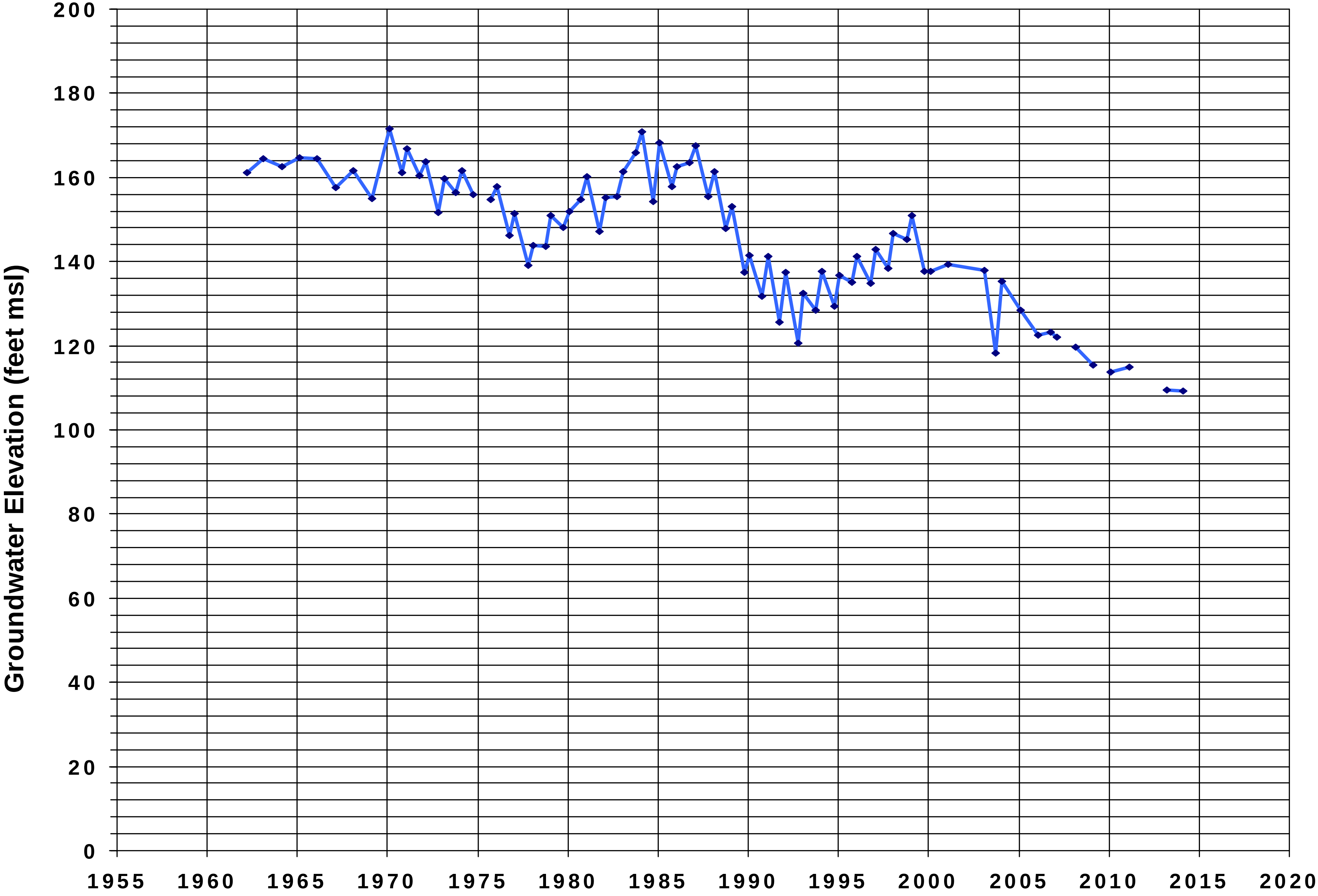
368888N1203599W001
12S15E17E001M
Zone: Unknown
Map Label: 17E1
Groundwater Elevation (feet msl)
160
140
120
100
80
60
40
20
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

368946N1201107W001

12S17E16A002M

Zone: Outside CC, Unknown

Map Label: 16A2

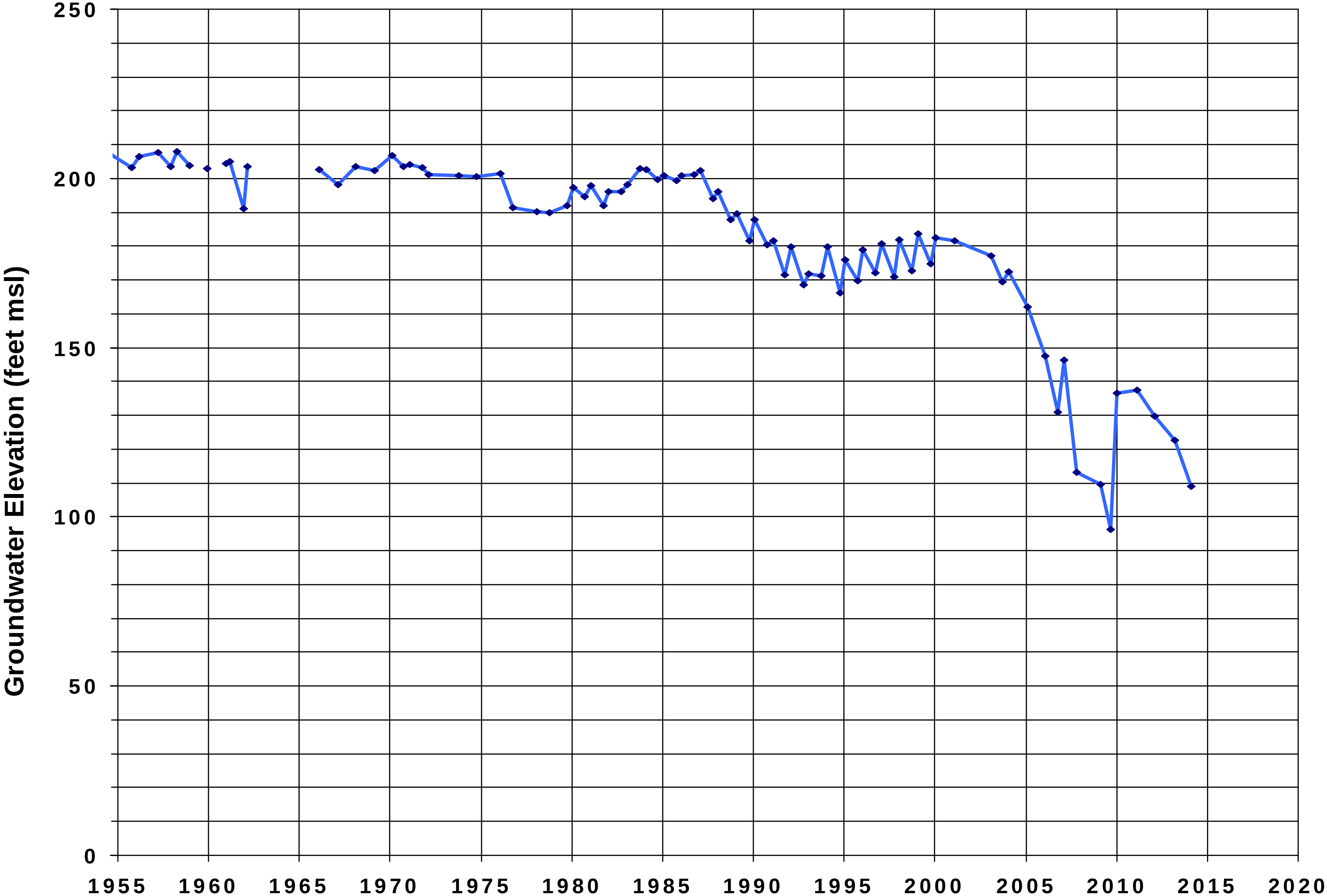


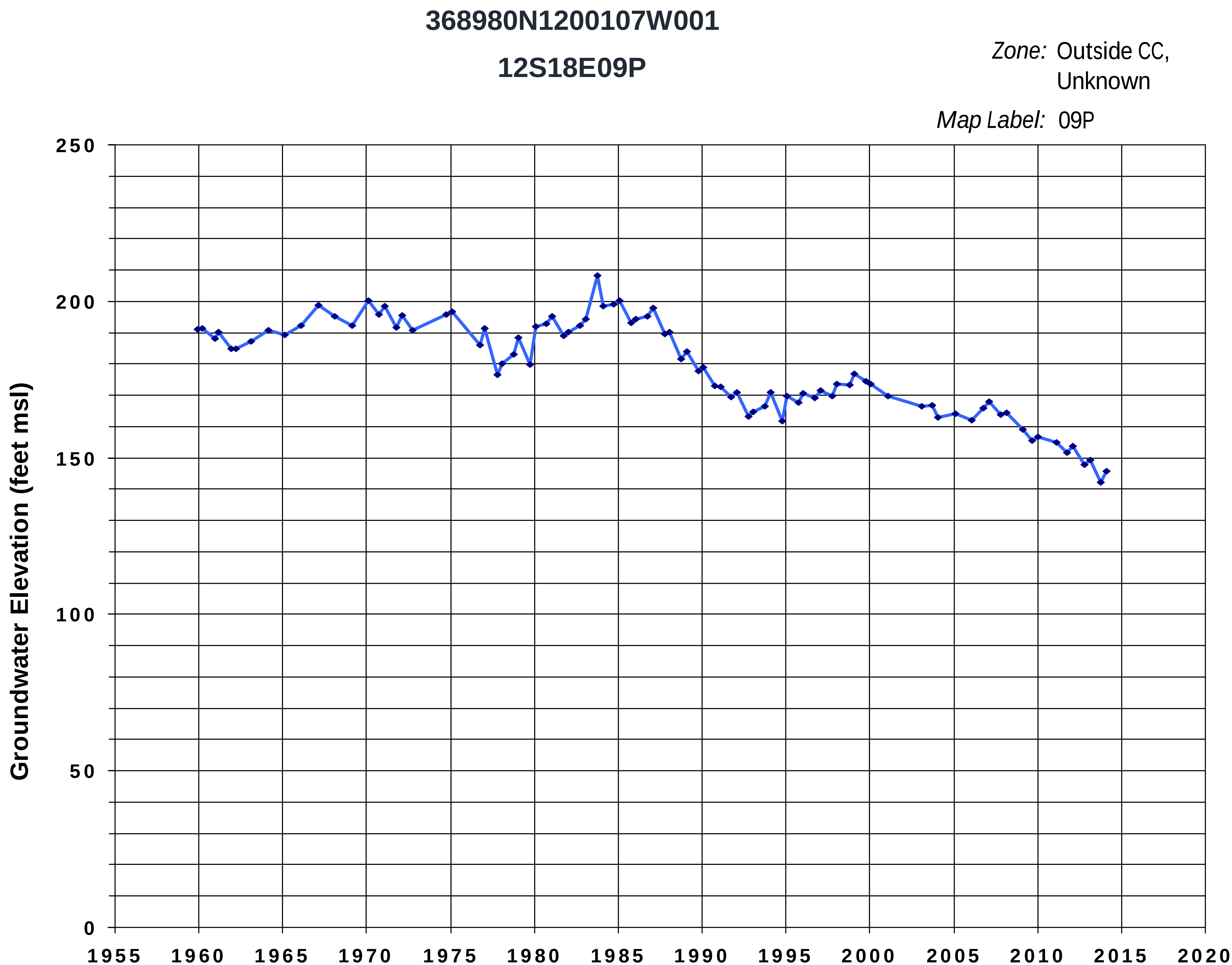
368960N1199629W001

12S18E12N001M

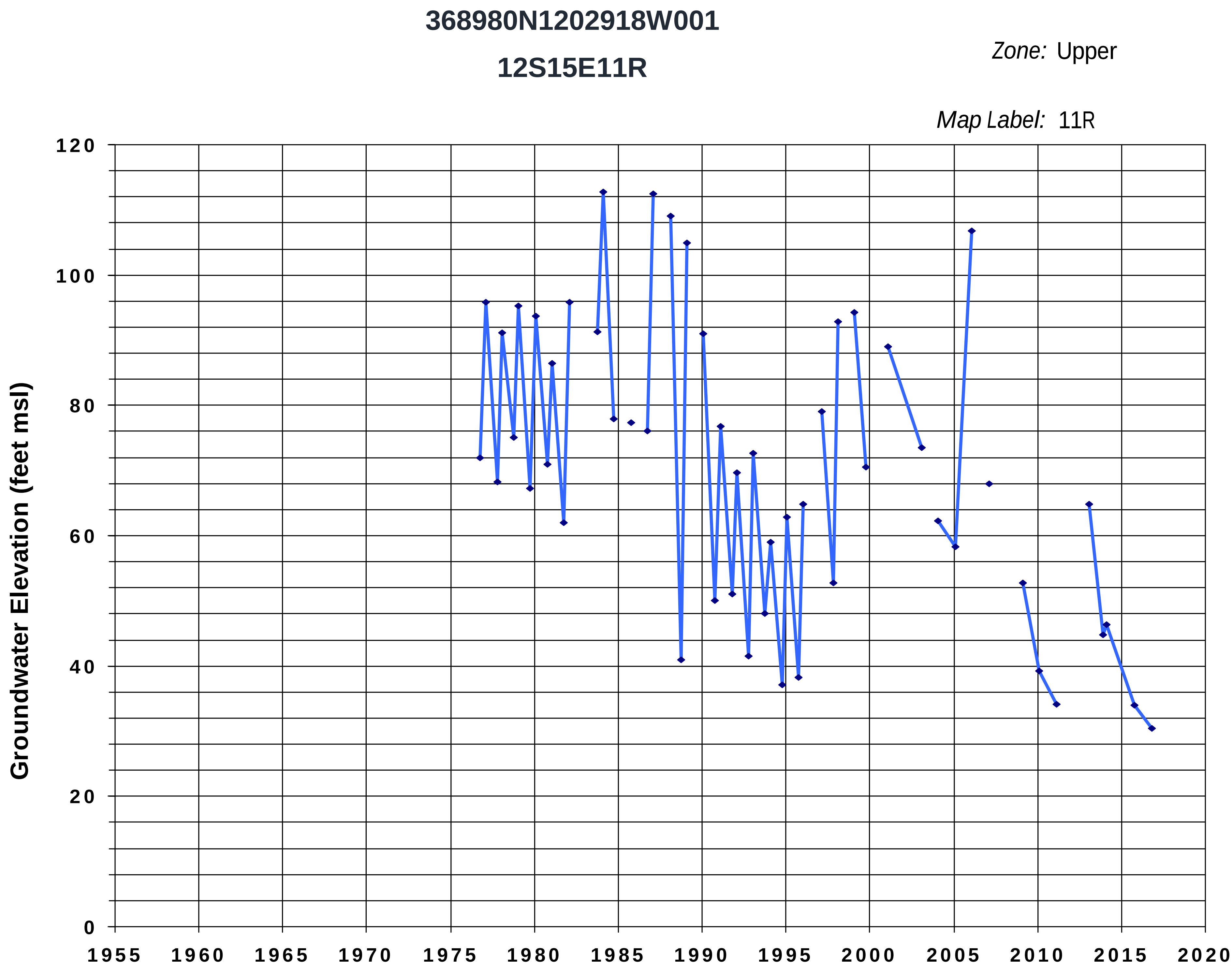
Zone: Outside CC, Unknown

Map Label: 12N1

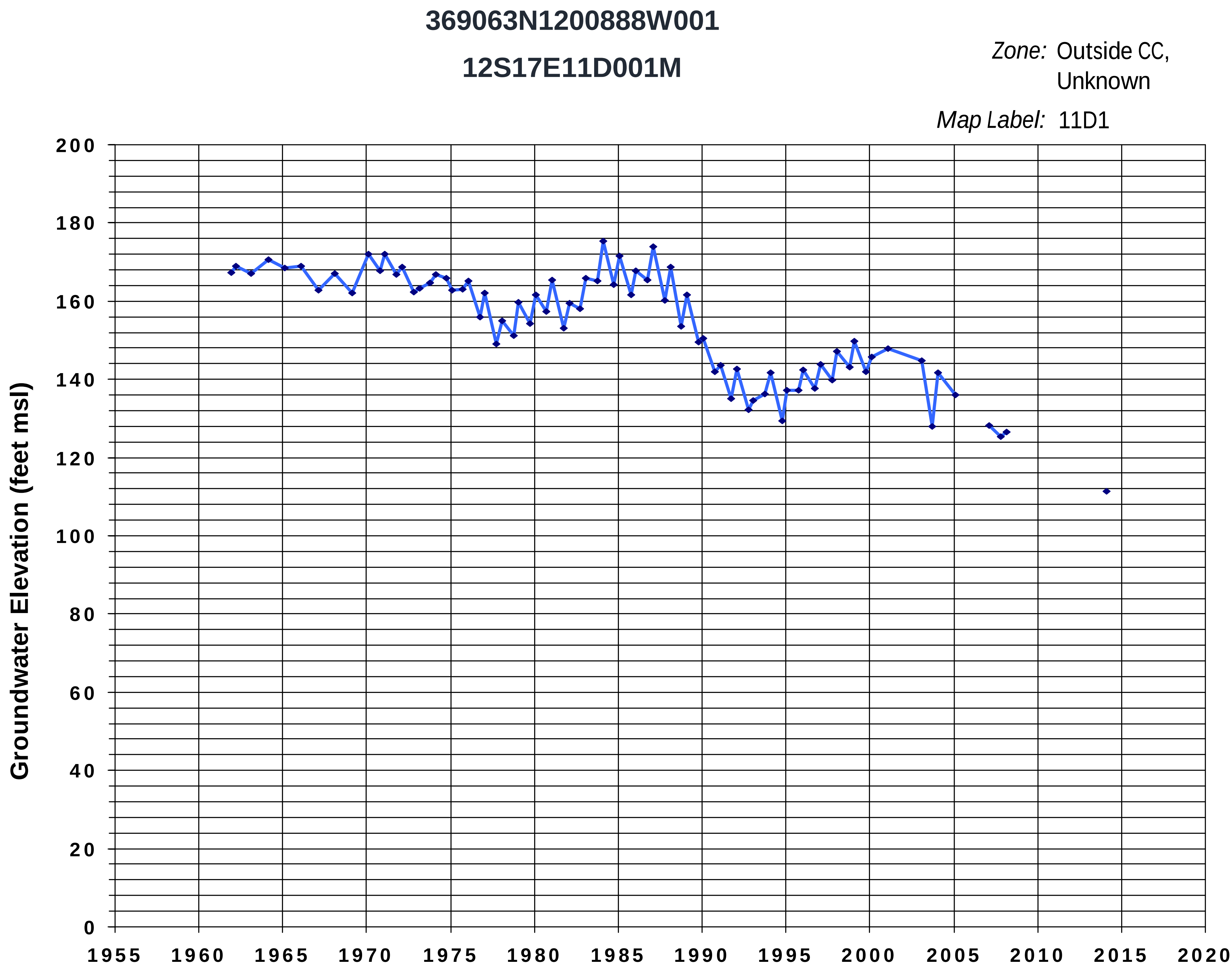




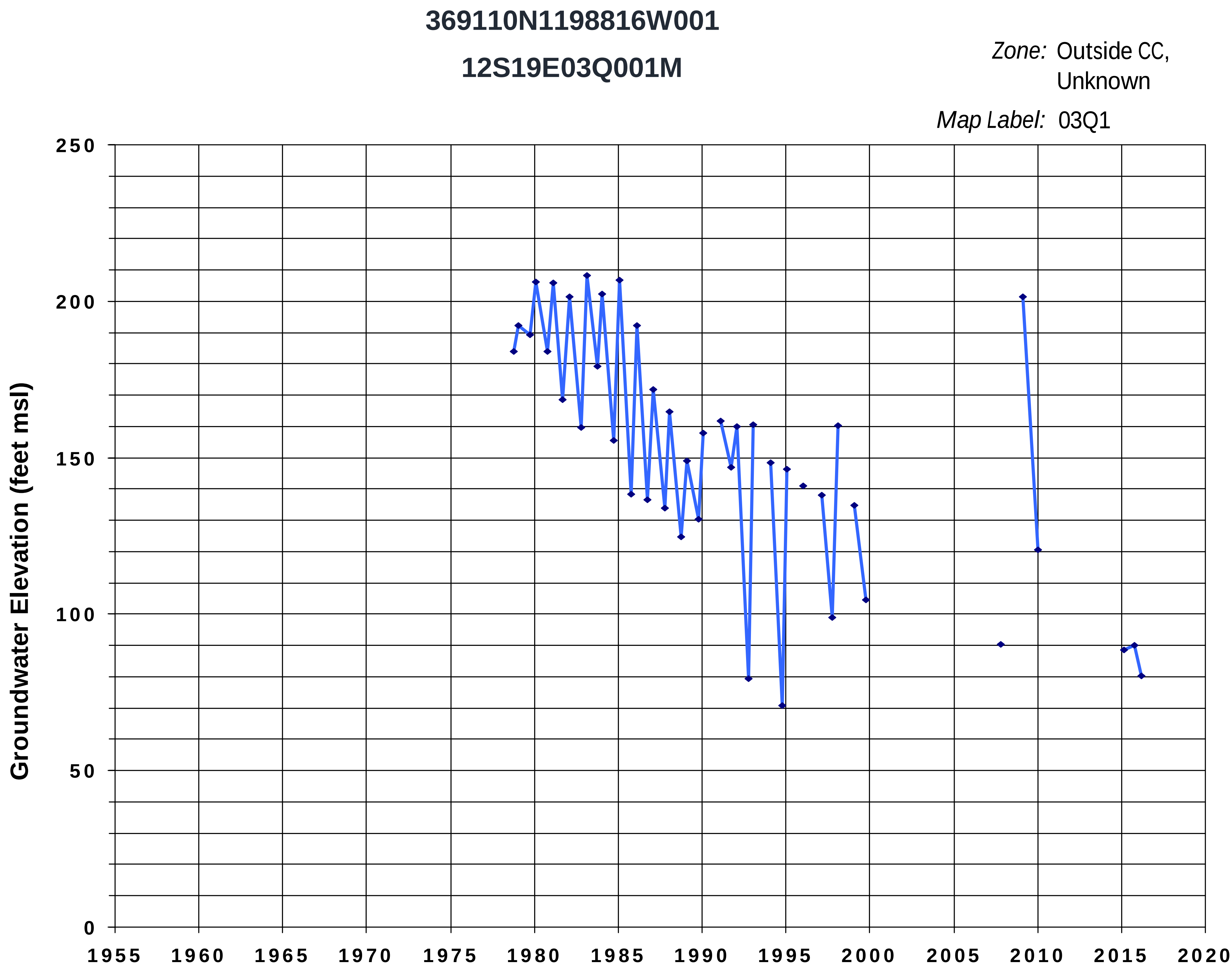
368980N1200107W001
12S18E09P
Zone: Outside CC, Unknown
Map Label: 09P
Groundwater Elevation (feet msl)
250
200
150
100
50
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



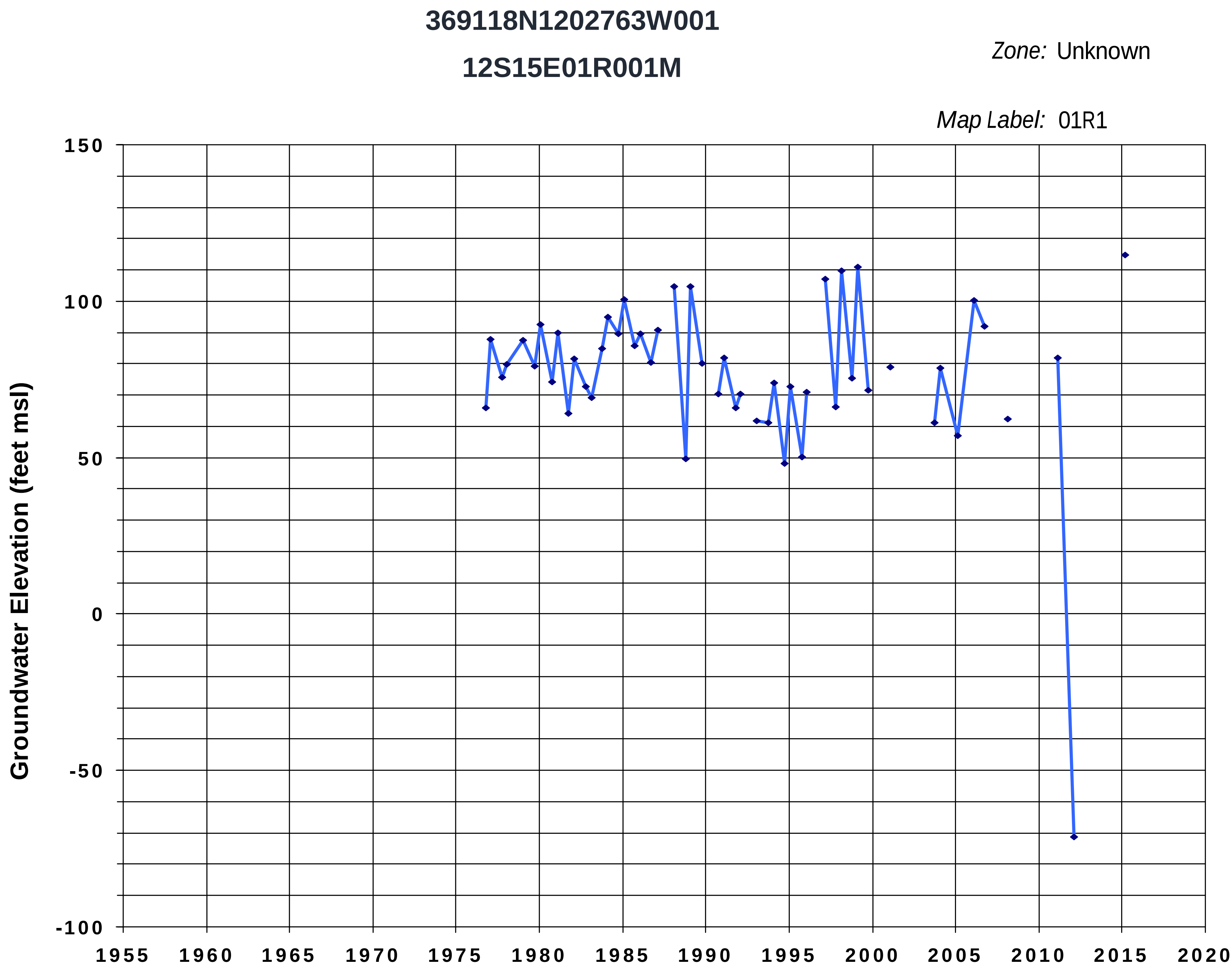
368980N1202918W001
12S15E11R
Zone: Upper
Map Label: 11R
Groundwater Elevation (feet msl)
120
100
80
60
40
20
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



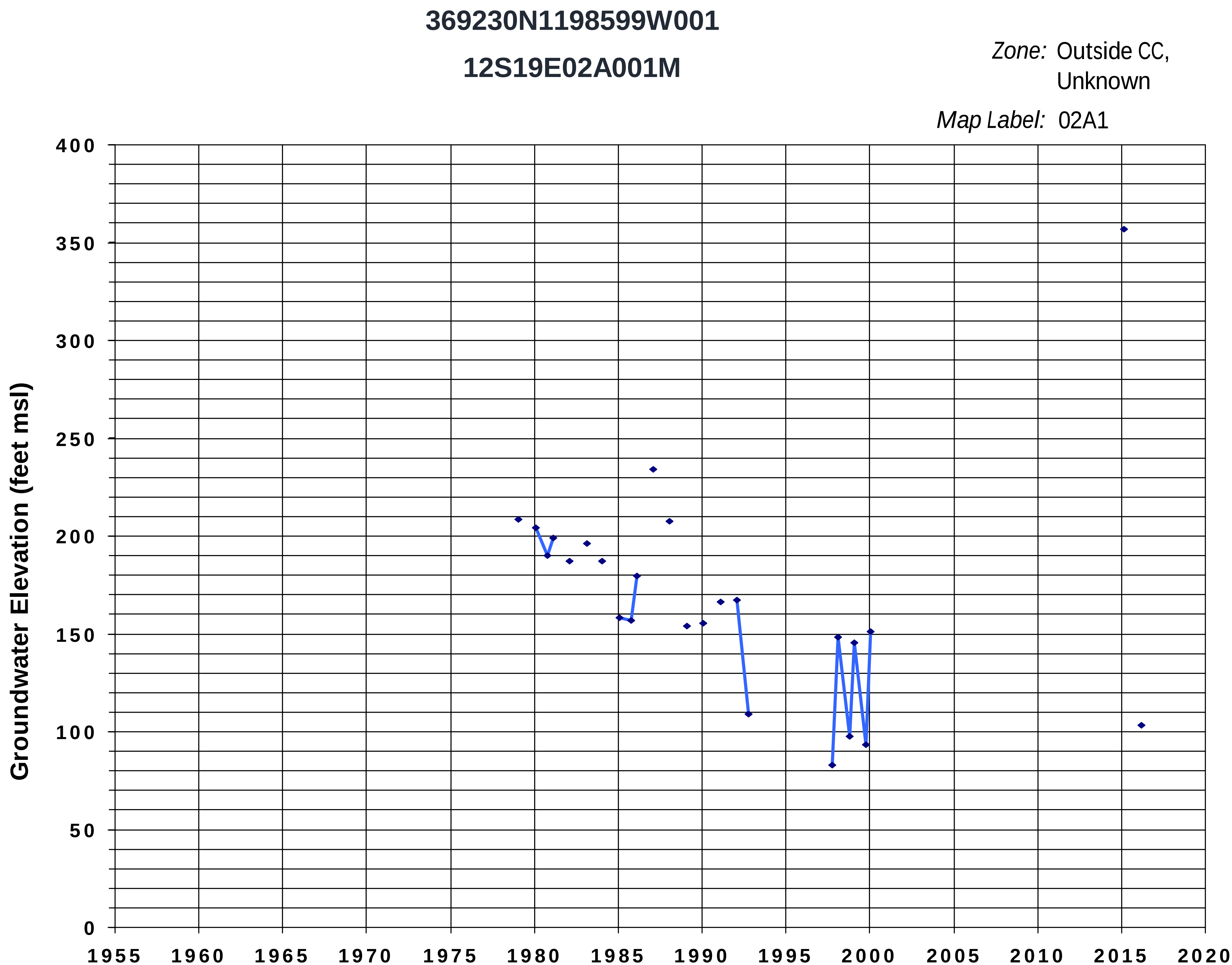
369063N1200888W001
12S17E11D001M
Zone: Outside CC, Unknown
Map Label: 11D1
Groundwater Elevation (feet msl)
200
180
160
140
120
100
80
60
40
20
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



369110N1198816W001
12S19E03Q001M
Zone: Outside CC, Unknown
Map Label: 03Q1
Groundwater Elevation (feet msl)
250
200
150
100
50
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



369118N1202763W001
12S15E01R001M
Zone: Unknown
Map Label: 01R1
Groundwater Elevation (feet msl)
150
100
50
0
-50
-100
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

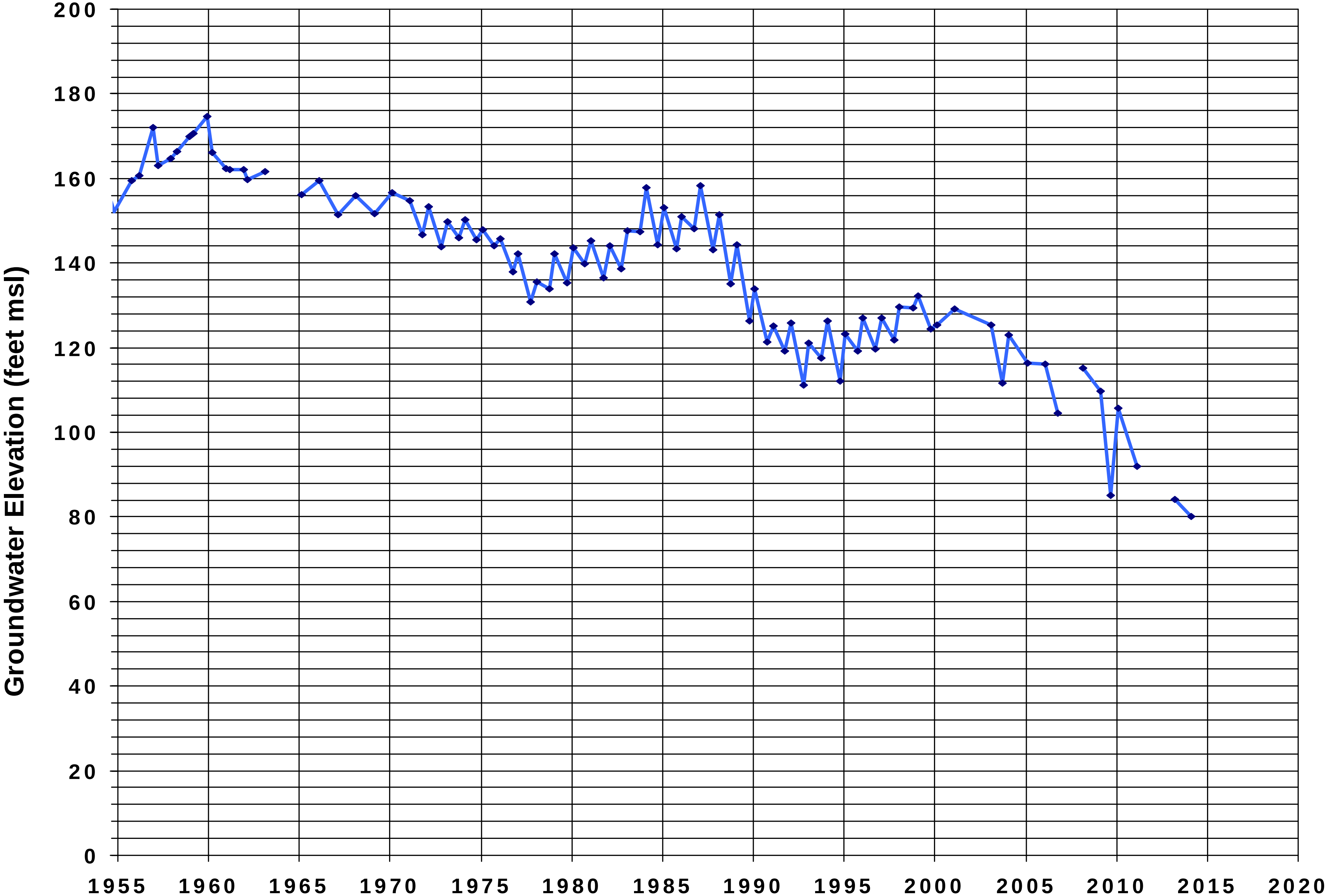

369230N1198599W001
12S19E02A001M
Zone: Outside CC, Unknown
Map Label: 02A1
Groundwater Elevation (feet msl)
400
350
300
250
200
150
100
50
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

369232N1201477W001

12S17E06A003M

Zone: Outside CC, Unknown

Map Label: 06A3

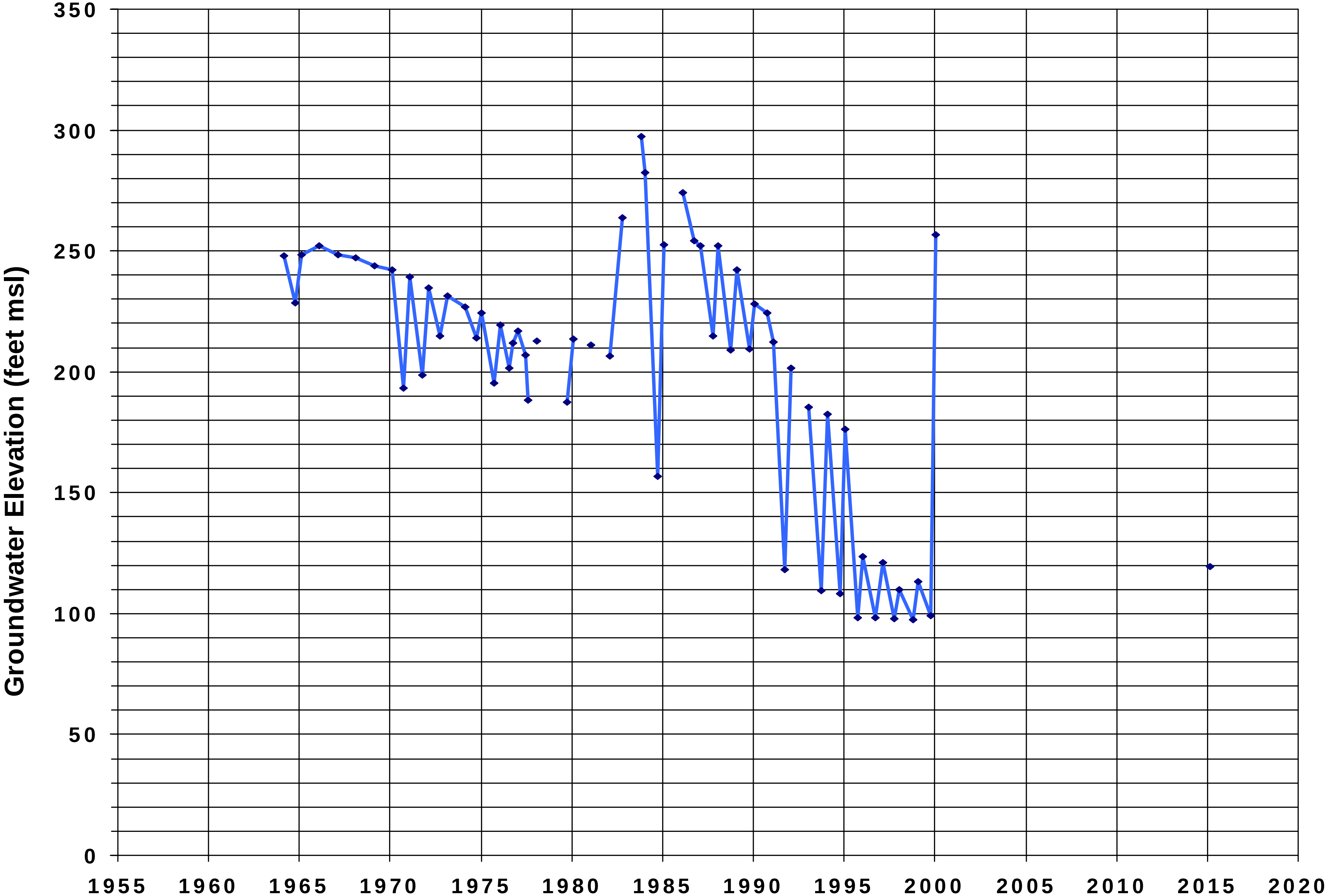


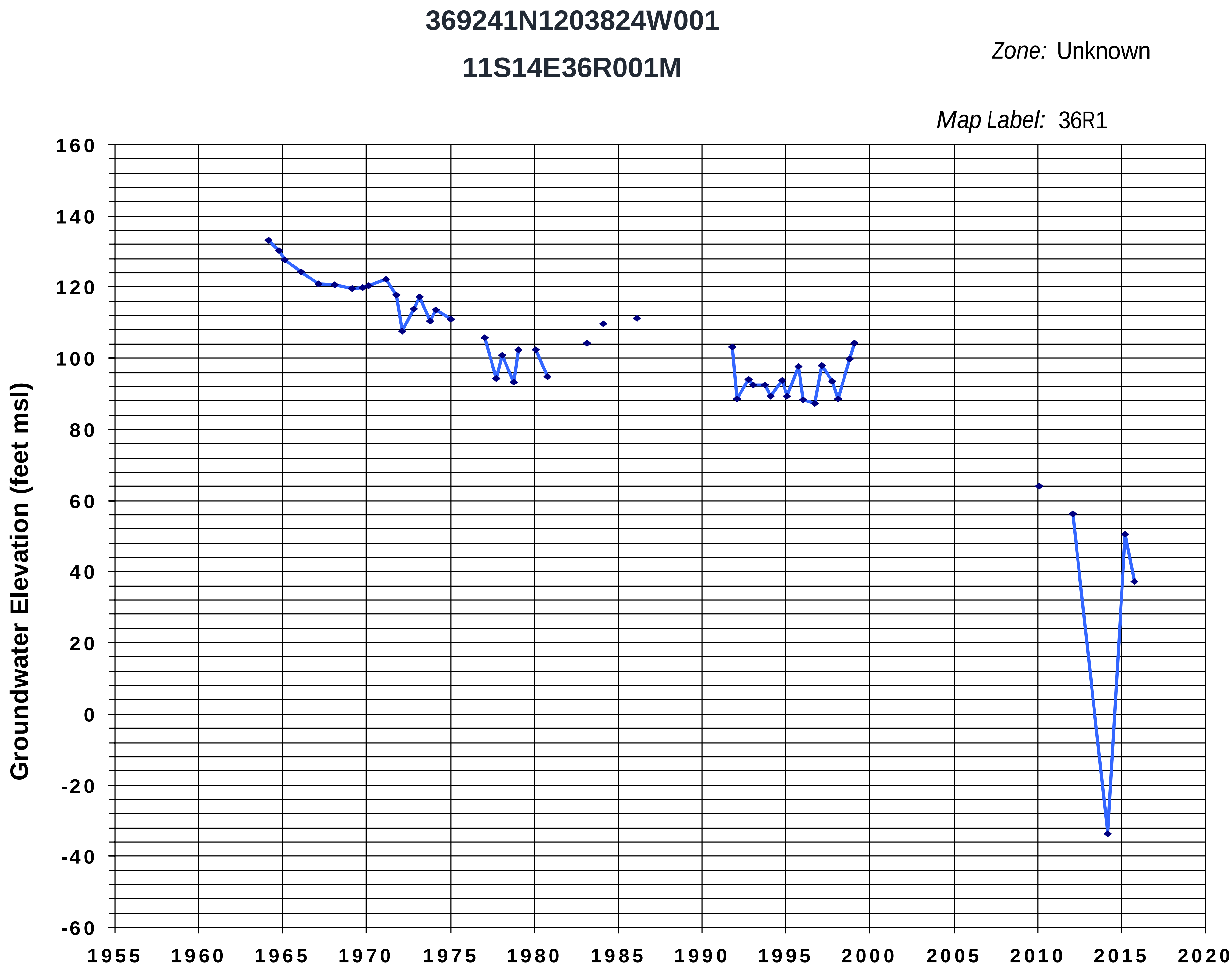
369235N1198313W001

11S20E31P001M

Zone: Outside CC, Unknown

Map Label: 31P1





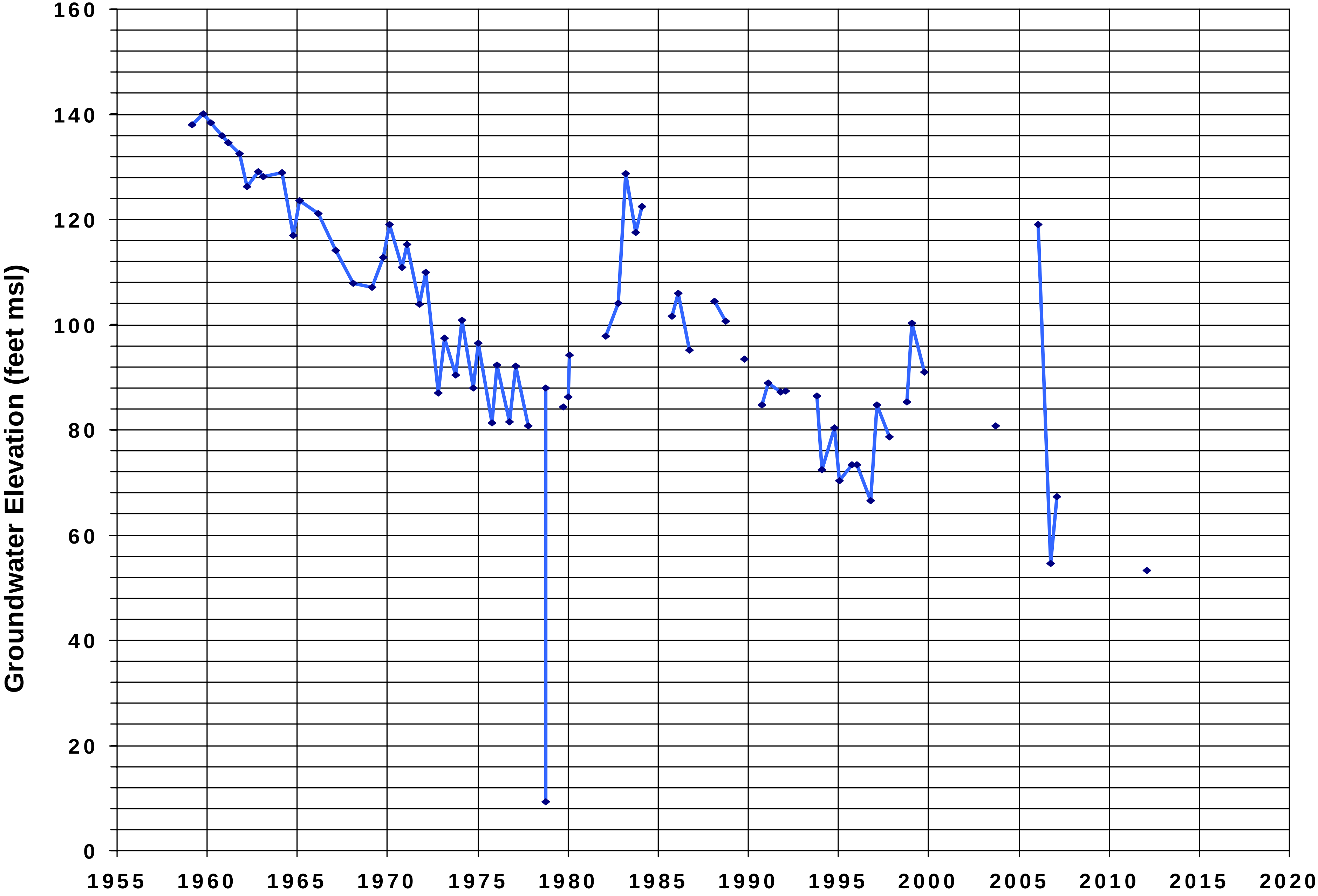
369241N1203824W001
11S14E36R001M
Zone: Unknown
Map Label: 36R1
Groundwater Elevation (feet msl)
160
140
120
100
80
60
40
20
0
-20
-40
-60
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

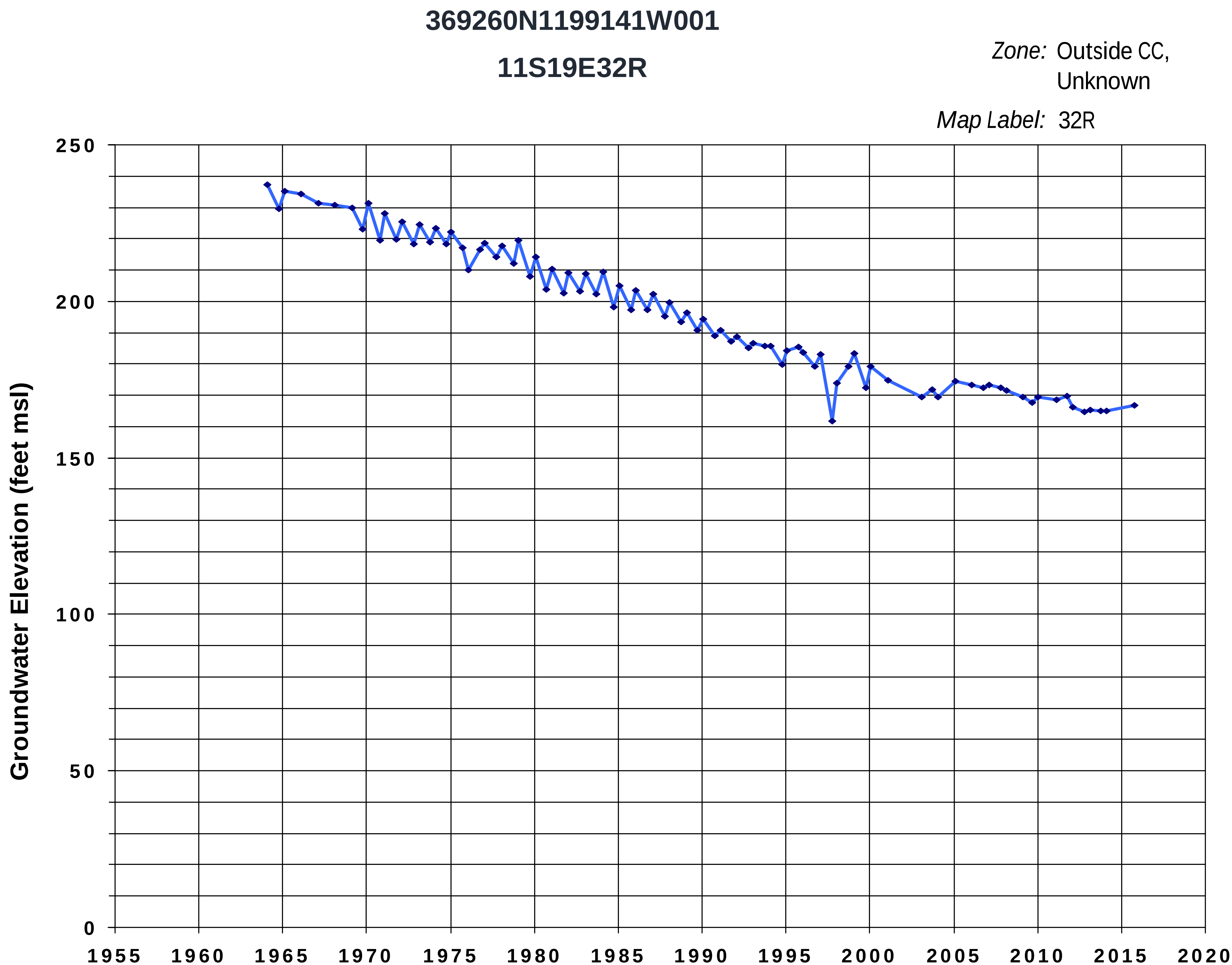
369257N1203046W001

11S15E35P001M

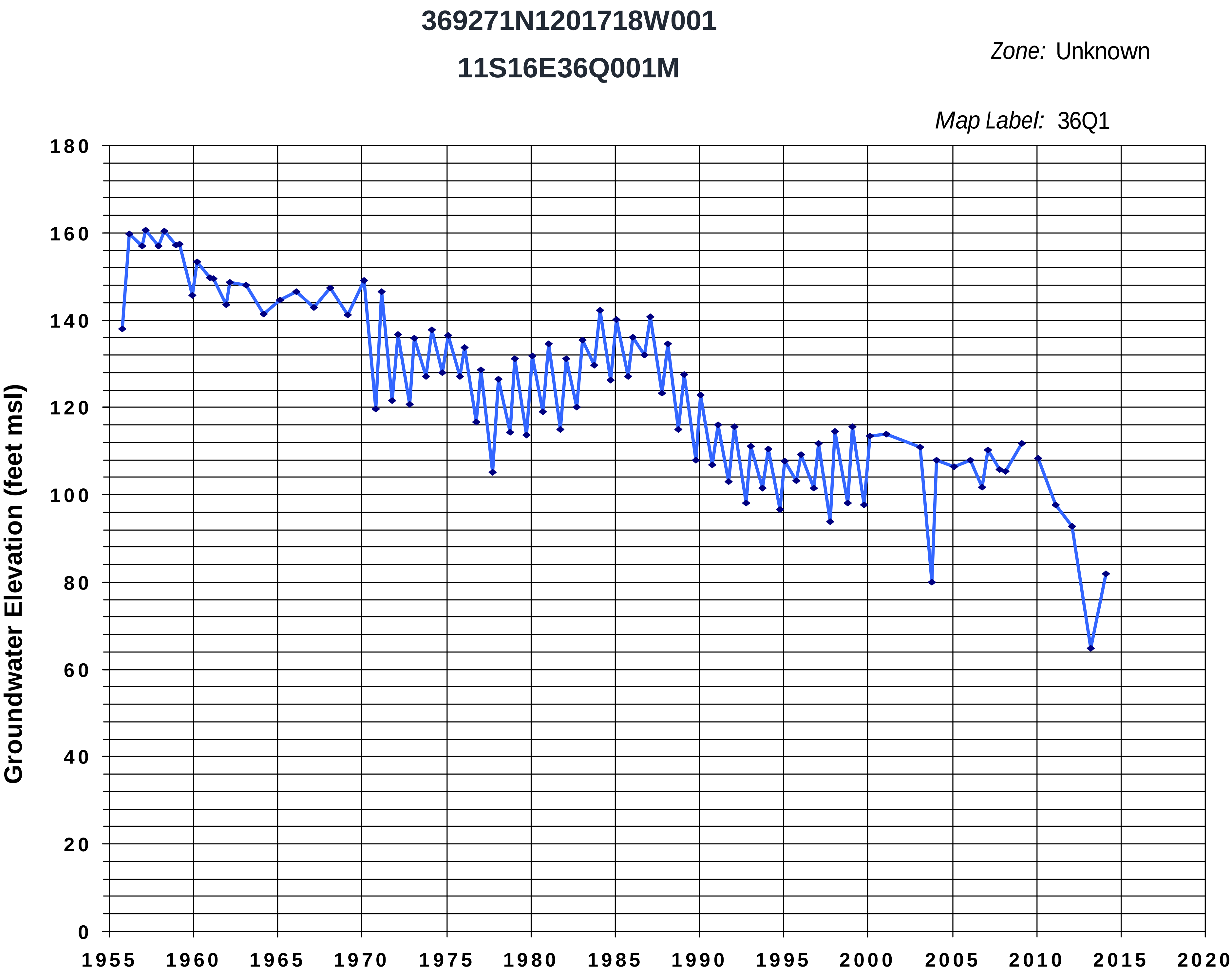
Zone: Unknown

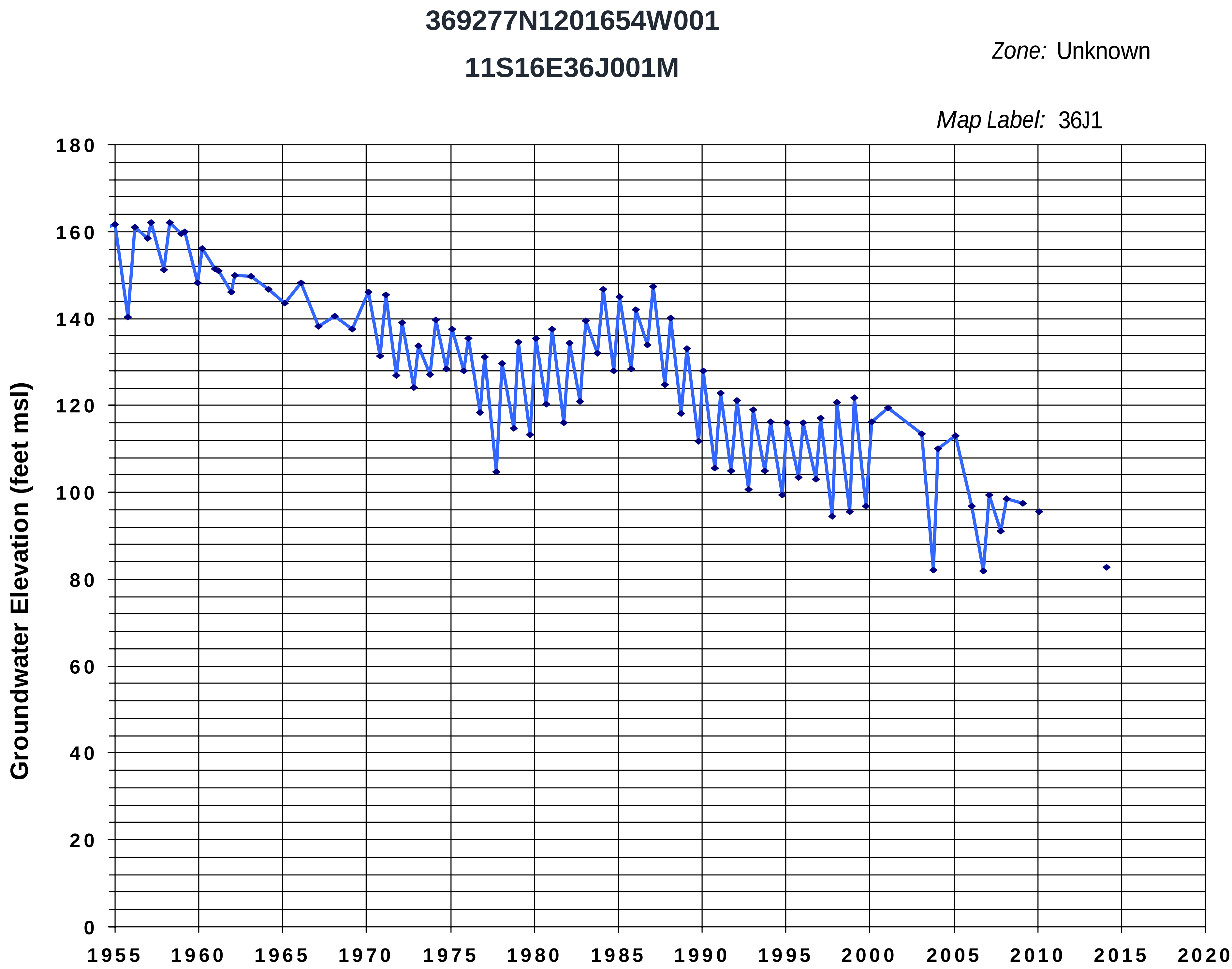
Map Label: 35P1





369260N1199141W001
11S19E32R
Zone: Outside CC, Unknown
Map Label: 32R
Groundwater Elevation (feet msl)
250
200
150
100
50
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


369271N1201718W001
11S16E36Q001M
Zone: Unknown
Map Label: 36Q1
Groundwater Elevation (feet msl)
180
160
140
120
100
80
60
40
20
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



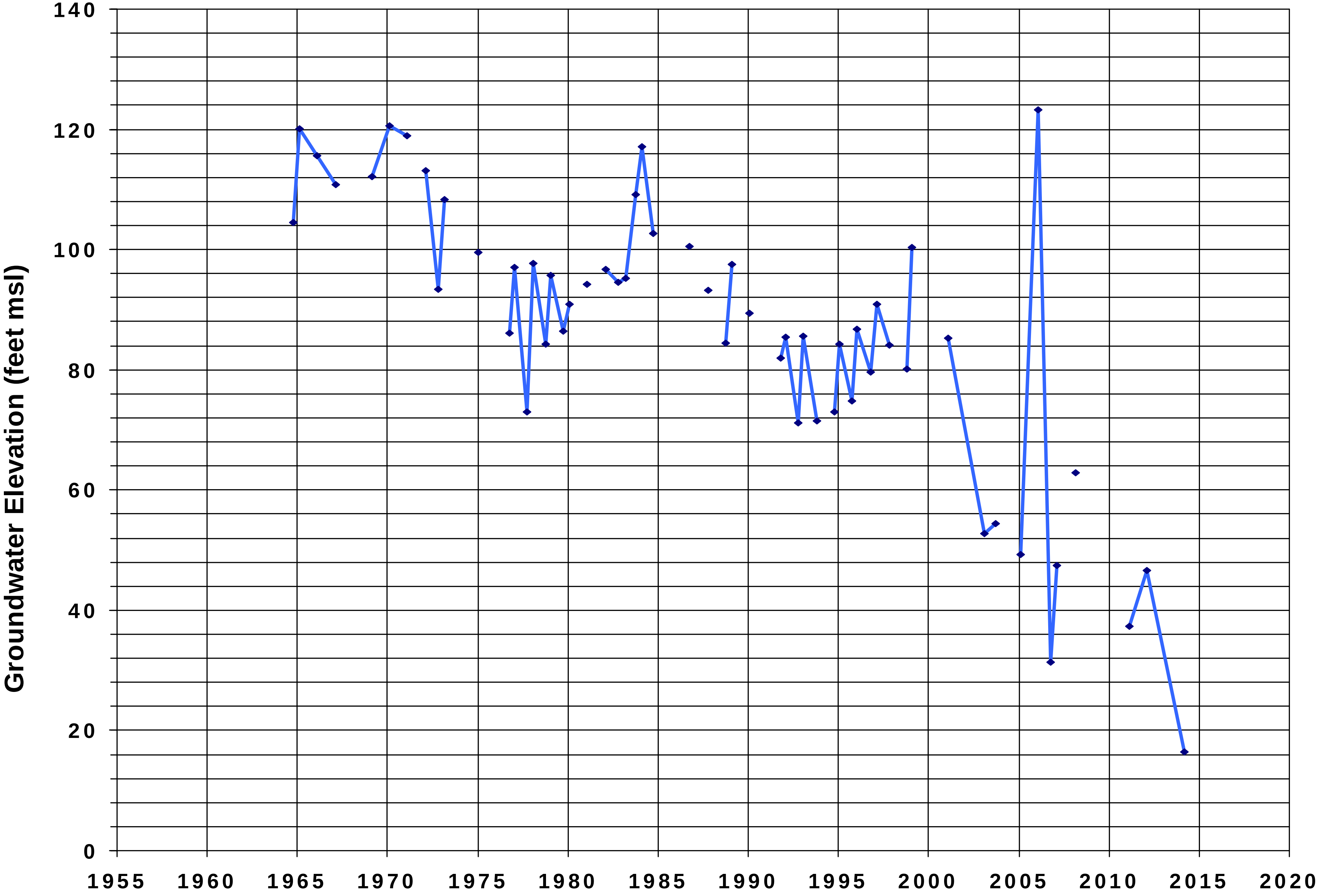
369277N1201654W001
11S16E36J001M
Zone: Unknown
Map Label: 36J1
Groundwater Elevation (feet msl)
180
160
140
120
100
80
60
40
20
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

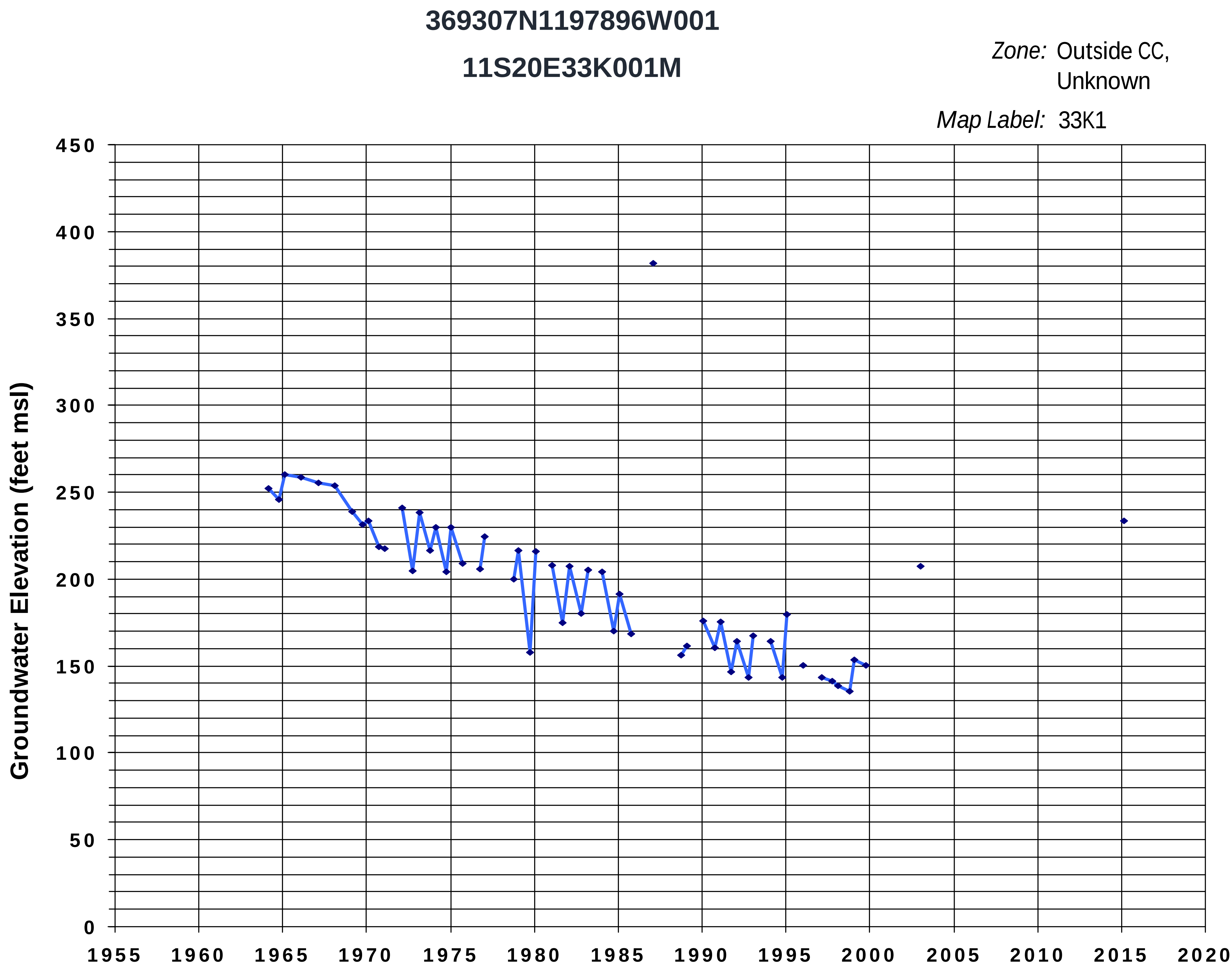
369305N1203638W001

11S15E31J001M

Zone: Unknown

Map Label: 31J1



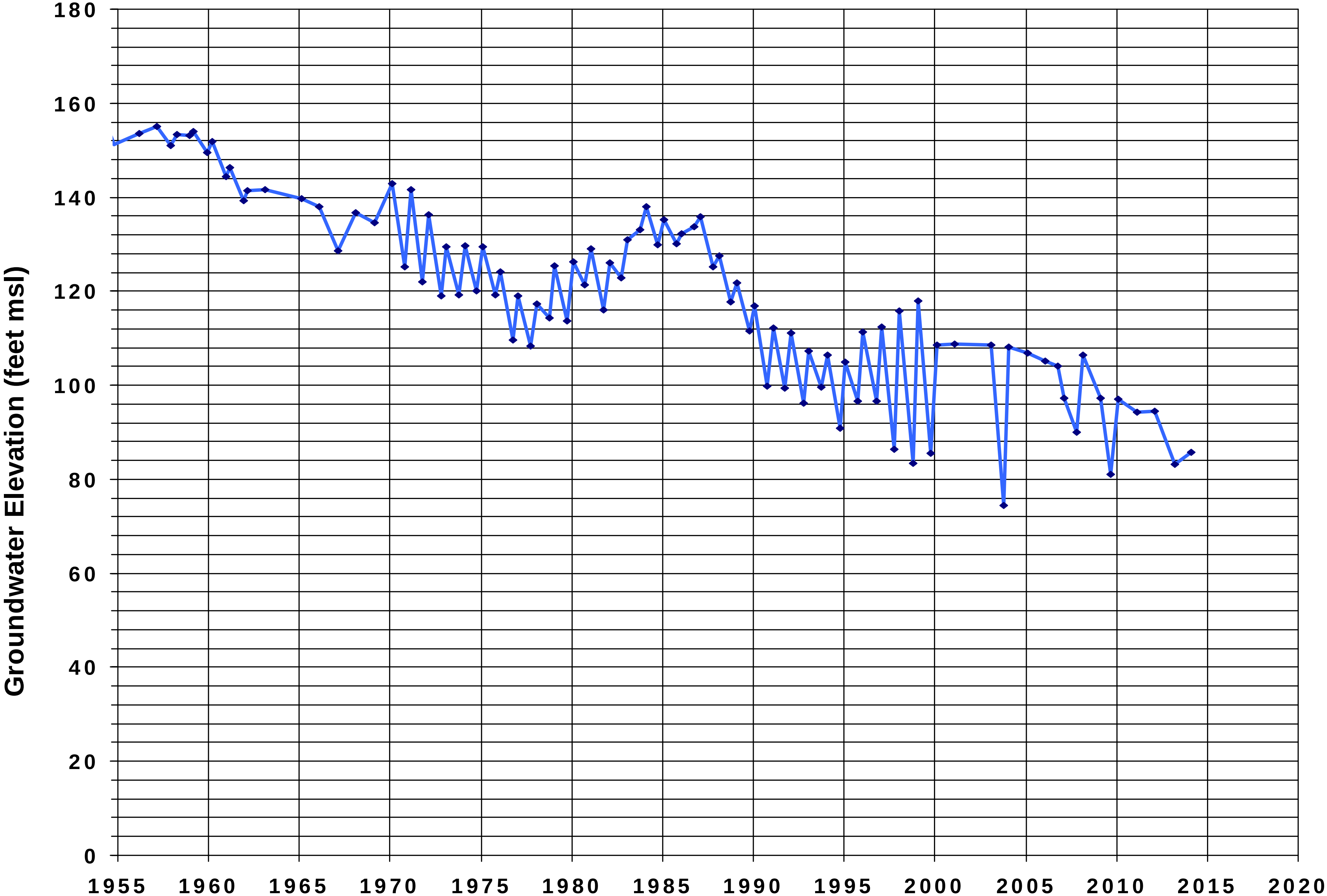

369307N1197896W001
11S20E33K001M
Zone: Outside CC, Unknown
Map Label: 33K1
Groundwater Elevation (feet msl)
0
50
100
150
200
250
300
350
400
450
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

369307N1201835W001

11S16E35H001M

Zone: Unknown

Map Label: 35H1

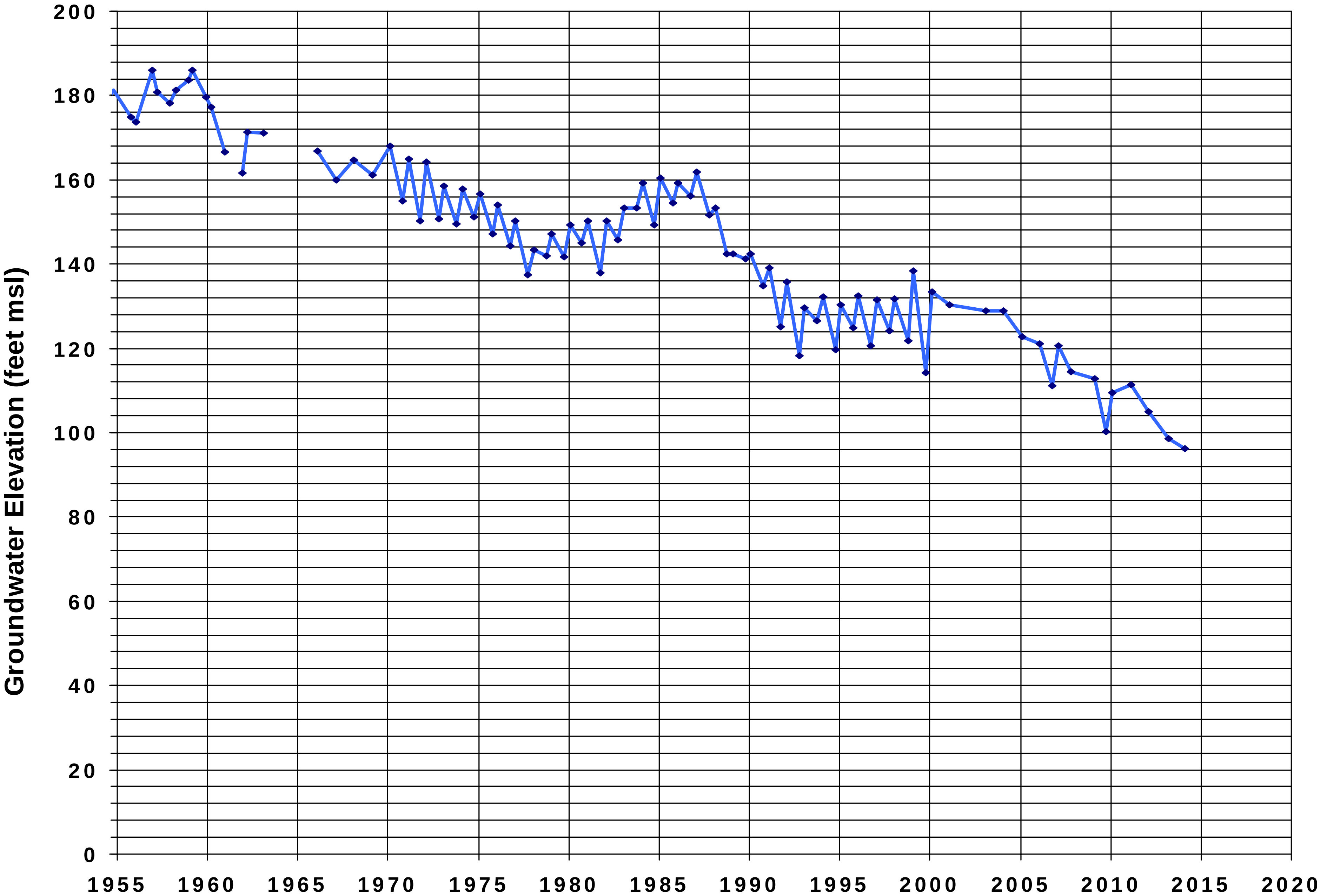


369341N1201107W001

11S17E33H001M

Zone: Outside CC, Unknown

Map Label: 33H1

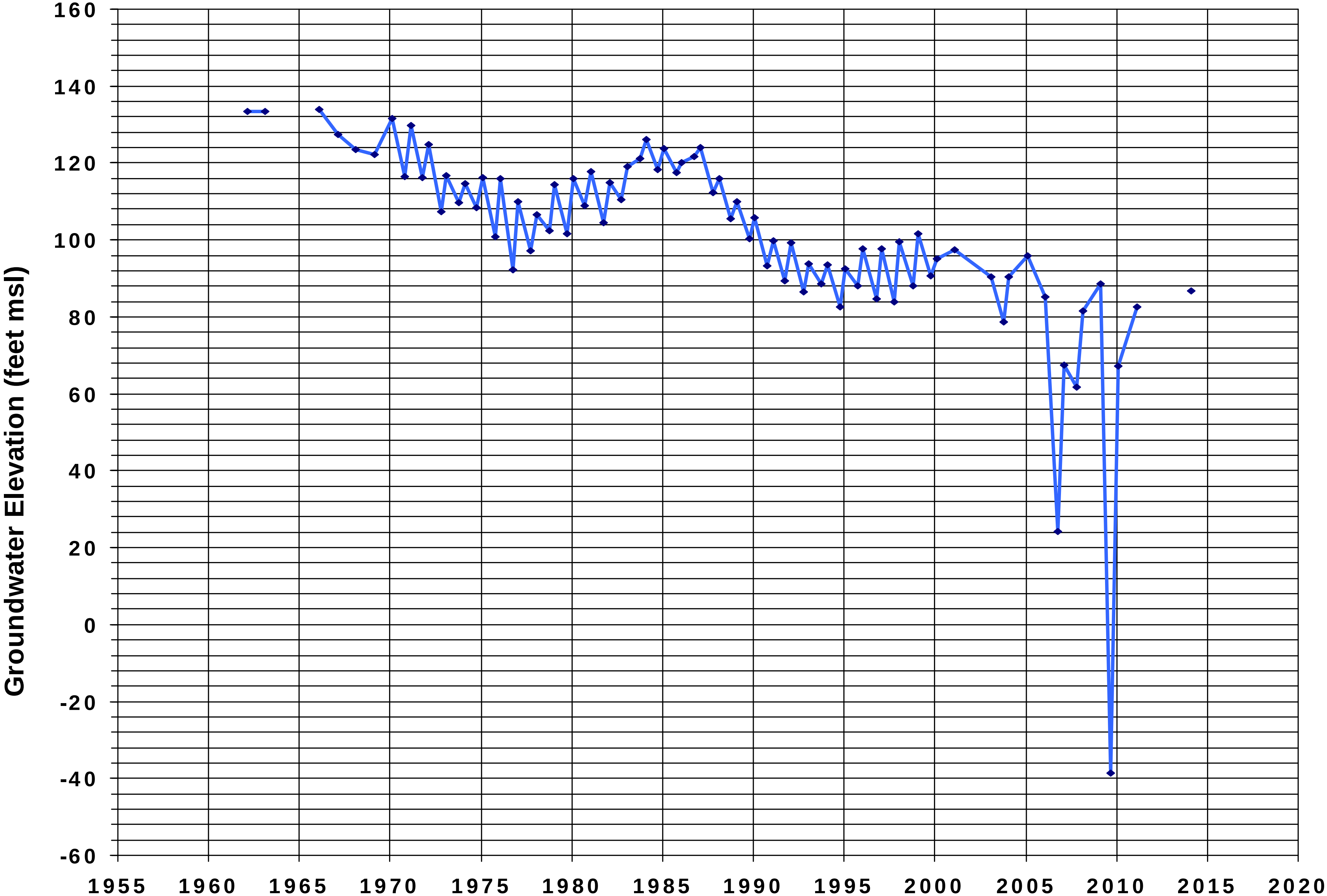


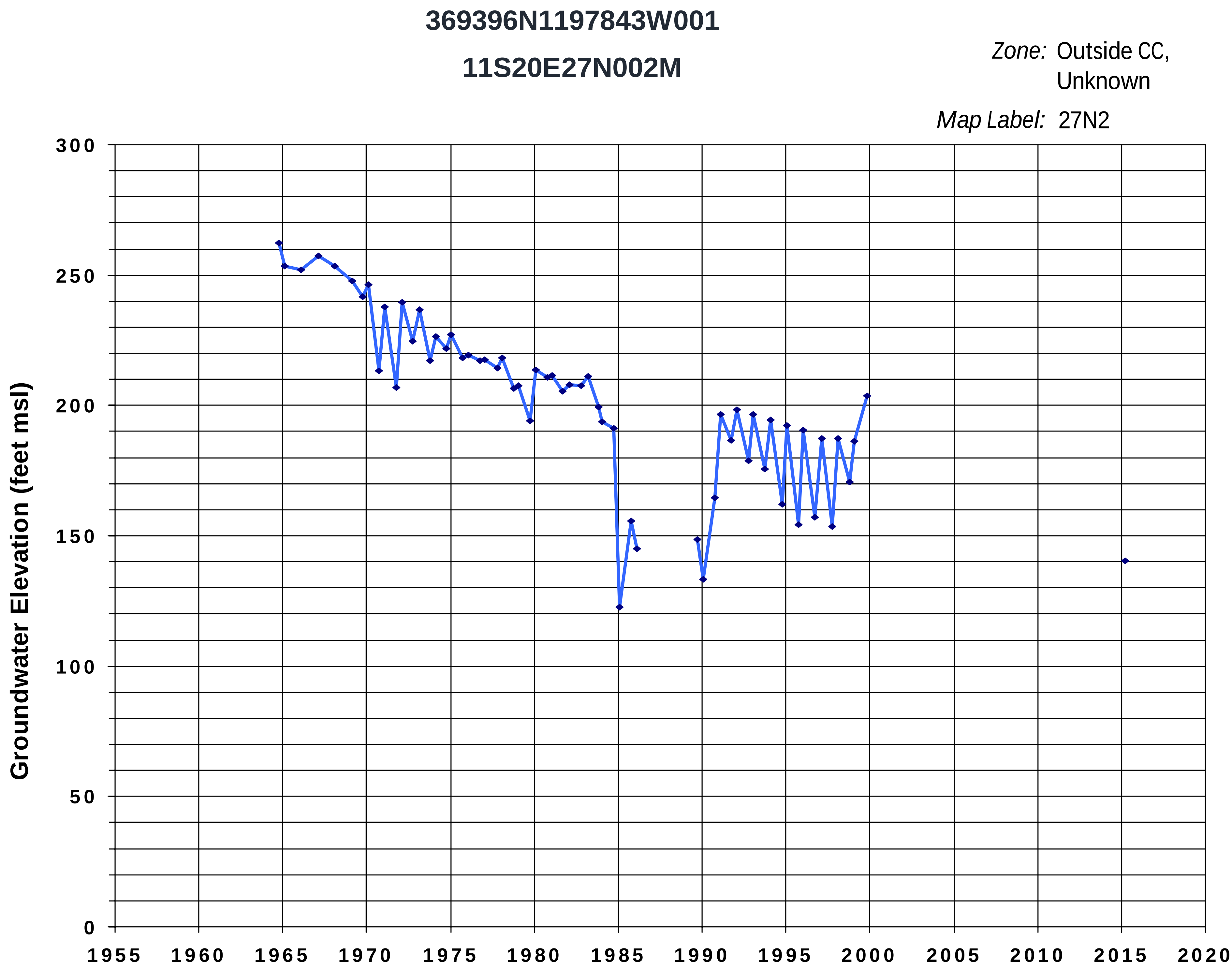
369343N1202196W001

11S16E34D001M

Zone: Unknown

Map Label: 34D1





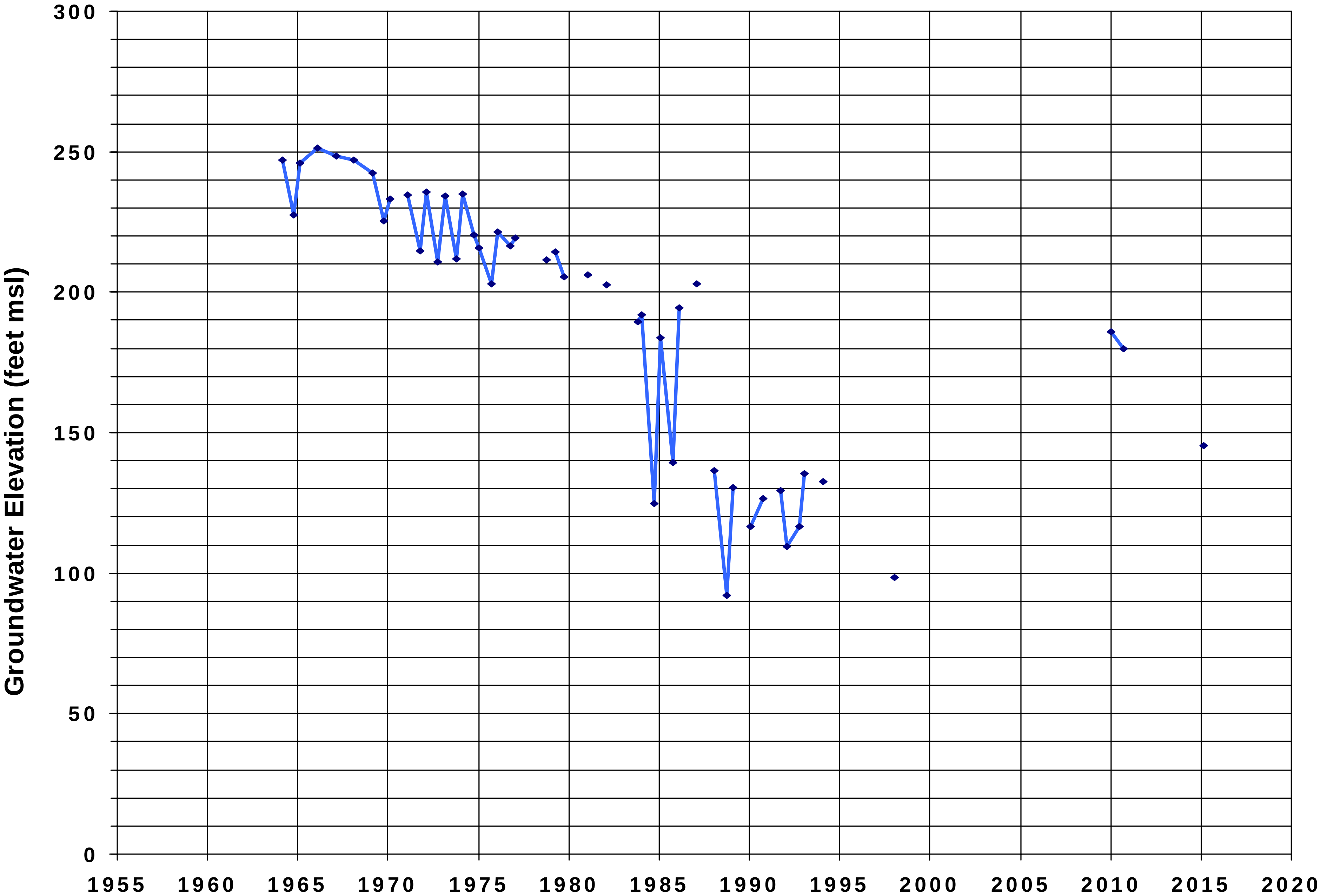
369396N1197843W001
11S20E27N002M
Zone: Outside CC, Unknown
Map Label: 27N2
Groundwater Elevation (feet msl)
300
250
200
150
100
50
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

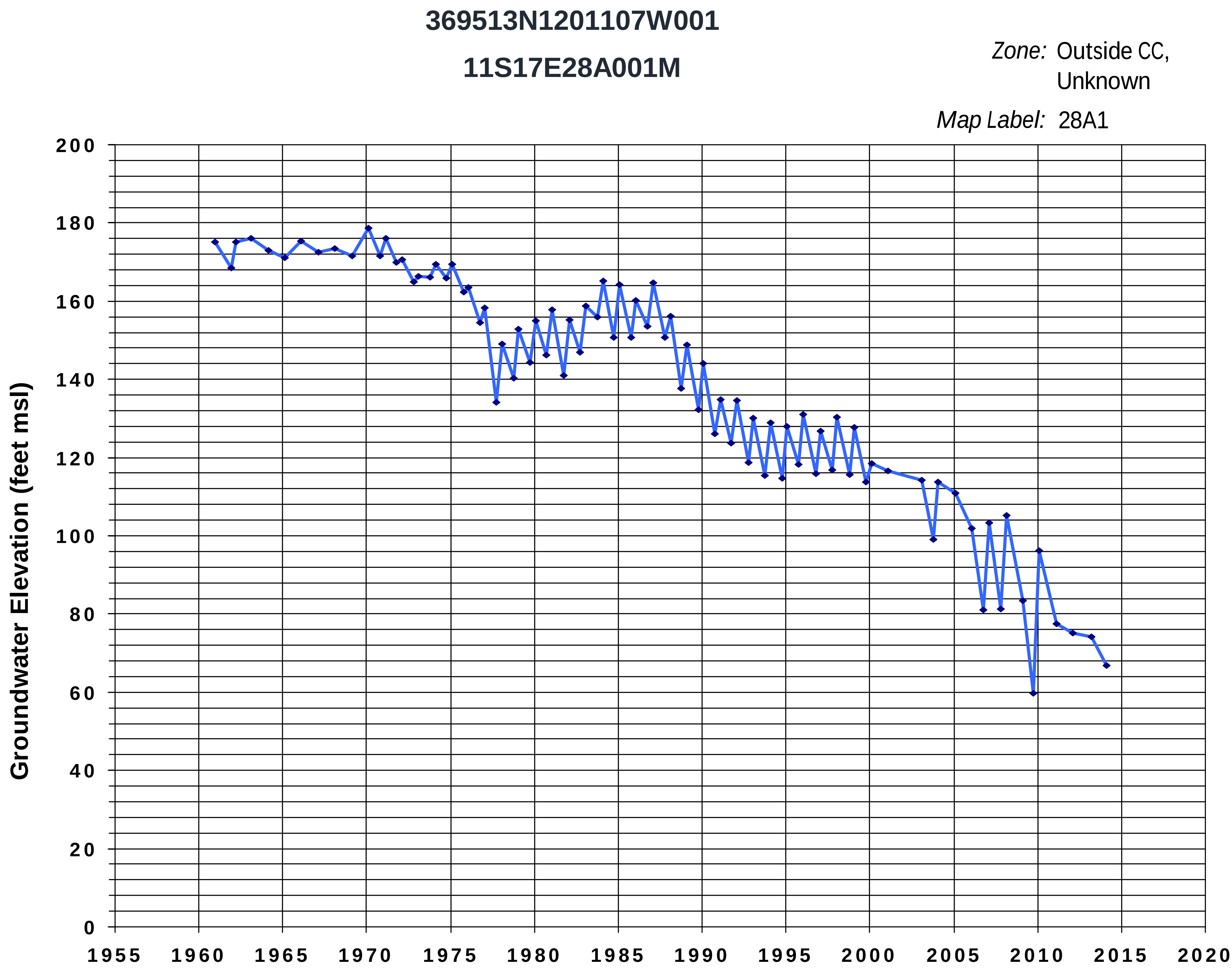
369455N1198346W001

11S20E30F001M

Zone: Outside CC, Unknown

Map Label: 30F1



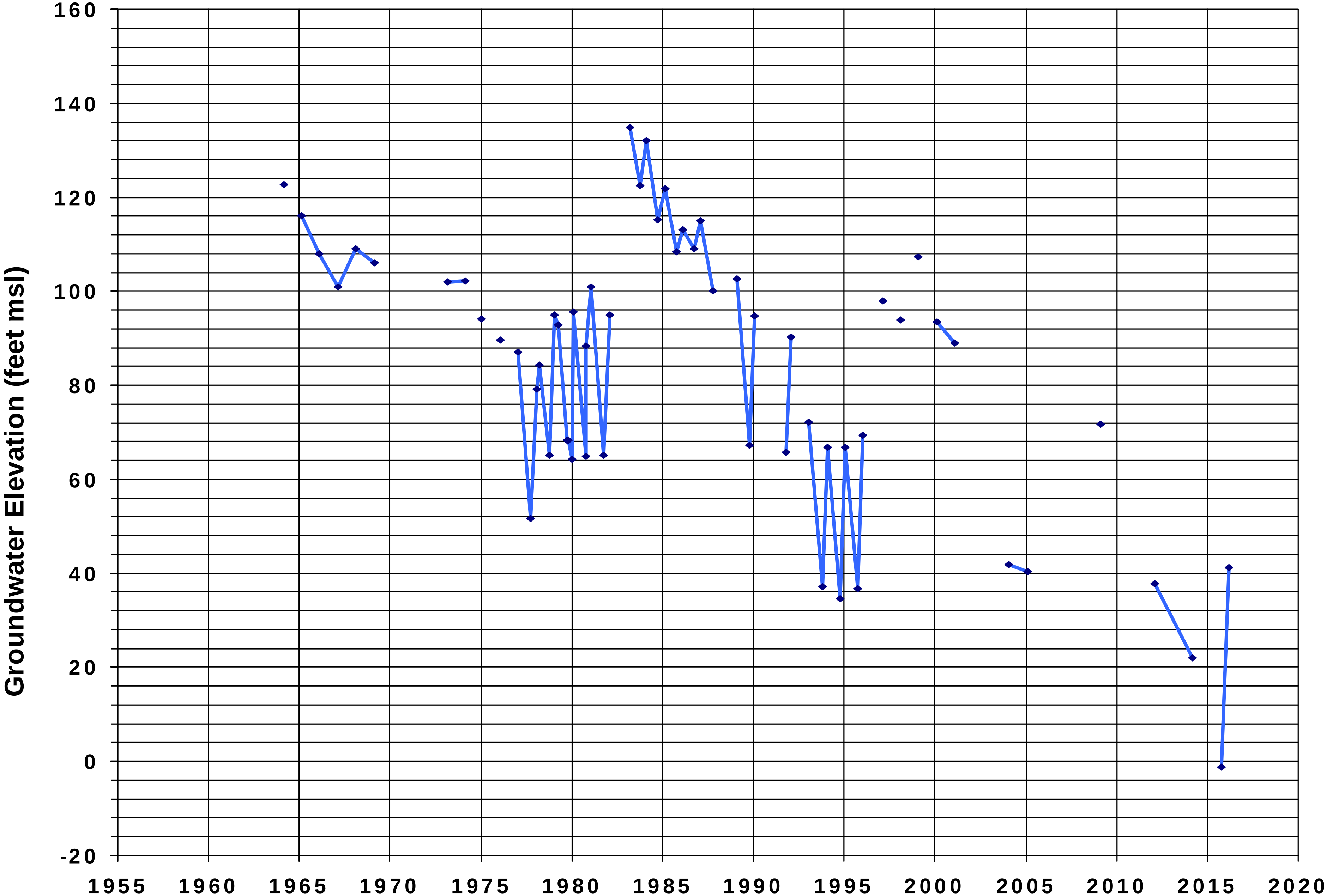

369513N1201107W001
11S17E28A001M
Zone: Outside CC, Unknown
Map Label: 28A1
Groundwater Elevation (feet msl)
200
180
160
140
120
100
80
60
40
20
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

369521N1203643W001

11S15E30A001M

Zone: Unknown

Map Label: 30A1

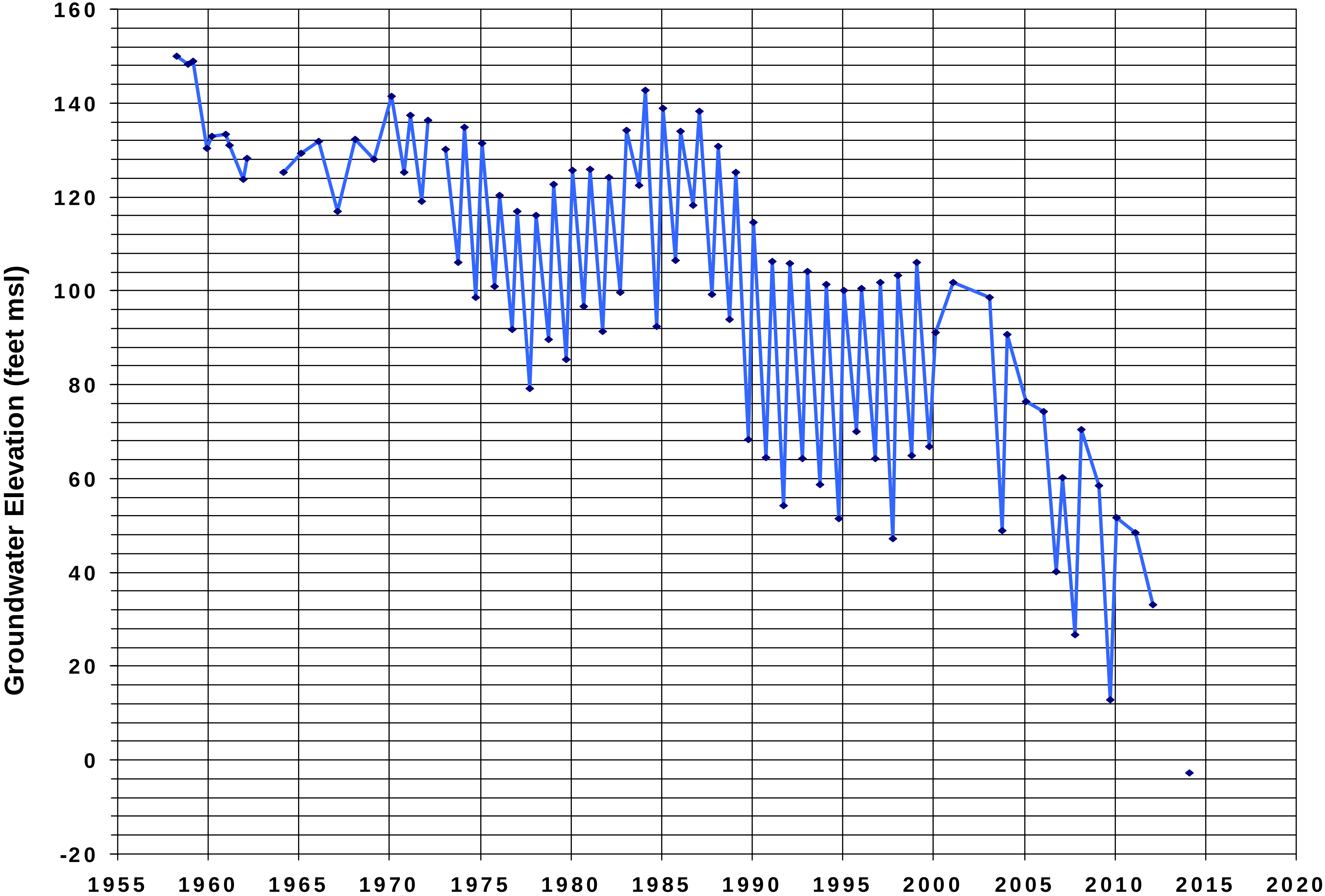


369582N1202110W001

11S16E22K001M

Zone: Unknown

Map Label: 22K01

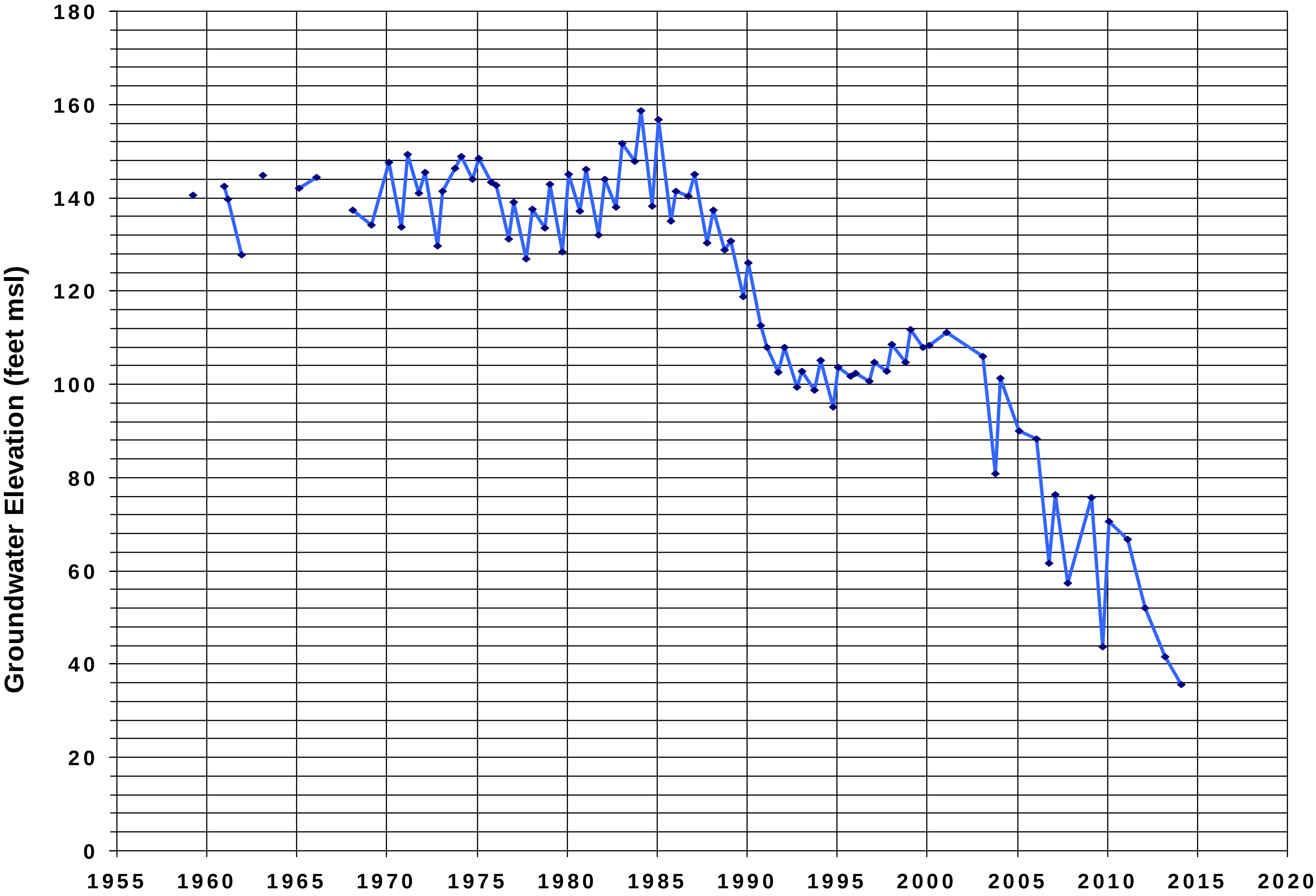


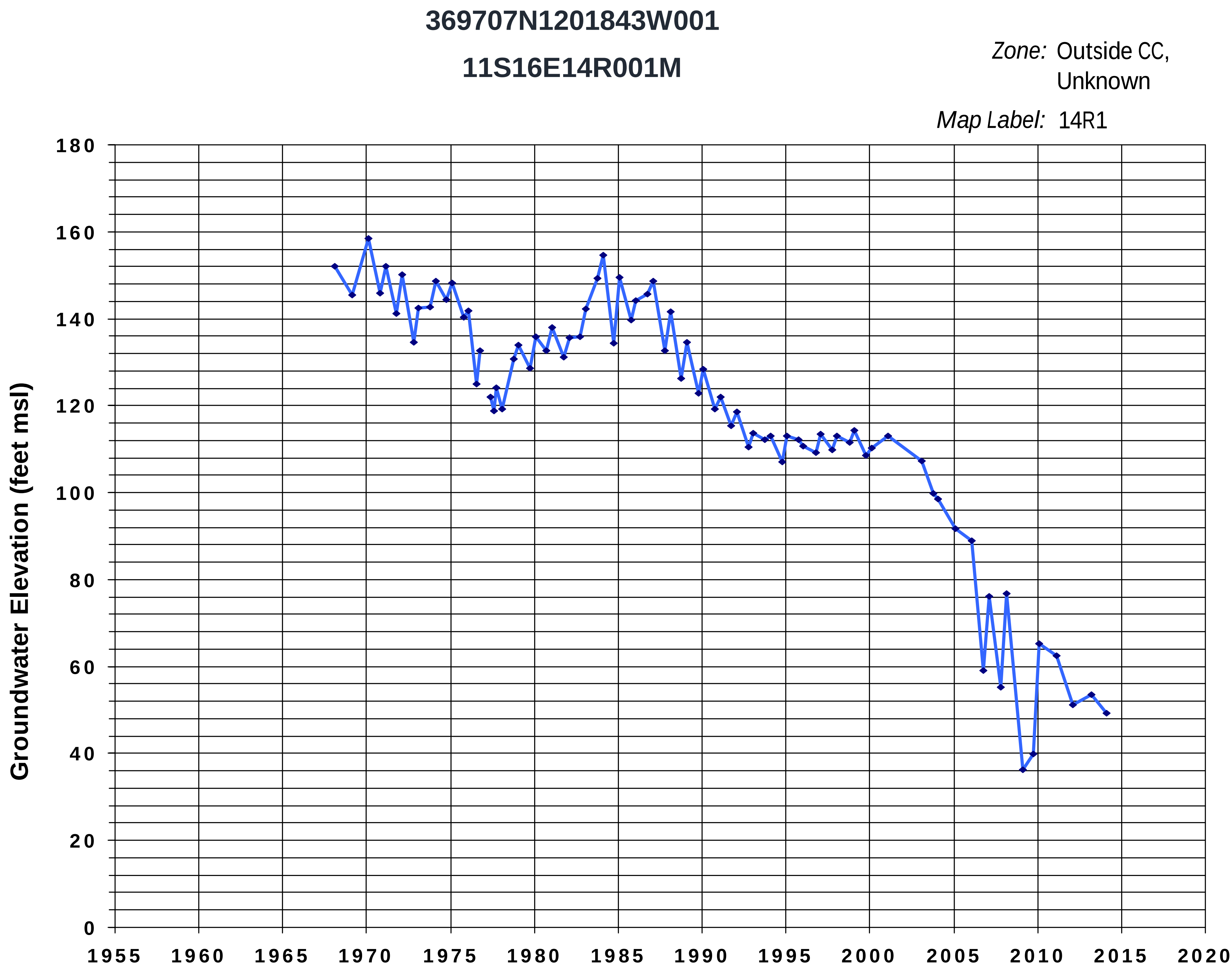
369599N1201793W001

11S16E24M001M

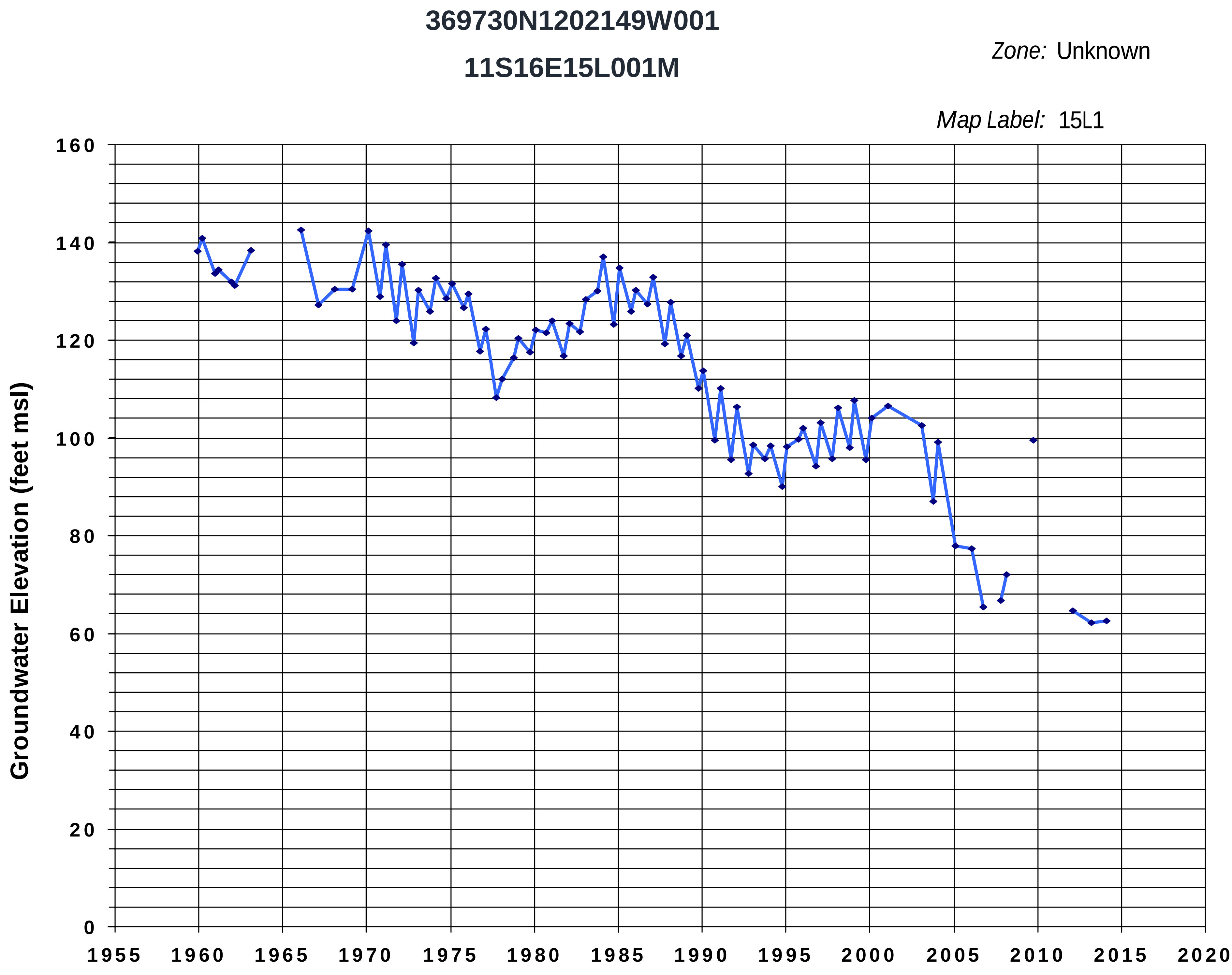
Zone: Outside CC, Unknown

Map Label: 24M1





369707N1201843W001
11S16E14R001M
Zone: Outside CC, Unknown
Map Label: 14R1
Groundwater Elevation (feet msl)
180
160
140
120
100
80
60
40
20
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



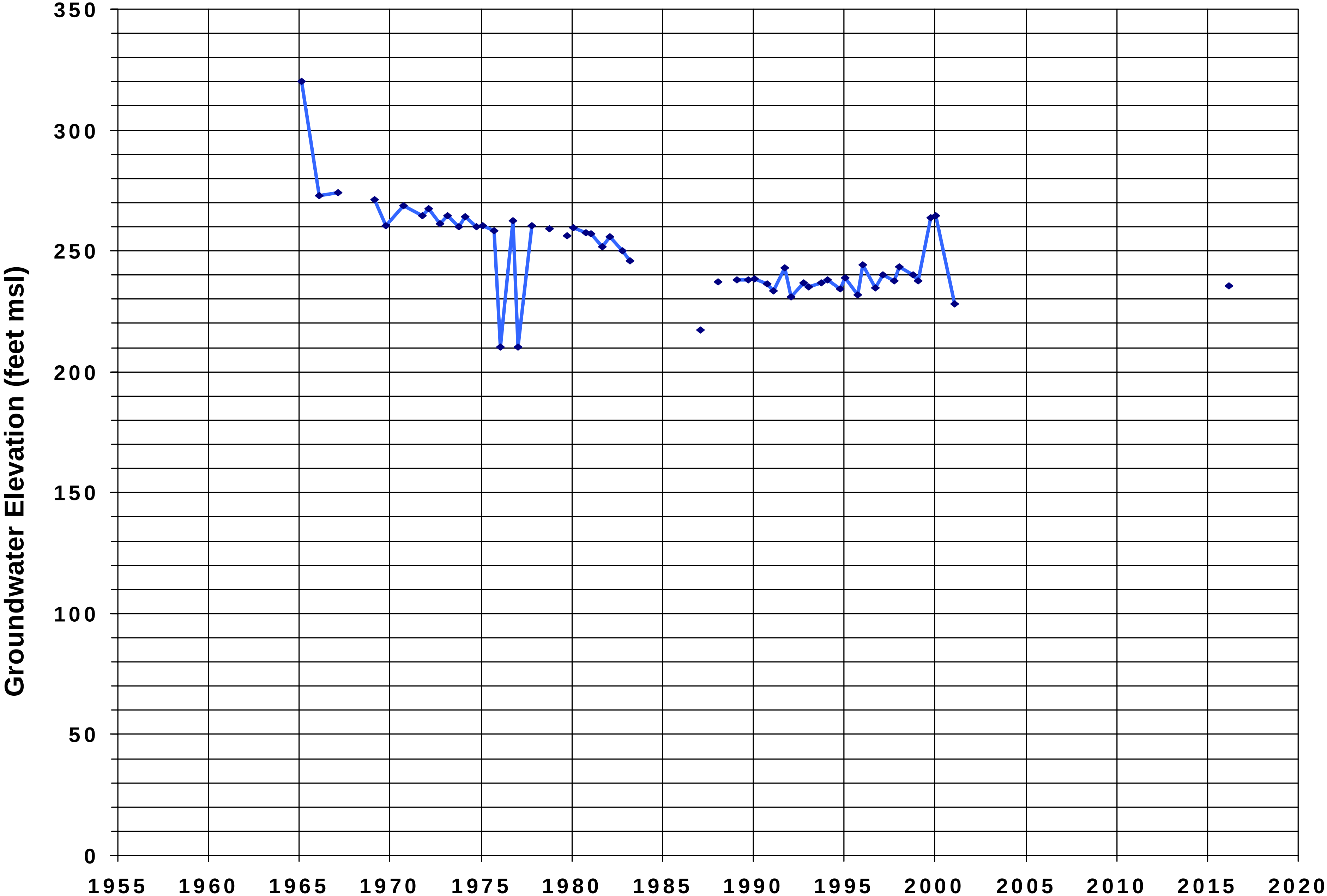
369730N1202149W001
11S16E15L001M
Zone: Unknown
Map Label: 15L1
Groundwater Elevation (feet msl)
160
140
120
100
80
60
40
20
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

369735N1198307W001

11S20E18L001M

Zone: Outside CC, Unknown

Map Label: 18L1

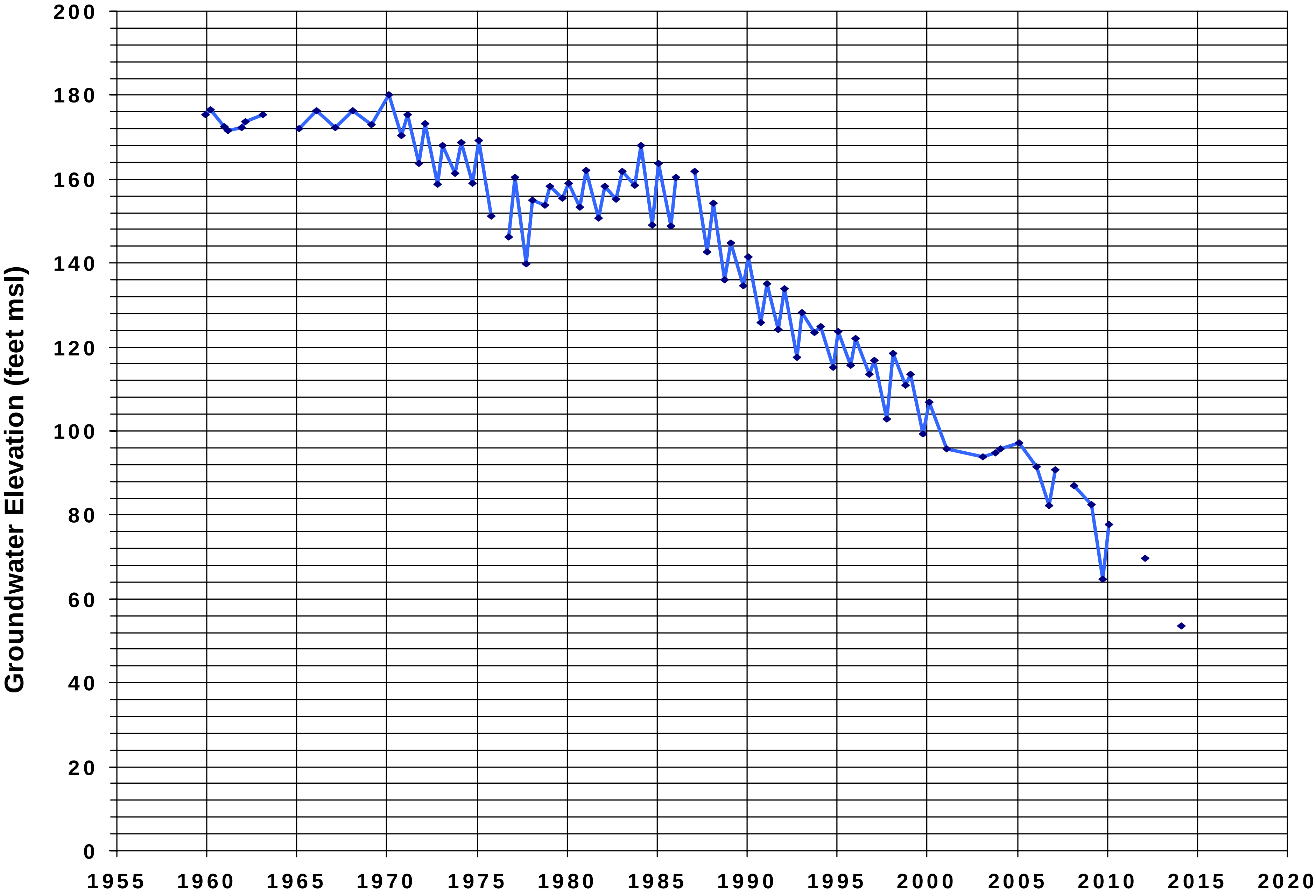


369746N1201124W001

11S17E16H001M

Zone: Outside CC, Unknown

Map Label: 16H1

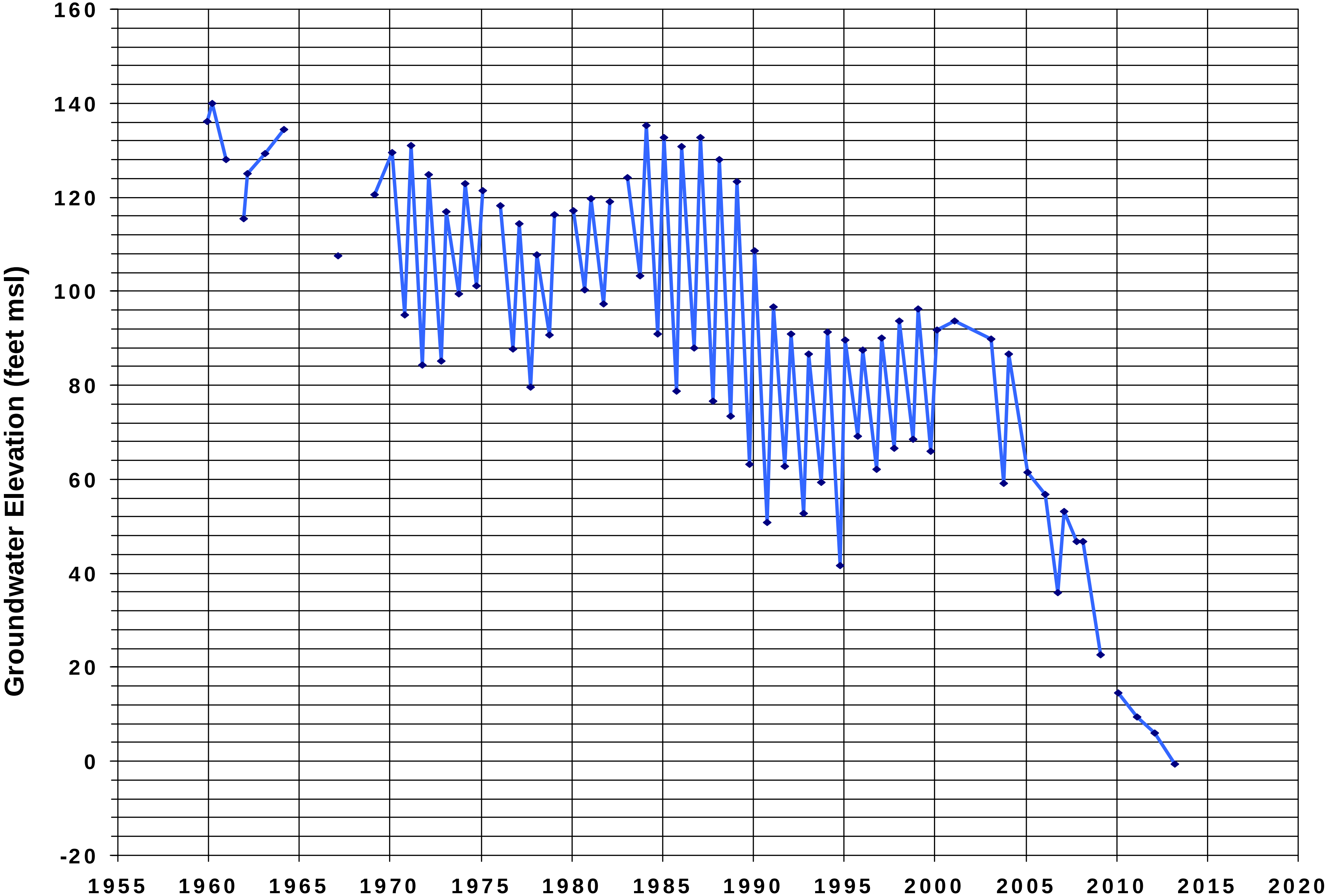


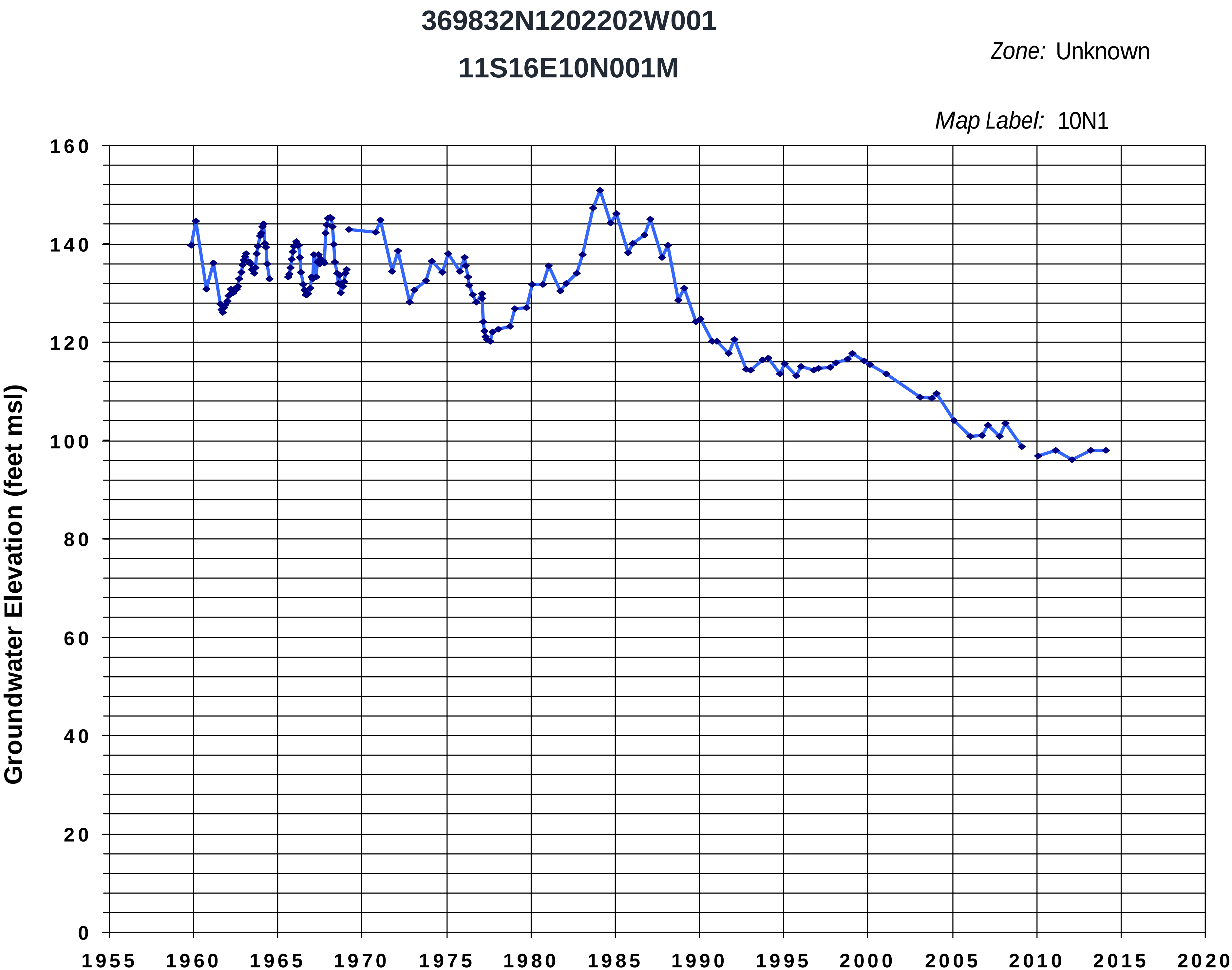
369816N1202527W001

11S16E17D001M

Zone: Unknown

Map Label: 17D1





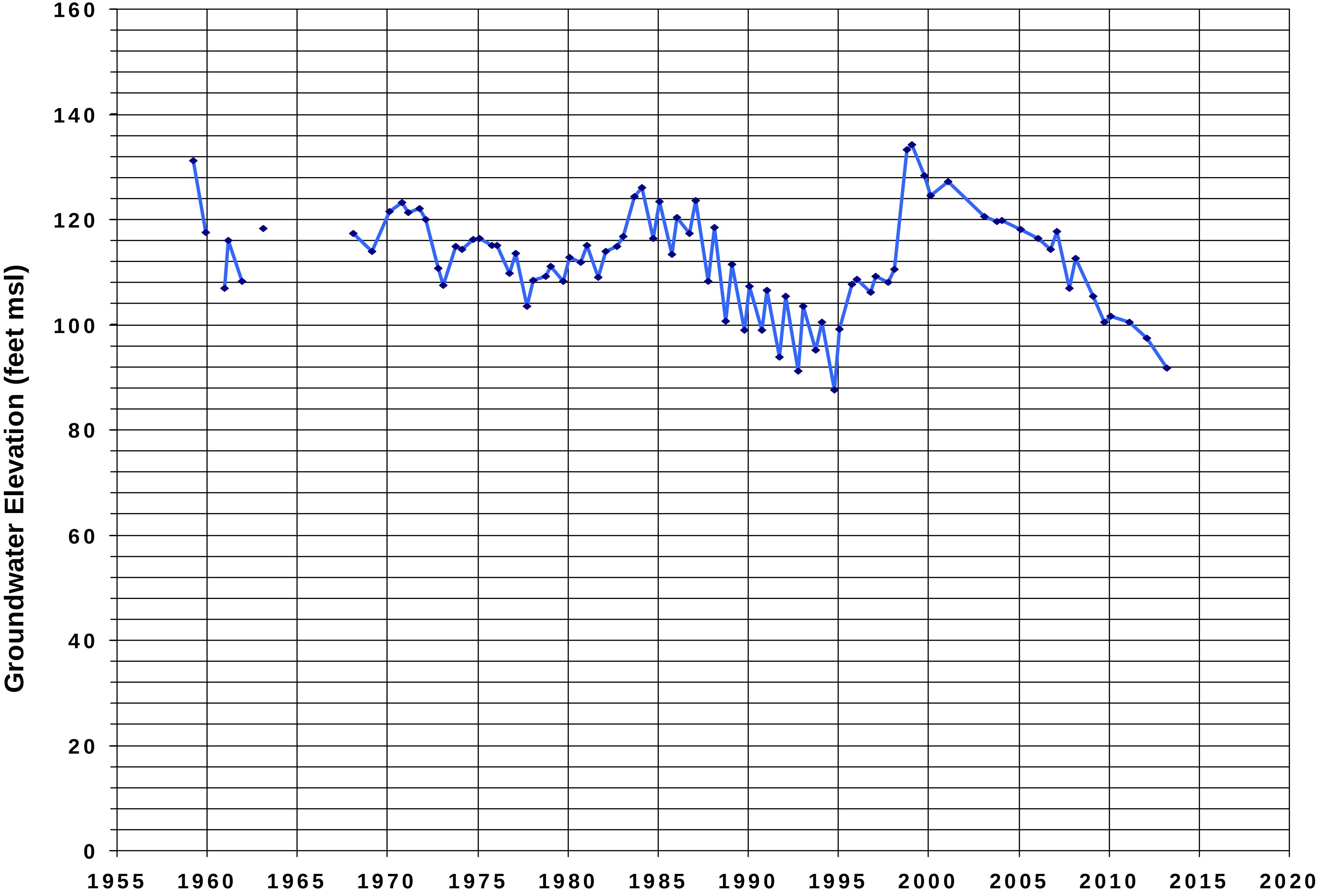
369832N1202202W001
11S16E10N001M
Zone: Unknown
Map Label: 10N1
Groundwater Elevation (feet msl)
160
140
120
100
80
60
40
20
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

369877N1203113W001

11S15E10J001M

Zone: Unknown

Map Label: 10J1

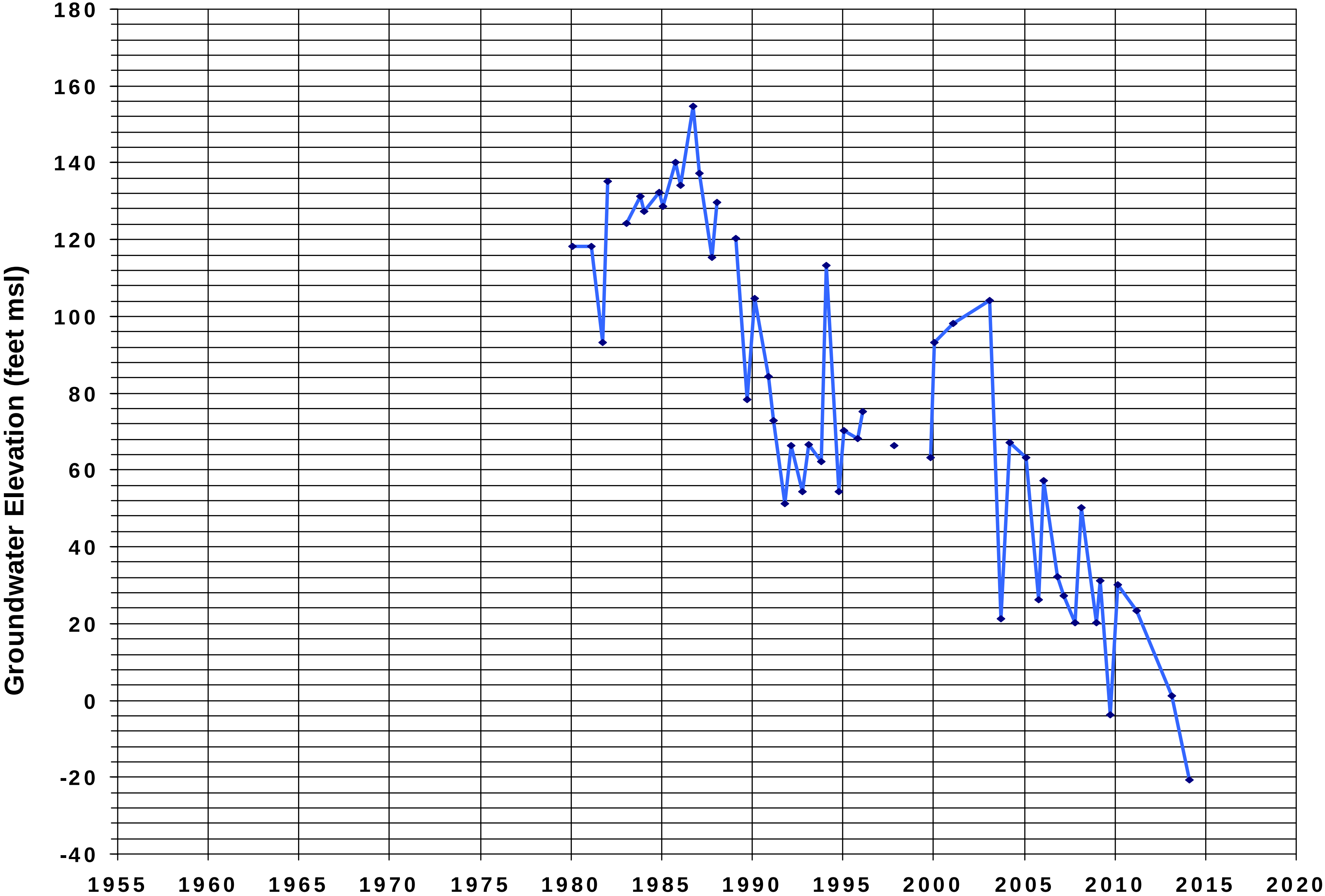


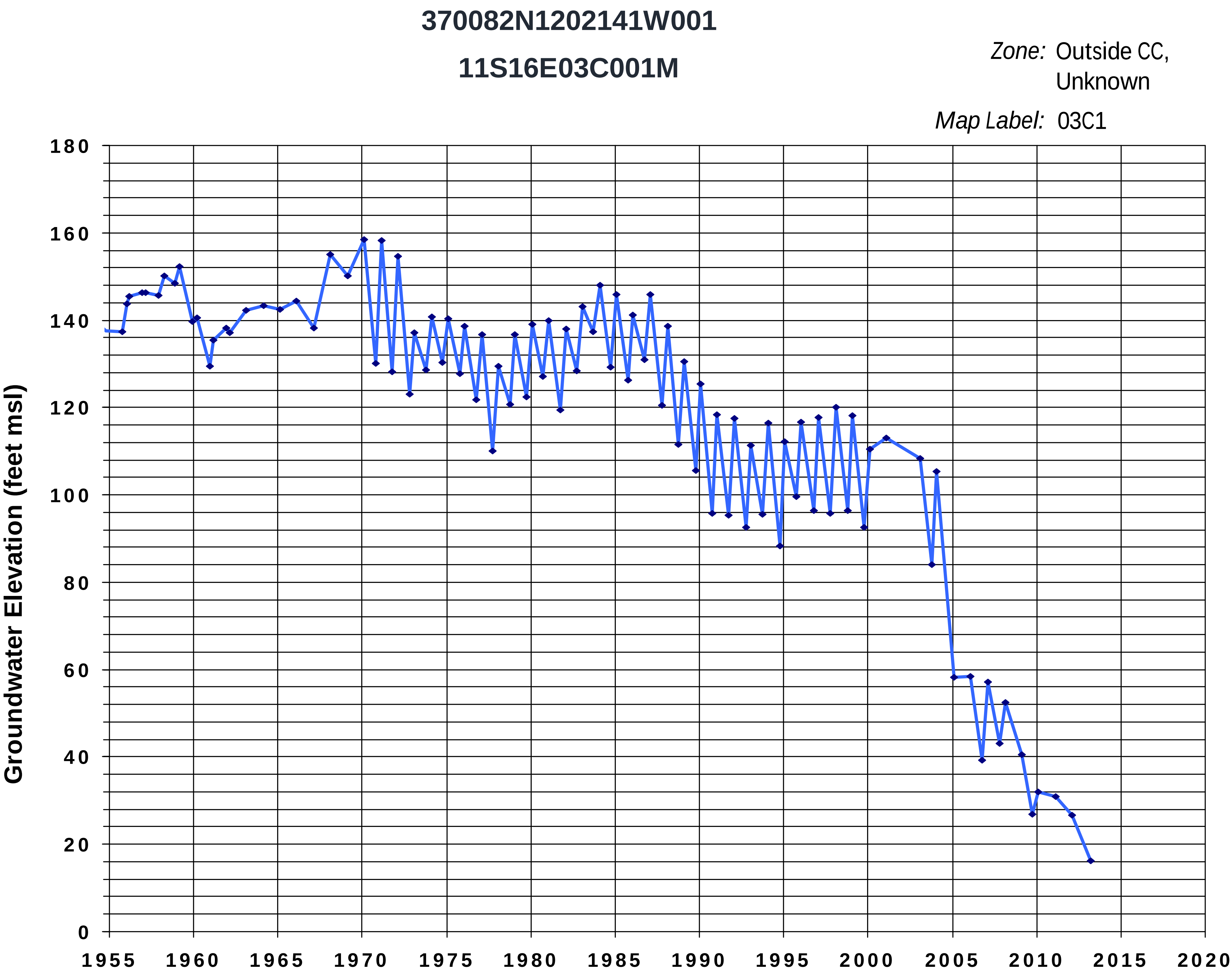
370035N1202746W001

11S15E01H002M

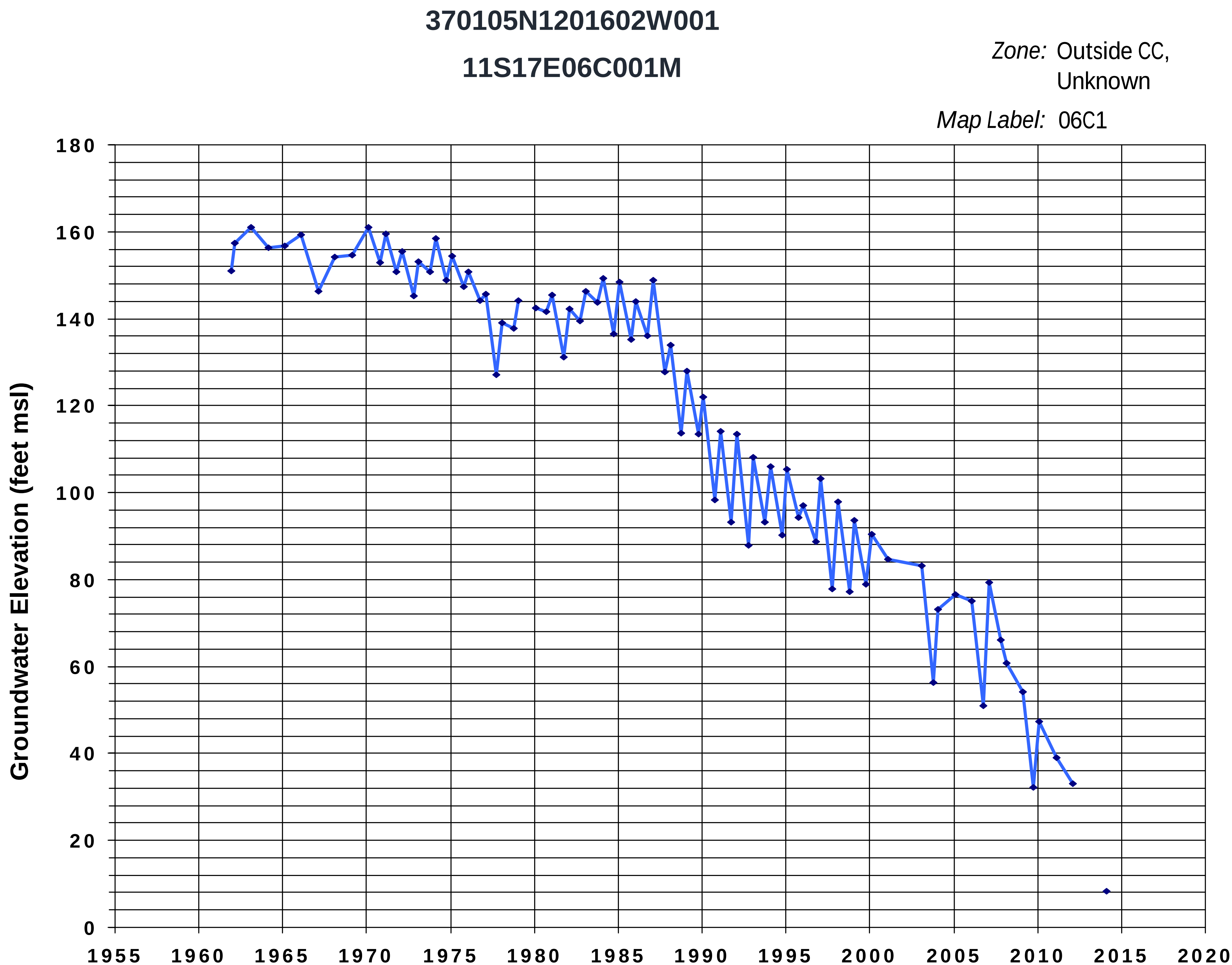
Zone: Outside CC, Unknown

Map Label: 01H2





370082N1202141W001
11S16E03C001M
Zone: Outside CC, Unknown
Map Label: 03C1
Groundwater Elevation (feet msl)
0
20
40
60
80
100
120
140
160
180
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

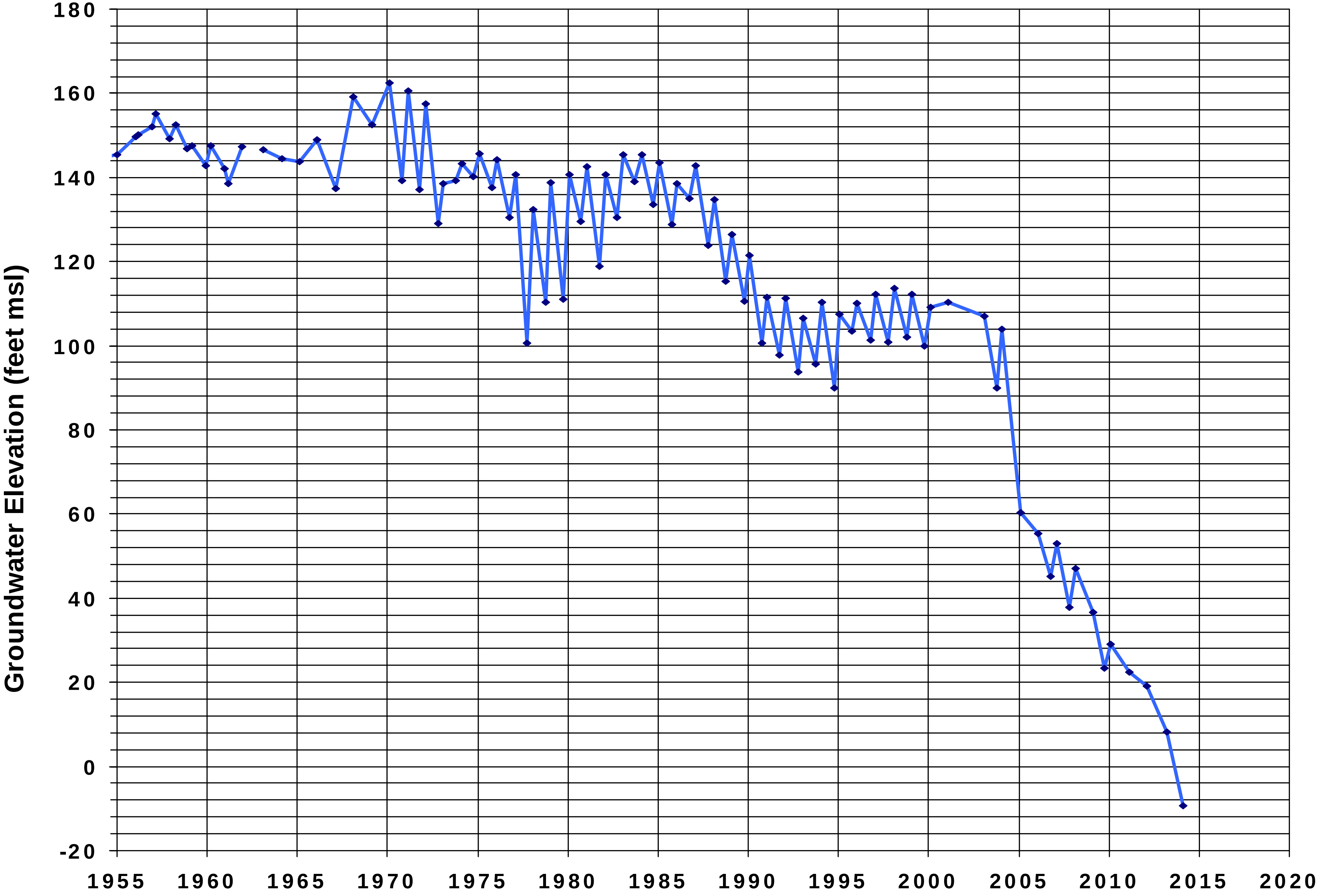

370105N1201602W001
11S17E06C001M
Zone: Outside CC, Unknown
Map Label: 06C1
Groundwater Elevation (feet msl)
0
20
40
60
80
100
120
140
160
180
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

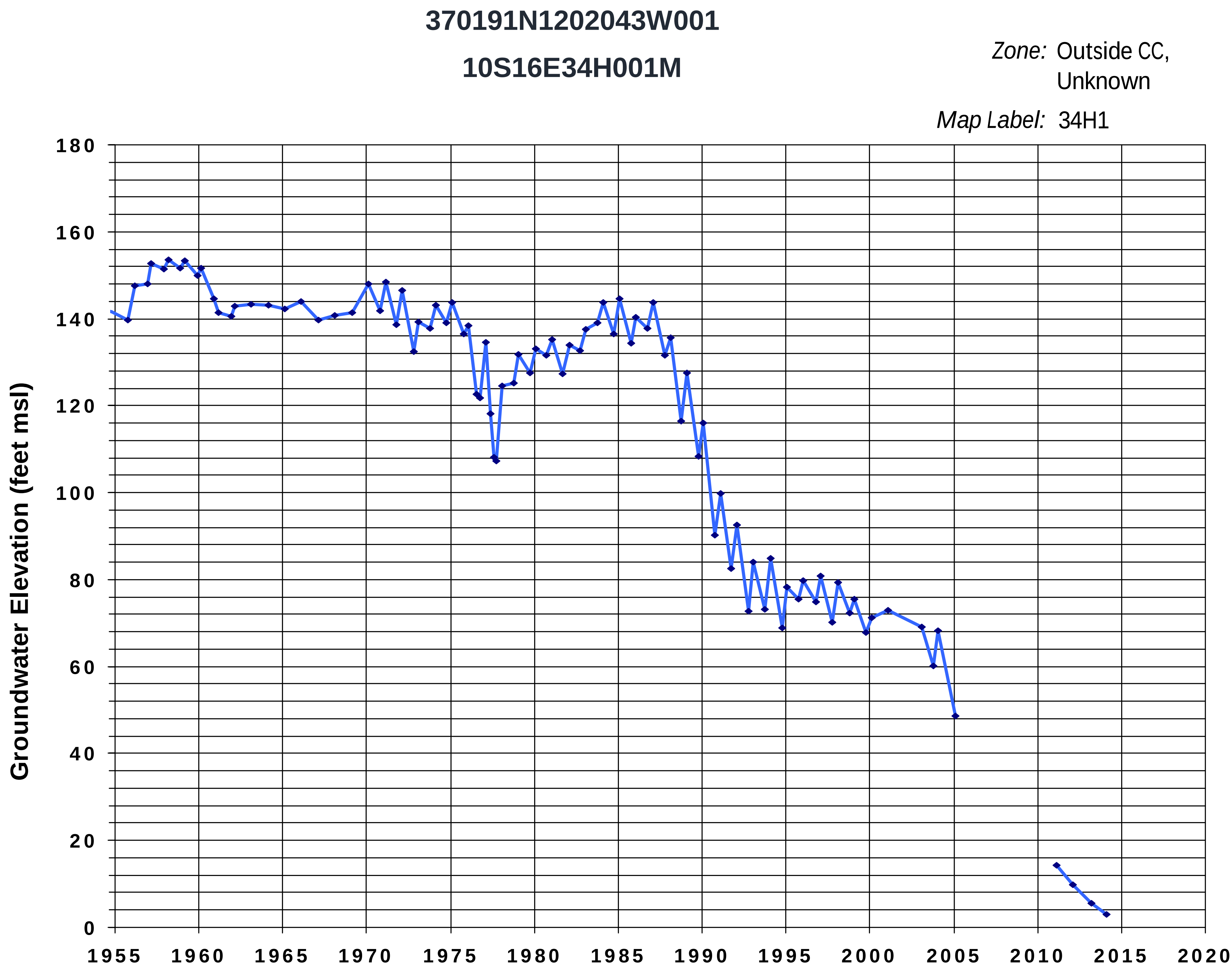
370107N1202027W001

11S16E03A001M

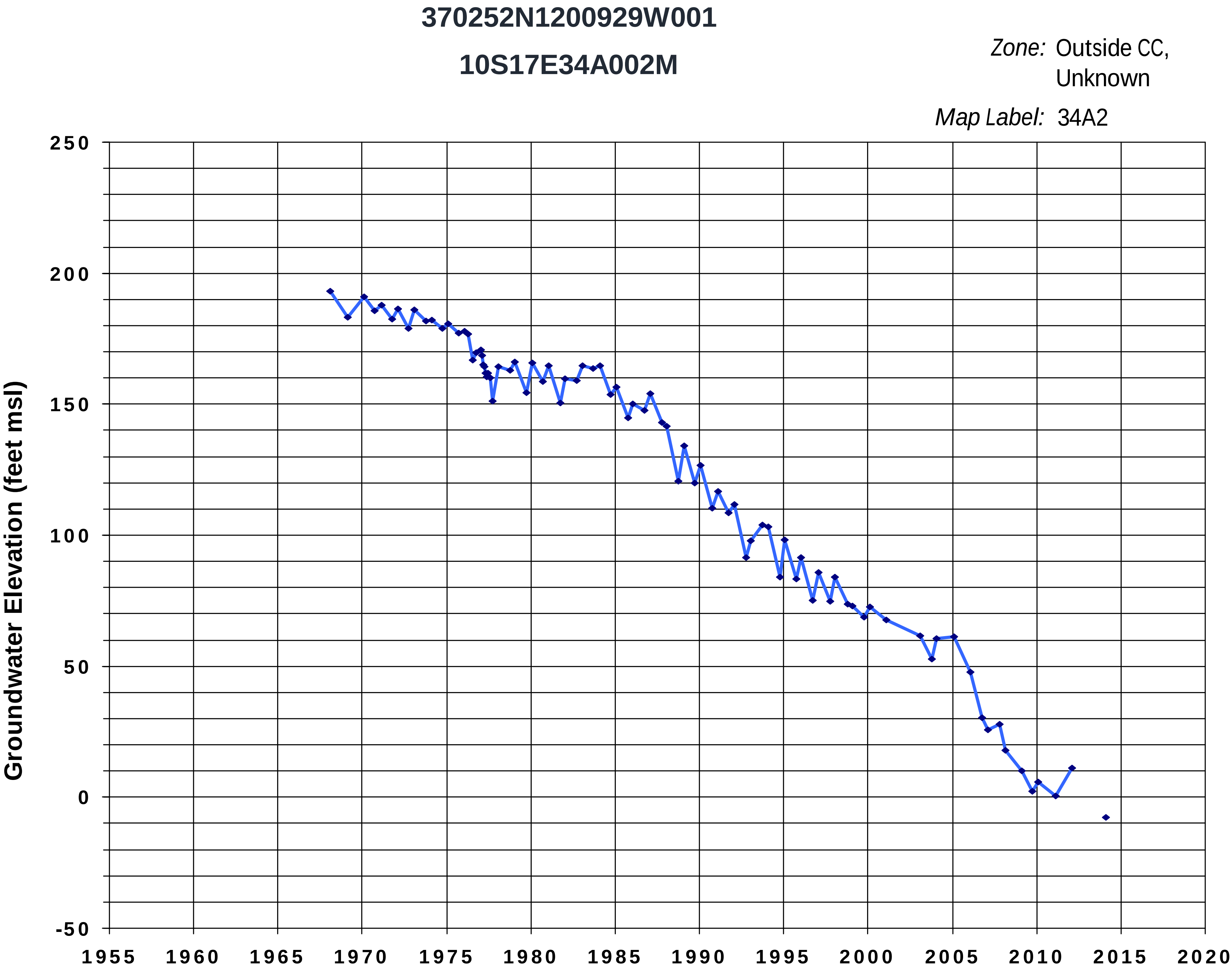
Zone: Outside CC, Unknown

Map Label: 03A1

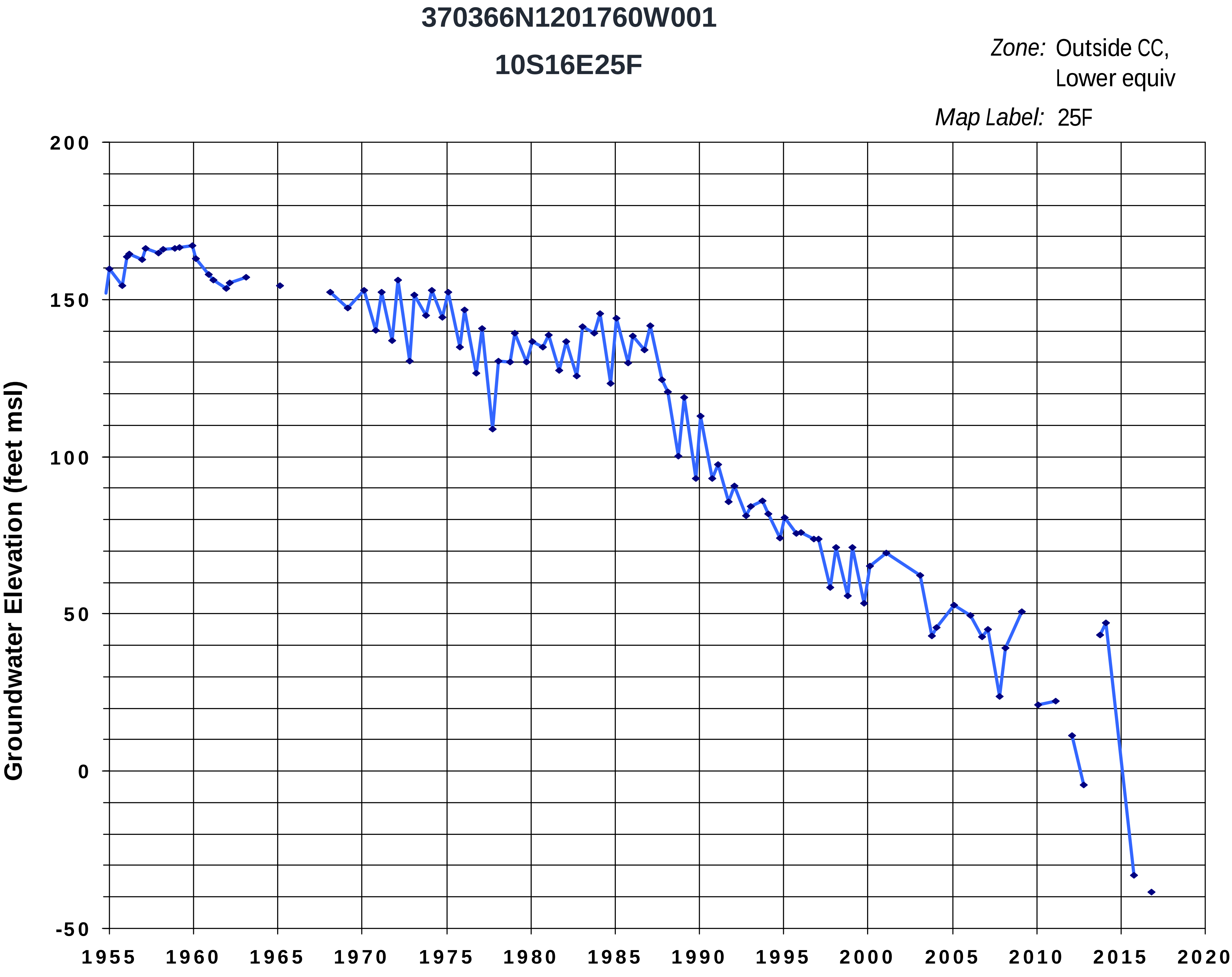


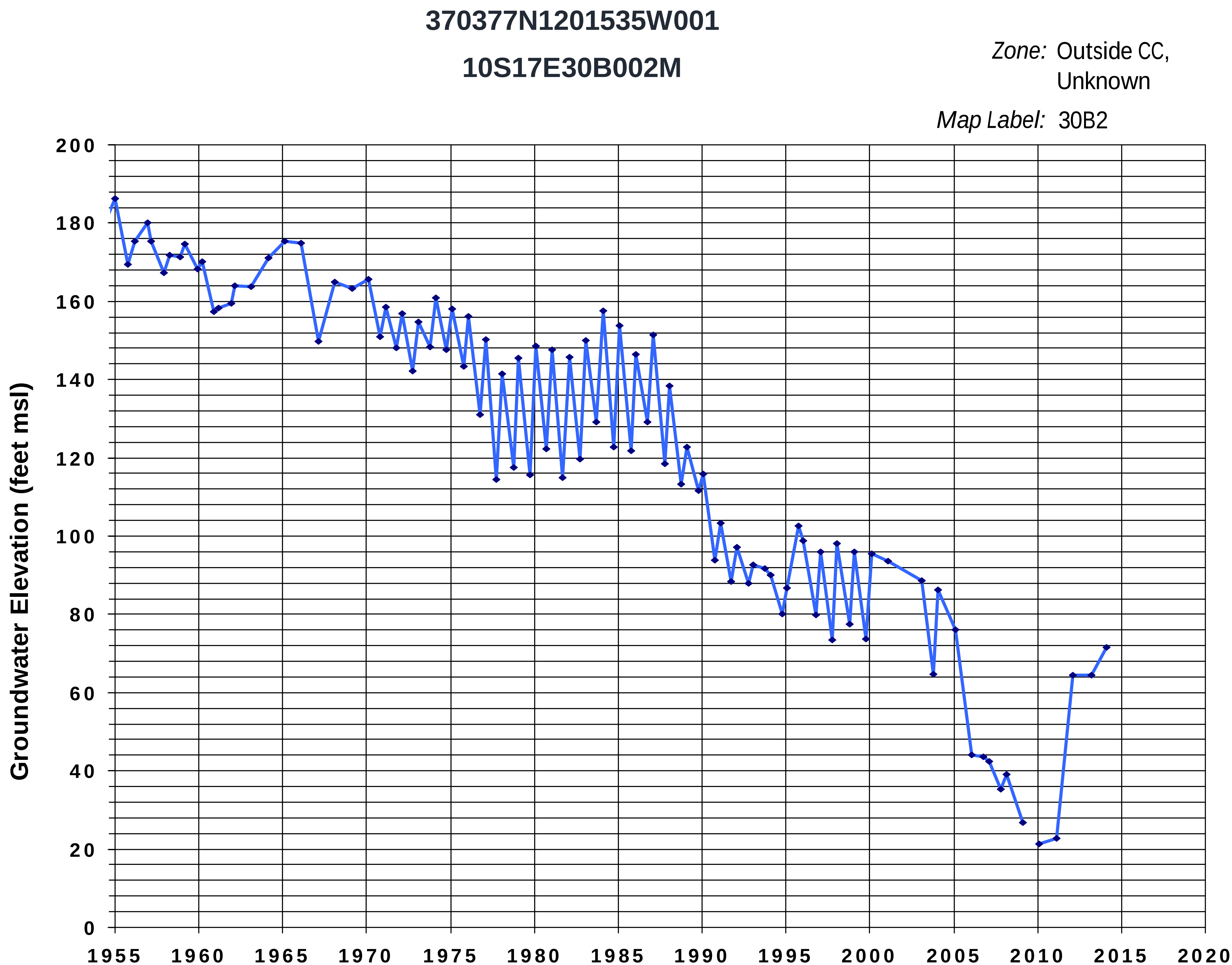


370191N1202043W001
10S16E34H001M
Zone: Outside CC, Unknown
Map Label: 34H1
Groundwater Elevation (feet msl)
180
160
140
120
100
80
60
40
20
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

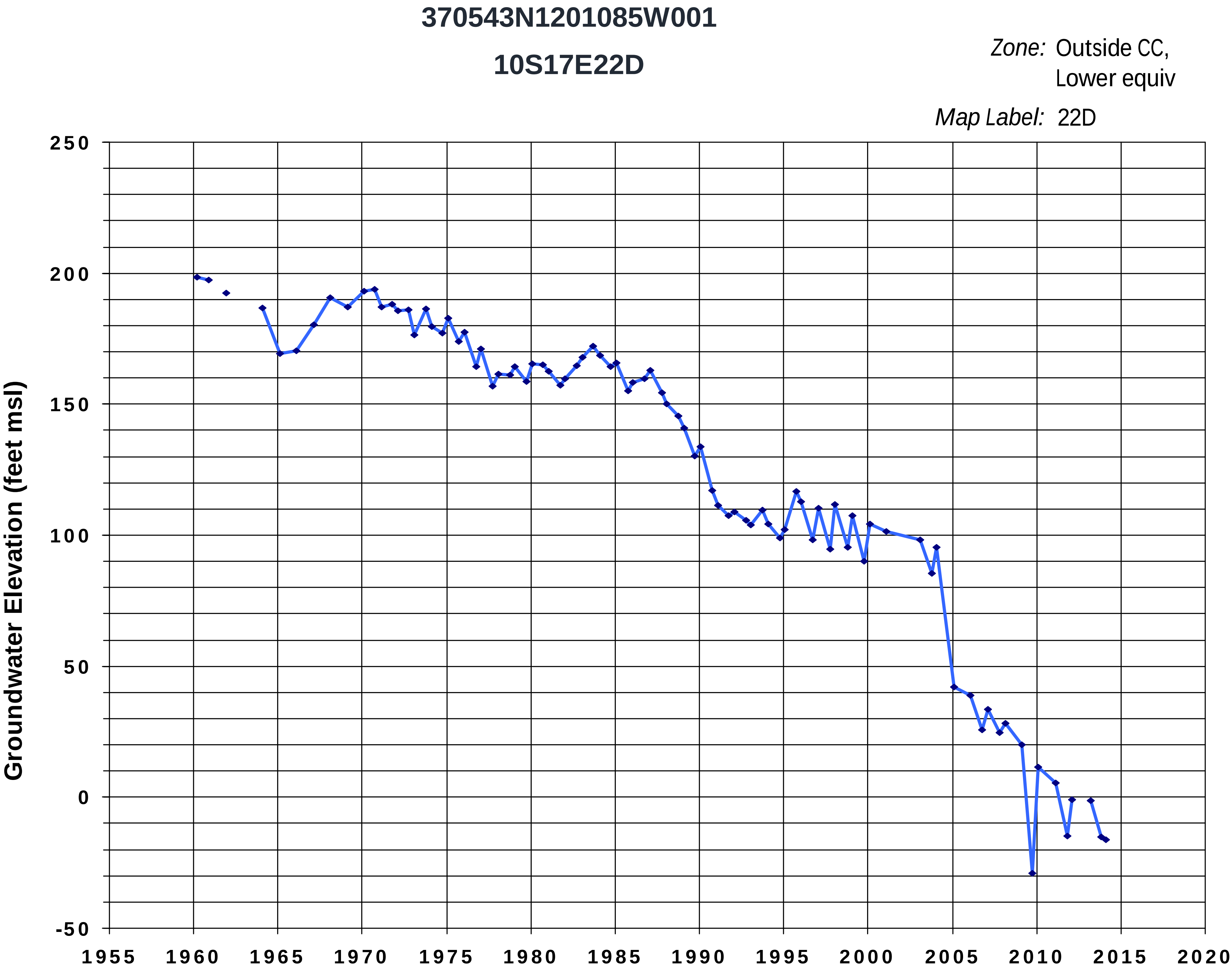


370252N1200929W001
10S17E34A002M
Zone: Outside CC, Unknown
Map Label: 34A2
Groundwater Elevation (feet msl)
250
200
150
100
50
0
-50
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

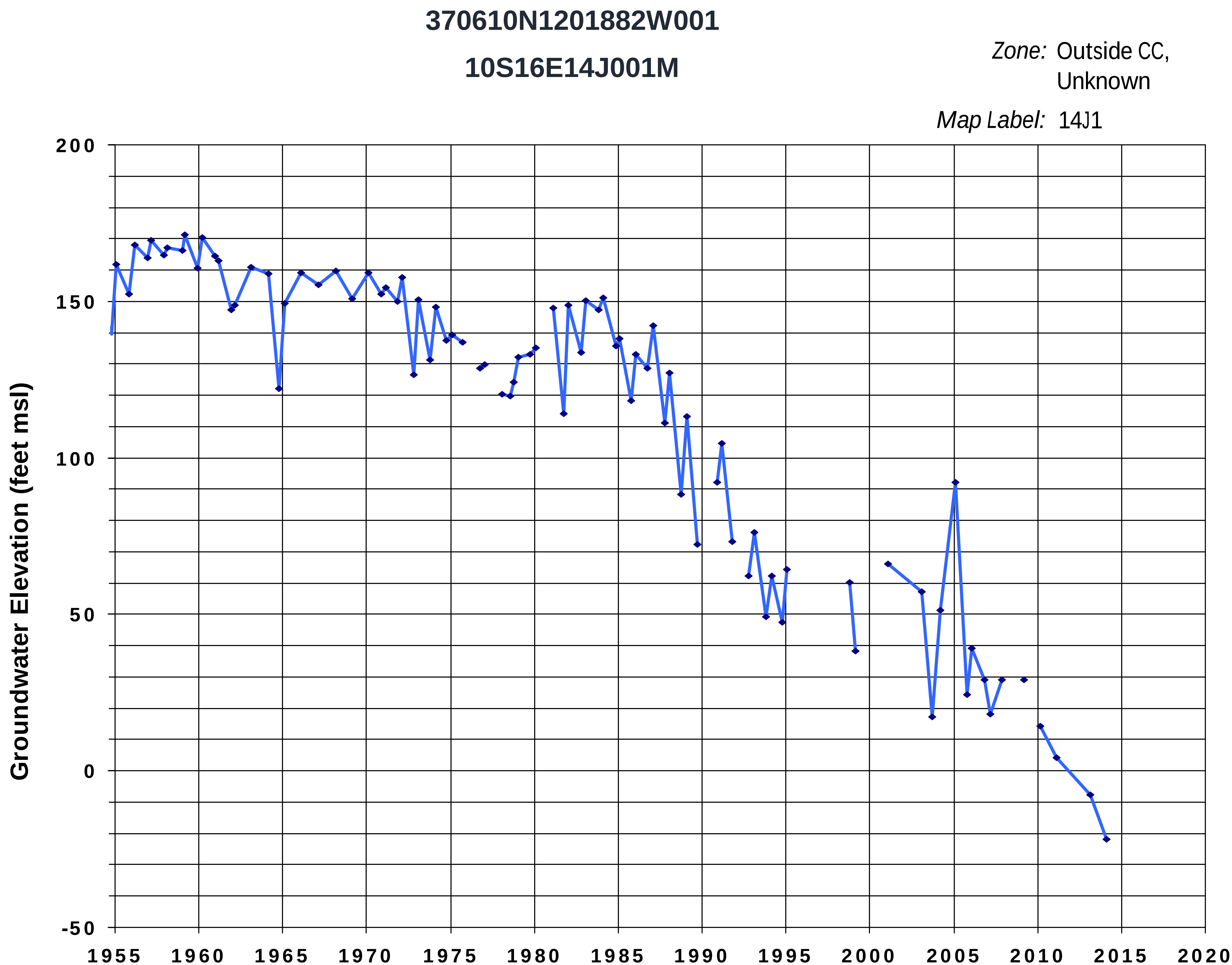

370366N1201760W001
10S16E25F
Zone: Outside CC, Lower equiv
Map Label: 25F
Groundwater Elevation (feet msl)
200
150
100
50
0
-50
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

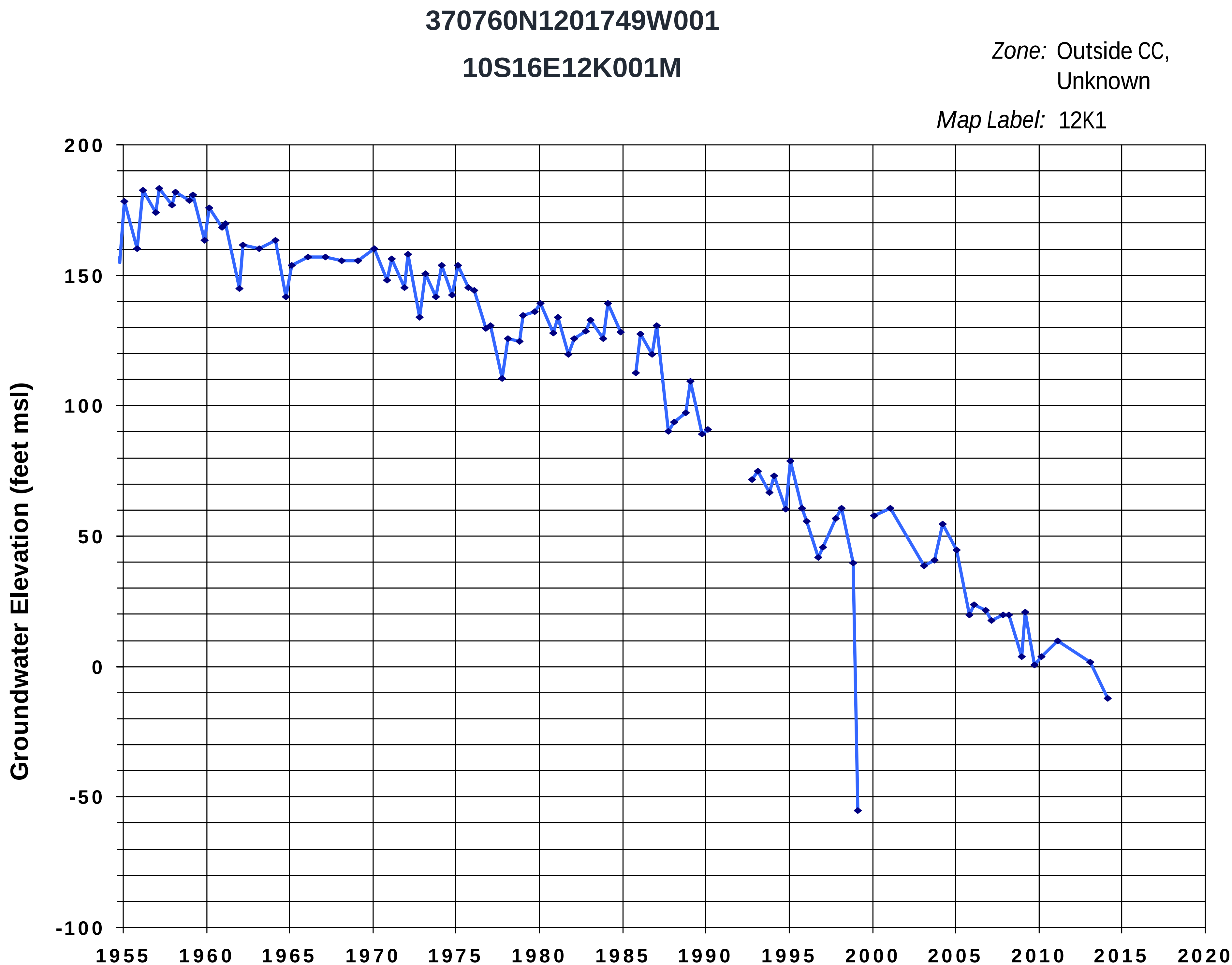


370377N1201535W001
10S17E30B002M
Zone: Outside CC, Unknown
Map Label: 30B2
Groundwater Elevation (feet msl)
200
180
160
140
120
100
80
60
40
20
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



370543N1201085W001
10S17E22D
Zone: Outside CC, Lower equiv
Map Label: 22D
Groundwater Elevation (feet msl)
250
200
150
100
50
0
-50
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


370610N1201882W001
10S16E14J001M
Zone: Outside CC, Unknown
Map Label: 14J1
Groundwater Elevation (feet msl)
200
150
100
50
0
-50
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



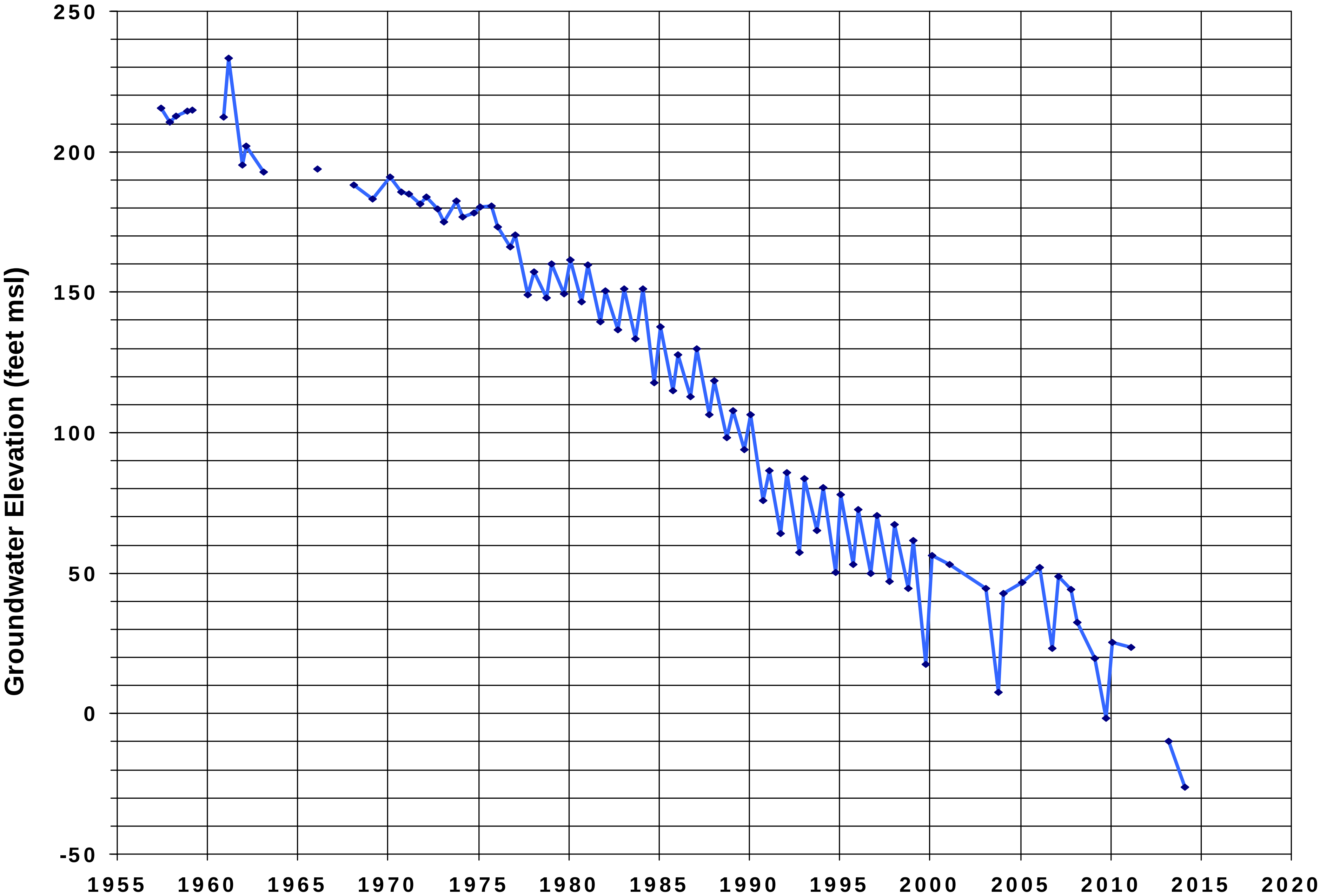
370760N1201749W001
10S16E12K001M
Zone: Outside CC, Unknown
Map Label: 12K1
Groundwater Elevation (feet msl)
200
150
100
50
0
-50
-100
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

370913N1201029W001

10S17E03F001M

Zone: Outside CC, Unknown

Map Label: 03F1

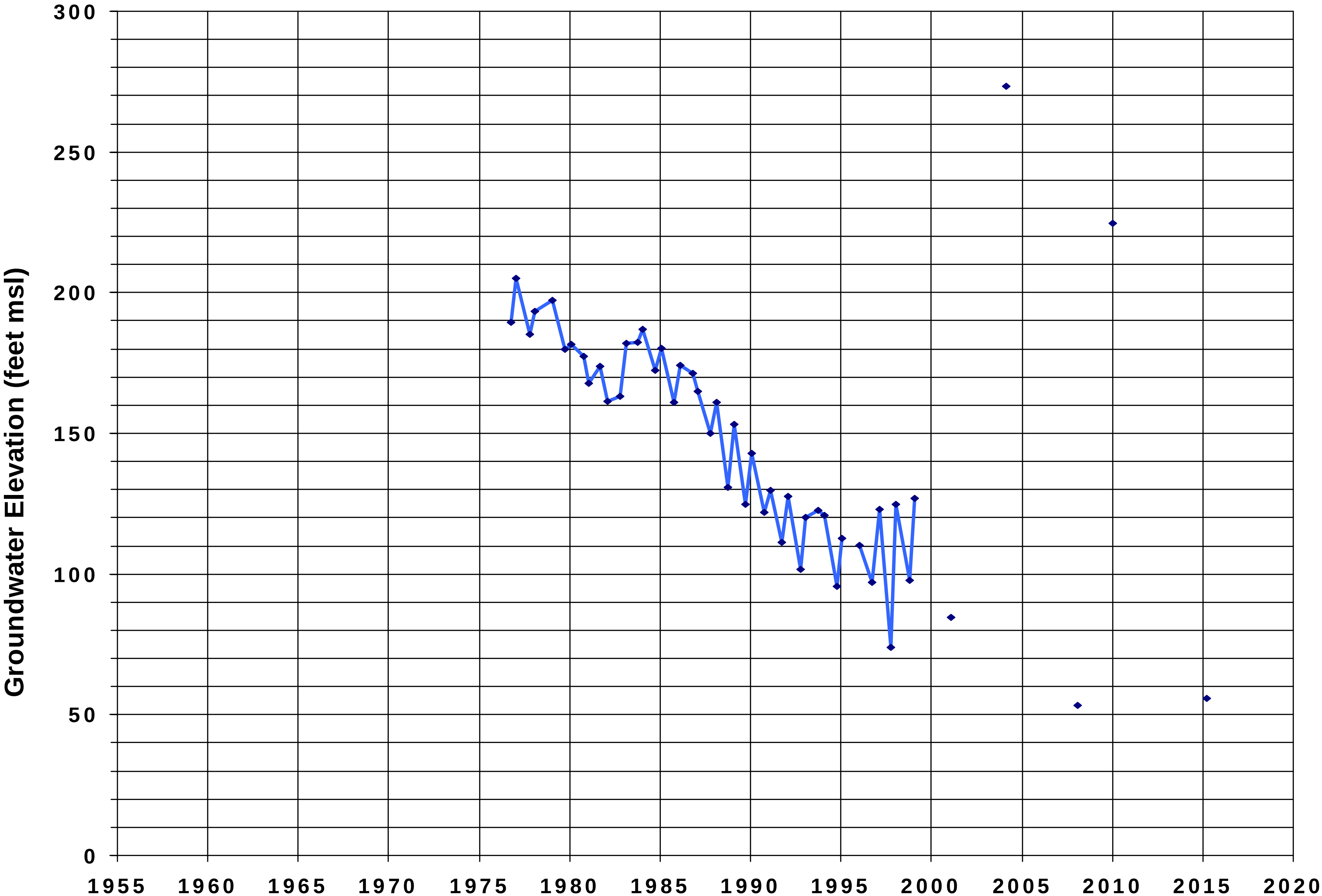


371046N1200879W001

09S17E35L001M

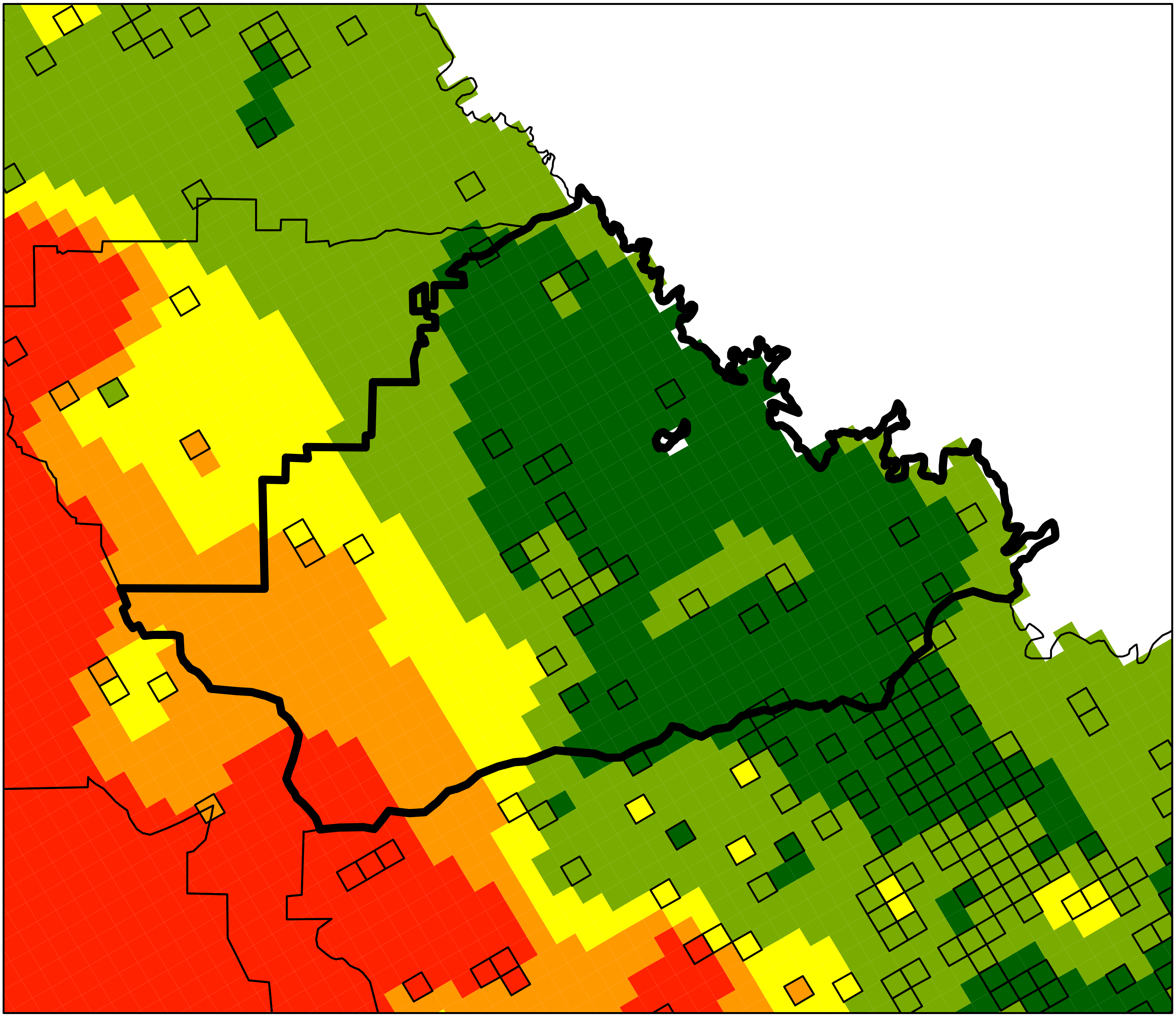
Zone: Outside CC, Unknown

Map Label: 35L1



APPENDIX D

GROUNDWATER QUALITY MAPS



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 5 10 Miles

DWR B118 Code:5-22.06

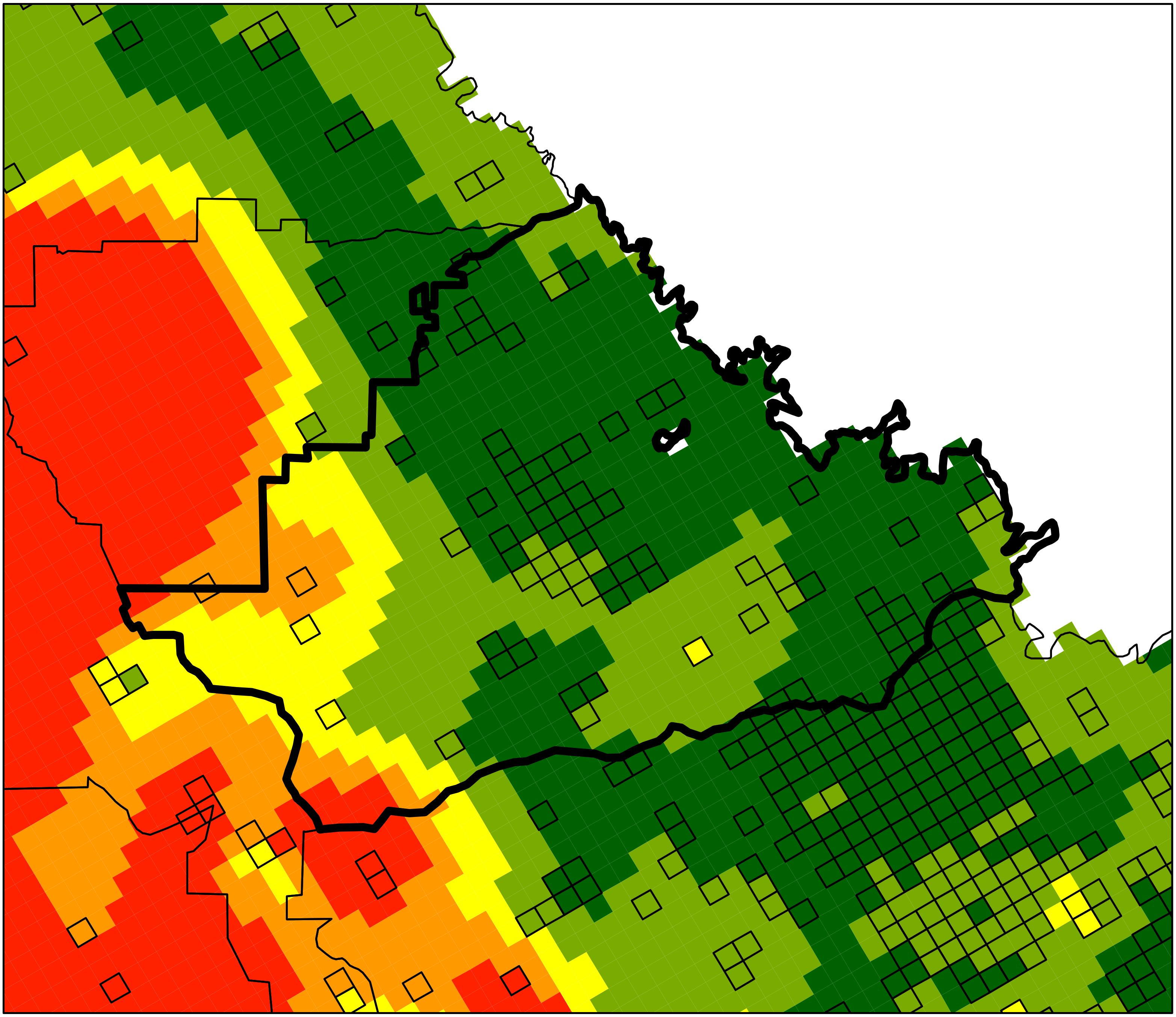
Groundwater Basin:
SAN JOAQUIN VALLEY

Groundwater Subbasin:
MADERA

LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

LARRY WALKER ASSOCIATES

Figure 157



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 5 10 Miles

DWR B118 Code:5-22.06

Groundwater Basin:
SAN JOAQUIN VALLEY

Groundwater Subbasin:
MADERA

LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

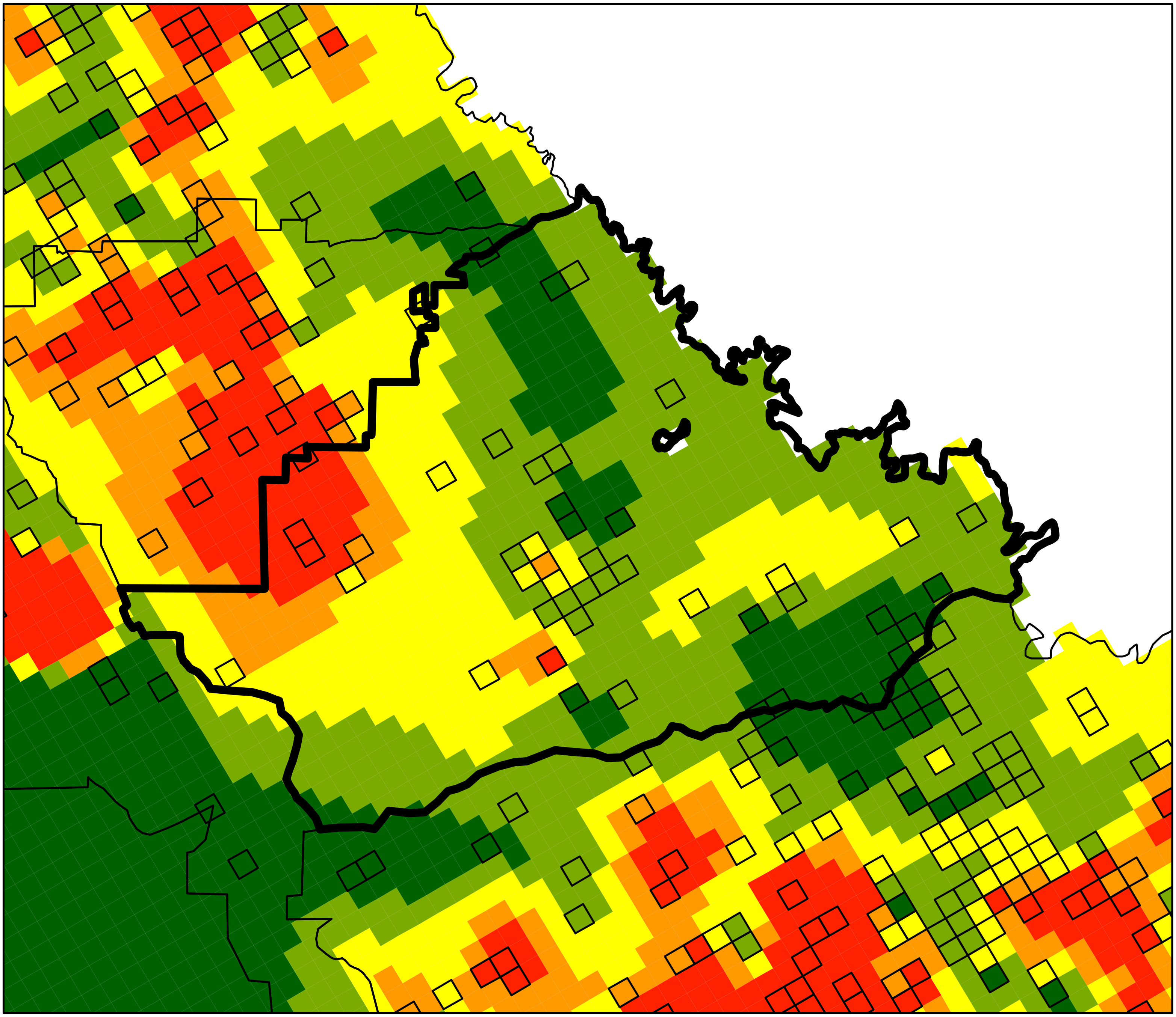
LARRY WALKER ASSOCIATES

Figure 198

	Number of Wells	Wells With Construction Information	Wells Without Construction Information
Wells With TDS Results	**12,591**	**5,369**	**7,222**
ENVIRONMENTAL MONITORING (WELLS)	36	3	33
USGS (Unknown well type)	58	57	1
UpperLower	26	26	0
CDPH	20	20	0
USGS (Unknown well type)	6	6	0
Lower	53	18	35
CDPH	42	16	26
USGS (Unknown well type)	2	2	0
WATER SUPPLY (WELLS)	9	0	9
Below CC	104	65	39
CDPH	78	55	23
USGS (Unknown well type)	10	10	0
WATER SUPPLY (WELLS)	16	0	16
SAN JOAQUIN VALLEY: MERCED (B118 Code: 5-22.04)	231	135	96
Upper	80	39	41
CDPH	4	4	0
ENVIRONMENTAL MONITORING (WELLS)	55	20	35
USGS (Unknown well type)	21	15	6
UpperLower	13	13	0
CDPH	9	9	0
USGS (Unknown well type)	4	4	0
Lower	62	32	30
CDPH	40	29	11
USGS (Unknown well type)	3	3	0
WATER SUPPLY (WELLS)	19	0	19
Below CC	74	49	25
CDPH	48	37	11
USGS (Unknown well type)	12	12	0
WATER SUPPLY (WELLS)	14	0	14
Too Deep	2	2	0
CDPH	1	1	0
USGS (Unknown well type)	1	1	0
SAN JOAQUIN VALLEY: CHOWCHILLA (B118 Code: 5-22.05)	72	25	47
Upper	21	0	21
monitoring	21	0	21
UpperLower	1	1	0
USGS (Unknown well type)	1	1	0
Lower	5	1	4
CDPH	4	1	3
WATER SUPPLY (WELLS)	1	0	1
Below CC	45	23	22
CDPH	21	10	11
USGS (Unknown well type)	13	13	0
WATER SUPPLY (WELLS)	11	0	11
SAN JOAQUIN VALLEY: MADERA (B118 Code: 5-22.06)	181	105	76

	Number of Wells	Wells With Construction Information	Wells Without Construction Information
Wells With TDS Results	**12,591**	**5,369**	**7,222**
Upper	22	7	15
CDPH	2	2	0
monitoring	12	0	12
USGS (Unknown well type)	8	5	3
UpperLower	26	26	0
CDPH	16	16	0
USGS (Unknown well type)	10	10	0
Lower	126	67	59
CDPH	97	60	37
USGS (Unknown well type)	7	7	0
WATER SUPPLY (WELLS)	22	0	22
Below CC	5	5	0
CDPH	1	1	0
USGS (Unknown well type)	4	4	0
Oustide IAZs	2	0	2
CDPH	2	0	2
SAN JOAQUIN VALLEY: DELTA-MENDOTA (B118 Code: 5-22.07)	419	184	235
Upper	241	105	136
CDPH	10	10	0
ENVIRONMENTAL MONITORING (WELLS)	197	62	135
USGS (Unknown well type)	34	33	1
UpperLower	34	34	0
CDPH	28	28	0
USGS (Unknown well type)	6	6	0
Lower	76	15	61
CDPH	44	15	29
WATER SUPPLY (WELLS)	32	0	32
Below CC	46	30	16
CDPH	14	10	4
USGS (Unknown well type)	20	20	0
WATER SUPPLY (WELLS)	12	0	12
Oustide IAZs	1	0	1
WATER SUPPLY (WELLS)	1	0	1
Unknown	21	0	21
Undetermined	7	0	7
#N/A	14	0	14
SAN JOAQUIN VALLEY: KINGS (B118 Code: 5-22.08)	1,129	627	502
Upper	260	144	116
CDPH	30	30	0
ENVIRONMENTAL MONITORING (WELLS)	68	29	39
monitoring	67	0	67
USGS (Unknown well type)	95	85	10
UpperLower	181	181	0
CDPH	133	133	0
USGS (Unknown well type)	48	48	0

		Average Well TDS Concentration Statistics				
DWR B118 Groundwater Basin Code	Aquifer Zone	Number of Wells	Minimum	Average	Median	Maximum
5-21.64	Upper and Lower Zone	103	80	249	231	667
	Lower Zone	239	58	256	234	691
	Below Production Zone	5	175	372	333	678
	Unknown	20	106	268	260	449
5-21.65	Upper Zone	175	76	646	405	27,276
	Upper and Lower Zone	88	77	217	179	670
	Lower Zone	149	80	211	172	867
	Below Production Zone	13	129	151	150	192
	Unknown	3	169	186	169	220
5-21.66	Upper Zone	169	164	1,868	765	56,500
	Upper and Lower Zone	24	138	394	385	954
	Lower Zone	94	54	508	425	1,600
	Below Production Zone	6	284	335	303	423
	Unknown	8	290	1,170	562	5,387
5-21.67	Upper Zone	194	100	1,488	1,050	6,657
	Upper and Lower Zone	17	262	528	461	1,510
	Lower Zone	87	110	539	543	1,510
	Below Production Zone	8	313	421	346	841
	Unknown	11	184	465	505	720
5-22.01	Upper Zone	451	74	2,418	740	178,909
	Upper and Lower Zone	175	83	335	292	1,230
	Lower Zone	232	35	304	249	1,911
	Below CC Zone	14	186	343	297	718
	Below Production Zone	6	132	1,045	594	3,406
	Unknown	41	92	308	214	957
5-22.02	Upper Zone	186	81	602	489	3,811
	Upper and Lower Zone	94	67	312	270	1,121
	Lower Zone	79	67	273	206	1,700
	Below CC Zone	108	92	465	323	5,974
	Below Production Zone	2	160	178	178	196
5-22.03	Upper Zone	117	37	506	488	1,758
	Upper and Lower Zone	26	74	394	393	1,176
	Lower Zone	53	74	285	225	1,136
	Below CC Zone	104	144	377	260	1,819
5-22.04	Upper Zone	80	111	498	392	1,951
	Upper and Lower Zone	13	125	249	246	354
	Lower Zone	62	111	289	211	2,005
	Below CC Zone	74	90	268	224	1,035
	Below Production Zone	2	246	280	280	314
5-22.05	Upper Zone	21	117	625	623	1,117
	Lower Zone	5	165	370	208	841
	Below CC Zone	45	132	412	198	3,923
5-22.06	Upper Zone	22	94	500	518	1,049
	Upper and Lower Zone	26	62	207	189	380
	Lower Zone	126	51	234	194	1,048
	Below CC Zone	5	125	333	282	621
	Outside Valley Floor	2	163	164	164	164
5-22.07	Upper Zone	241	207	1,234	1,080	4,462
	Upper and Lower Zone	34	194	833	793	3,255
	Lower Zone	76	185	922	809	3,242
	Below CC Zone	46	387	1,165	1,015	4,314
	Unknown	21	276	989	1,033	2,665
5-22.08	Upper Zone	260	69	637	504	5,266
	Upper and Lower Zone	181	74	286	231	1,916
	Lower Zone	654	10	267	214	9,268
	Below CC Zone	8	125	321	323	601
	Below Production Zone	20	109	588	186	8,096
	Outside Valley Floor	5	319	472	411	703
5-22.09	Upper Zone	2	313	1,305	1,305	2,297
	Upper and Lower Zone	4	849	1,036	968	1,360
	Lower Zone	19	305	1,058	894	2,980
	Below CC Zone	4	563	923	939	1,249



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 5 10 Miles

DWR B118 Code:5-22.06

Groundwater Basin:
SAN JOAQUIN VALLEY

Groundwater Subbasin:
MADERA

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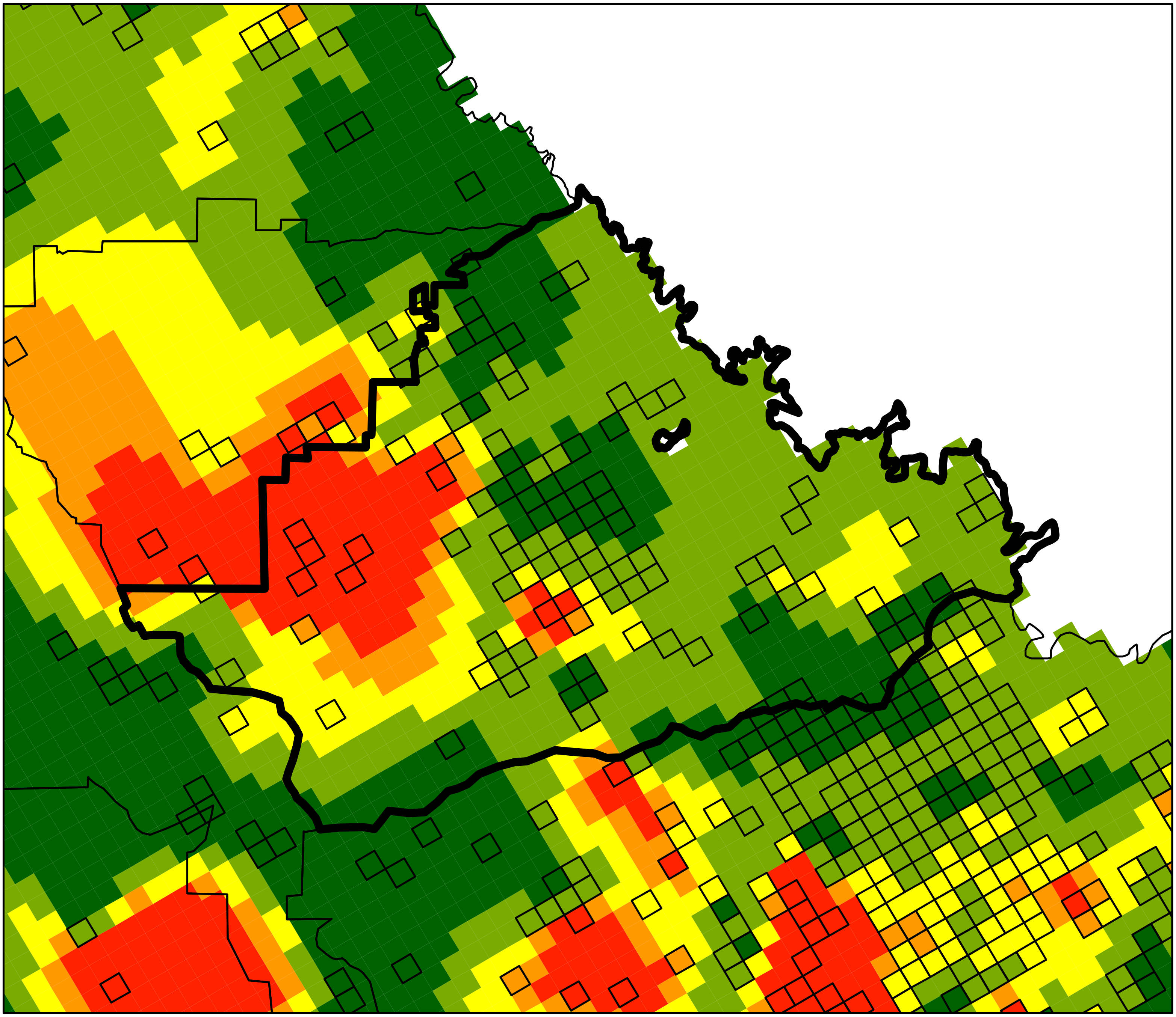
LARRY WALKER ASSOCIATES

Figure 34



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 5 10 Miles

DWR B118 Code:5-22.06

Groundwater Basin: SAN JOAQUIN VALLEY

Groundwater Subbasin: MADERA

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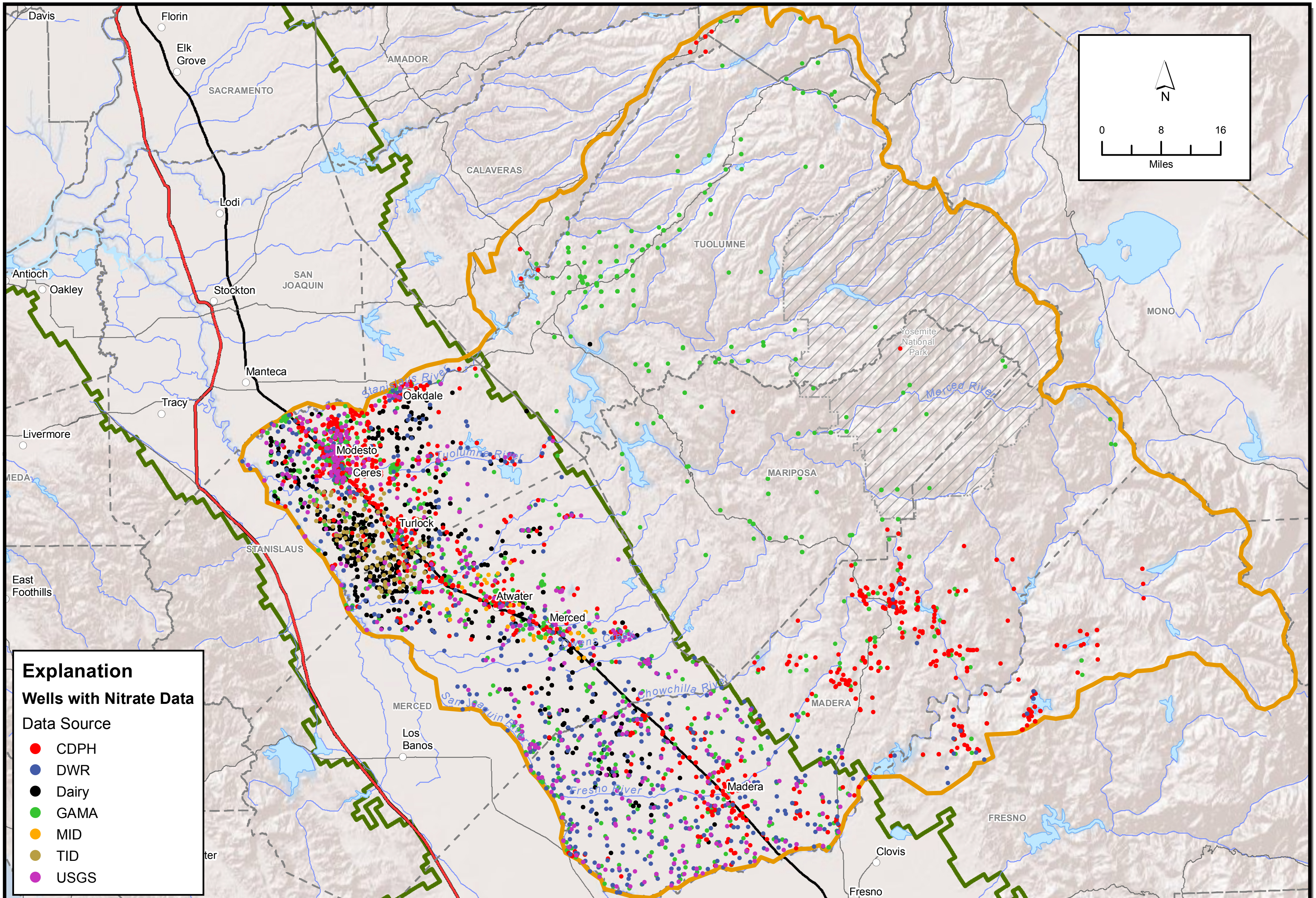
Figure 75

	Number of Wells	Wells With Construction Information	Wells Without Construction Information
Wells With Nitrate Results	**20,539**	**6,349**	**14,190**
CDPH	64	44	20
ENVIRONMENTAL MONITORING (WELLS)	4	4	0
USGS (Unknown well type)	7	7	0
WATER SUPPLY (WELLS)	7	0	7
Too Deep	1	1	0
CDPH	1	1	0
SAN JOAQUIN VALLEY: CHOWCHILLA (B118 Code: 5-22.05)	270	26	244
Upper	114	0	114
Domestic	92	0	92
monitoring	22	0	22
UpperLower	1	1	0
USGS (Unknown well type)	1	1	0
Lower	14	2	12
Agricultural	8	0	8
CDPH	5	2	3
WATER SUPPLY (WELLS)	1	0	1
Below CC	141	23	118
Agricultural	92	0	92
CDPH	25	10	15
USGS (Unknown well type)	13	13	0
WATER SUPPLY (WELLS)	11	0	11
SAN JOAQUIN VALLEY: MADERA (B118 Code: 5-22.06)	247	115	132
Upper	44	9	35
CDPH	4	4	0
Domestic	9	0	9
ENVIRONMENTAL MONITORING (WELLS)	11	0	11
monitoring	12	0	12
USGS (Unknown well type)	8	5	3
UpperLower	27	27	0
CDPH	17	17	0
USGS (Unknown well type)	10	10	0
Lower	165	73	92
Agricultural	9	0	9
CDPH	127	66	61
USGS (Unknown well type)	7	7	0
WATER SUPPLY (WELLS)	22	0	22
Below CC	8	5	3
Agricultural	2	0	2
CDPH	2	1	1
USGS (Unknown well type)	4	4	0
Too Deep	1	1	0
CDPH	1	1	0
Outside Valley Floor	2	0	2
CDPH	2	0	2
SAN JOAQUIN VALLEY: DELTA-MENDOTA (B118 Code: 5-22.07)	707	204	503

		Average Well Nitrate Concentration Statistics				
DWR B118 Groundwater Basin Code	Aquifer Zone	Number of Wells	Minimum	Average	Median	Maximum
5-21.64	Upper Zone	236	0.02	13.83	1.32	1219.84
	Upper and Lower Zone	109	0.22	1.65	1.52	5.88
	Lower Zone	252	0.07	1.56	1.28	6.88
	Below Production Zone	4	0.23	0.99	0.23	3.27
	Unknown	19	0.17	1.38	0.84	3.69
	Outside Valley Floor	4	0.23	0.23	0.23	0.23
5-21.65	Upper Zone	440	0.07	3.35	0.68	81.32
	Upper and Lower Zone	91	0.02	1.97	1.62	7.17
	Lower Zone	213	0.07	2.06	1.54	18.10
	Below Production Zone	13	0.21	0.22	0.23	0.23
	Unknown	3	1.48	1.92	1.94	2.34
5-21.66	Upper Zone	197	0.10	14.16	2.66	218.39
	Upper and Lower Zone	25	0.22	1.68	0.57	7.91
	Lower Zone	130	0.20	2.45	0.88	17.40
	Below Production Zone	5	0.23	0.62	0.58	1.11
	Unknown	8	0.20	3.29	1.63	14.02
5-21.67	Upper Zone	431	0.06	36.78	1.90	1541.75
	Upper and Lower Zone	21	0.23	4.19	4.40	9.21
	Lower Zone	120	0.09	3.50	3.45	18.91
	Below Production Zone	8	0.23	0.46	0.26	1.11
	Unknown	11	0.23	2.36	0.25	8.52
5-21.68	Lower Zone	3	2.82	6.87	7.55	10.23
5-22.01	Upper Zone	1012	0.05	22.43	3.12	1920.68
	Upper and Lower Zone	183	0.10	2.85	2.02	40.90
	Lower Zone	589	0.05	5.28	2.71	67.30
	Below CC Zone	24	0.23	3.49	2.69	13.30
	Below Production Zone	6	0.23	0.66	0.23	2.32
	Unknown	42	0.15	3.74	2.40	18.75
5-22.02	Upper Zone	440	0.06	9.58	5.20	85.80
	Upper and Lower Zone	96	0.87	4.34	3.98	12.39
	Lower Zone	109	0.23	4.51	3.31	21.70
	Below CC Zone	123	0.23	6.17	3.96	54.20
5-22.03	Upper Zone	925	0.15	17.87	11.95	282.28
	Upper and Lower Zone	23	1.24	7.32	6.48	30.34
	Lower Zone	126	0.23	7.86	3.67	59.40
	Below CC Zone	221	0.20	13.15	6.00	127.30
5-22.04	Upper Zone	355	0.10	11.30	5.20	179.61
	Upper and Lower Zone	15	0.98	5.26	5.26	12.66
	Lower Zone	108	0.23	4.58	3.40	24.60
	Below CC Zone	191	0.10	7.52	3.00	71.00
5-22.05	Upper Zone	114	0.23	9.78	7.33	46.40
	Lower Zone	14	0.23	7.73	4.43	19.40
	Below CC Zone	141	0.20	8.24	4.32	65.00
5-22.06	Upper Zone	44	0.22	8.41	6.79	38.61
	Upper and Lower Zone	27	0.23	3.05	2.78	10.68
	Lower Zone	165	0.22	4.02	2.50	43.30
	Below CC Zone	8	0.85	7.61	6.22	19.30
	Outside Valley Floor	2	5.00	5.08	5.08	5.17
5-22.07	Upper Zone	478	0.03	13.67	7.07	602.30
	Upper and Lower Zone	36	0.23	4.71	4.63	14.15
	Lower Zone	109	0.19	4.71	2.22	49.00
	Below CC Zone	62	0.03	5.97	4.06	24.19
	Unknown	21	0.07	6.61	5.20	18.98
5-22.08	Upper Zone	390	0.03	11.24	6.24	111.46
	Upper and Lower Zone	163	0.23	4.36	3.87	13.94
	Lower Zone	796	0.10	6.29	3.56	63.05
	Below CC Zone	14	0.23	15.13	13.45	59.60
	Below Production Zone	15	0.23	2.79	2.46	7.34
	Outside Valley Floor	7	0.75	10.75	2.21	35.58
5-22.09	Upper Zone	4	0.27	0.91	0.51	2.34
	Upper and Lower Zone	4	0.05	3.11	2.61	7.16
	Lower Zone	22	0.05	5.58	0.28	79.06



Path: X:\2012 Job Files\12-118\Report\Figures\Final GIS Map Files\Figure 5-1a Groundwater Quality Data by Source Nitrate.mxd

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Figure 5-1a
Groundwater Quality Data by Source: Nitrate

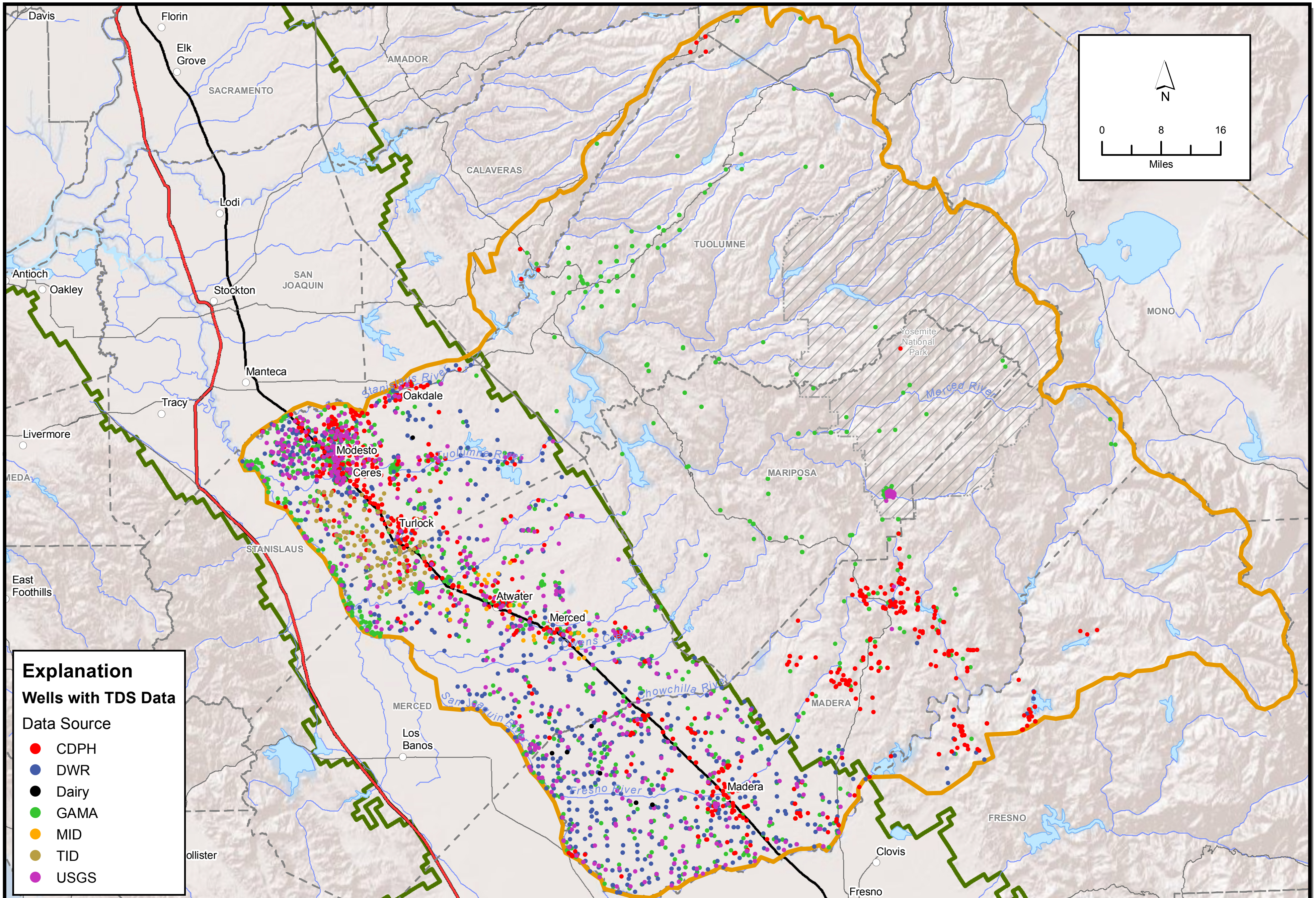

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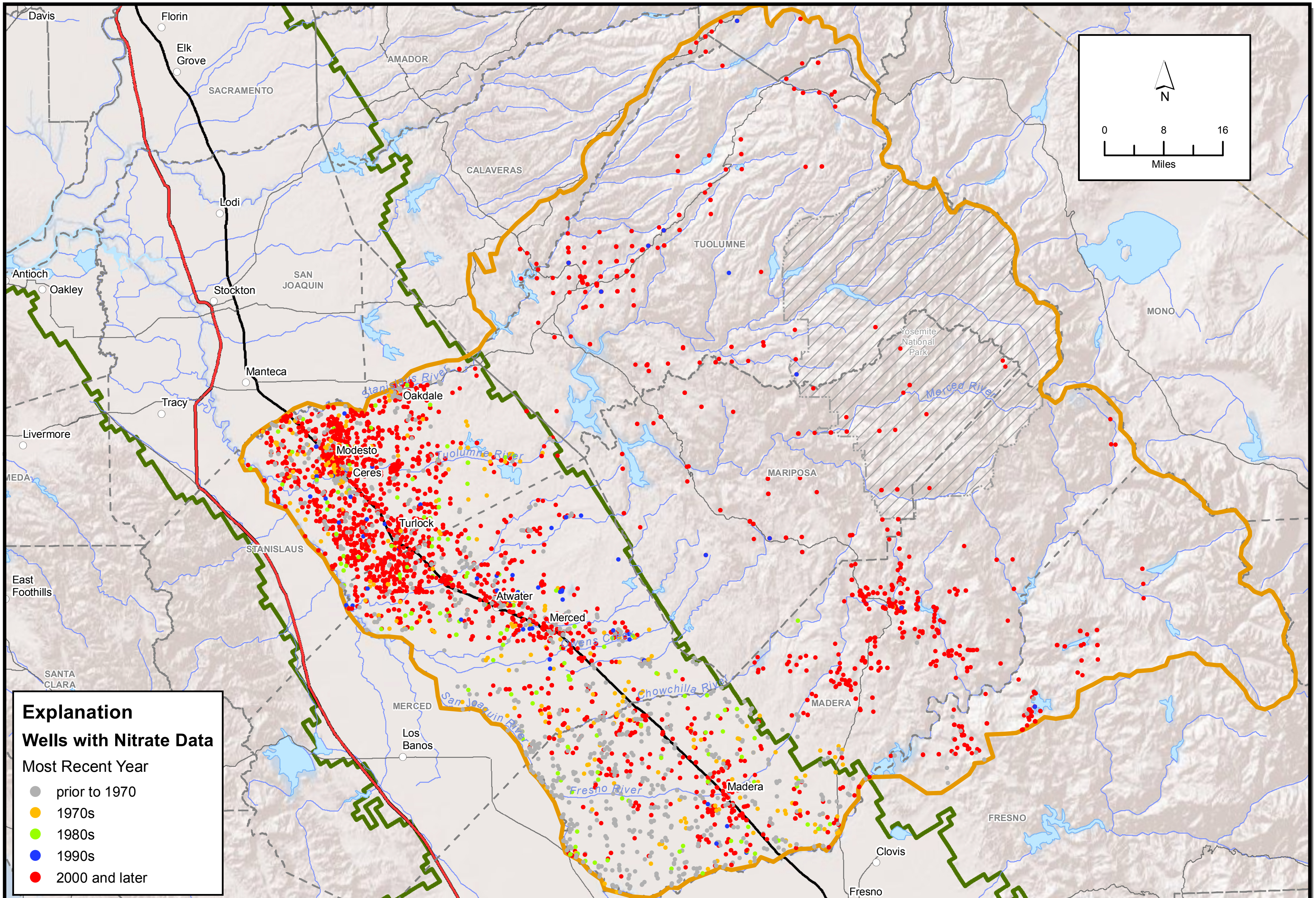
Figure 5-1b
Groundwater Quality Data by Source: TDS



Path: X:\2012 Job Files\12-118\Report\Figures\Final GIS Map Files\Figure 5-2a Groundwater NO3 Data by Year.mxd

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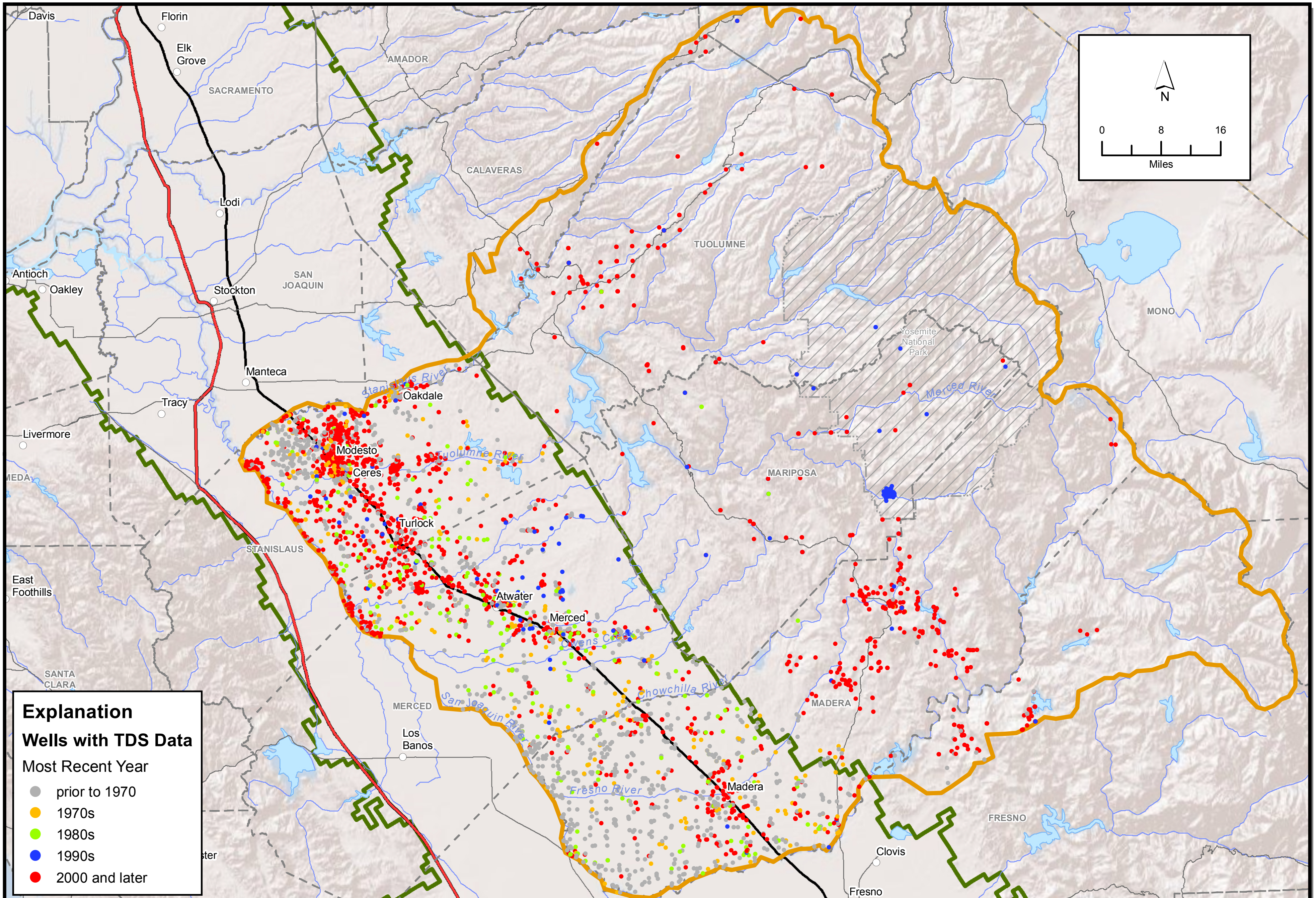
Figure 5-2a
Groundwater Quality Data by Most Recent Year: Nitrate



Path: X:\2012 Job Files\12-118\Report\Figures\Final GIS Map Files\Figure 5-2b Groundwater TDS Data by Year.mxd

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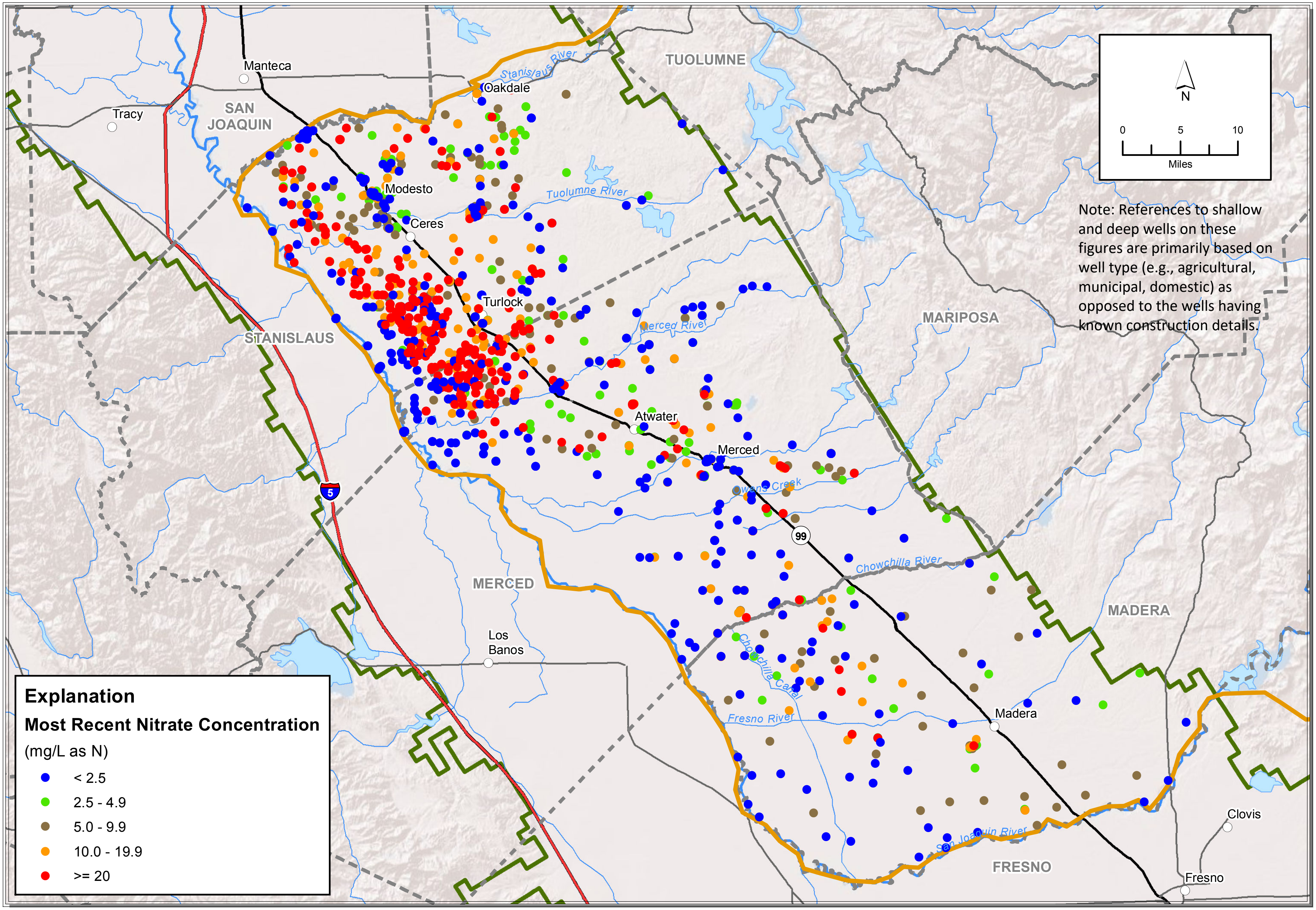
Figure 5-2b
Groundwater Quality Data by Most Recent Year: TDS



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

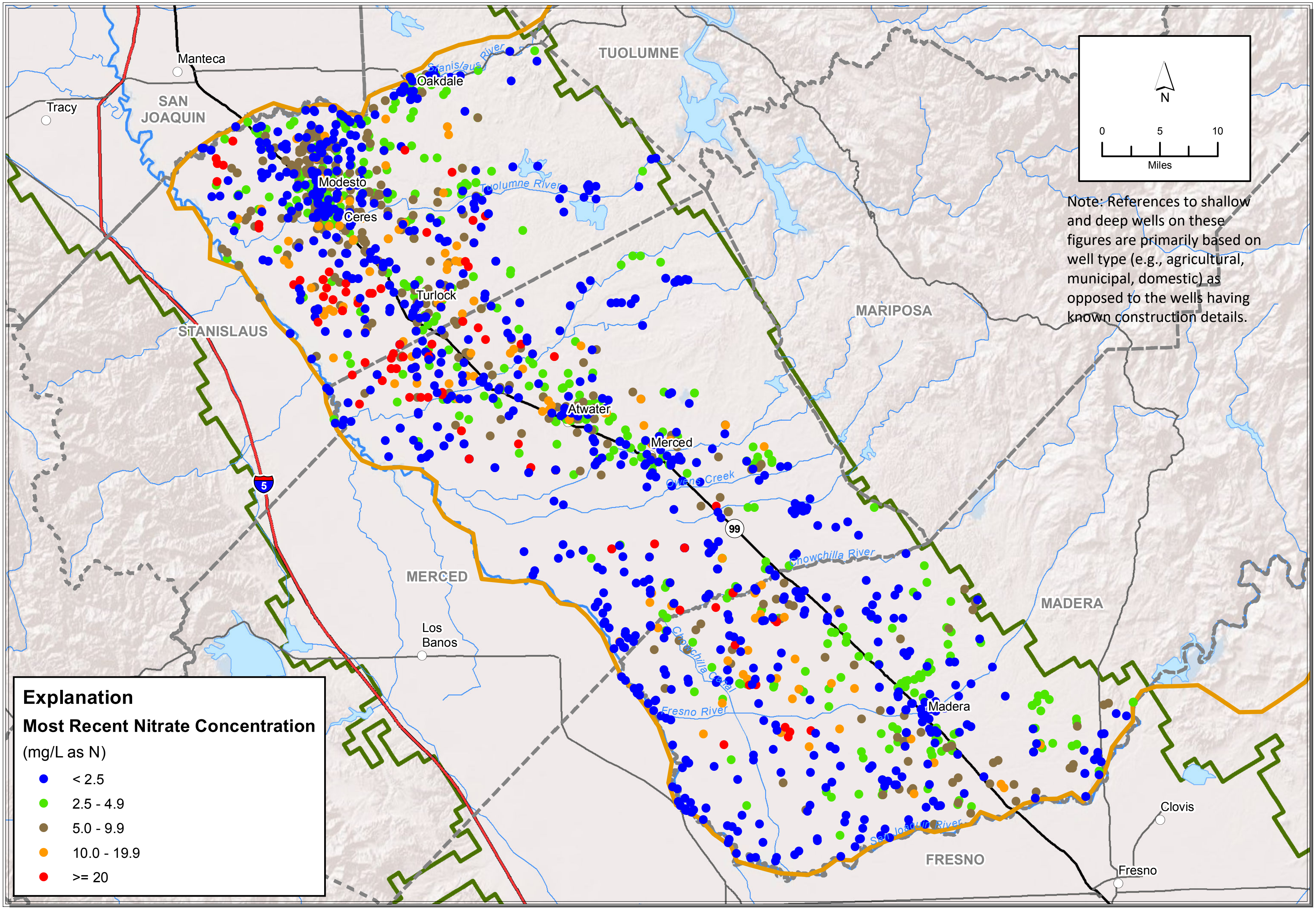

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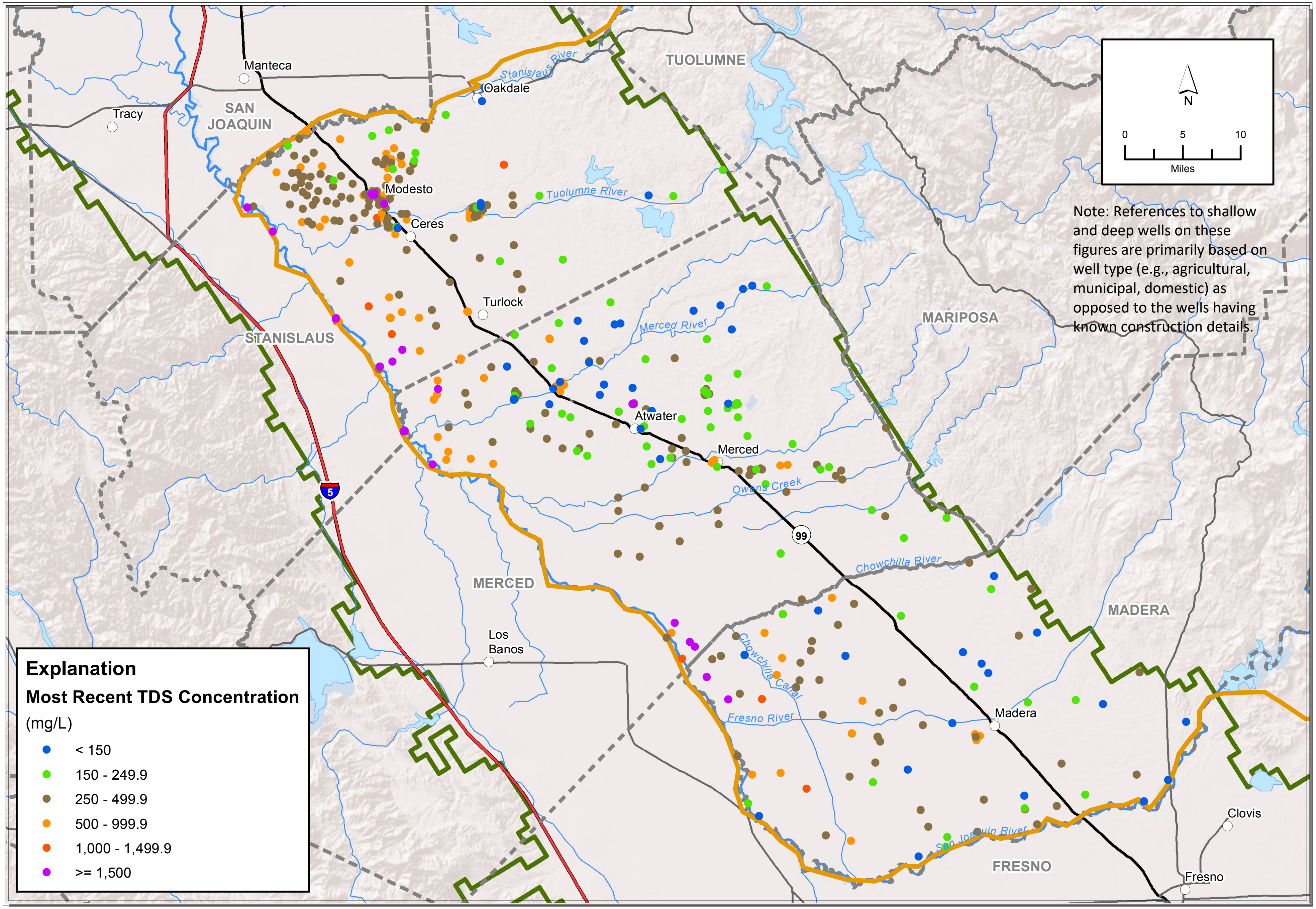
Figure 5-5
Nitrate Concentrations in the Central Valley Floor: Deep Wells



Path: X:\2012 Job Files\12-118\Report\Figures\Final GIS Map Files\Figure 5-7 TDS Concentrations in Central Valley Floor Shallow Wells.mxd

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Figure 5-7
TDS Concentrations in the Central Valley Floor: Shallow Wells

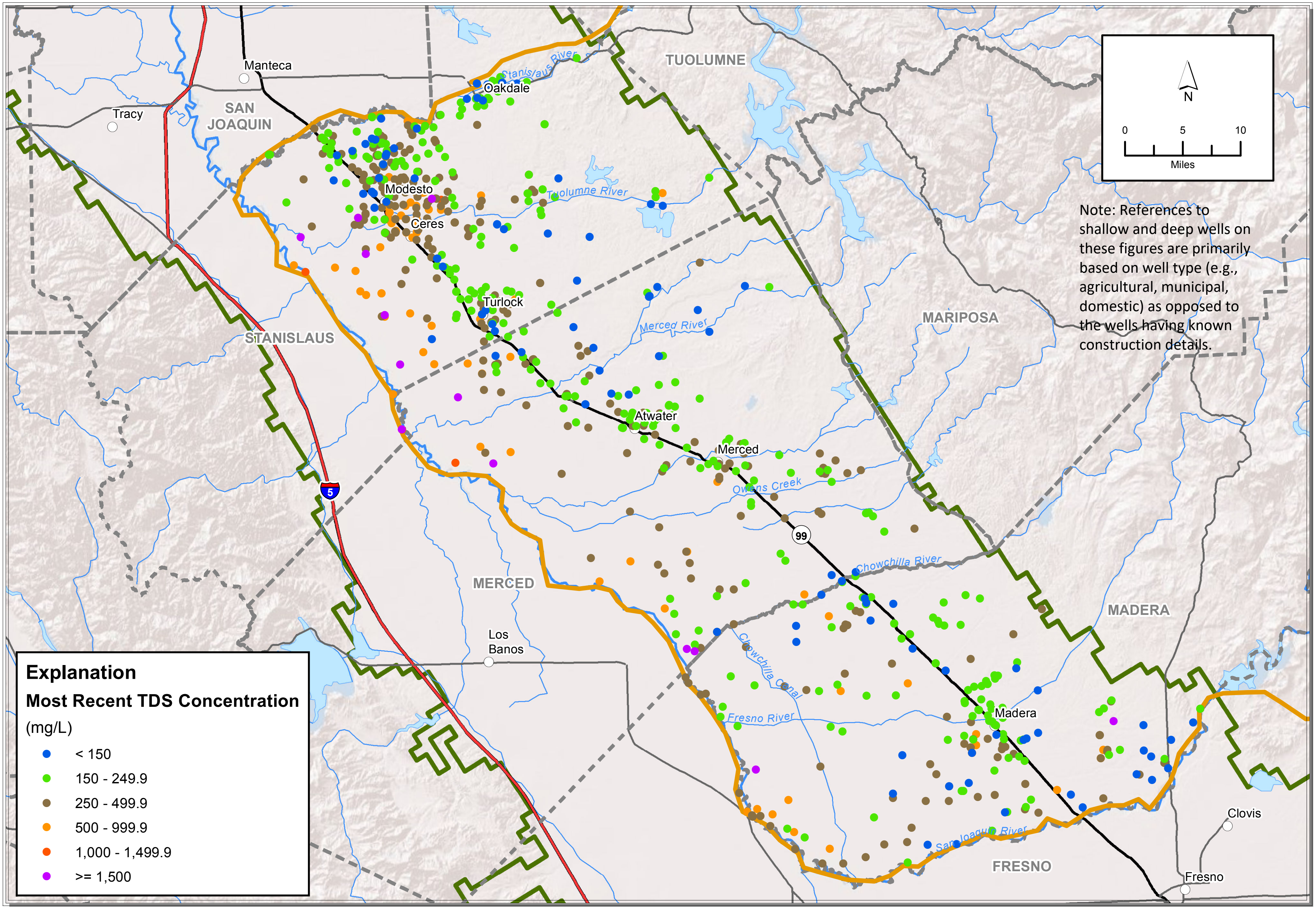

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Figure 5-8

TDS Concentrations in the Central Valley Floor: Deep Wells

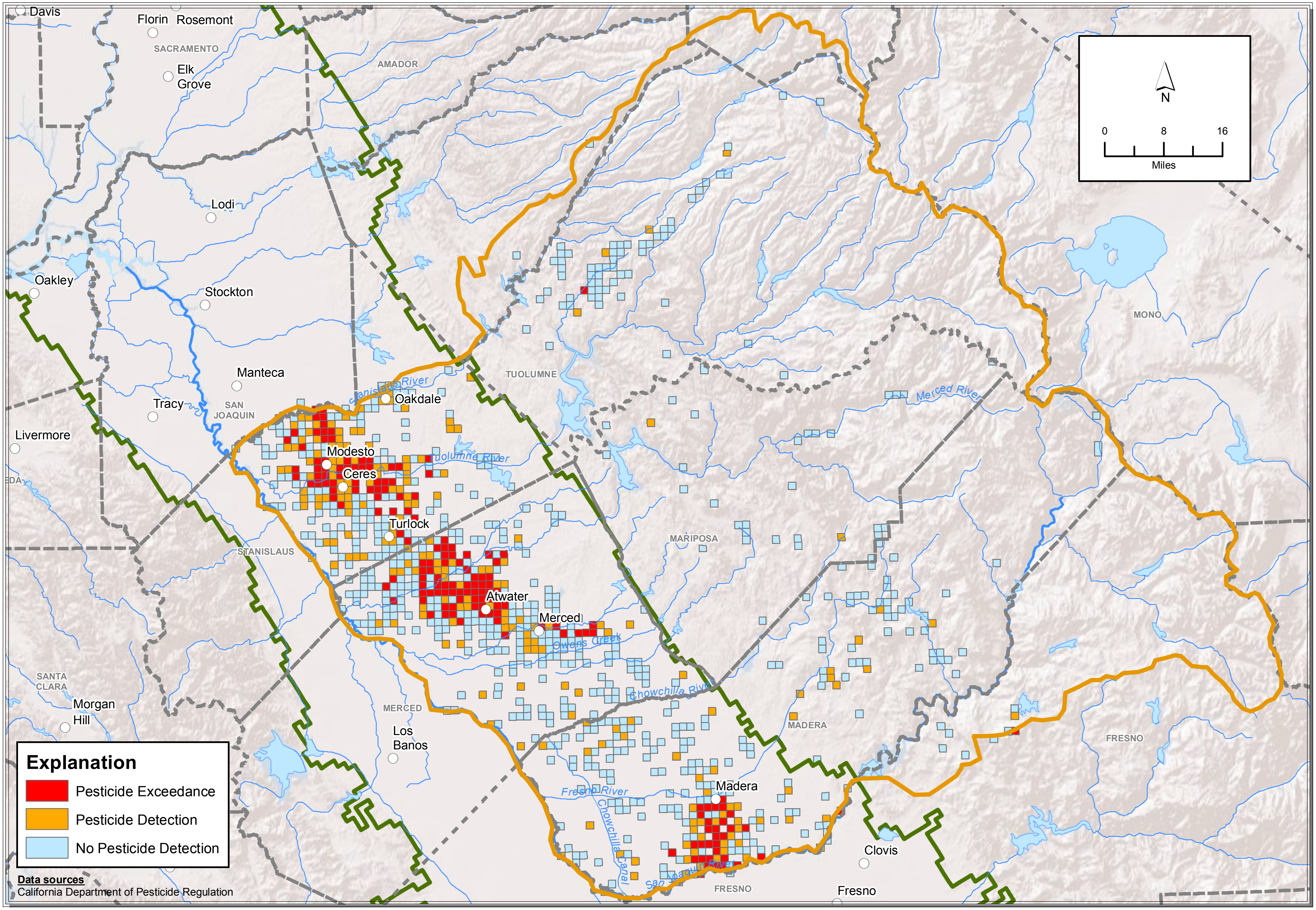

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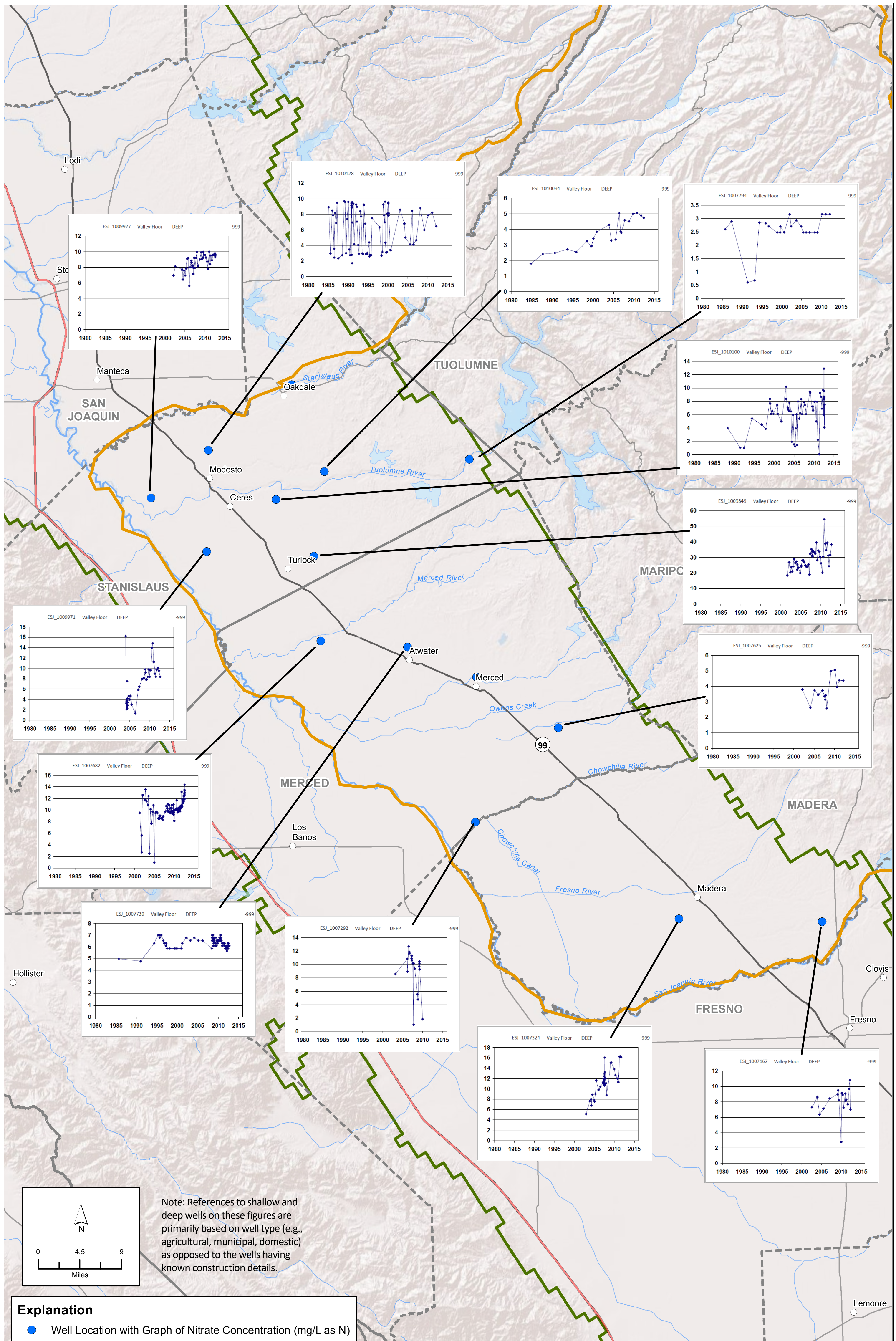
Figure 5-10c
Pesticide Detection Or Exceedance By Section



Path: X:\2012 Job Files\12-118\Report\Figures\Final GIS Map Files\Figure 5-12 Select Graphs of Nitrate Concentrations in Central Valley Floor Deep Wells.mxd

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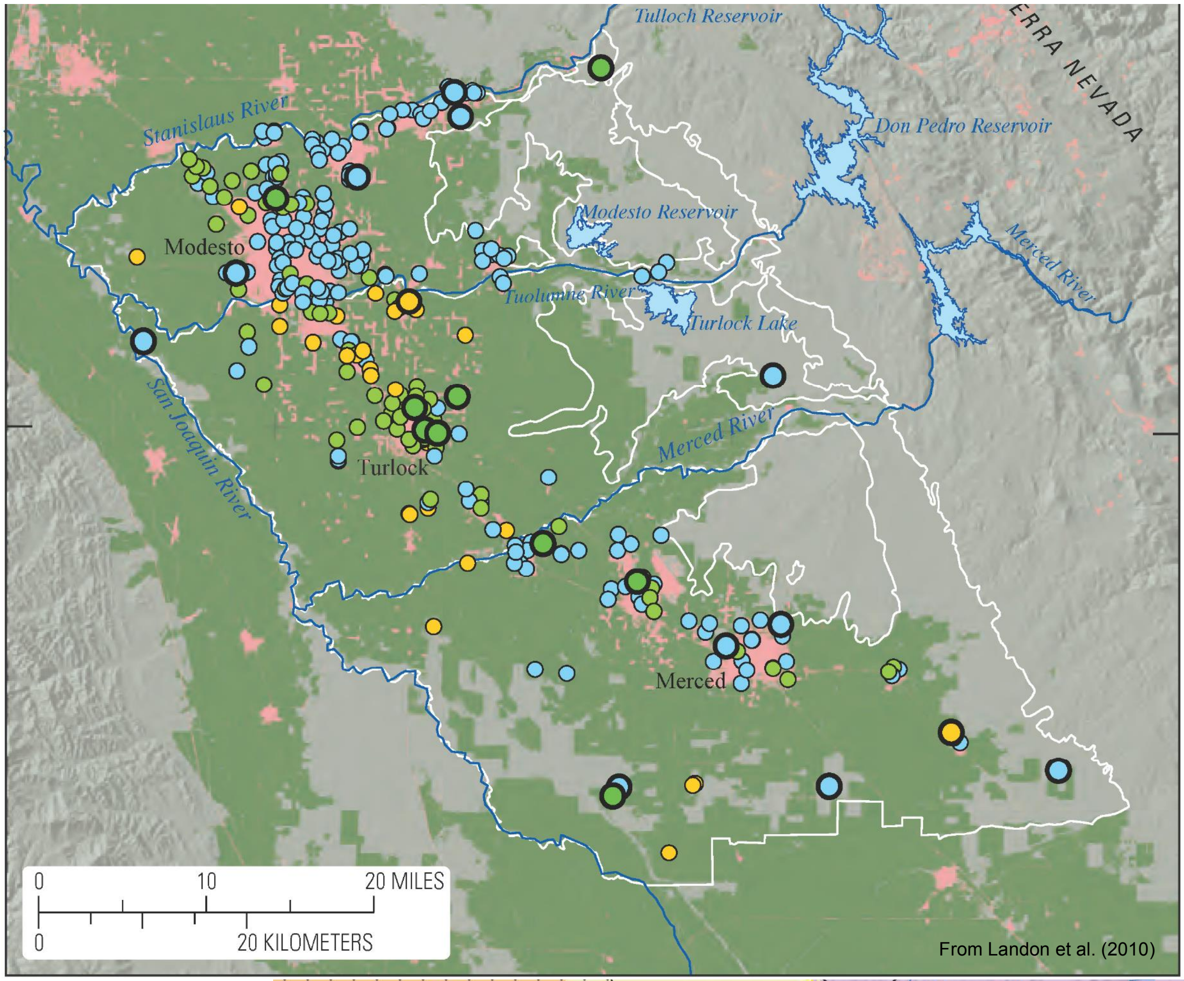
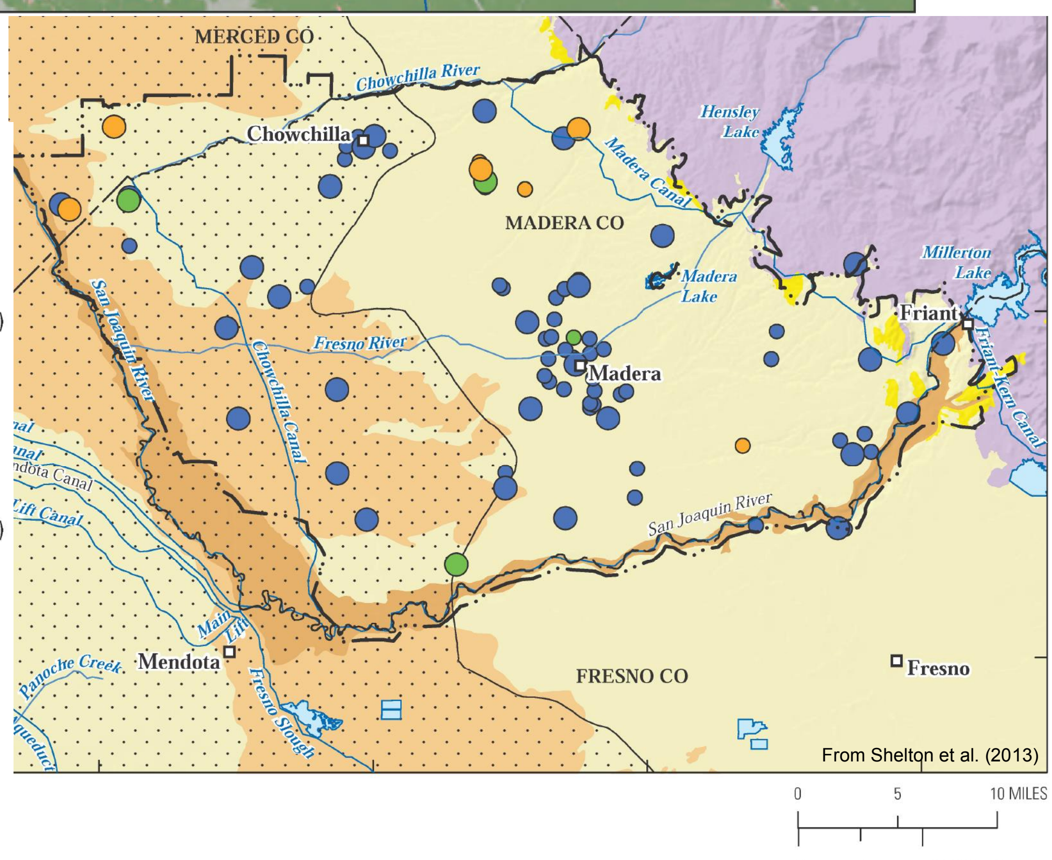
Figure 5-12
Select Graphs of Nitrate Concentrations in the Central Valley Floor: Deep Wells





EXPLANATION

USGS GAMA arsenic

- Low (< 5 micrograms per liter)
- Moderate (5 – 10 micrograms per liter)
- High (> 10 micrograms per liter)

CDPH arsenic

- Low (< 5 micrograms per liter)
- Moderate (5 – 10 micrograms per liter)
- High (> 10 micrograms per liter)

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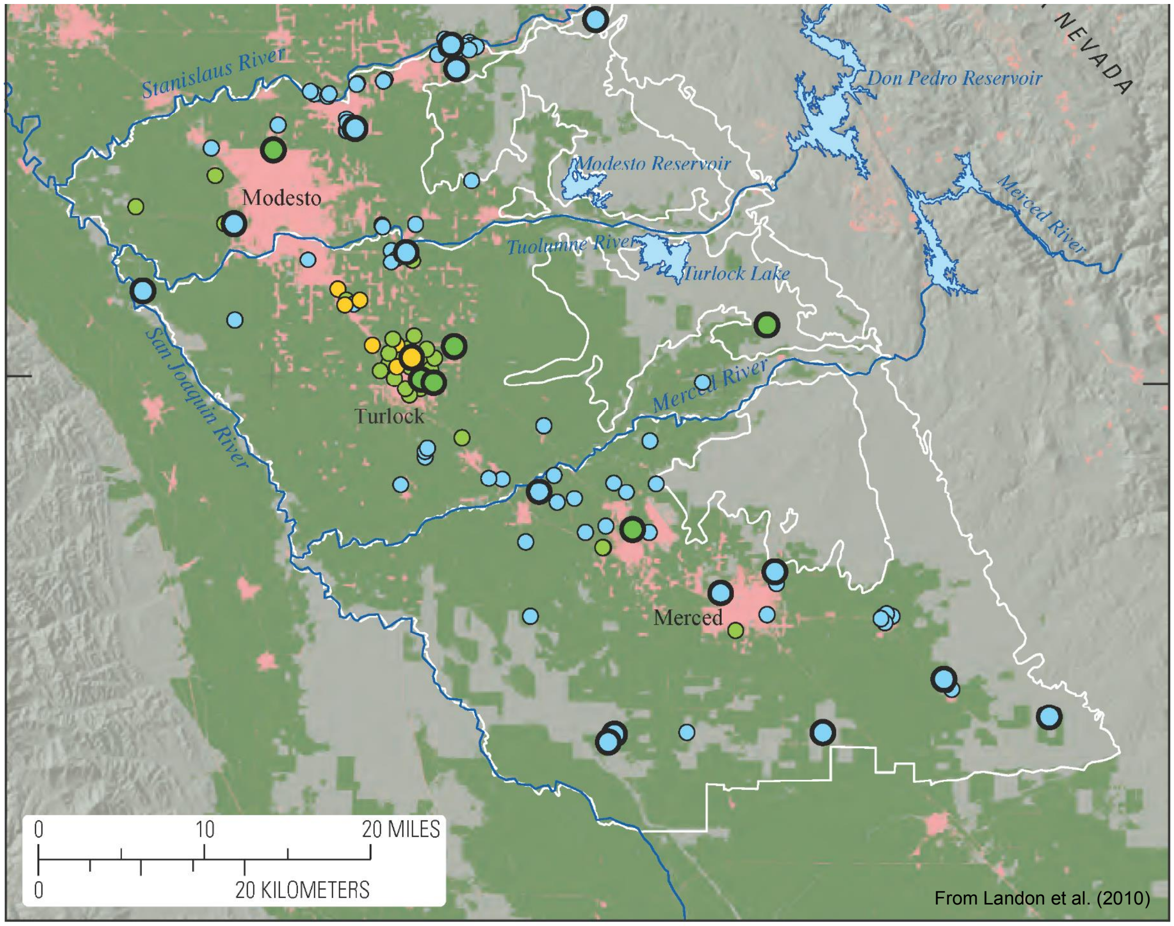
Figure 5-23a
Other Groundwater Quality Data: Arsenic



EXPLANATION

USGS GAMA vanadium

- Low (< 25 micrograms per liter)
- Moderate (25 – 50 micrograms per liter)
- High (> 50 micrograms per liter)

CDPH vanadium

- Low (< 25 micrograms per liter)
- Moderate (25 – 50 micrograms per liter)
- High (> 50 micrograms per liter)

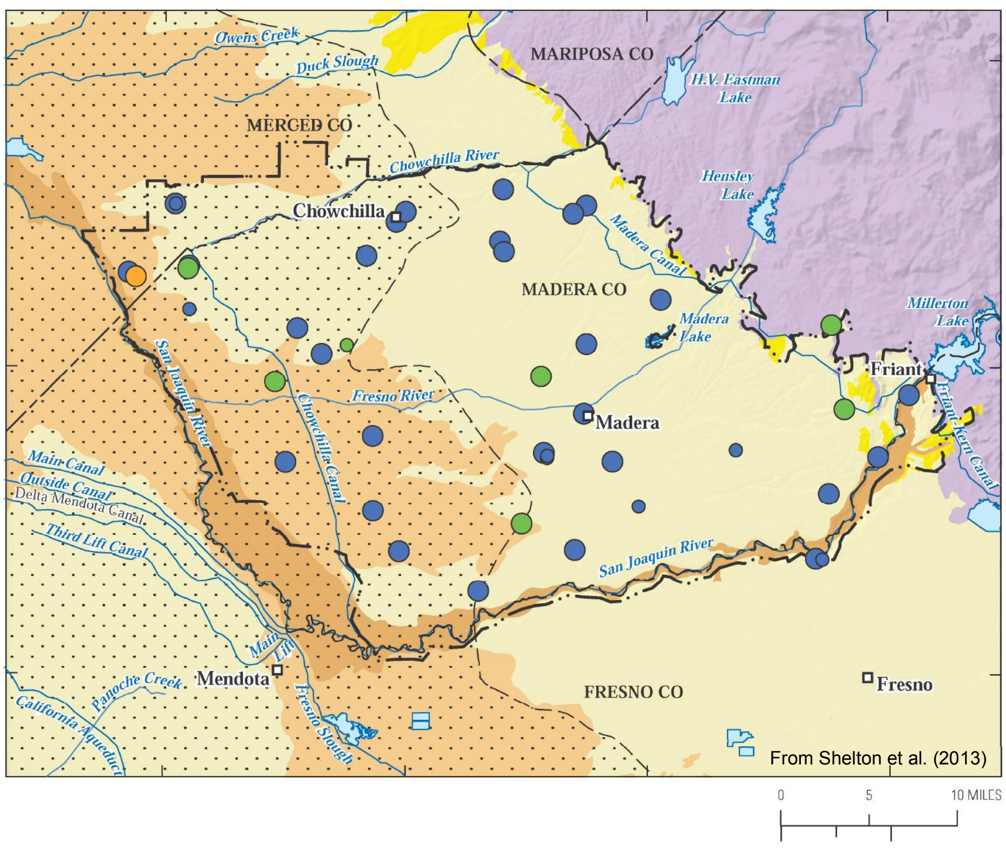


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Figure 5-23b
Other Groundwater Quality Data: Vanadium

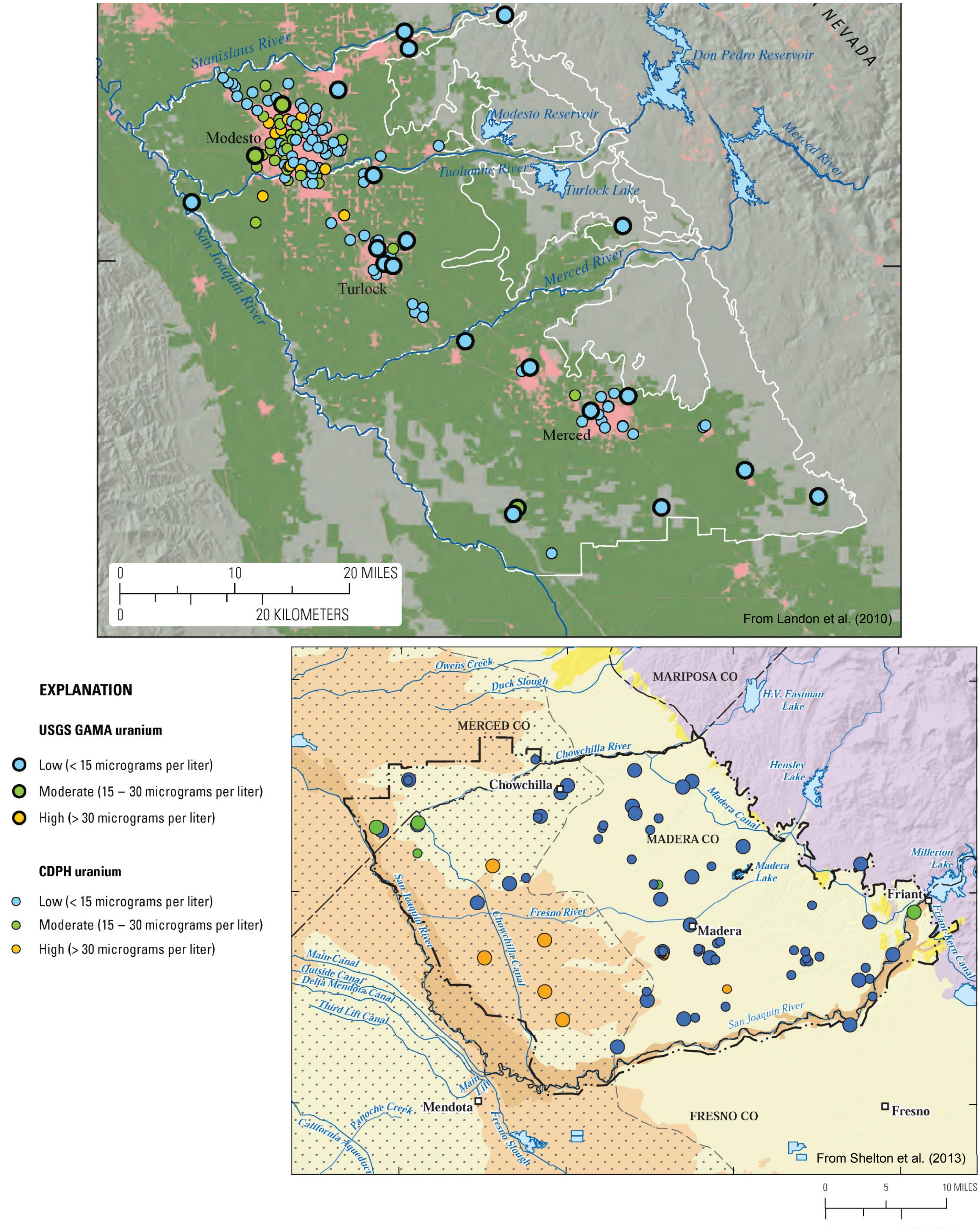
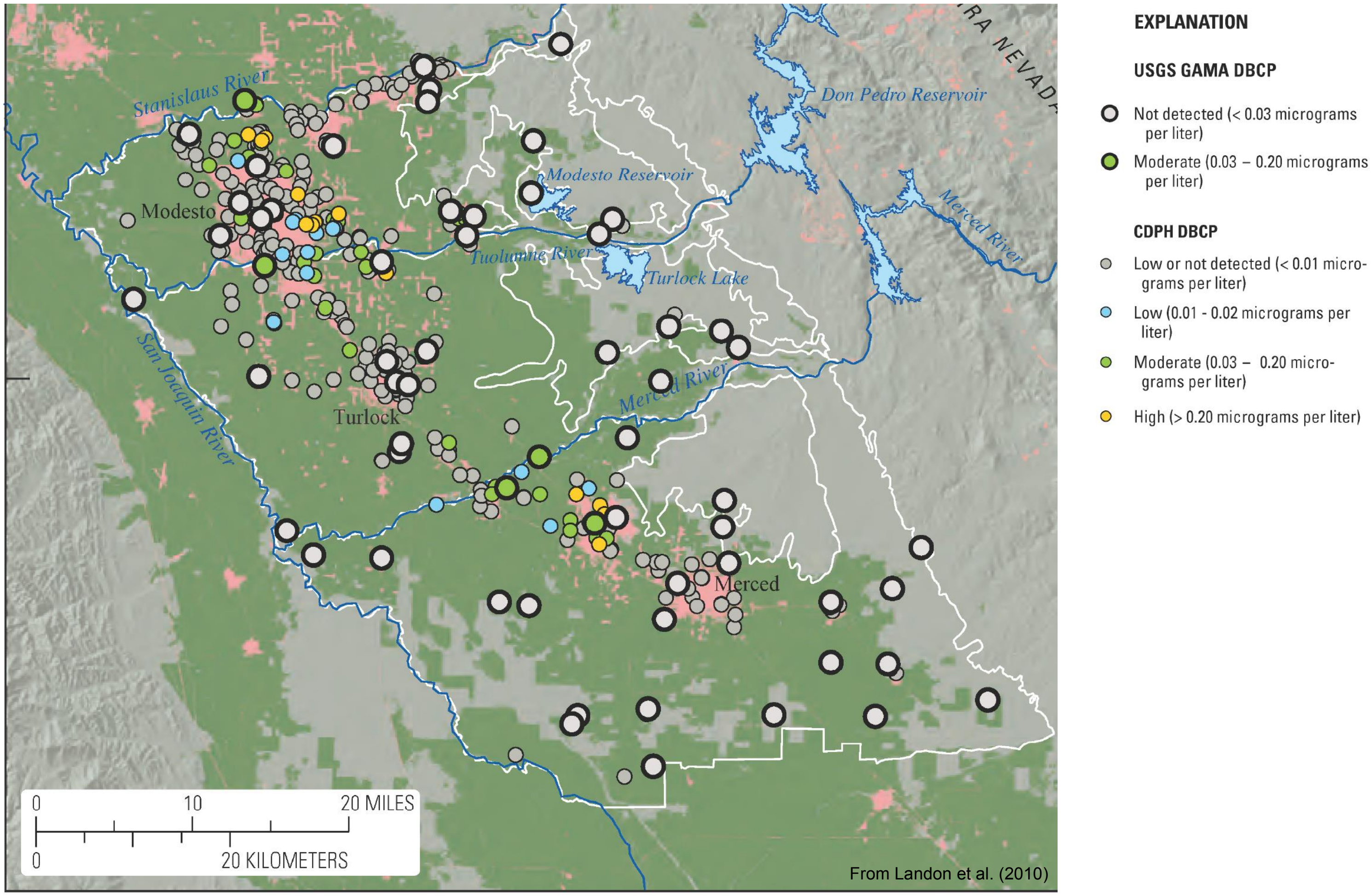


Figure 5-23c
Other Groundwater Quality Data: Uranium



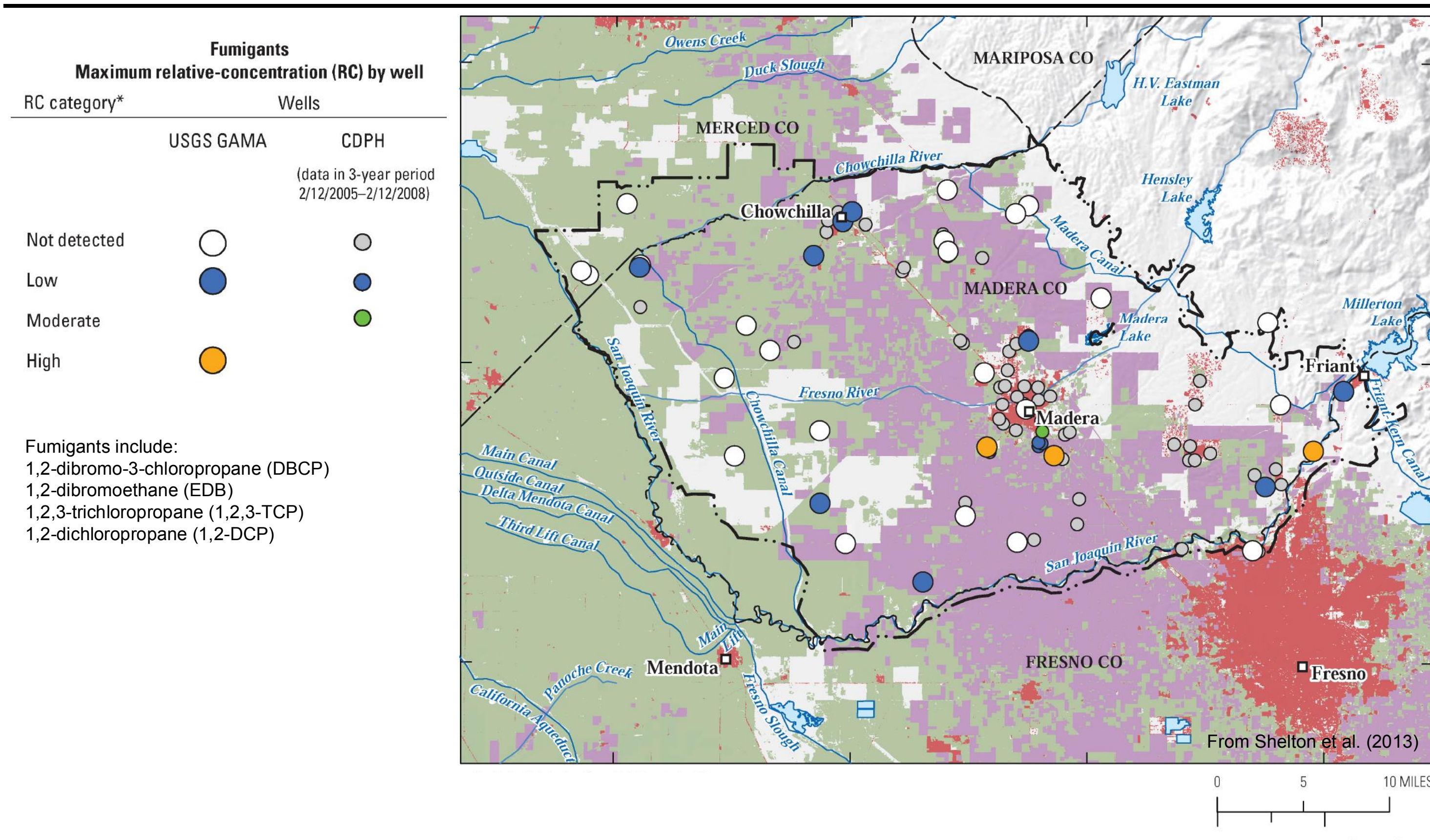
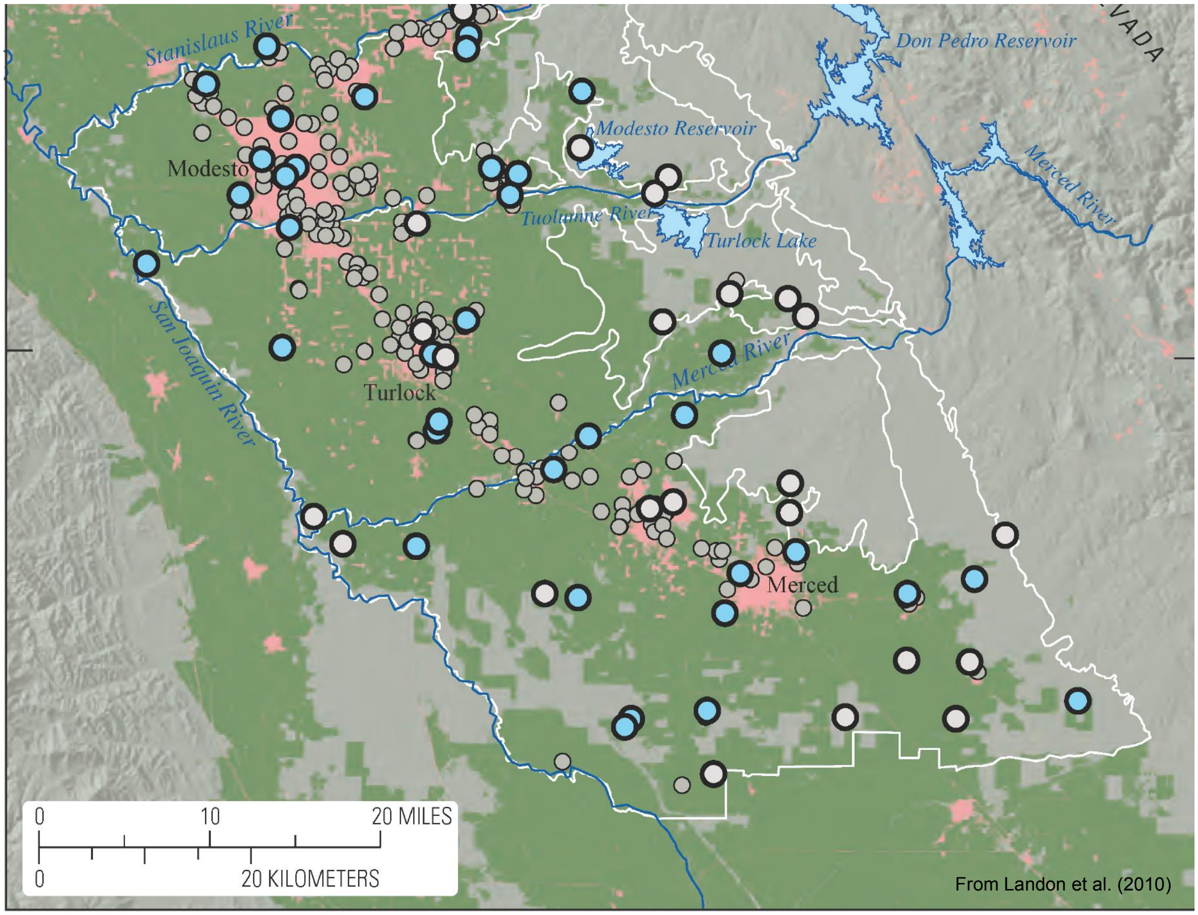
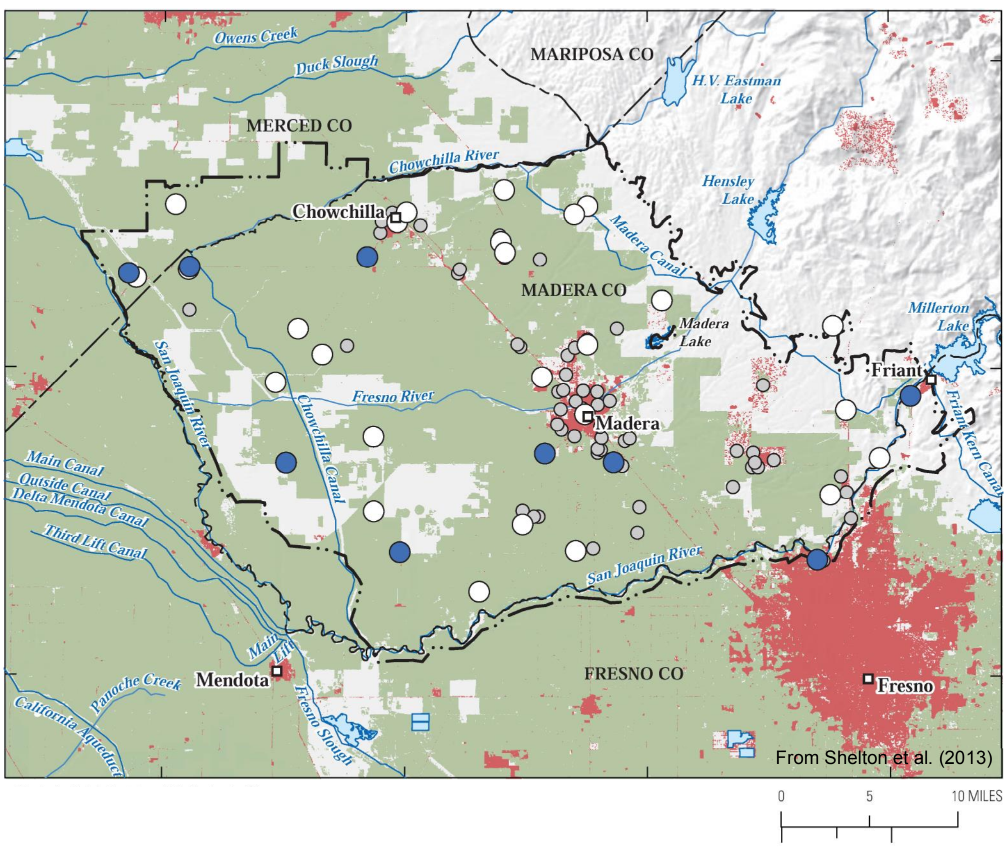


Figure 5-23d
Other Groundwater Quality Data: DBCP/Fumigants





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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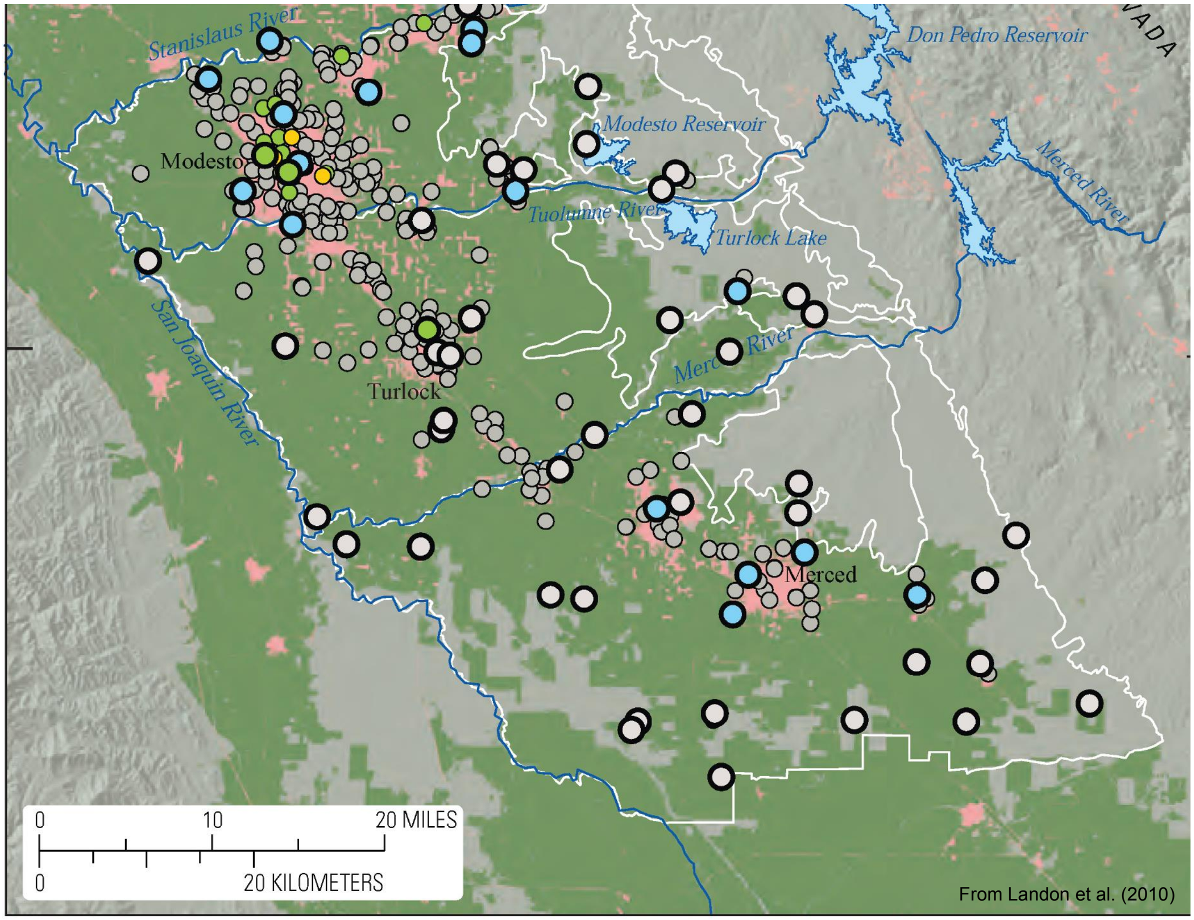
Figure 5-23e
Other Groundwater Quality Data: Herbicides



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

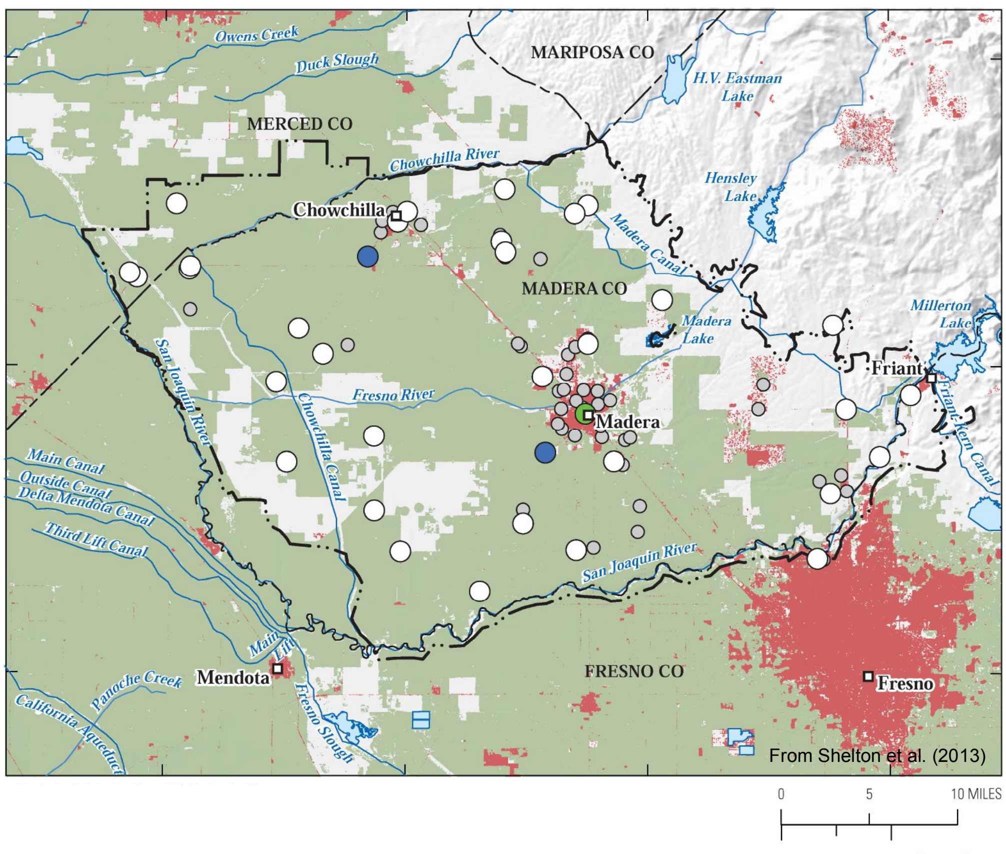


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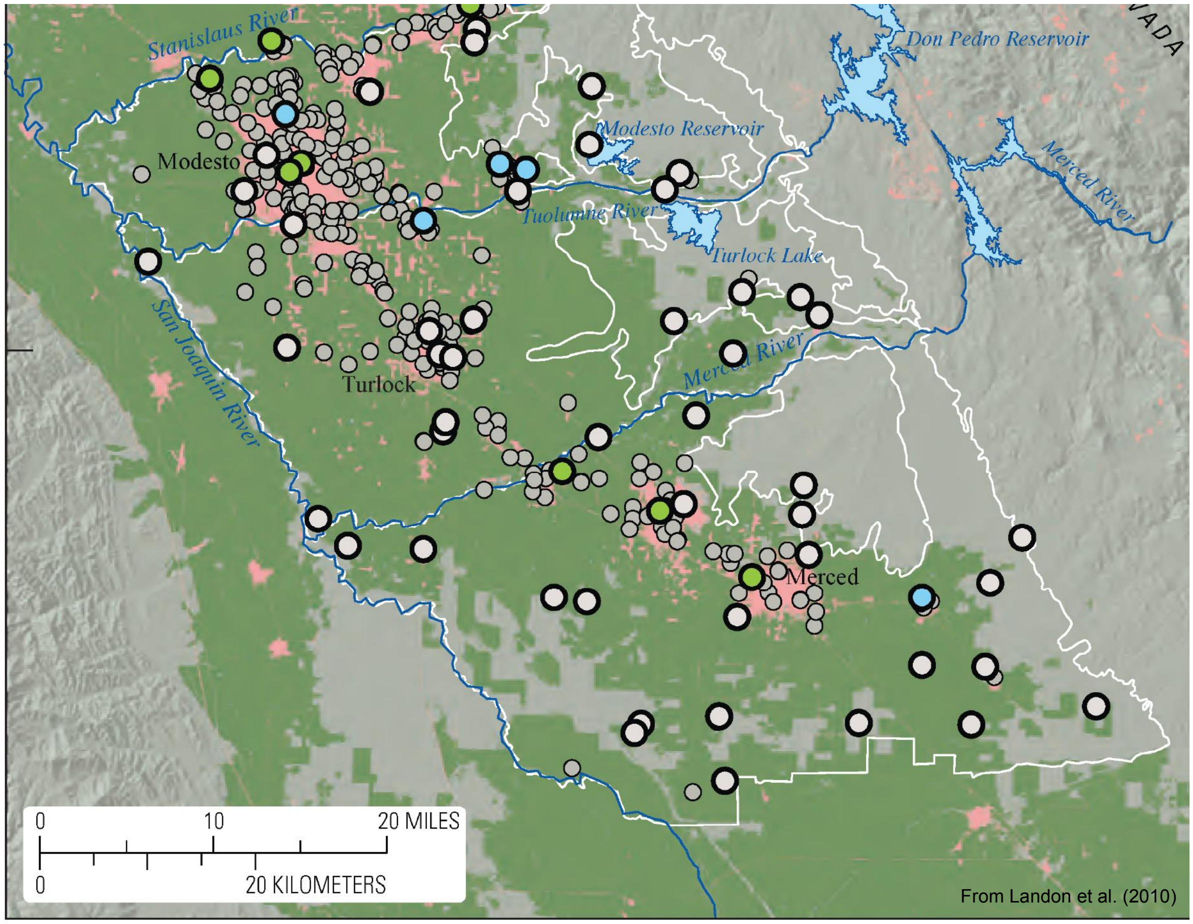
Figure 5-23f
Other Groundwater Quality Data: Solvents



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)

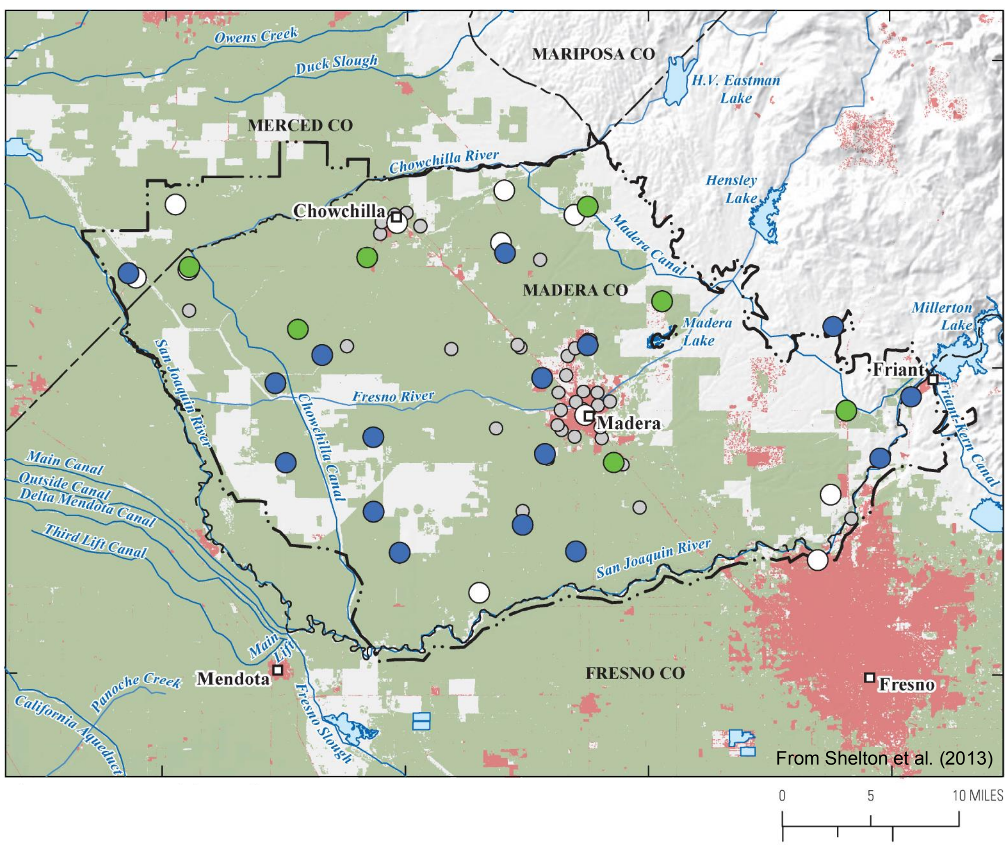
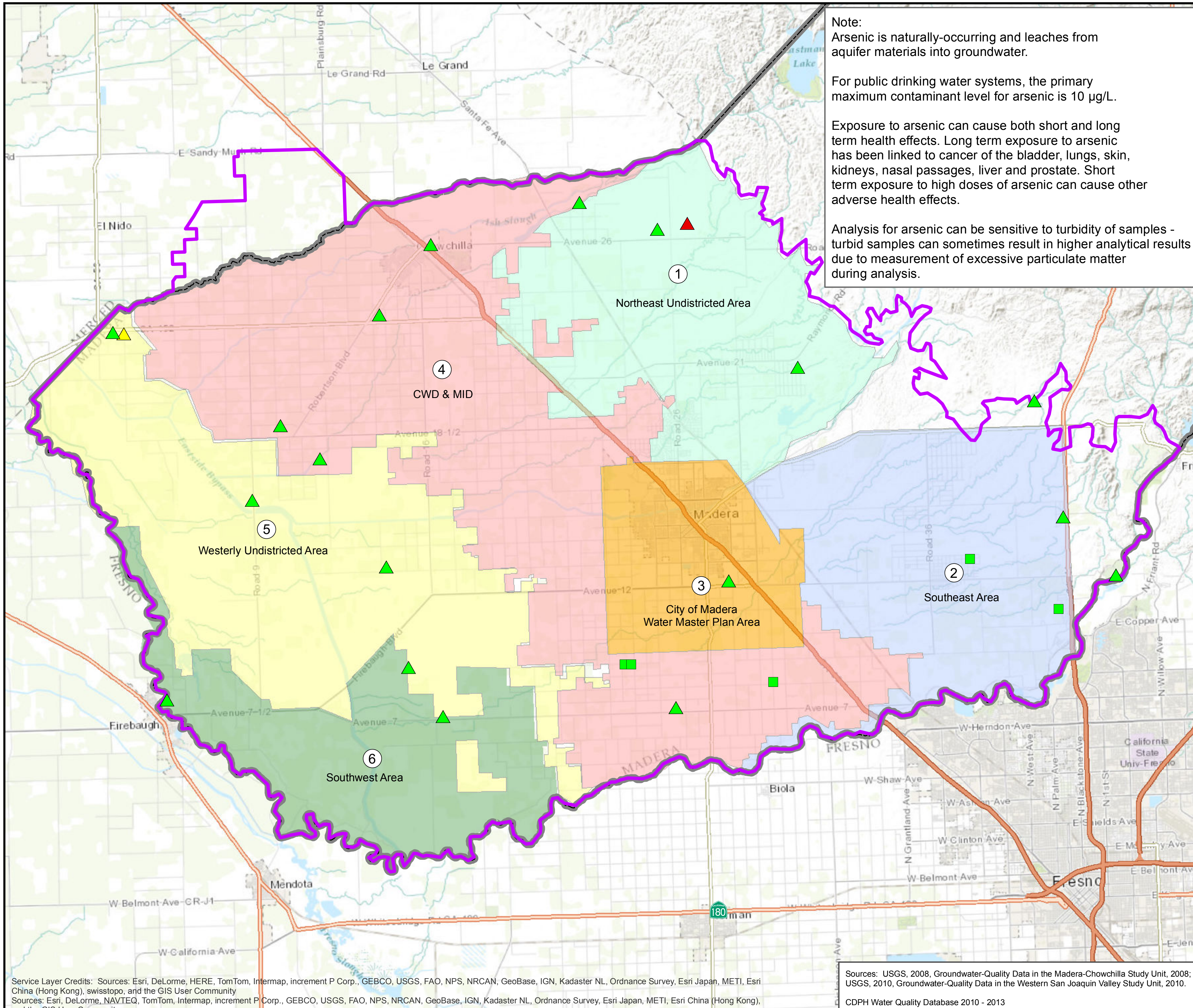


Figure 5-23g
Other Groundwater Quality Data: Perchlorate

MAP OF ARSENIC CONCENTRATION IN SHALLOW WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014

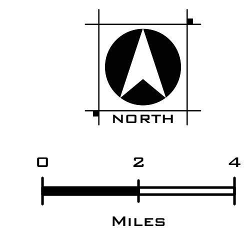


Note:
Arsenic is naturally-occurring and leaches from aquifer materials into groundwater.

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.

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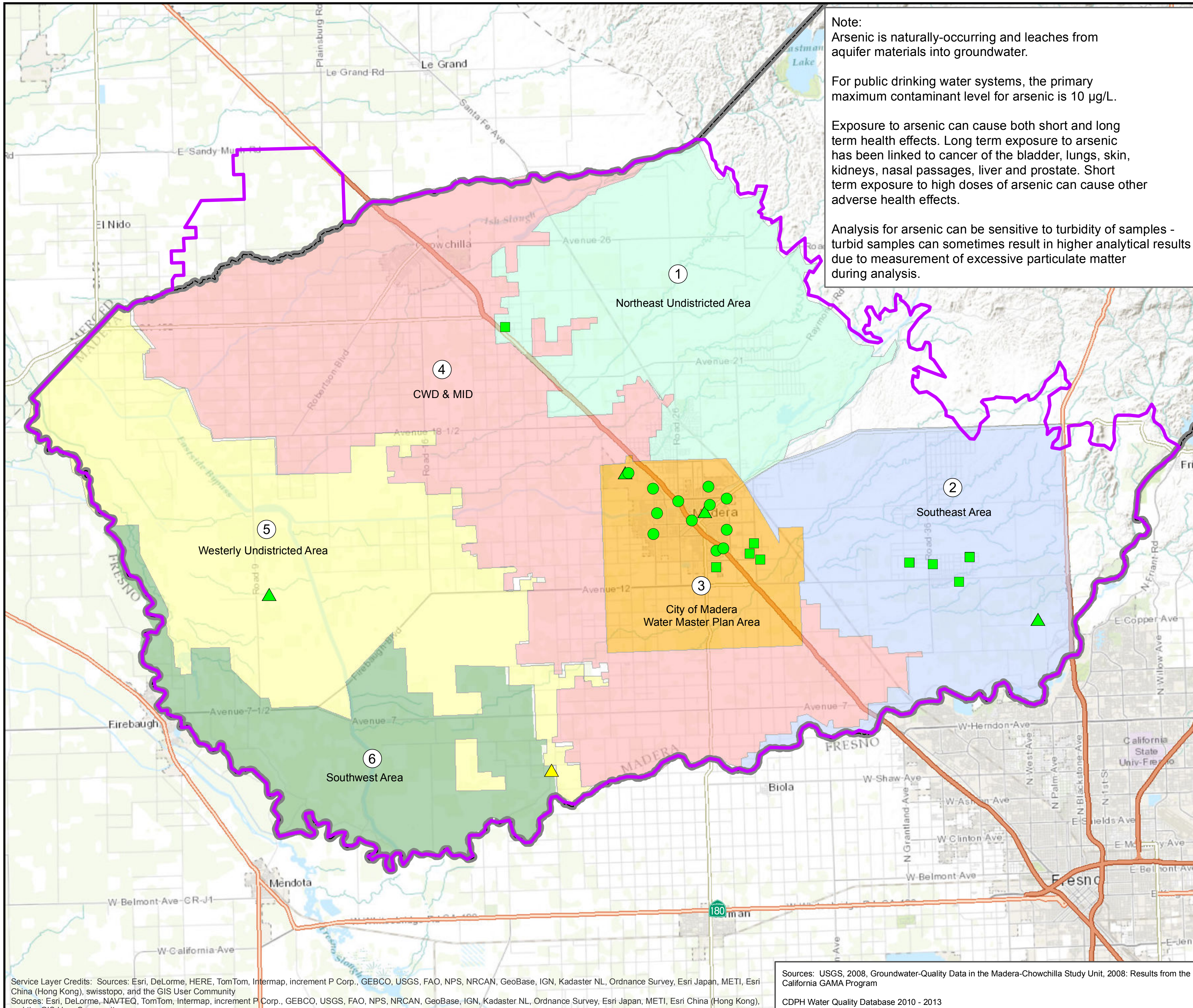

Note:
Arsenic is naturally-occurring and leaches from aquifer materials into groundwater.

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.

MAP OF ARSENIC CONCENTRATION IN INTERMEDIATE WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014

NORTH

0 2 4
MILES

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

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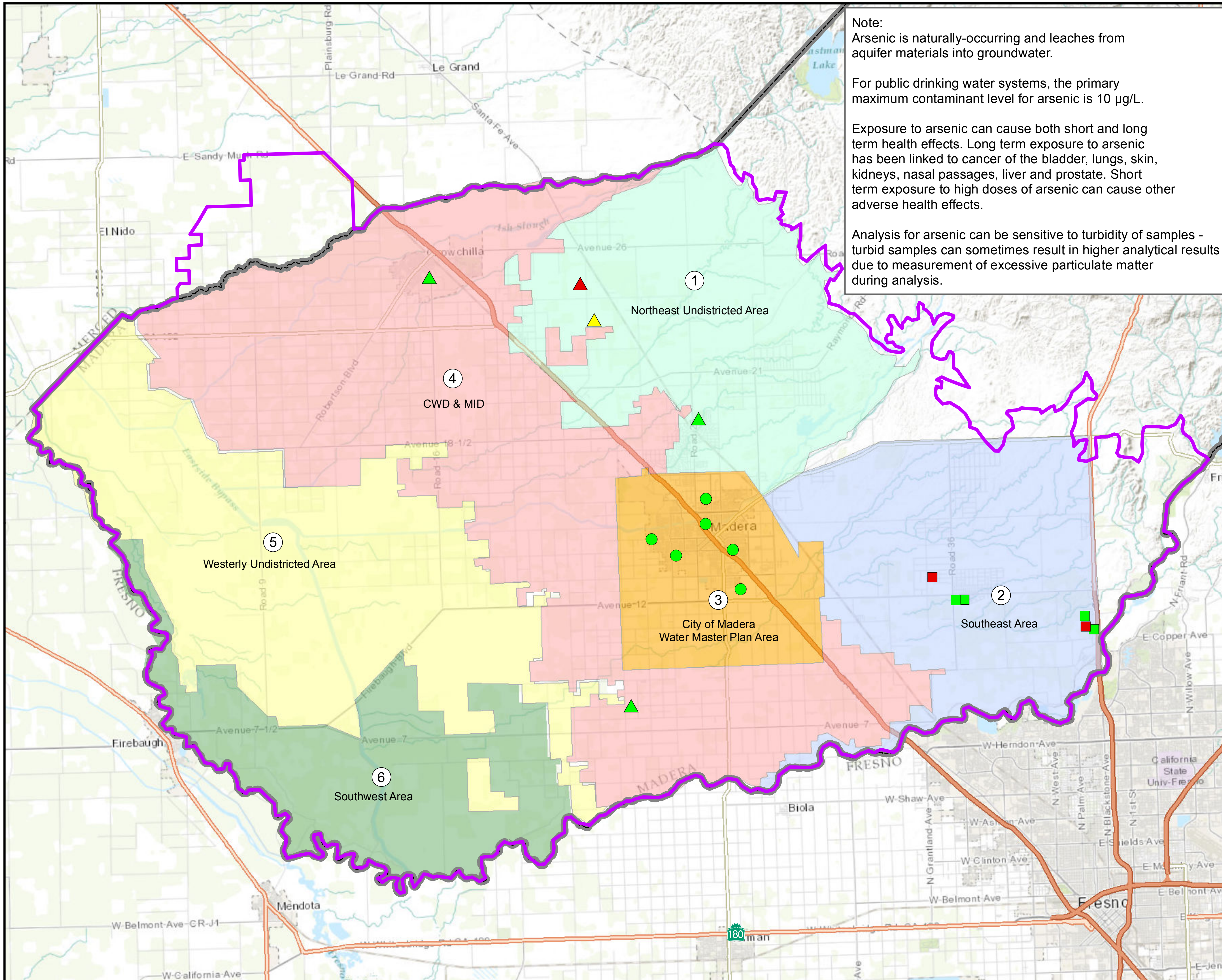
MAP OF ARSENIC CONCENTRATION IN DEEP WELLS

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.

NORTH

0 2 4
MILES

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.

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: USGS, 2008, Groundwater-Quality Data in the Madera-Chowchilla Study Unit, 2008: Results from the California GAMA Program

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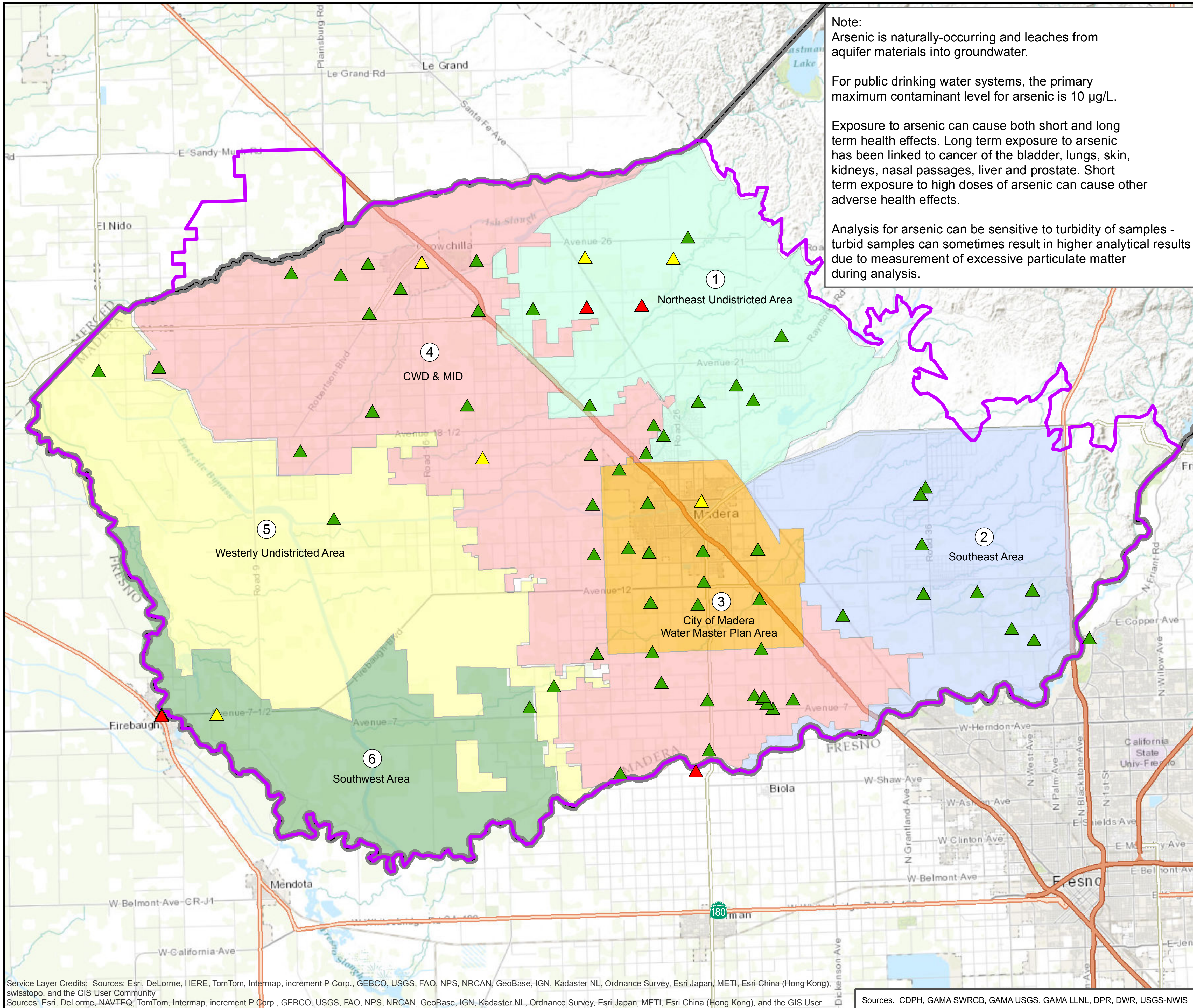
MAP OF ARSENIC CONCENTRATION IN WELLS OF UNKNOWN DEPTH

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014



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.

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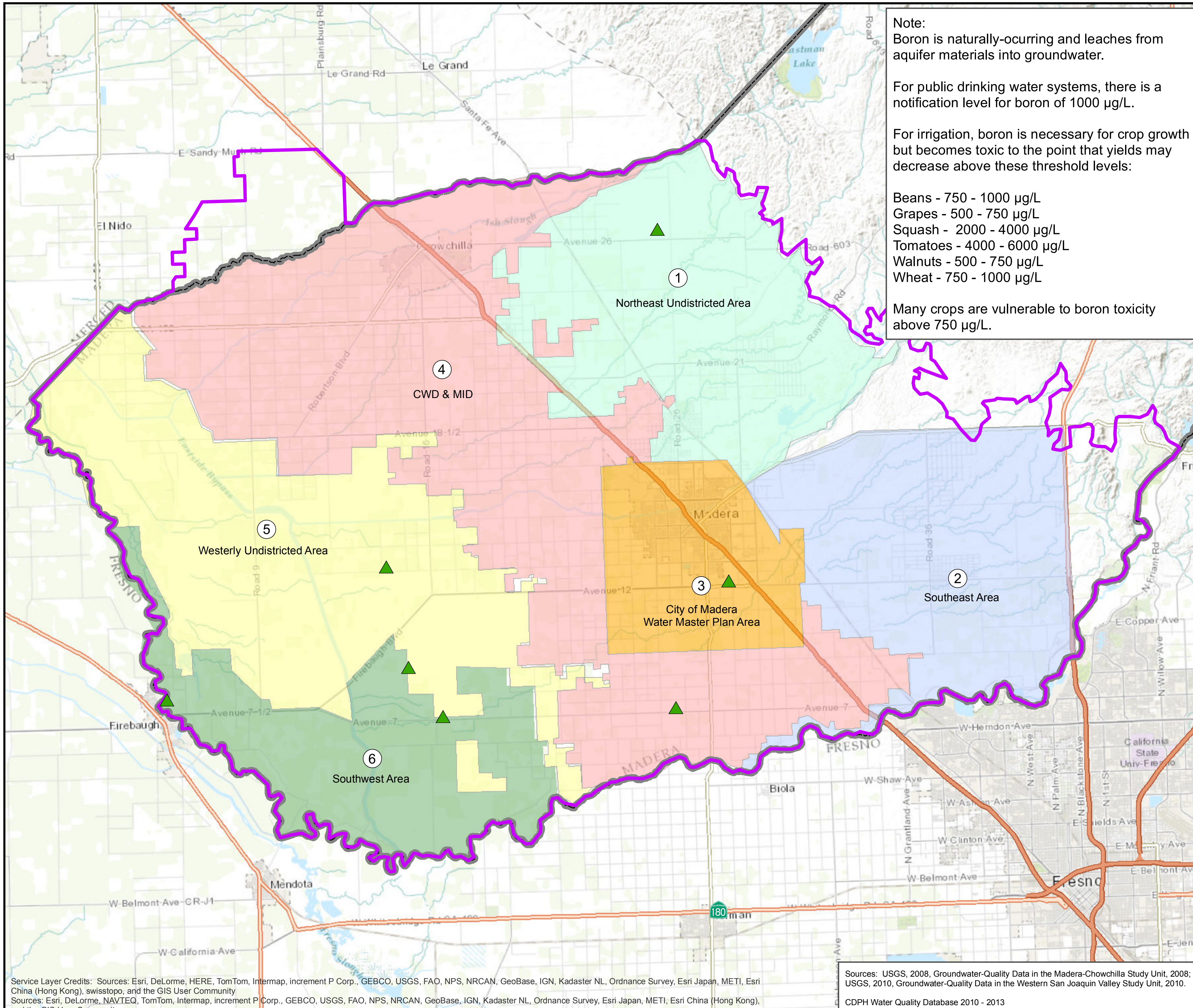

Note:
Boron is naturally-ocurring and leaches from aquifer materials into groundwater.

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.

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: 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

MAP OF BORON CONCENTRATION IN SHALLOW WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014

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

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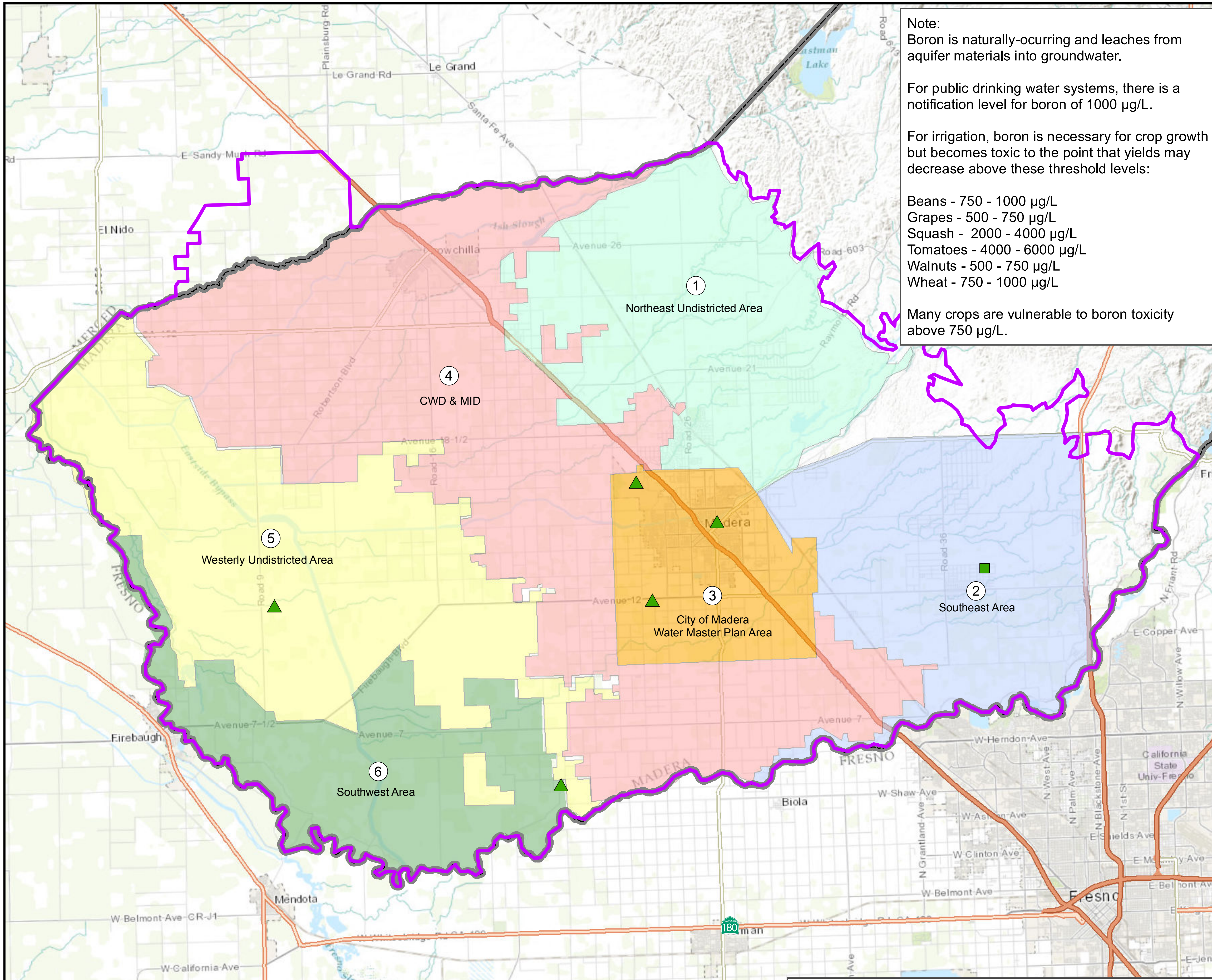
MAP OF BORON CONCENTRATION IN INTERMEDIATE WELLS

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.

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.

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: USGS, 2008, Groundwater-Quality Data in the Madera-Chowchilla Study Unit, 2008: Results from the California GAMA Program

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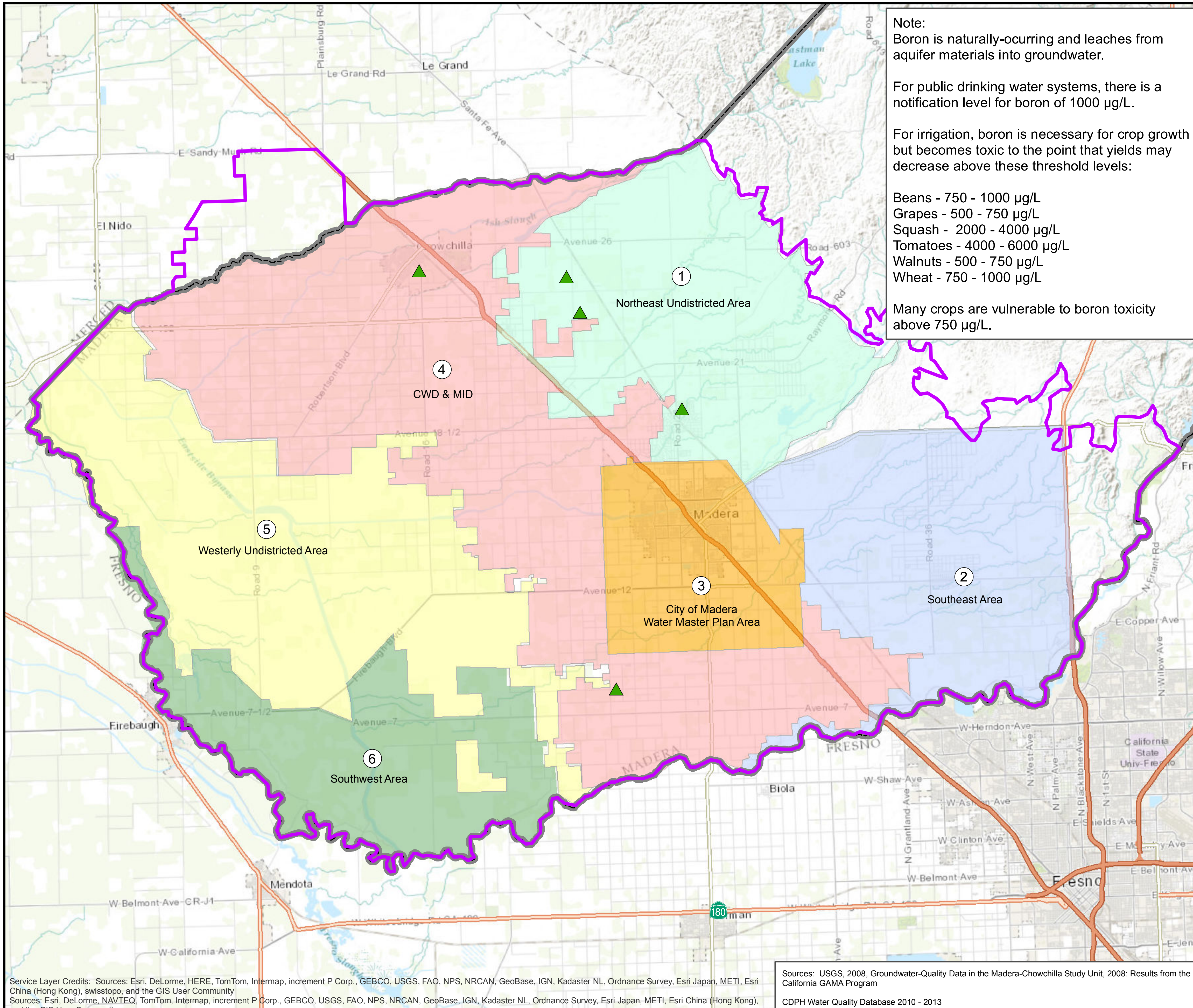
MAP OF BORON CONCENTRATION IN DEEP WELLS

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.

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Sources: USGS, 2008, Groundwater-Quality Data in the Madera-Chowchilla Study Unit, 2008: Results from the California GAMA Program

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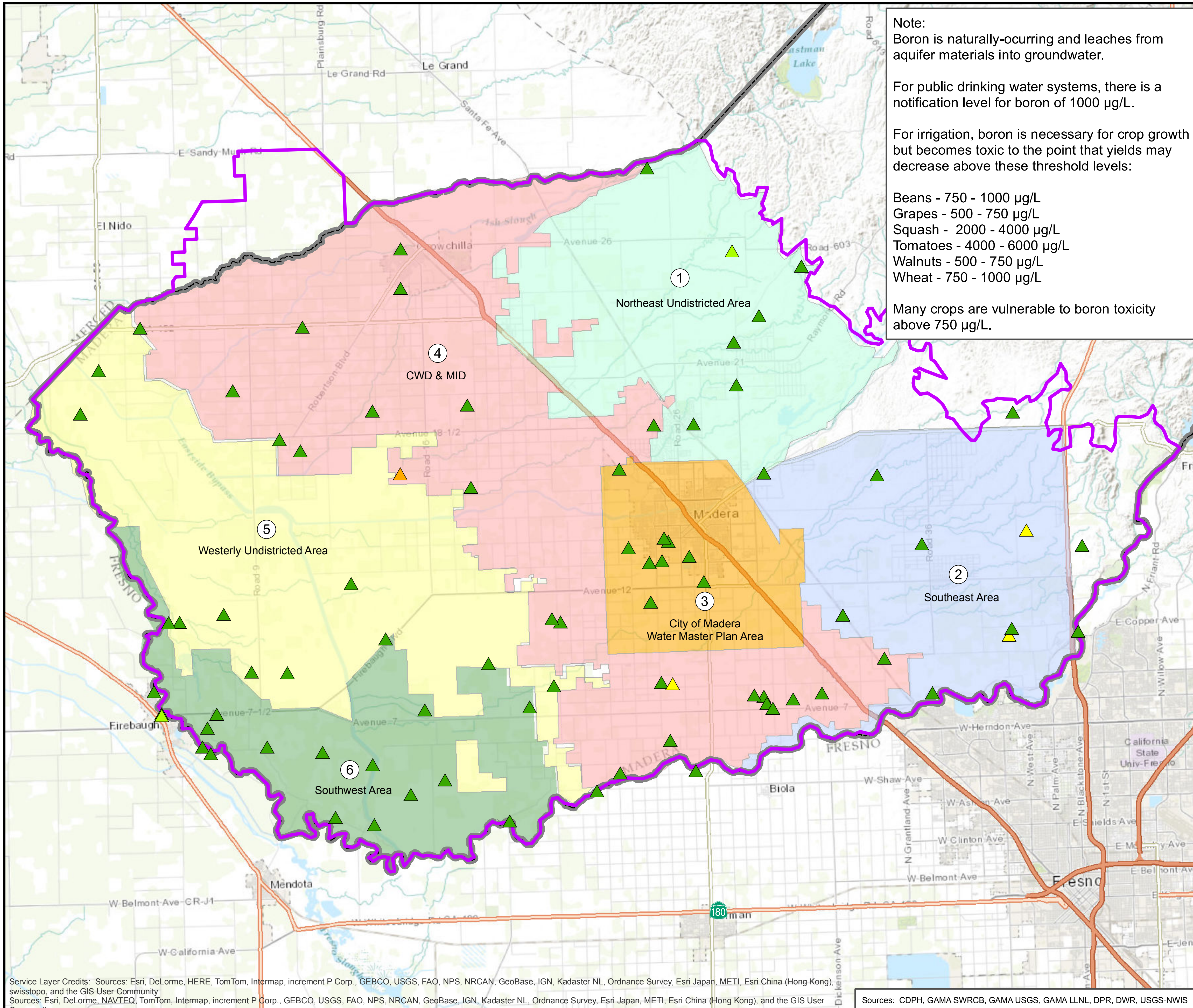
MAP OF BORON CONCENTRATION IN WELLS OF UNKNOWN DEPTH

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 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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Sources: CDPH, GAMA SWRCB, GAMA USGS, GAMA LLNL, DPR, DWR, USGS-NWIS

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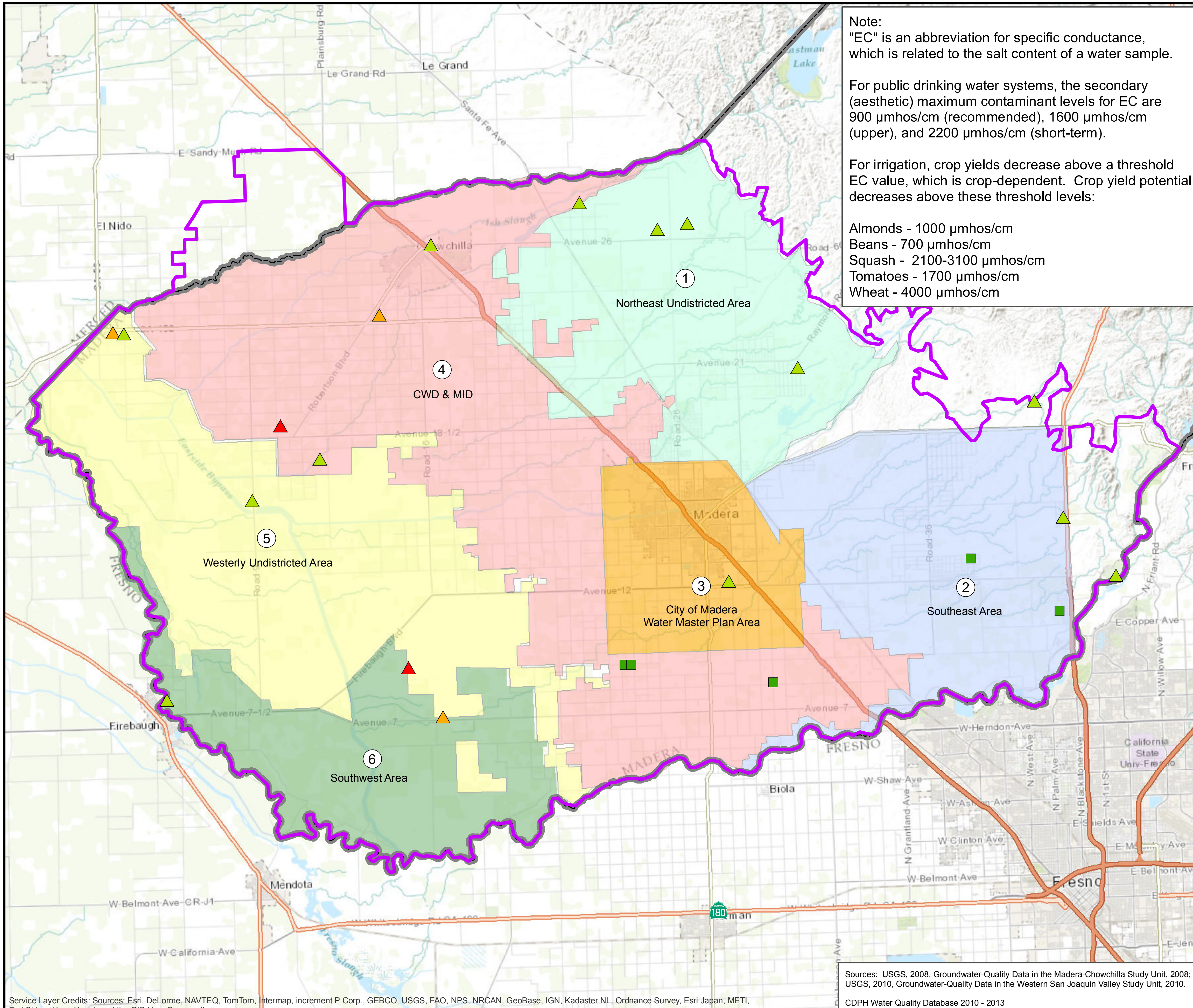
MAP OF SPECIFIC CONDUCTANCE IN SHALLOW WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014



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

NORTH

0 2 4
MILES

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.
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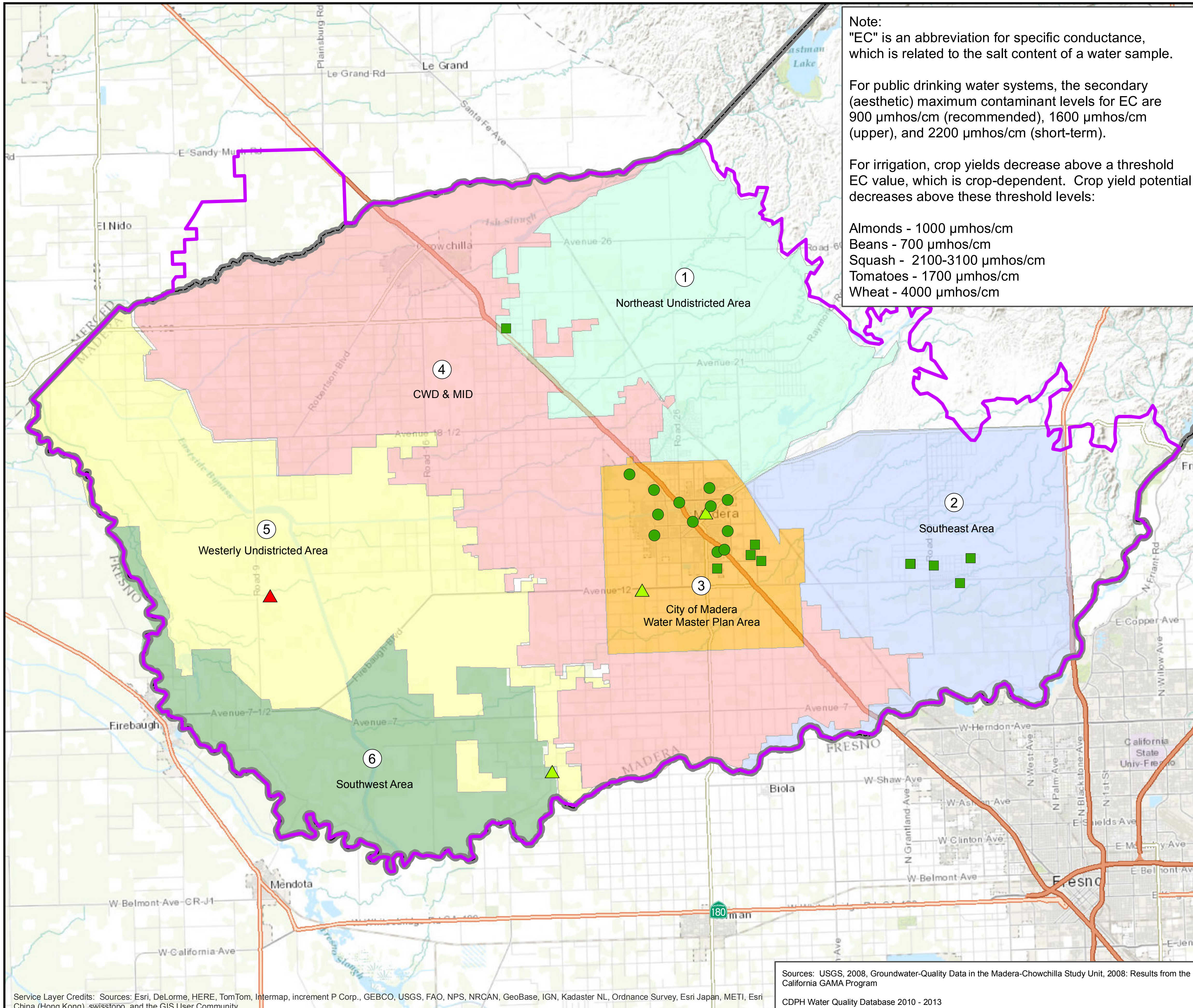

MAP OF SPECIFIC CONDUCTANCE IN INTERMEDIATE WELLS

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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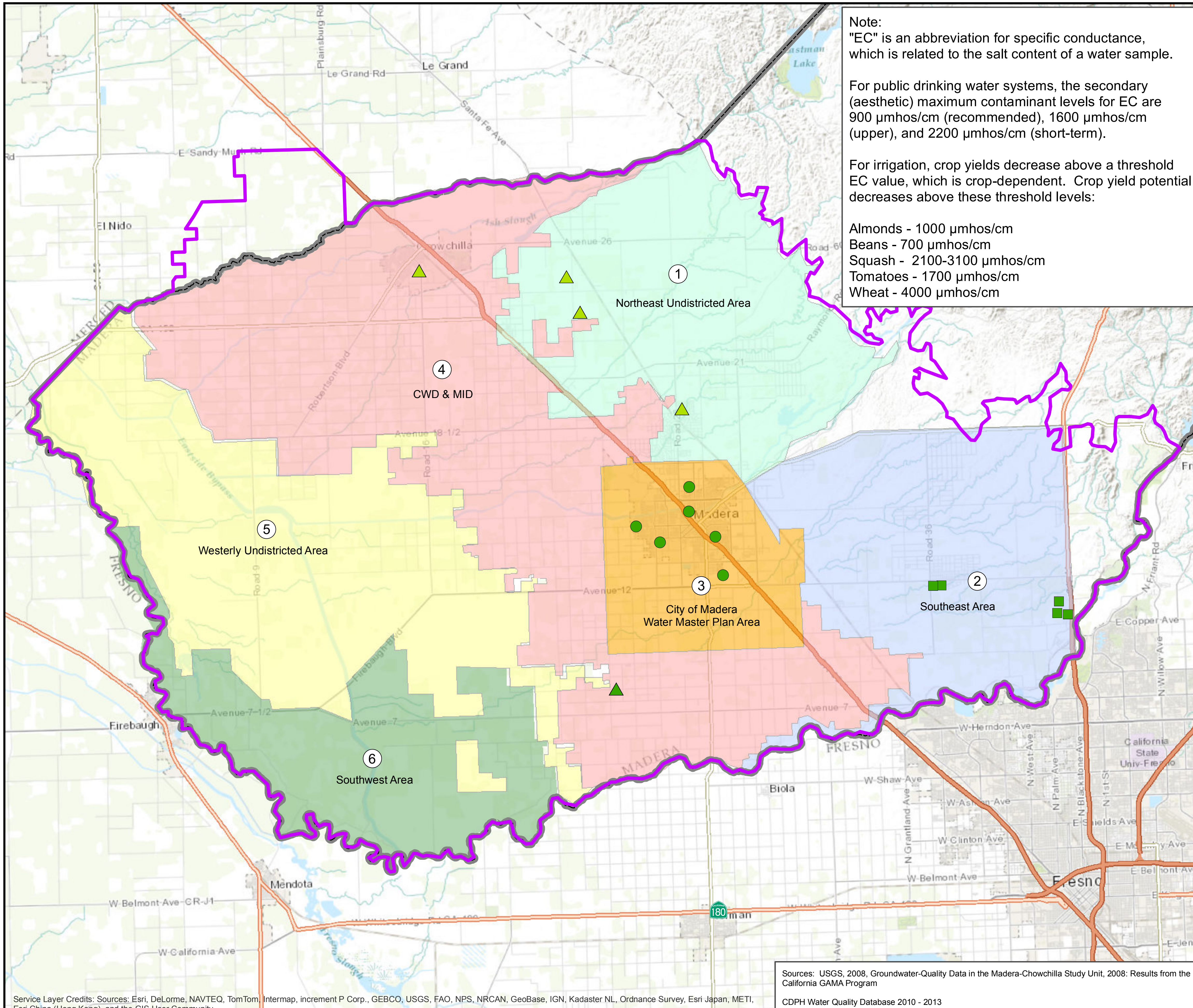
MAP OF SPECIFIC CONDUCTANCE IN DEEP WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014



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 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.

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Sources: USGS, 2008, Groundwater-Quality Data in the Madera-Chowchilla Study Unit, 2008: Results from the California GAMA Program

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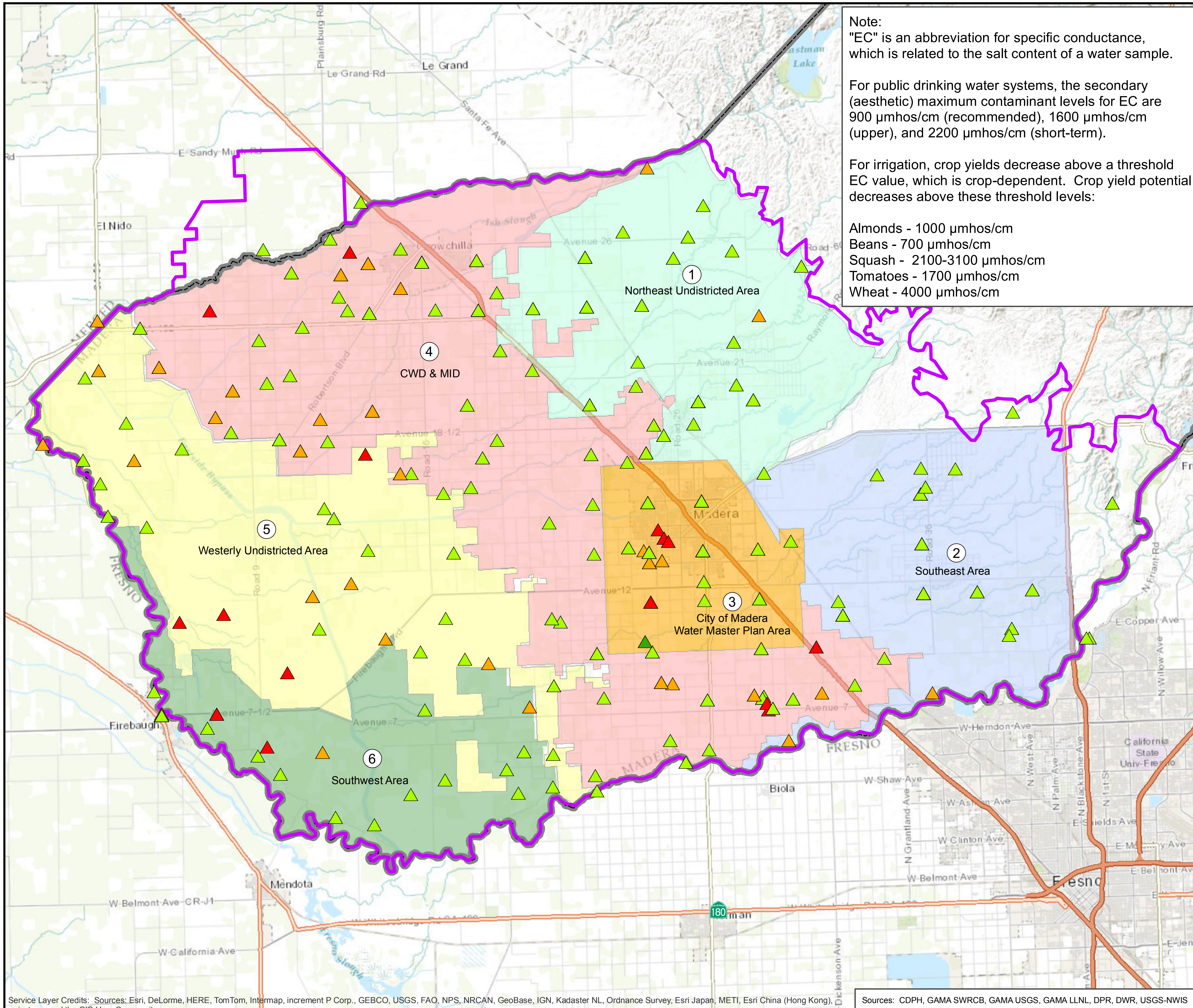

MAP OF SPECIFIC CONDUCTANCE IN WELLS OF UNKNOWN DEPTH

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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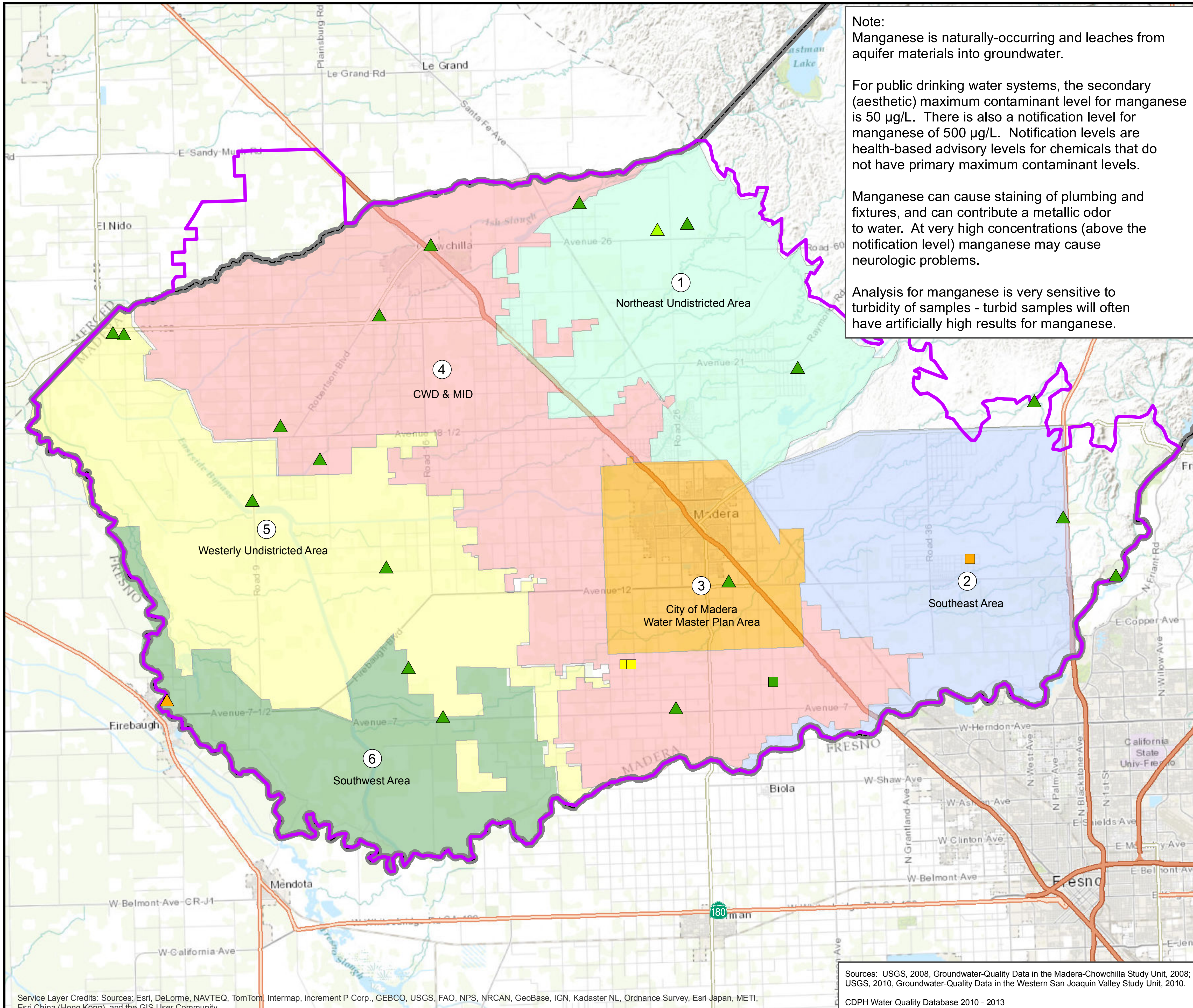
MAP OF MANGANESE CONCENTRATION IN SHALLOW WELLS

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.

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

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.

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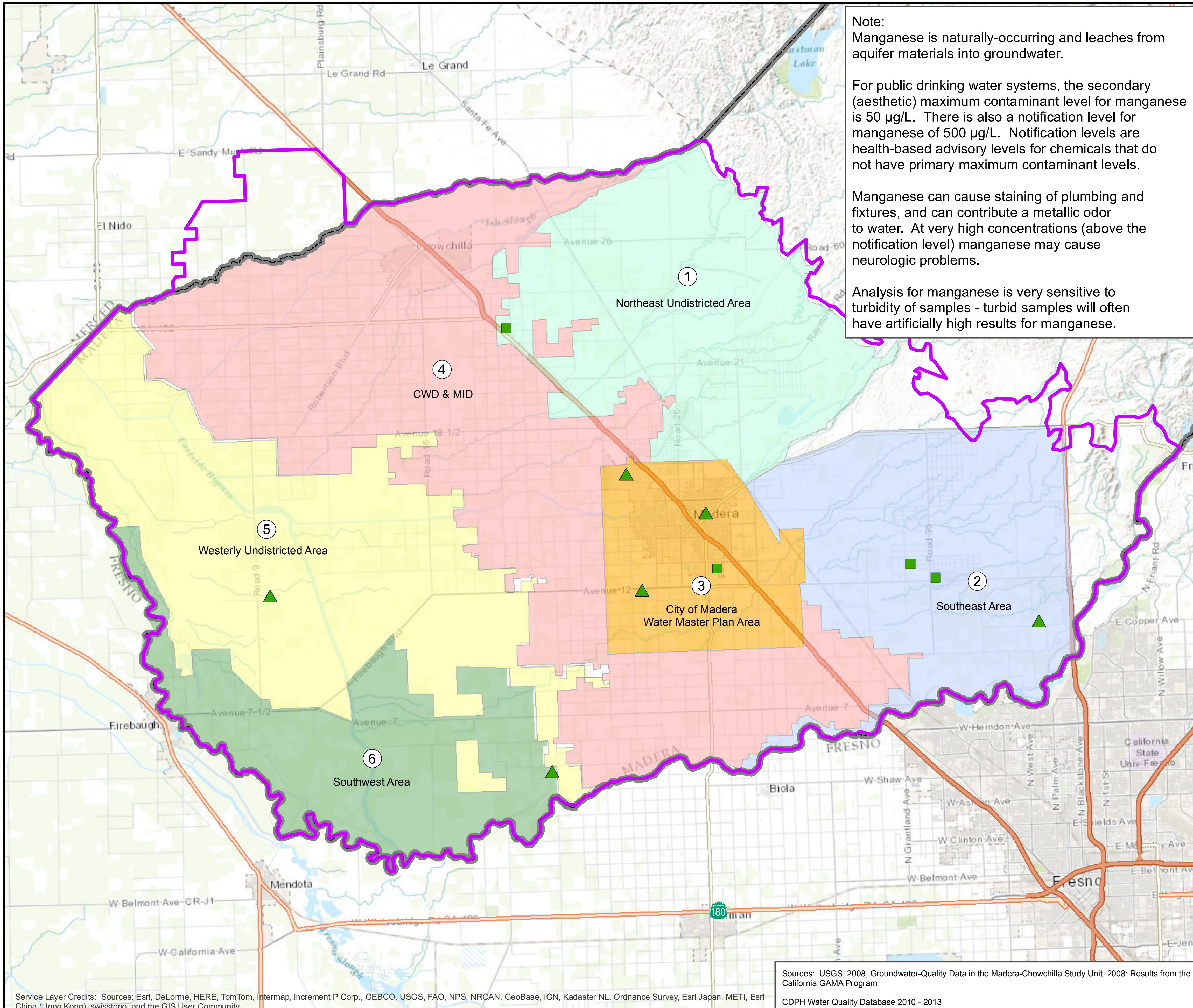
MAP OF MANGANESE CONCENTRATION IN INTERMEDIATE WELLS

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 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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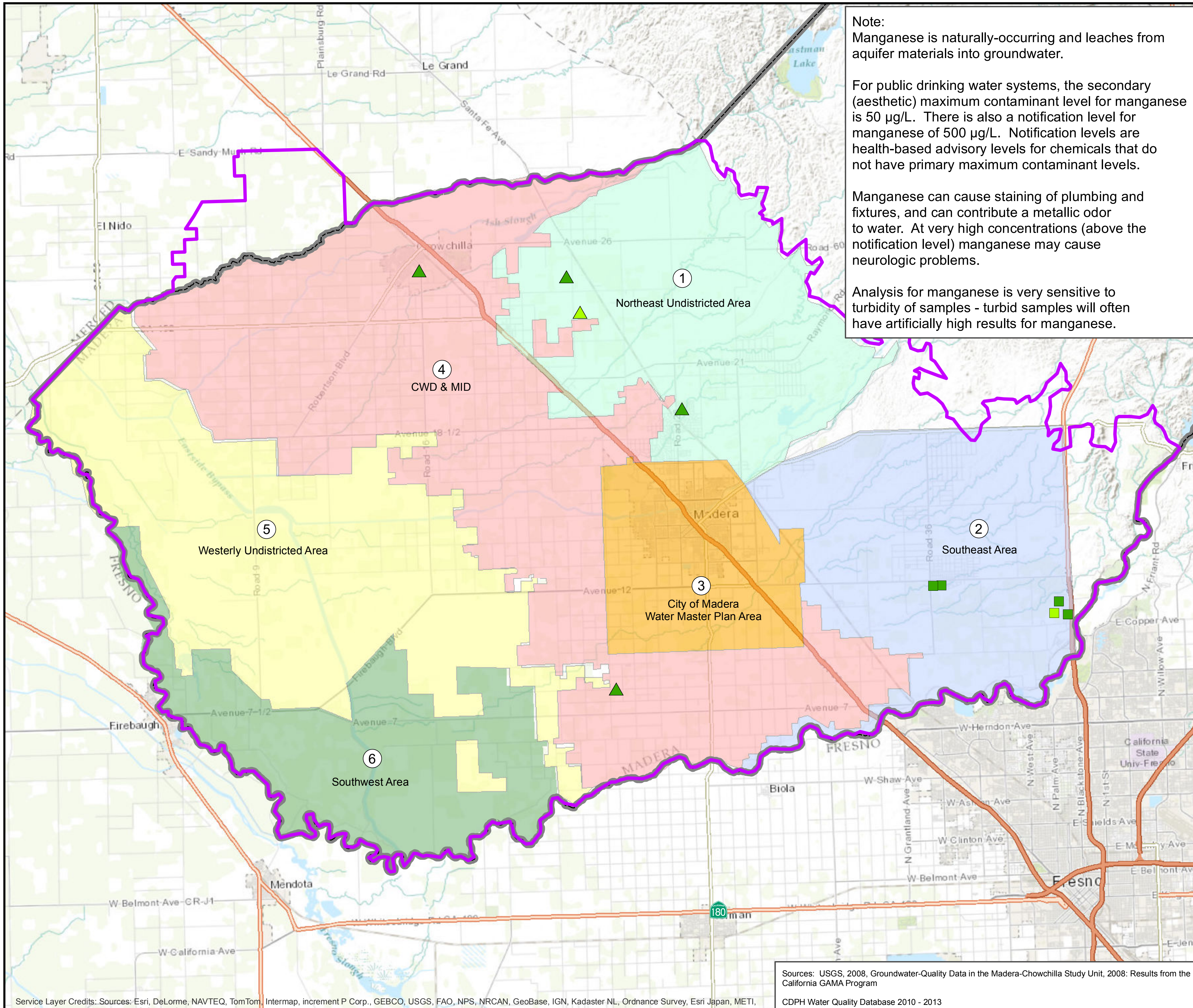
Sacramento, CA 95816 Fax: 916.341.7767

Document Path: J:\Jobs\8489_Madera_County\8489.005_Madera_County_GMP\GIS\Tasks\Water_Quality_Maps\20140407_Updated_Figures\Madera_Mang_Map_2_Intermediate_20140407.mxd

MAP OF MANGANESE CONCENTRATION IN DEEP WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014



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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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MAP OF MANGANESE CONCENTRATION IN WELLS OF UNKNOWN DEPTH

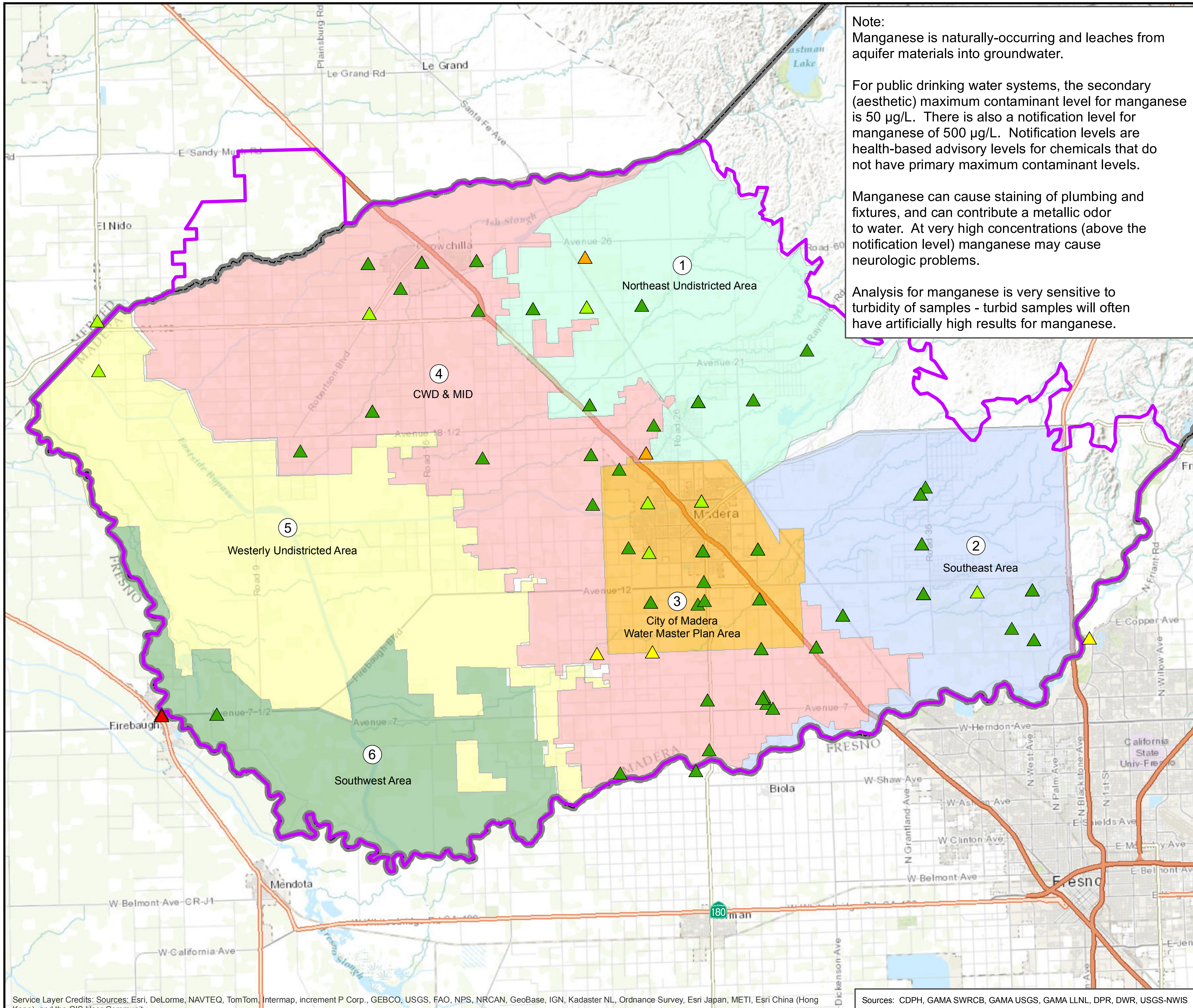
MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014

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 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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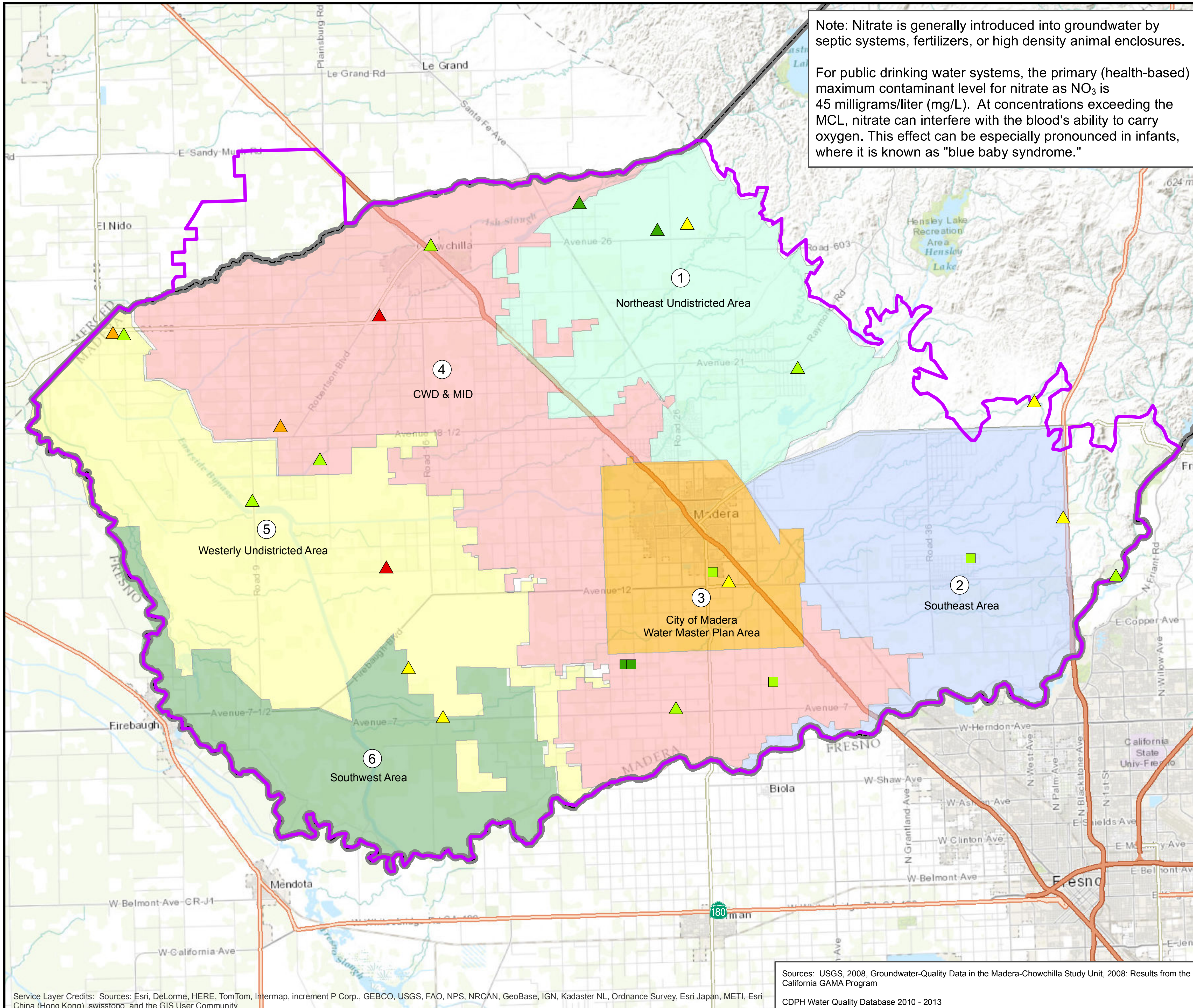

Note: Nitrate is generally introduced into groundwater by septic systems, fertilizers, or high density animal enclosures.

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 SHALLOW WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014

NORTH

0 2 4
MILES

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

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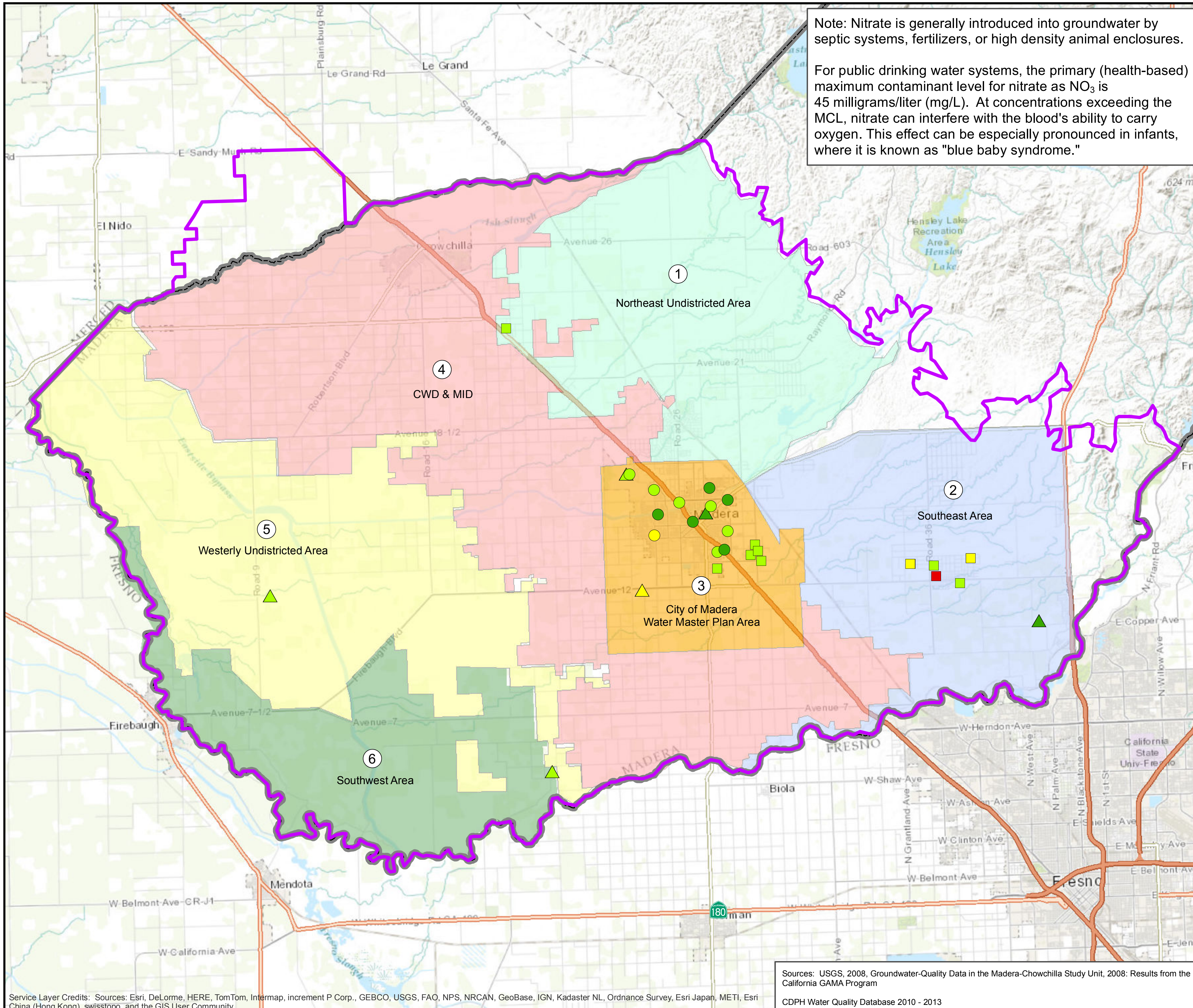
Document Path: J:\Jobs\8489_Madera_County\8489.005_Madera_County_GMP\GIS\Tasks\Water_Quality_Maps\20140407_Updated_Figures\Madera_Nitrate_Map_1_Shallow_20140407.mxd



Note: Nitrate is generally introduced into groundwater by septic systems, fertilizers, or high density animal enclosures.

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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

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

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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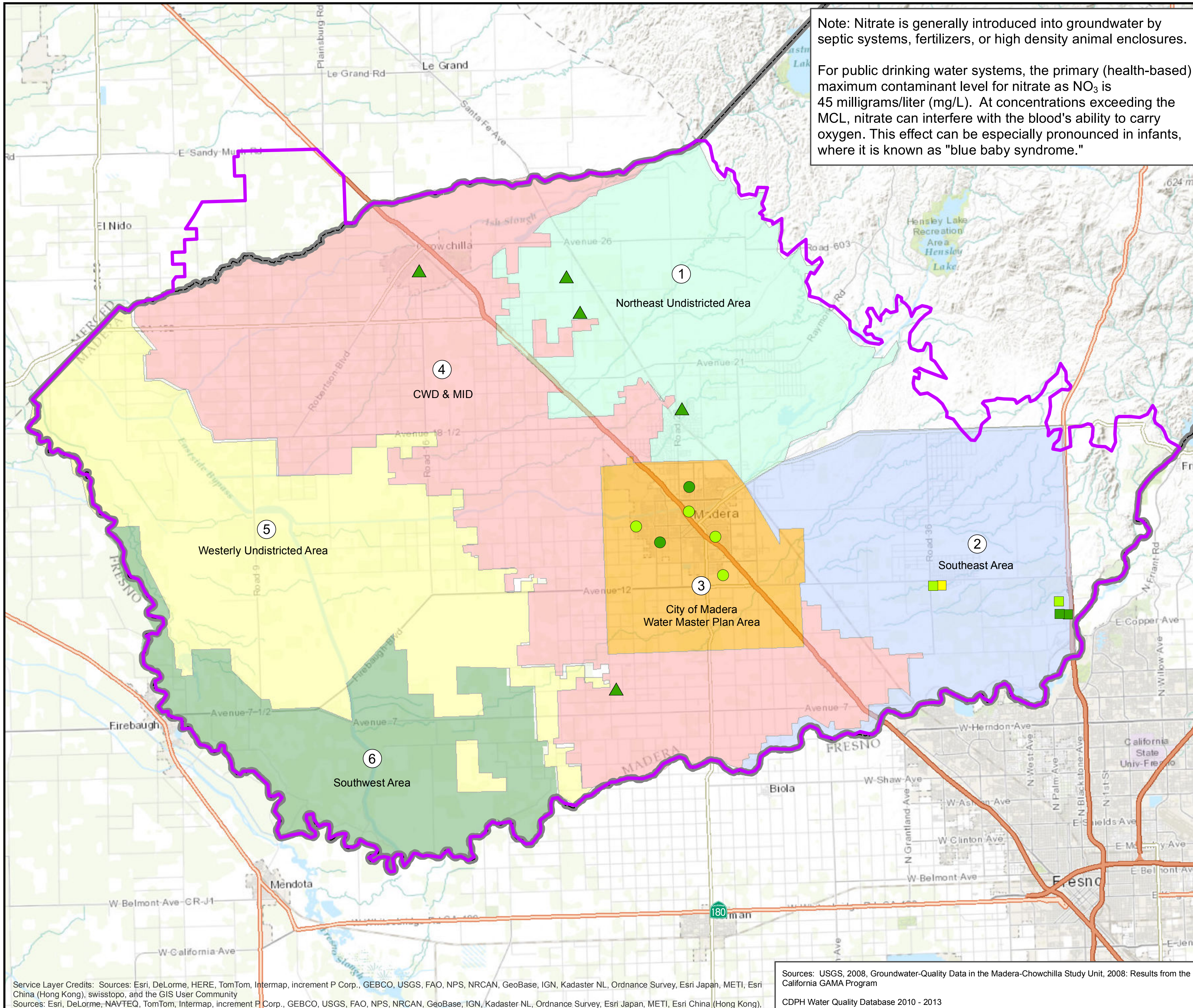

Note: Nitrate is generally introduced into groundwater by septic systems, fertilizers, or high density animal enclosures.

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."

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: USGS, 2008, Groundwater-Quality Data in the Madera-Chowchilla Study Unit, 2008: Results from the California GAMA Program

CDPH Water Quality Database 2010 - 2013

MAP OF NITRATE (AS NO_3) CONCENTRATION IN DEEP WELLS

MADERA REGIONAL
GROUNDWATER MANAGEMENT PLAN
APRIL 2014

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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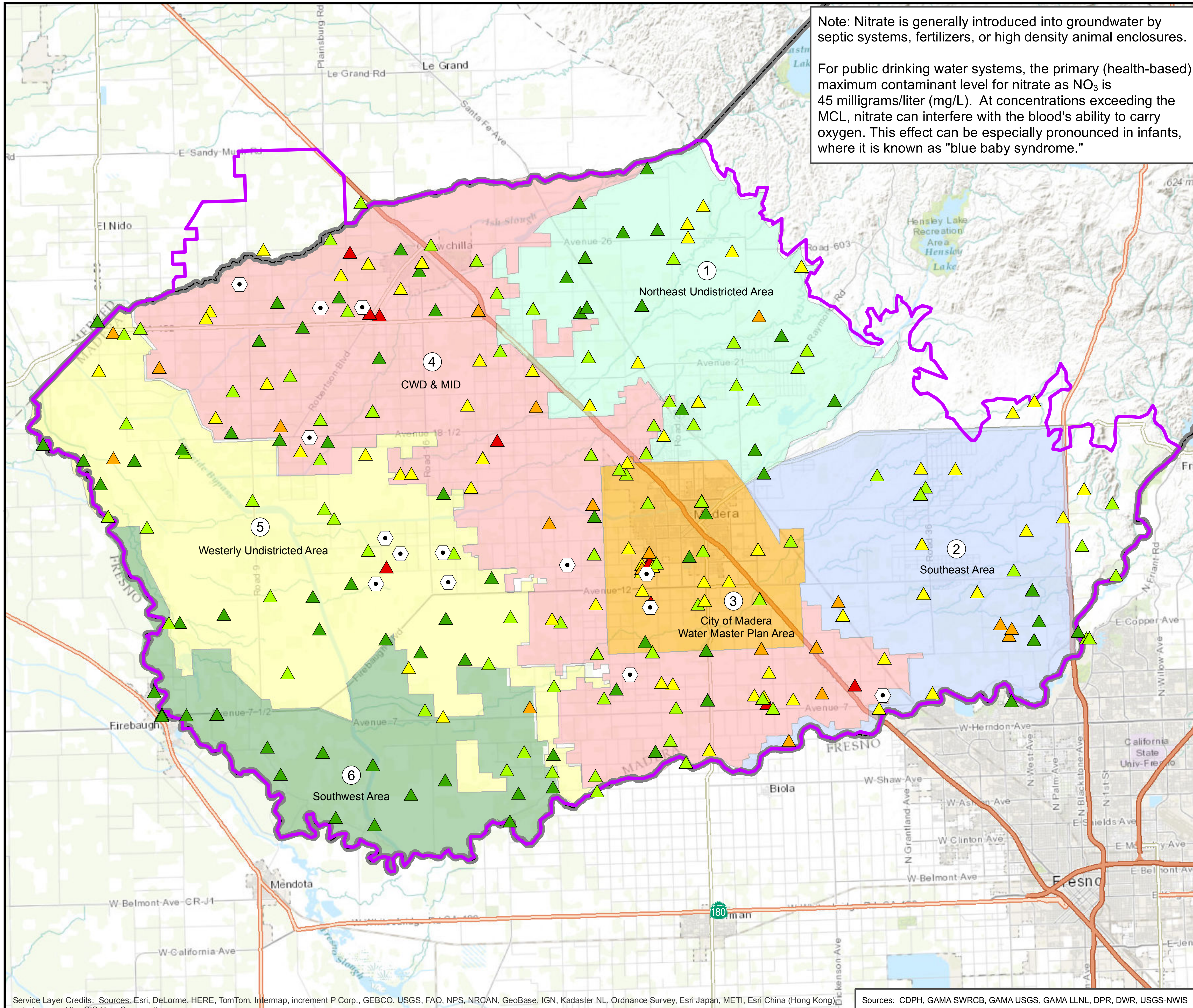
Document Path: J:\Jobs\8489_Madera_County\8489.005_Madera_County_GMP\GIS\Tasks\Water_Quality_Maps\20140407_Updated_Figures\Madera_Nitrate_Map_3_Deep_20140407.mxd

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.

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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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Sacramento, CA 95816 Fax: 916.341.7767

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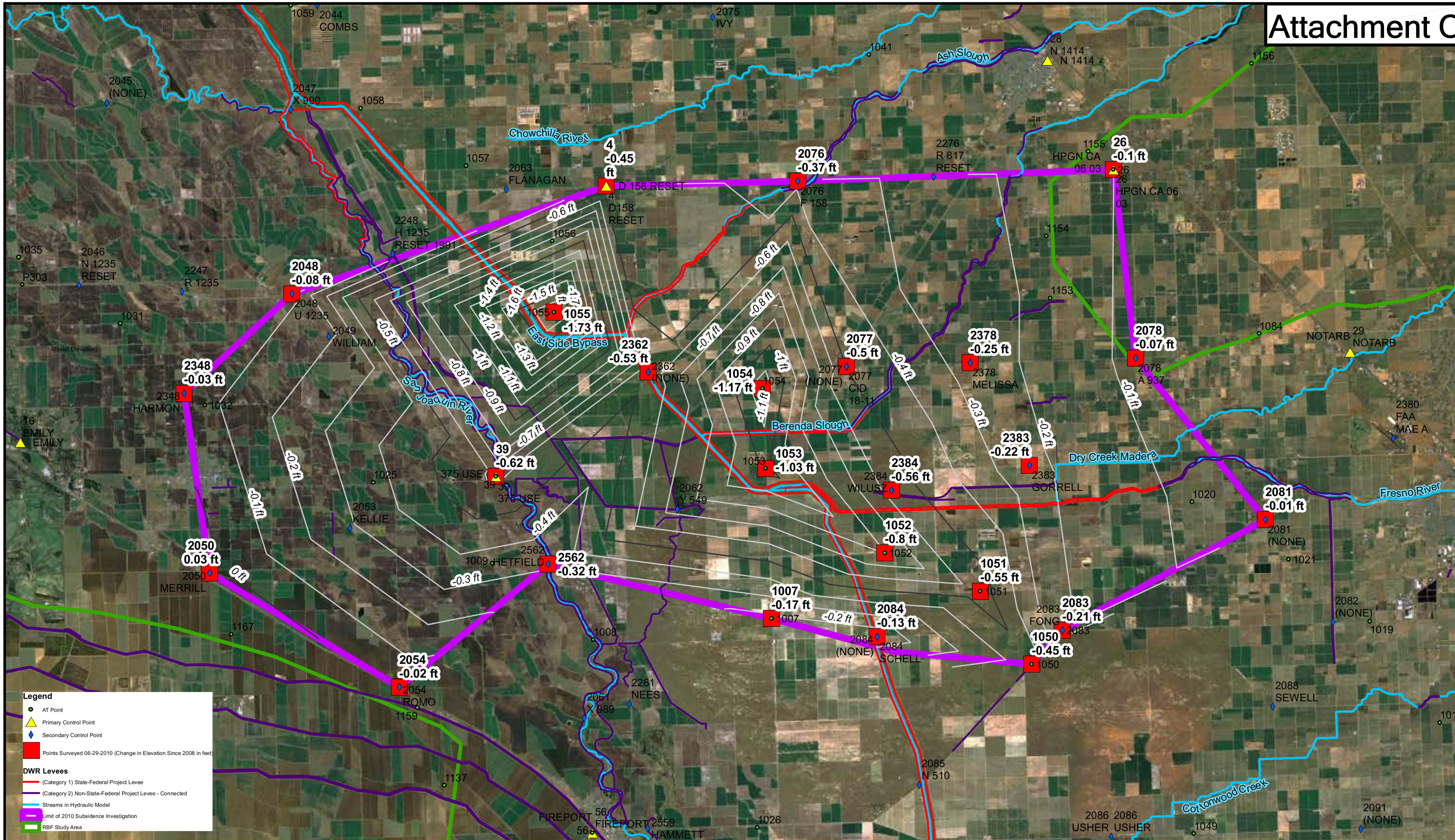
APPENDIX E

LAND SUBSIDENCE MAPS

Provost and Pritchard, 2012



1 " = 2 miles

0 0.5 1 2 Miles

Datum: NAD83, NAVD88
Zone: 10
Sources: RBF, ESRI

Projection: UTM
Units: Survey Feet

CVFED

TO19 Preliminary Subsidence Map

DRAFT

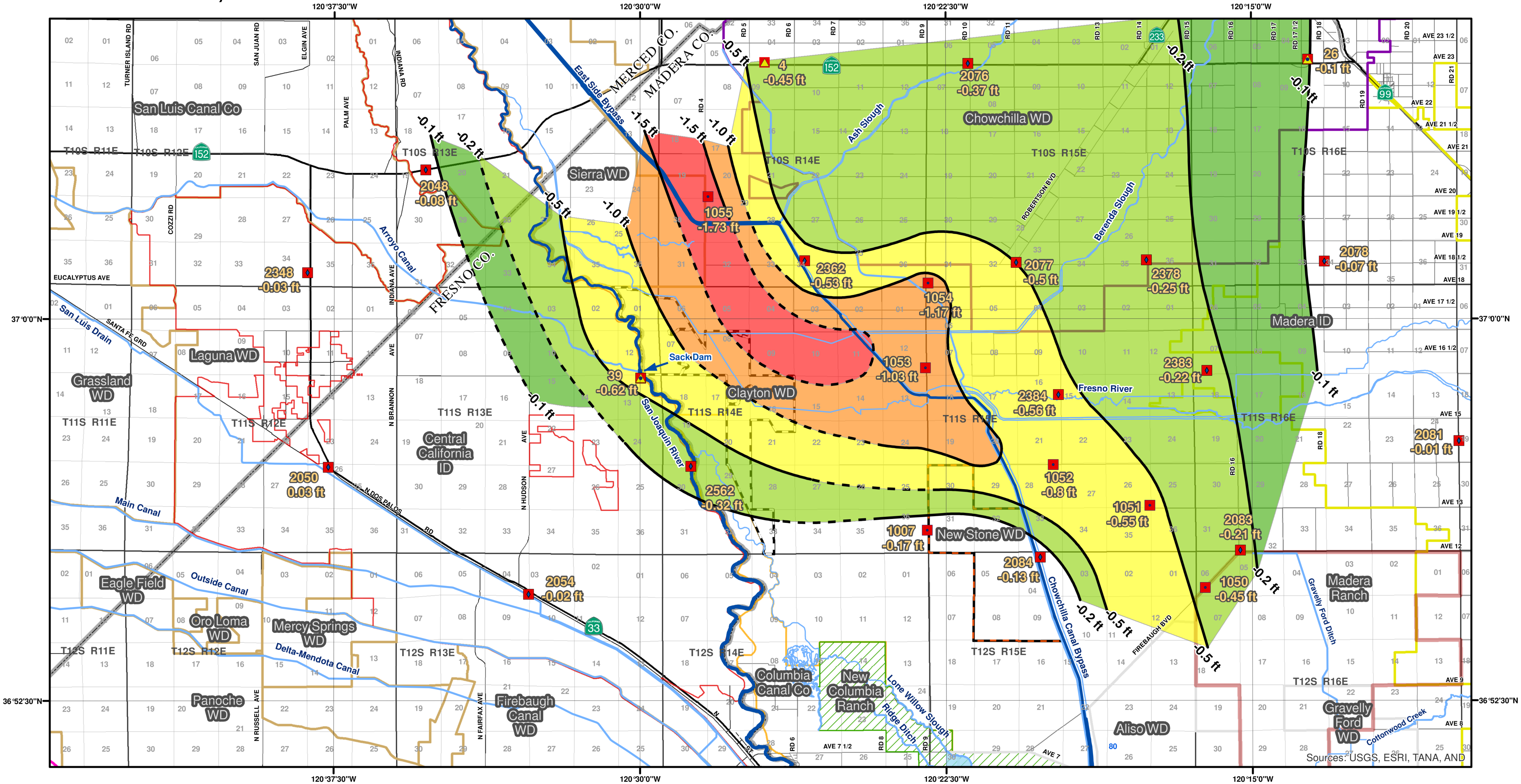
RBF CONSULTING

FloodSAFE CALIFORNIA DEPARTMENT OF WATER RESOURCES

Prepared By: JC	Figure: 1
Job No.: 60100317	Date: July 13, 2010

M:\MDATA\60100317\Plots\TO19\TO19_Calibration_Sites_with_Subsidence1_07132010.mxd

Provost and Pritchard, 2012



0 1 2 3 Miles

PROVOST & PRITCHARD CONSULTING GROUP — EST. 1968 — An Employee Owned Company

In Association with K.D. Schmidt Associates

Legend

- County
- Township/Range
- Major Canal / Slough / River

Elevation Change (Feet)

- -0.1 to -0.2
- -0.2 to -0.5
- -0.5 to -1.0
- -1.0 to -1.5
- -1.5

*Points Surveyed 06-29-2010
Labeled By Change In Elevation (ft) Since 2008

- AT Point
- Primary Control Pt
- Primary/AT Point
- Secondary Control Pt

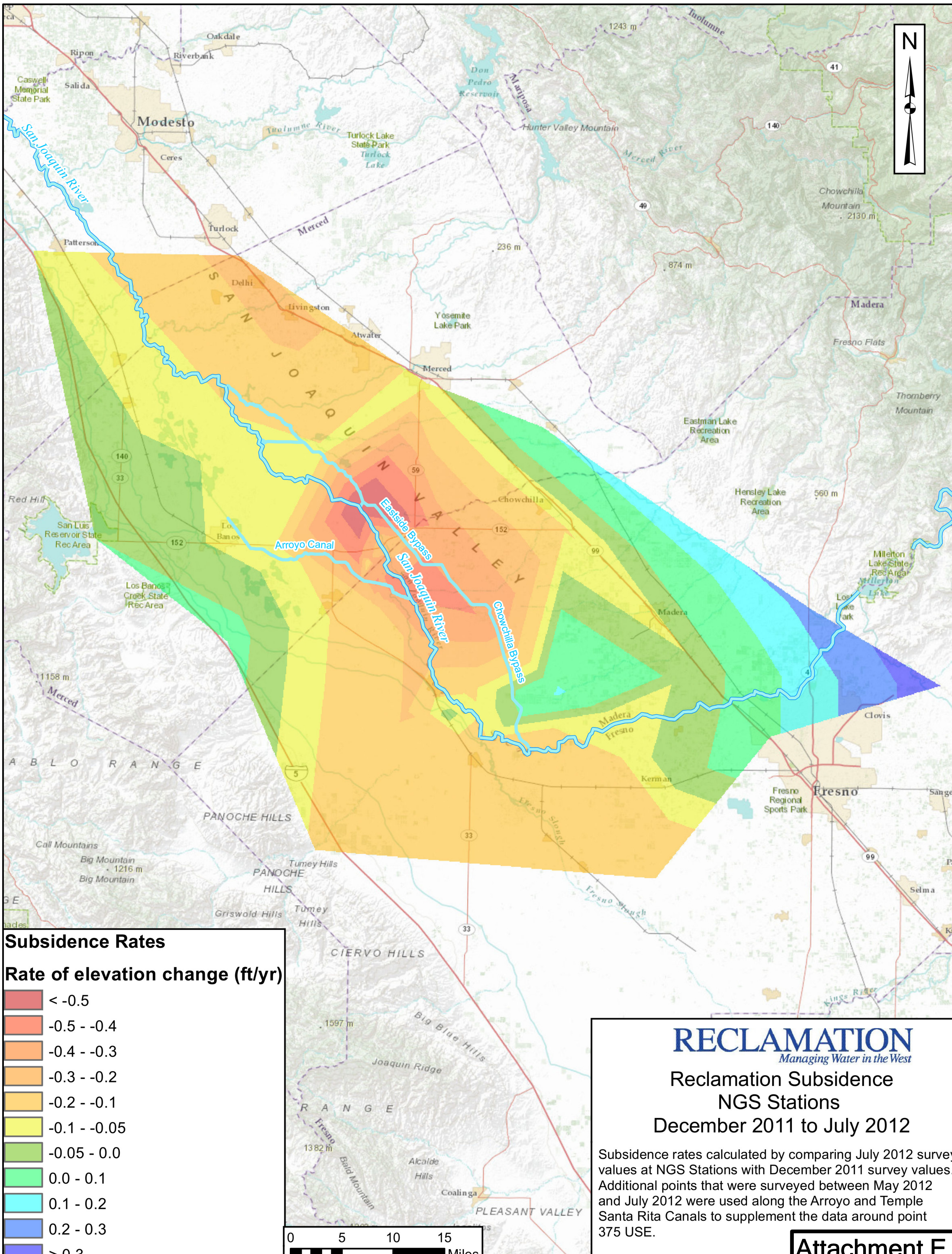
2008 to 2010 Change in Elevation of Ground Surface from TO19 Preliminary Subsidence Map

*Data from RBF Consulting Co.
Map for California Flood Safe July 13, 2010

Attachment D

Aerial Photo - NAIP 2010

Provost and Pritchard, 2012



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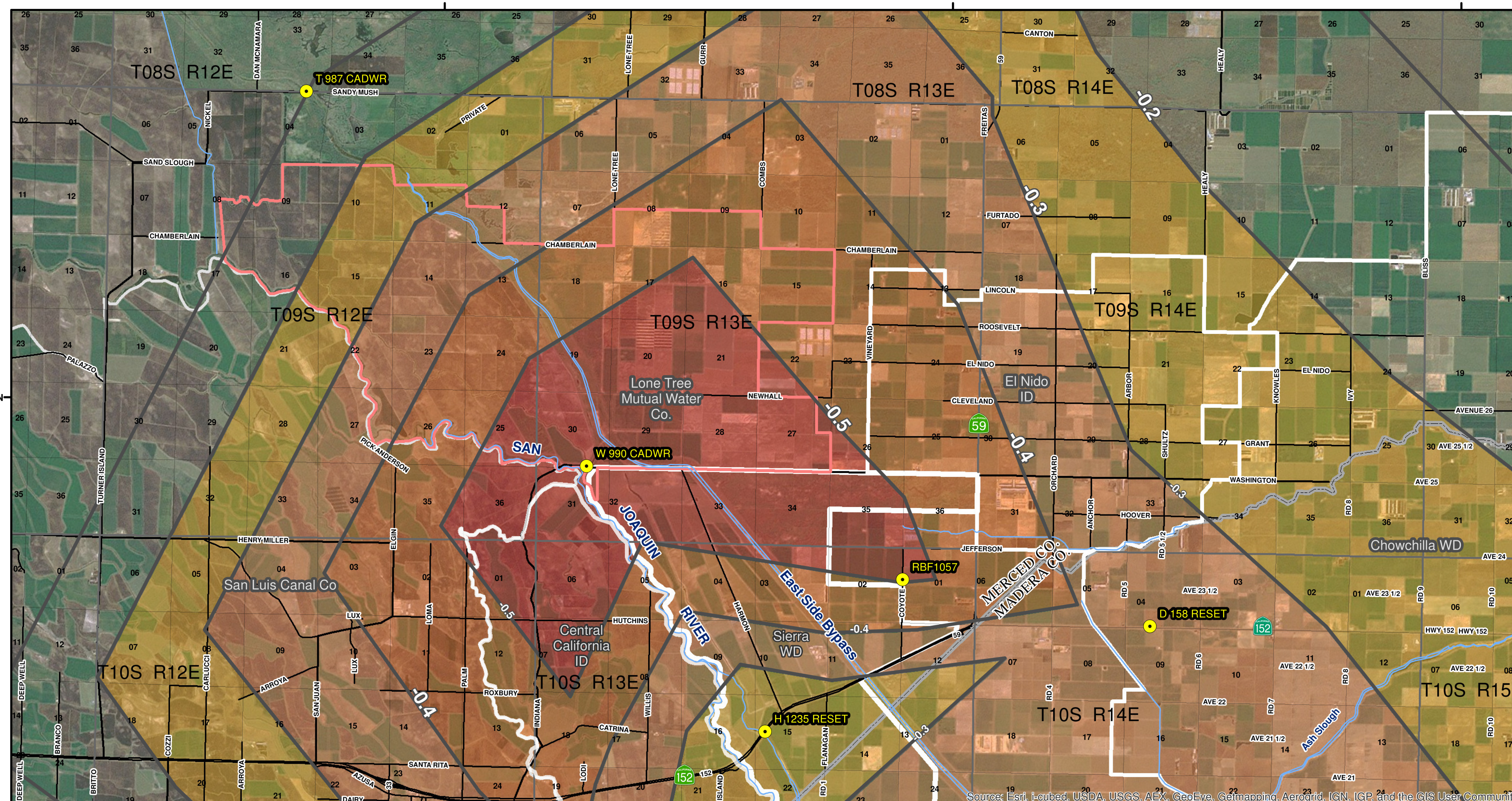
Provost and Pritchard, 2012



120°37'30"W 120°30'0"W 120°22'30"W

0 0.5 1 1.5 Miles

EST. 1968
PROVOST & PRITCHARD
CONSULTING GROUP
An Employee Owned Company

1800 30th Street, Suite 280
Bakersfield, CA 93301
661) 616-5900

Legend

- County
- Township/Range
- Major Canal / Slough / River

Survey Point - July 2012

- Labeled With Point Name

***Subsidence Rates (ft/yr) - Dec. 2011 to July 2012**

Dec. 2011 - July 2012

- < -0.5
- -0.5 - -0.4
- -0.4 - -0.3
- -0.3 - -0.2

**USBR survey data from Dec. 2011 and July 2012. Rates of change projected out to 1 full year. Lines of equal change digitiaed from USBR map figure.*

San Joaquin River Exchange Contractors
Subsidence Study

Attachment F

10/23/2012: W:\Clients\San Joaquin River Exch Contractors Auth -3495\349512B5 - Subsidence Western Madera Co\GIS\Map\Subsidence_North152.mxd

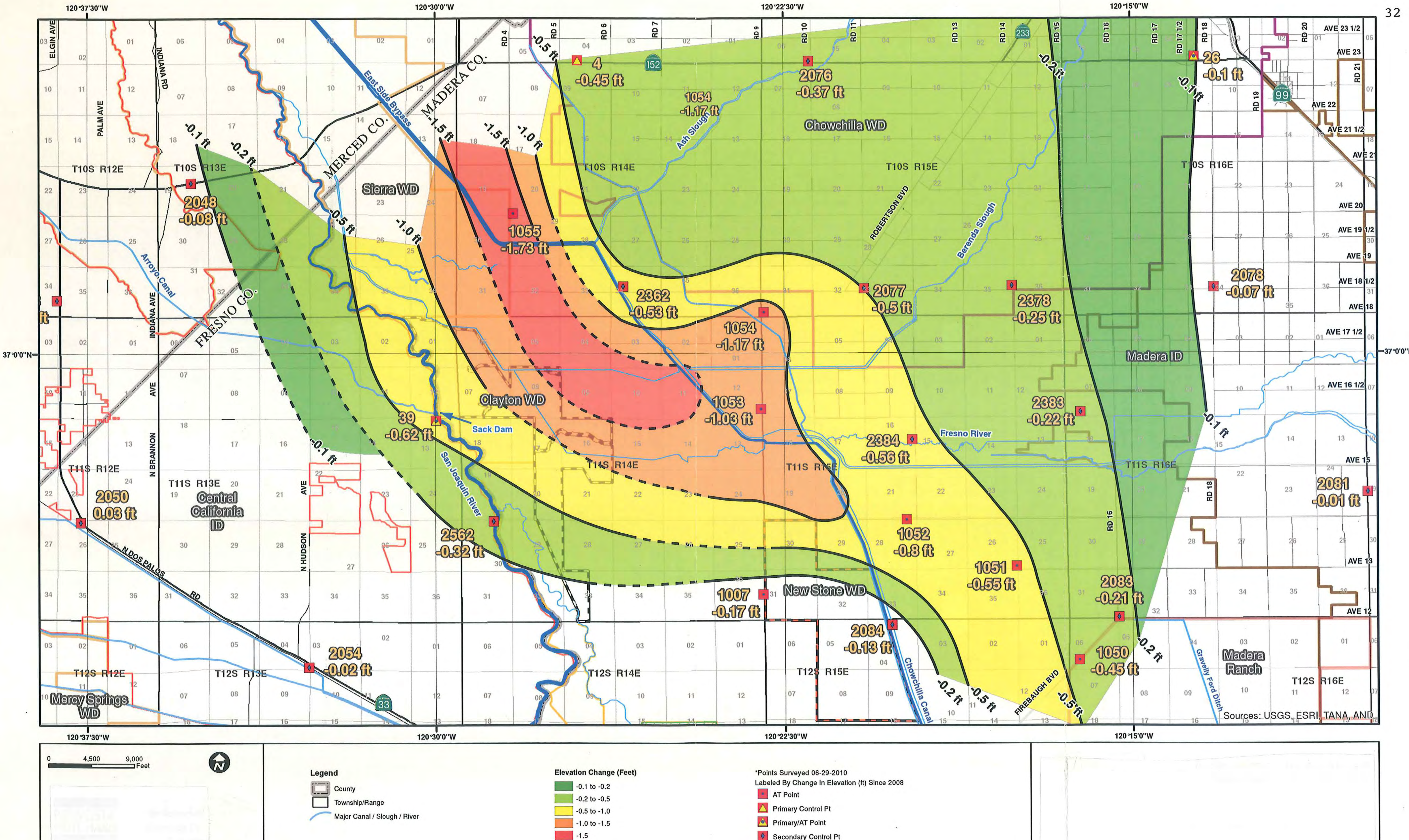


FIGURE 17- LAND SUBSIDENCE FOR 2008-10

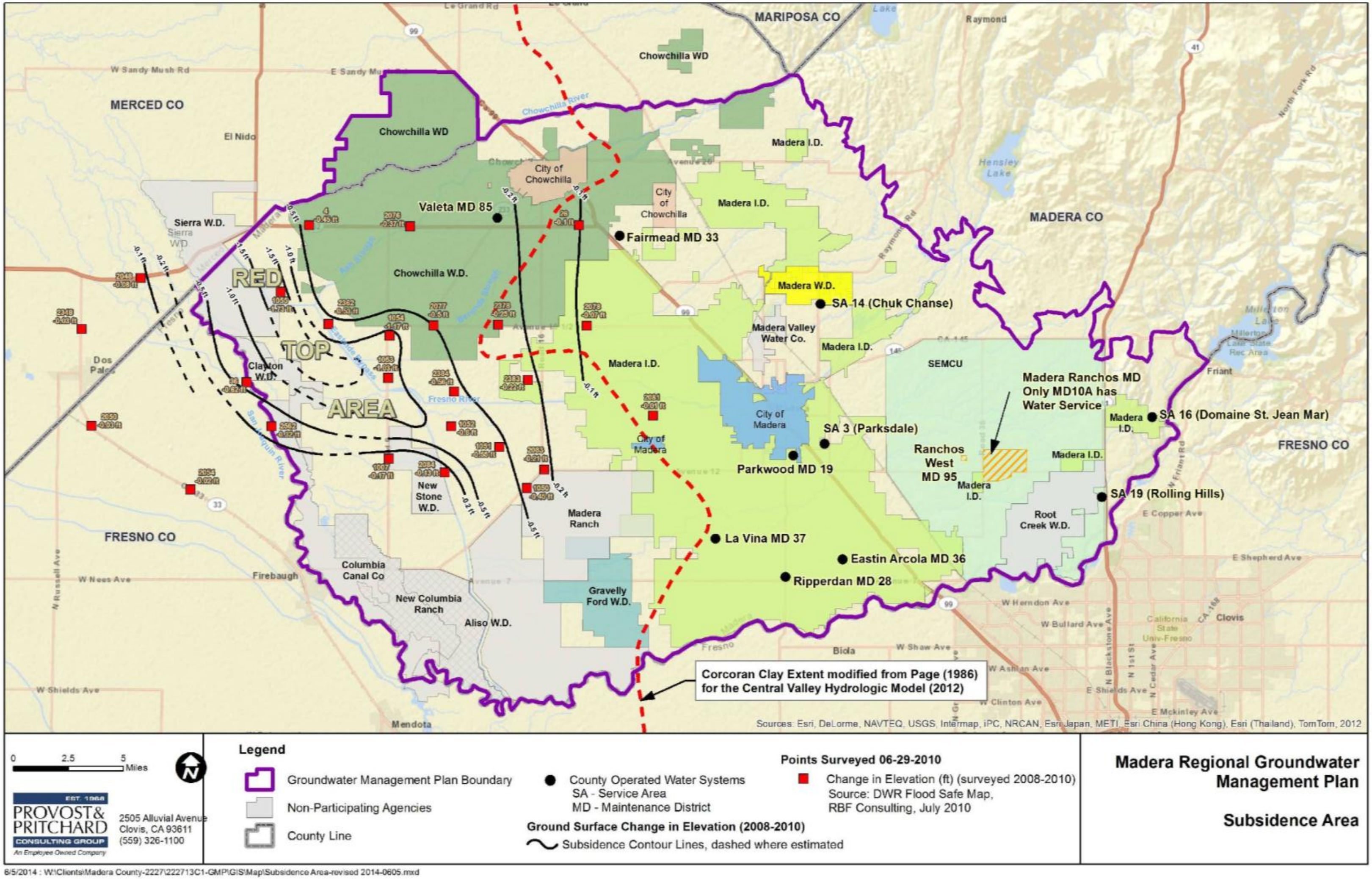


Figure 2.14 – Subsidence Area

LSCE, Borchers and Carpenter, 2014

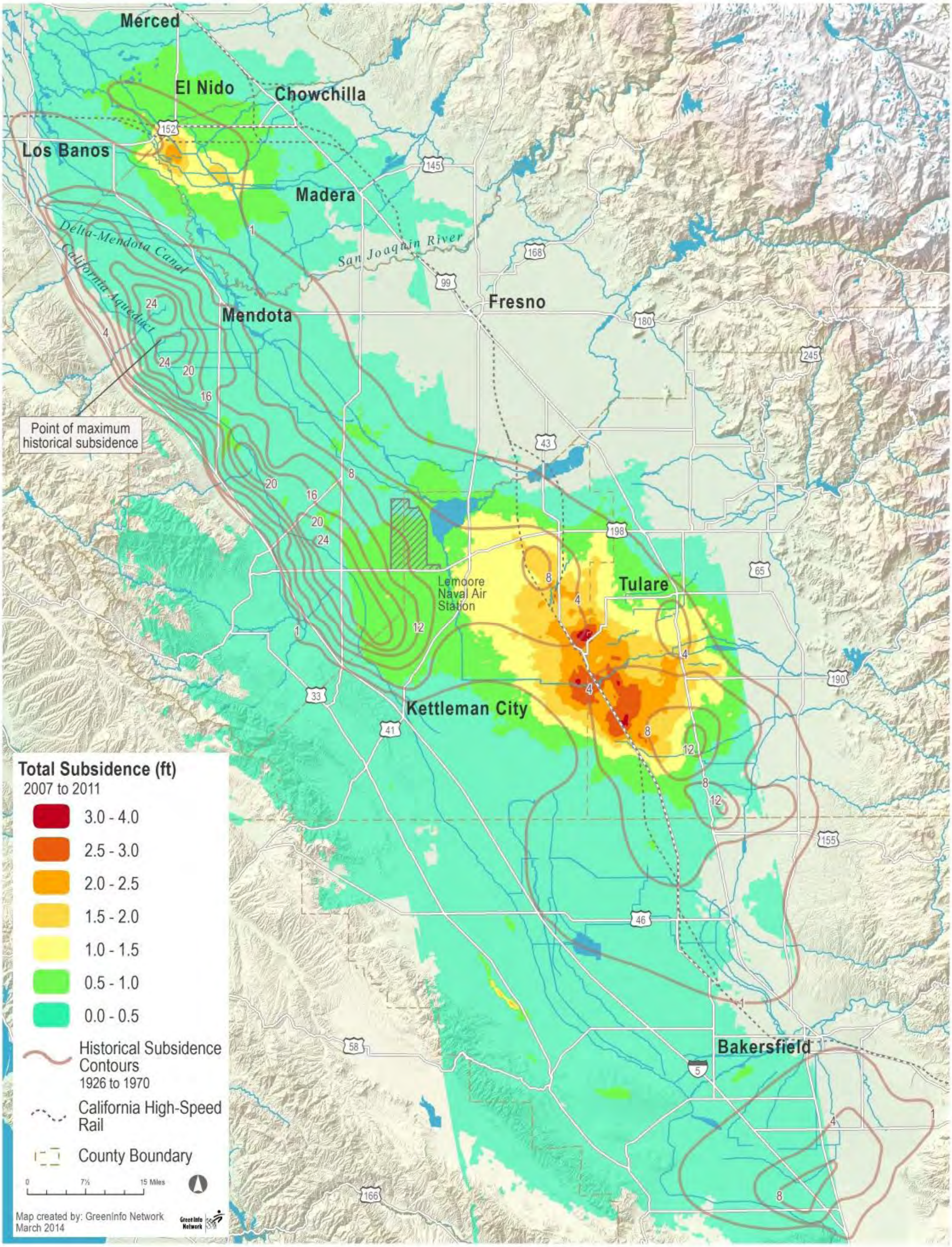


Figure 4-8. Recent subsidence in the in San Joaquin Valley January 2007-March 2011 shown as shaded regions compiled from Interferometric Synthetic Aperture Radar (InSAR) analysis. (InSAR derived subsidence data were provided as preliminary unpublished data courtesy of NASA-JPL.) Subsidence data were composited from three separate interferograms—eastern part of the area, 1/2007-7/2010; central part, 6/2007-6/2010; and western part, 1/2007-3/2011.). Brown contours are lines of equal magnitude of historical land subsidence, in feet, during 1926-1970 (Ireland et al., 1984). The proposed alternative alignments of the California High-Speed Rail system are shown as dotted lines.

LSCE, Borchers and Carpenter, 2014

A

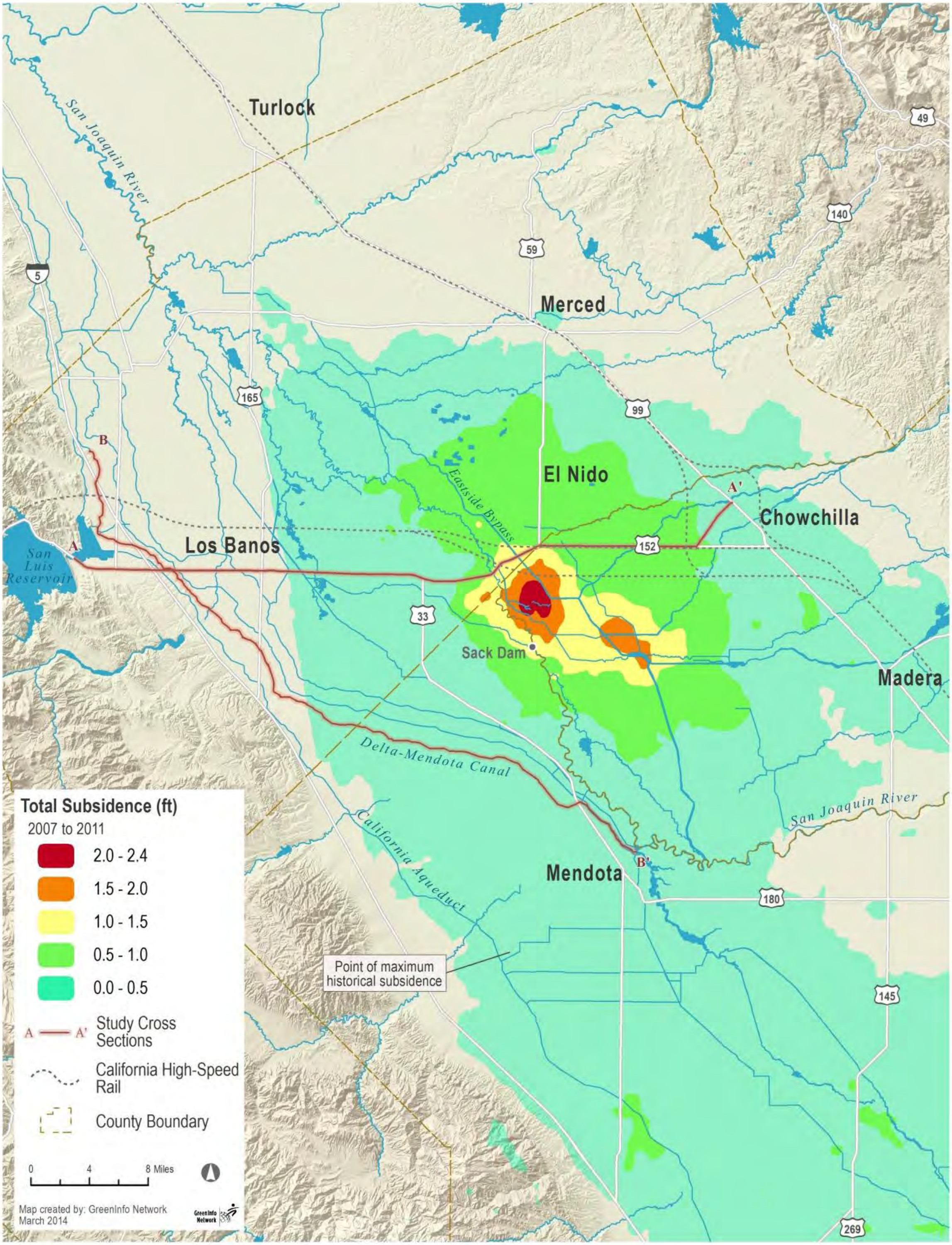
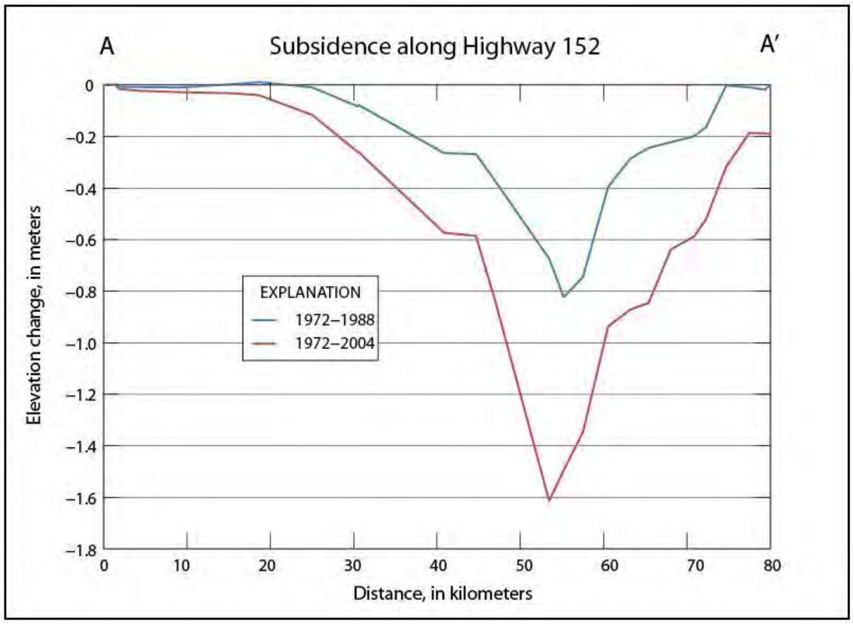


Figure 4-12 A. See full figure title on next page.

B



C

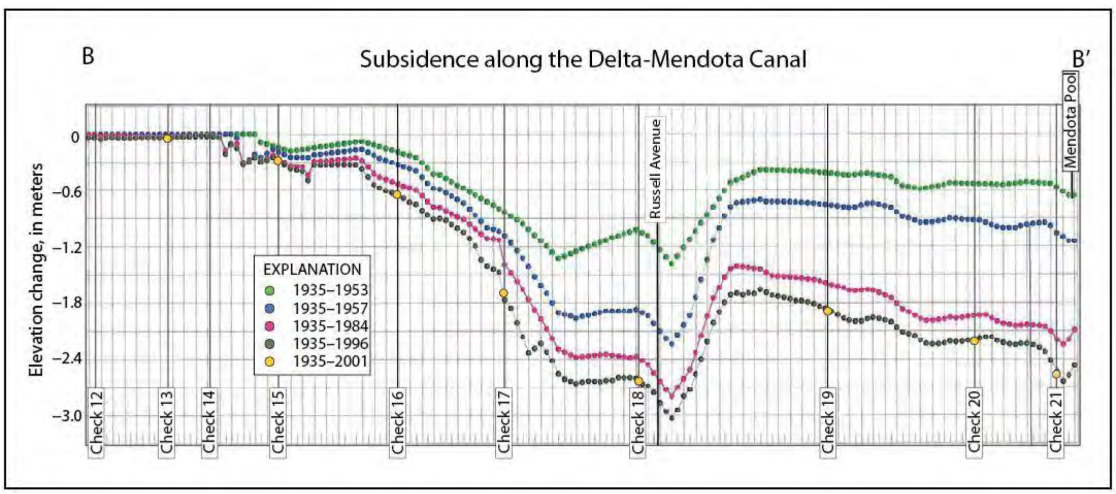
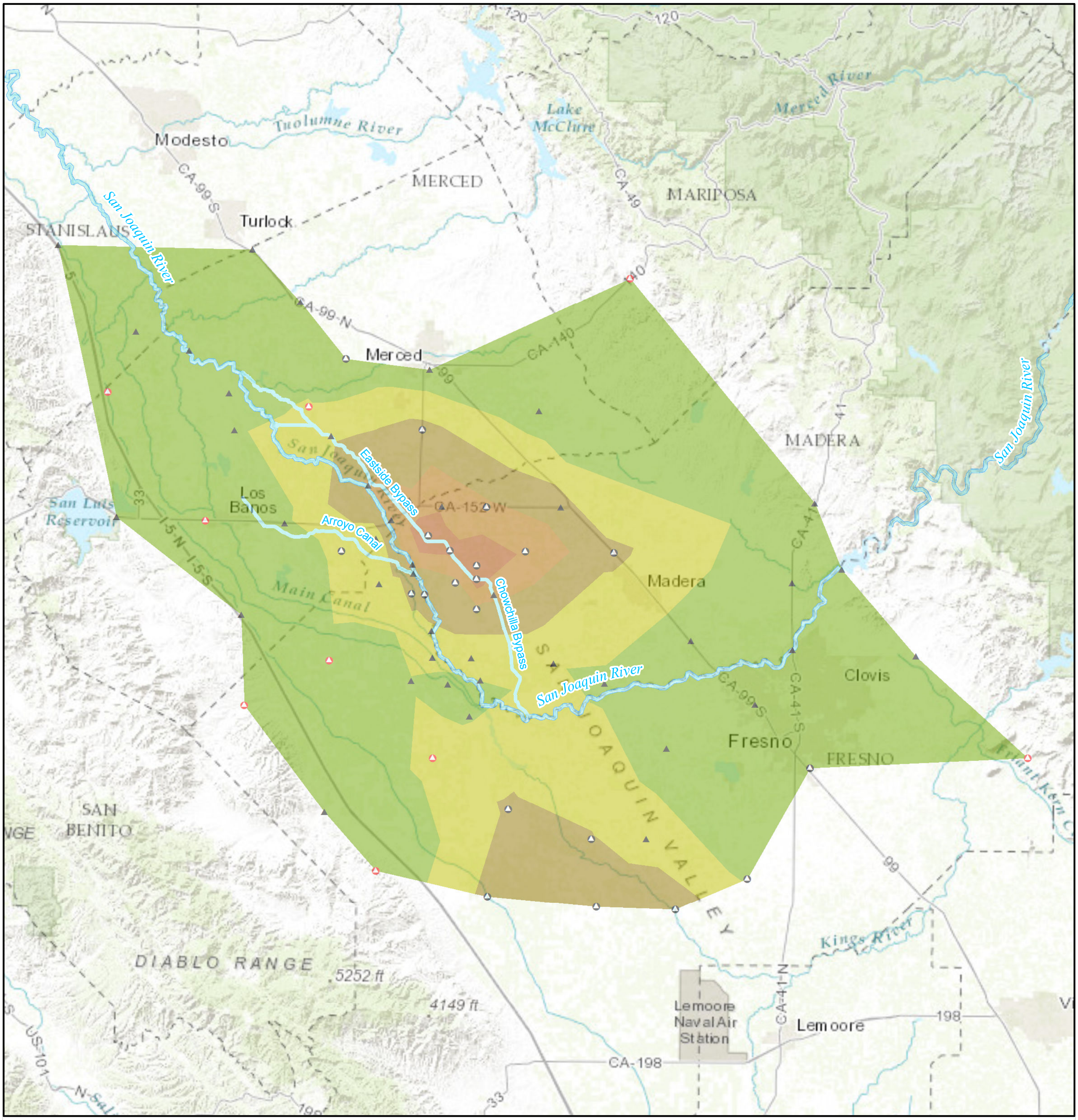


Figure 4-12**.** A) Recent subsidence in the central San Joaquin Valley near El Nido between January 2007 and March 2011. The location of proposed alignments for the Merced to San Jose rail line are shown in more detail and with additional points of geographic reference on Figure 4-13. B) Graph showing elevation changes computed from repeat geodetic surveys along Highway 152 for 1972–2004. C) Graph showing elevation changes computed from repeat geodetic surveys along the Delta-Mendota Canal for 1935–2001 (from Sneed et al., 2013, Fig. 17).

USBR, 2016



Subsidence Monitoring Points

- ▲ December 2011
- ○ Added July 2012
- ○ Added December 2013

Subsidence Rates (feet/year)
December 2011 to December 2016

- Less than 0.15 feet
- -0.3 to -0.15
- -0.45 to -0.3
- -0.6 to -0.45
- -0.75 to -0.6

0 7 14 21 Miles

N

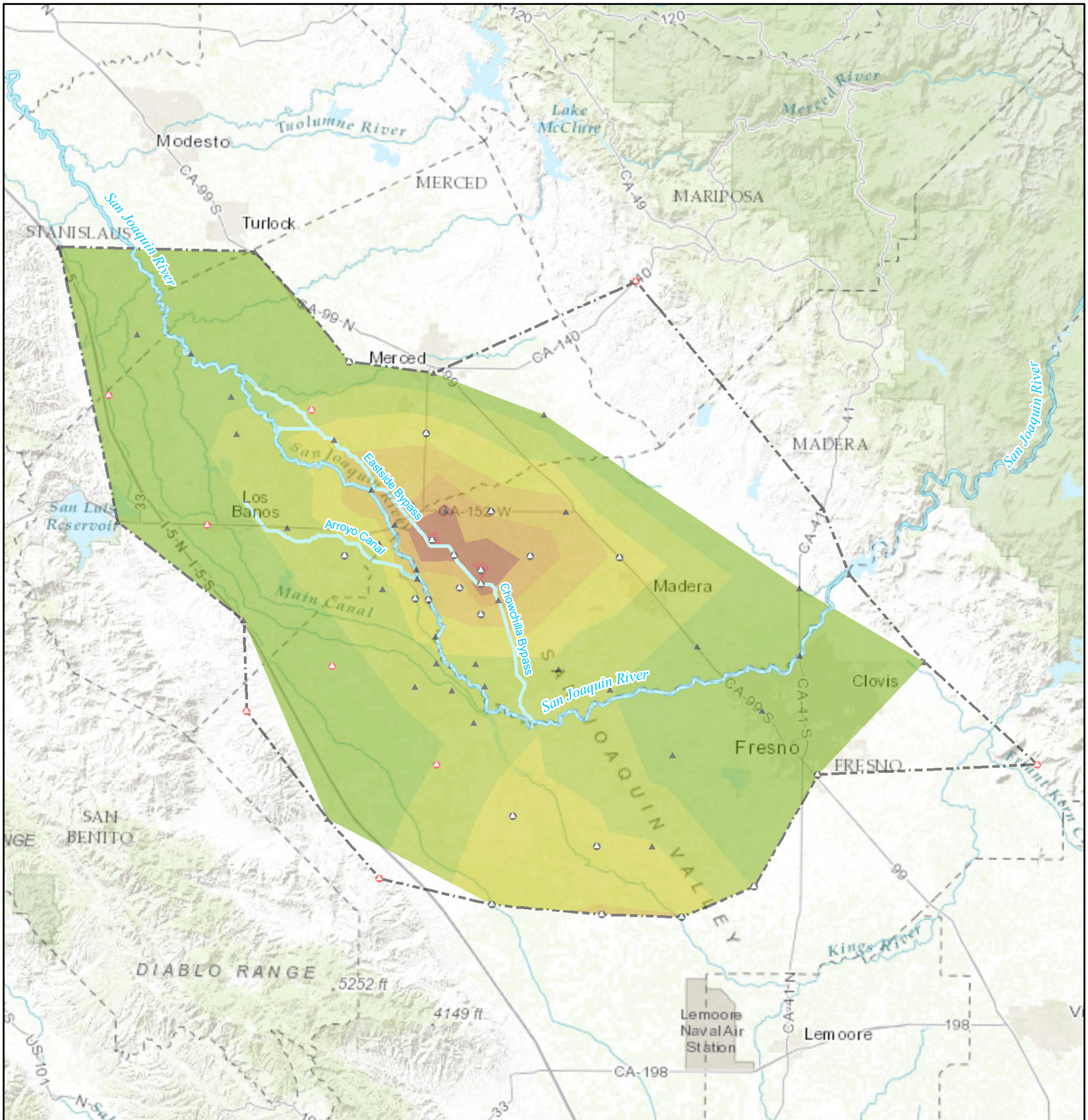
RECLAMATION
Managing Water in the West

Central Valley Subsidence
Annual Rates
December 2011 to December 2016

Subsidence rates calculated by comparing survey values at monitoring points for the dates specified in the legend.

Path: S:\3766-San Joaquin River Restoration Program\San Joaquin River\Subsidence Mapping_GIS\SJRRP-Subsidence Mapping-20161216.mxd

USBR, 2016



Subsidence (feet)
July 2012 to December 2016

- Less than 0.5
- -1 to -0.5
- -1.5 to -1
- -2 to -1.5
- -2.5 to -2
- -3 to -2.5
- -3.5 to -3

Subsidence Monitoring Points

- December 2011
- Added July 2012
- Added December 2013
- Area monitored after December 2013

0 7 14 21 Miles

N

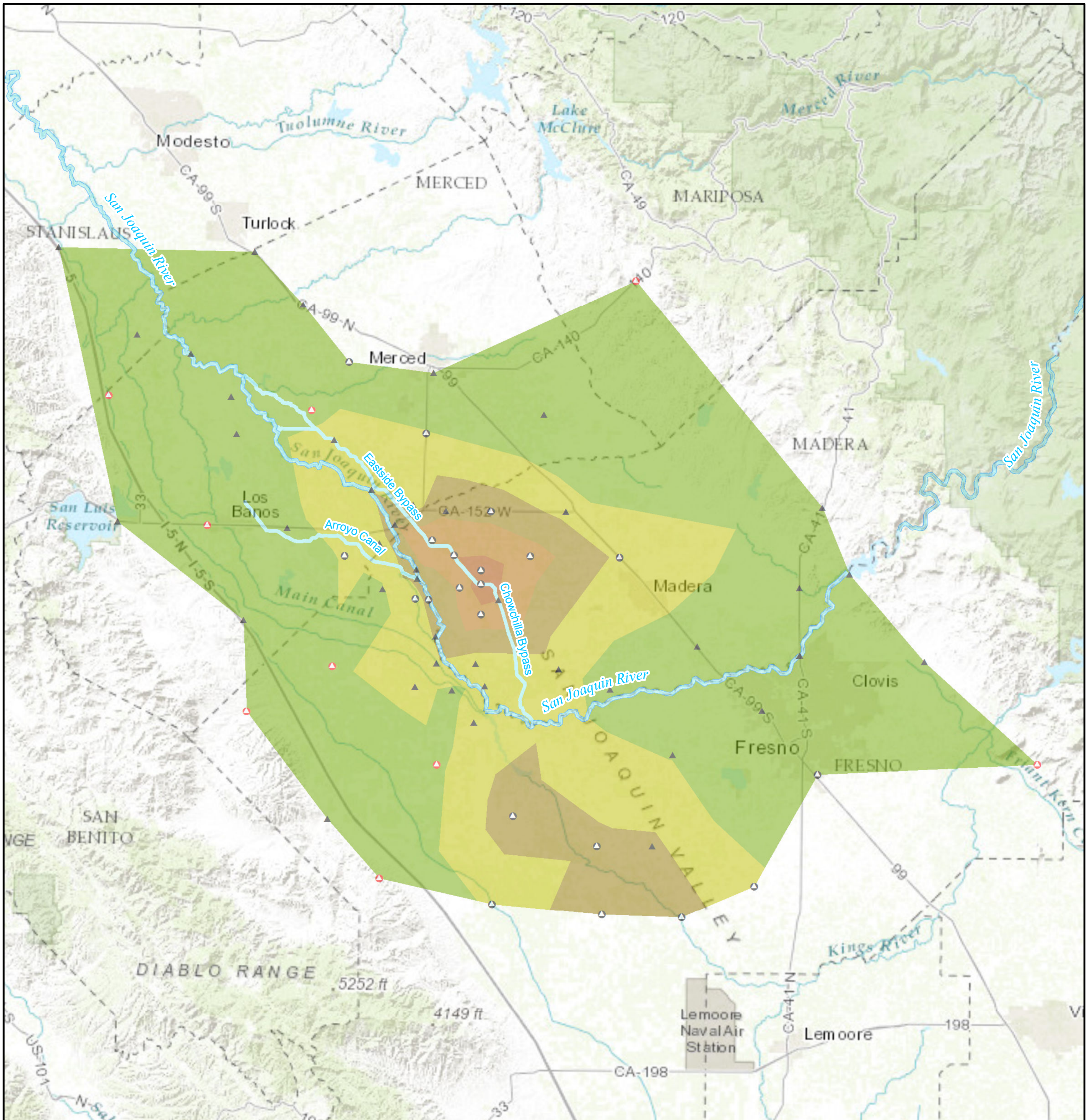
RECLAMATION
Managing Water in the West

Central Valley Subsidence
Total Subsidence
July 2012 to December 2016

Subsidence calculated by comparing survey values at monitoring points for the dates specified in the legend.

Path: S:\3766-San Joaquin River Restoration Program\San Joaquin River\Subsidence Mapping_GIS\SJRRP-Subsidence Mapping-20161216.mxd

USBR, 2016



Subsidence Rates (feet/year)
December 2015 to December 2016

- Less than 0.15 feet
- -0.3 to -0.15
- -0.45 to -0.3
- -0.6 to -0.45
- -0.75 to -0.6

Subsidence Monitoring Points

- December 2011
- Added July 2012
- Added December 2013

0 7 14 21 Miles

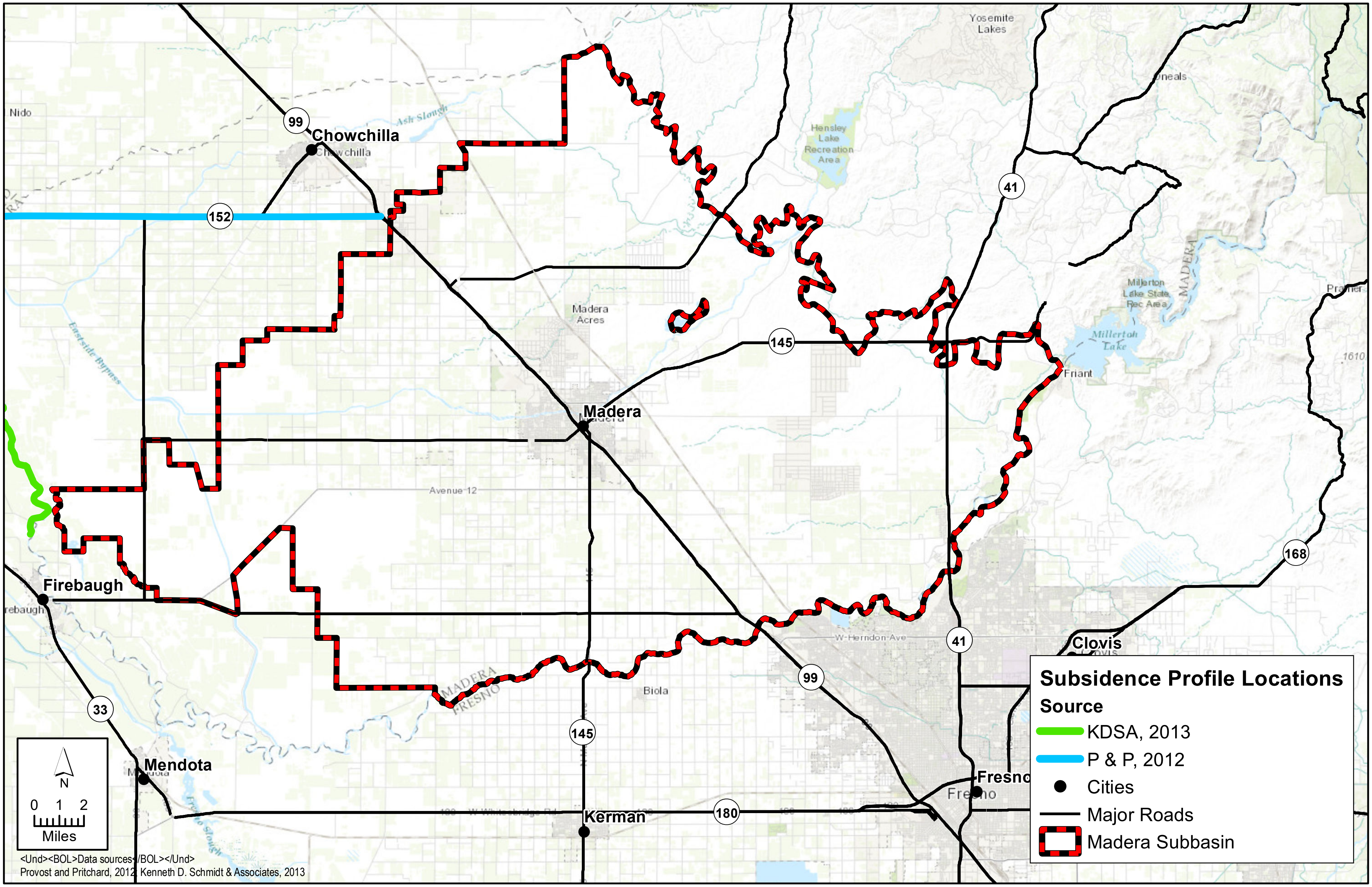
N

RECLAMATION
Managing Water in the West

Central Valley Subsidence
Annual Rates
December 2015 to December 2016

Subsidence rates calculated by comparing survey values at monitoring points for the dates specified in the legend.

Path: S:\3766-San Joaquin River Restoration Program\San Joaquin River\Subsidence Mapping_GIS\SJRRP-Subsidence Mapping-20161216.mxd



X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Appendix E Madera Subbasin Subsidence Profile Locations.mxd

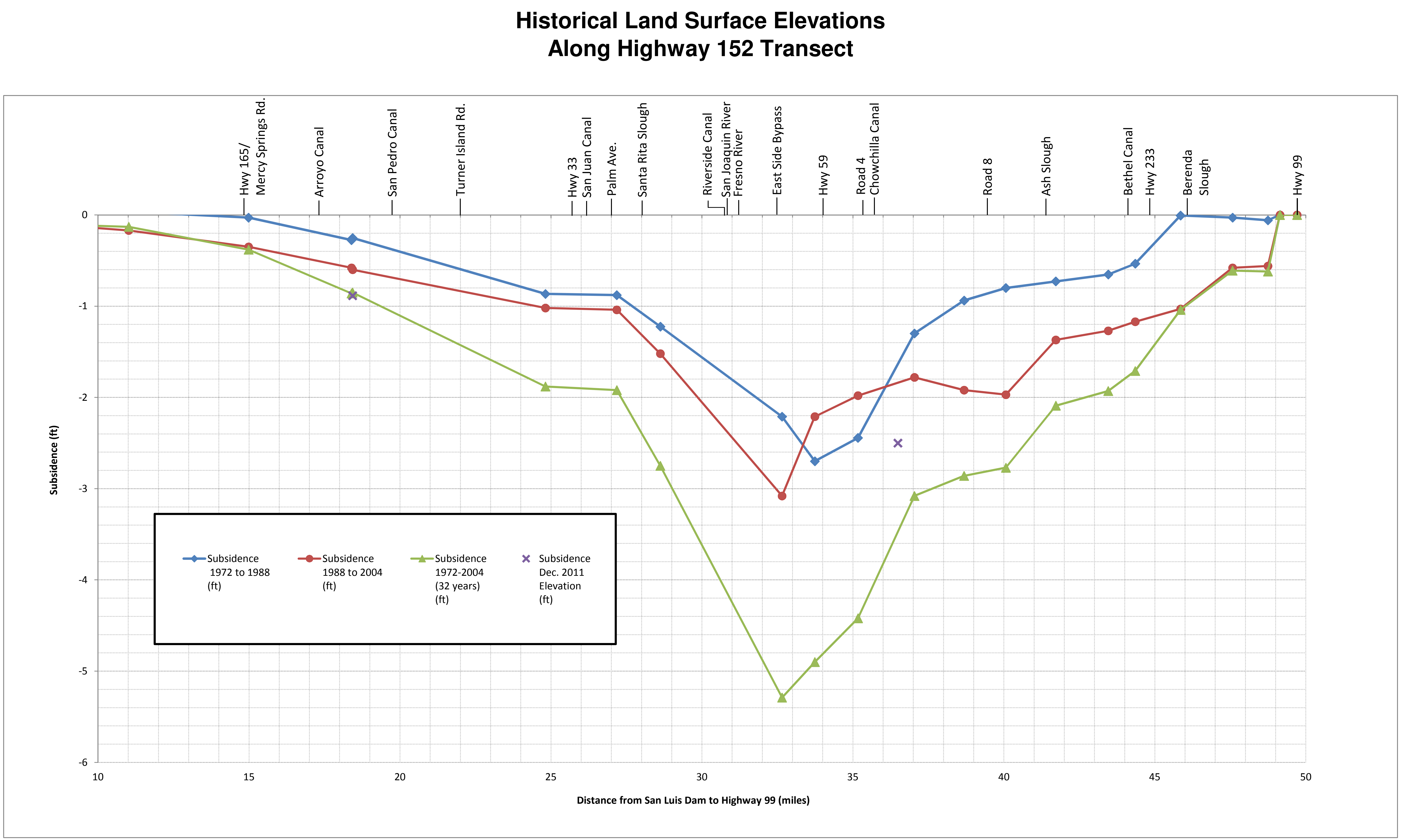
DAVIDS ENGINEERING, INC

LUHDORFF & SCALMANINI CONSULTING ENGINEERS

APPENDIX E
Subsidence Profile Locations

Madera County: Madera Subbasin
SGMA Data Collection and Analysis

Attachment B



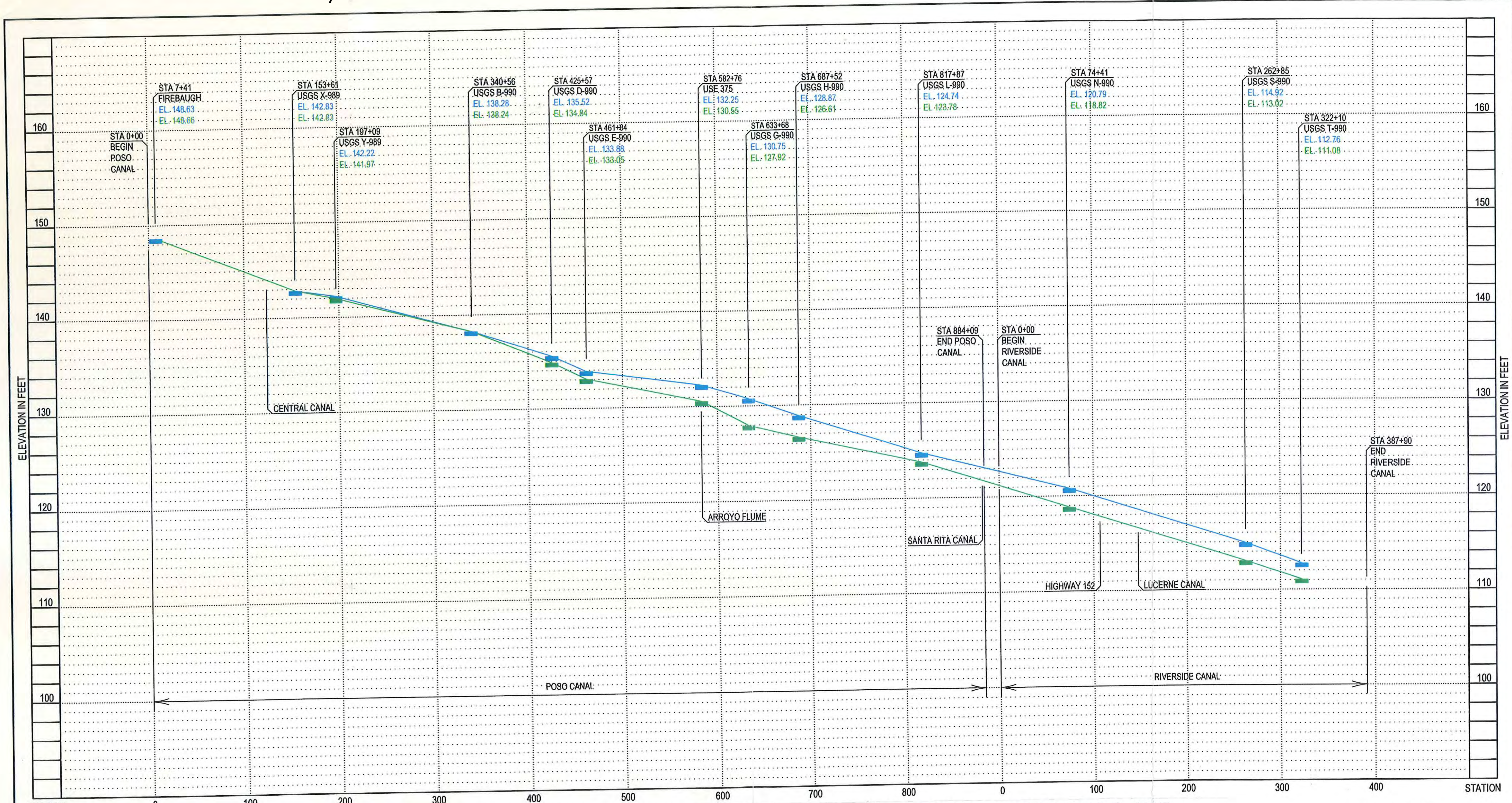


FIGURE 16- HISTORICAL LAND SURFACE ELEVATIONS ALONG POSO AND RIVERSIDE CANALS

LEGEND

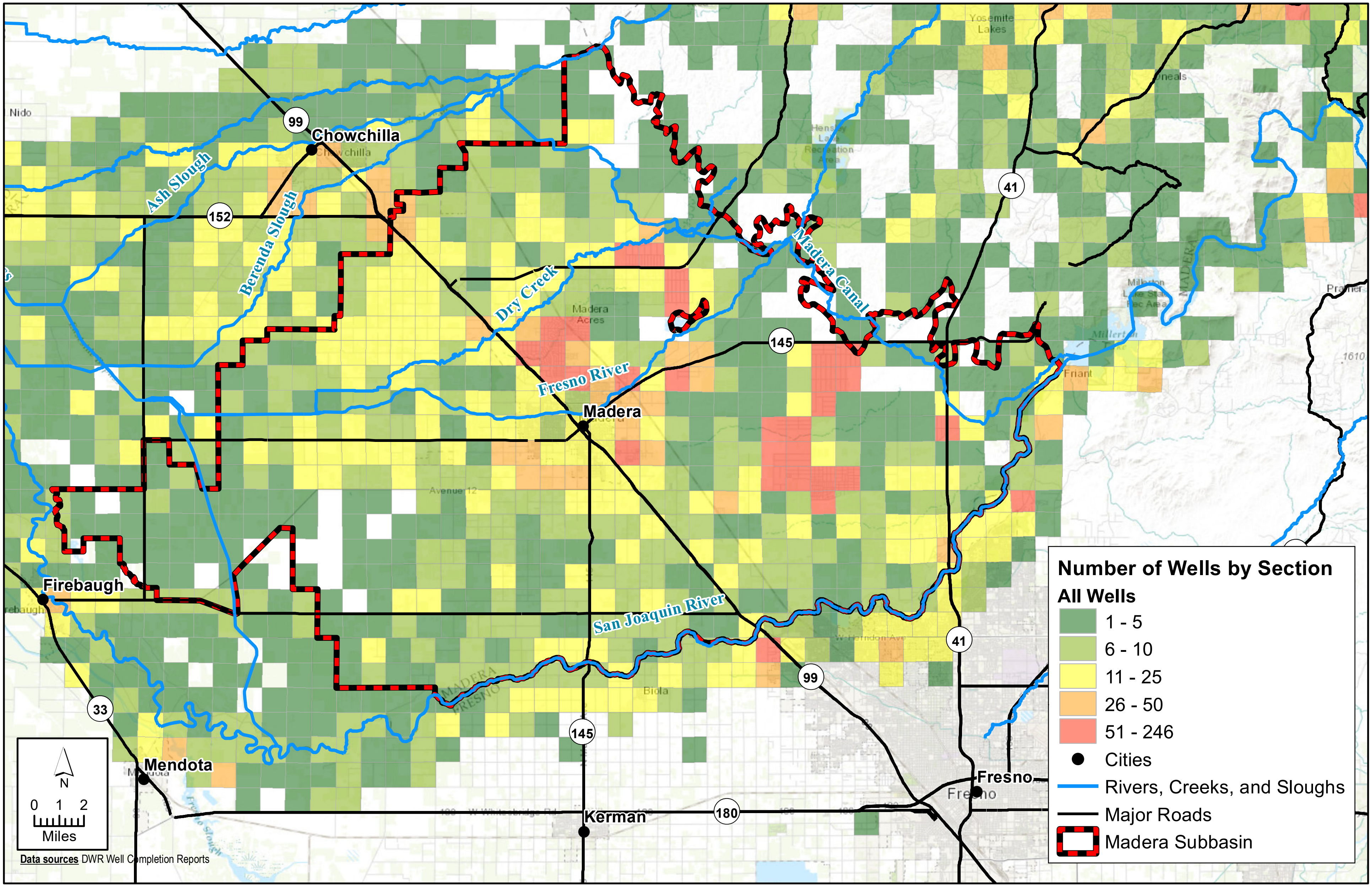
- 1981 BENCH MARK PROFILE
- XXX 1981 BENCH MARK ELEVATION
- 2012 BENCH MARK PROFILE
- XXX 2012 BENCH MARK ELEVATION

From Central California Irrigation District

APPENDIX F

DWR WELL COMPLETION REPORT LOCATION MAPS

Well Completion Reports (WCRs) were acquired from DWR for all areas of the Madera Subbasin. All WCRs were provided as PDF documents with an associated index table listing WCRs by Public Land Survey System (PLSS) township, range, and section location. As part of the acquisition of WCRs, DWR also provided a table summarizing select information contained in the WCRs (including screened interval) for the area of Madera County. The maps in this appendix summarize the WCRs received by well use and interpreted depth zone.



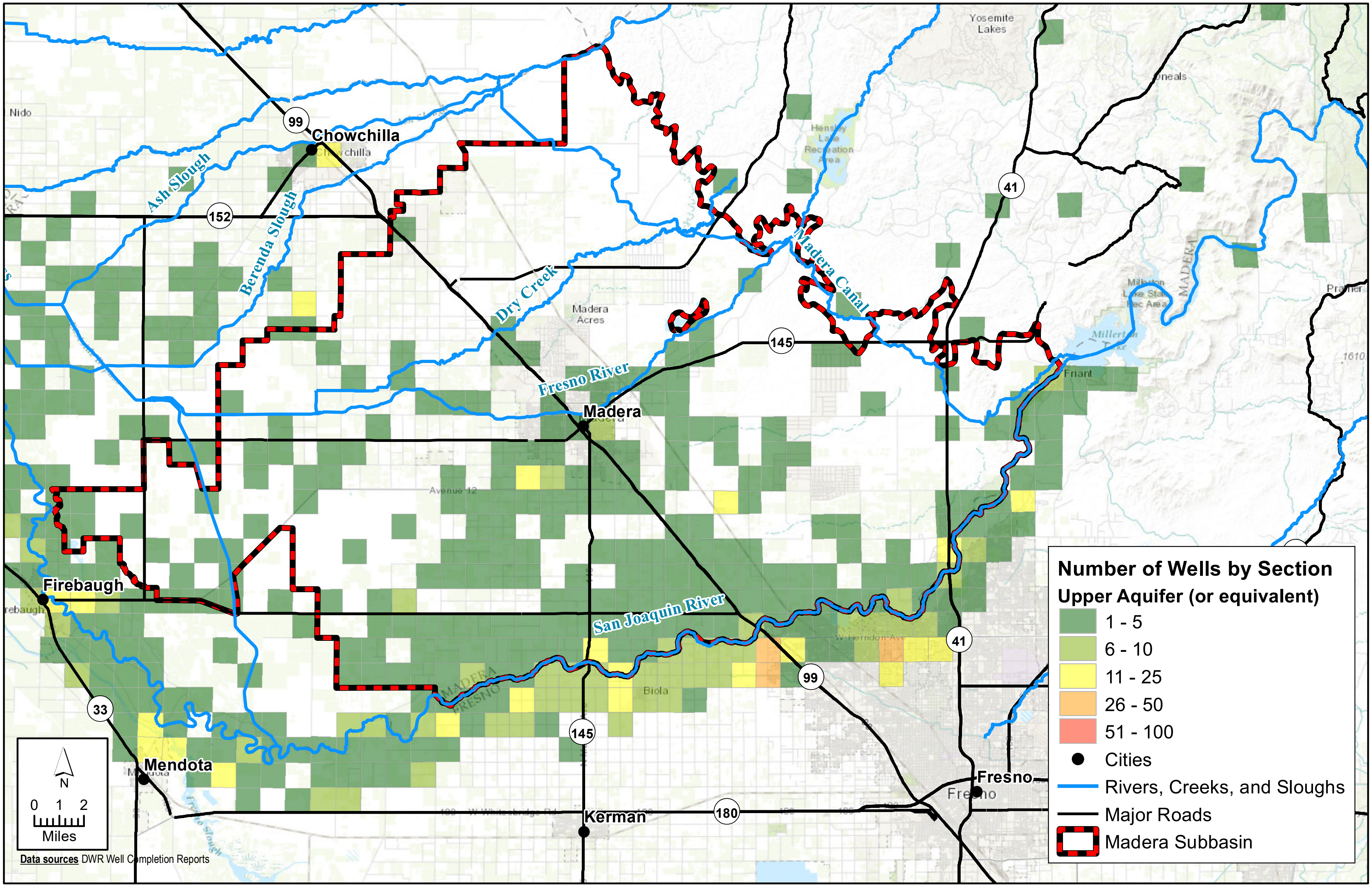
X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Appendix F Madera Subbasin WCRs By Section_Depth_AllWells.mxd

DAVIDS ENGINEERING, INC

LUHDORFF & SCALMANINI CONSULTING ENGINEERS

Madera Subbasin Wells: All Wells (from DWR WCR data)

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Appendix F Madera Subbasin WCRs By Section_Depth_Upper.mxd

DAVIDS ENGINEERING, INC

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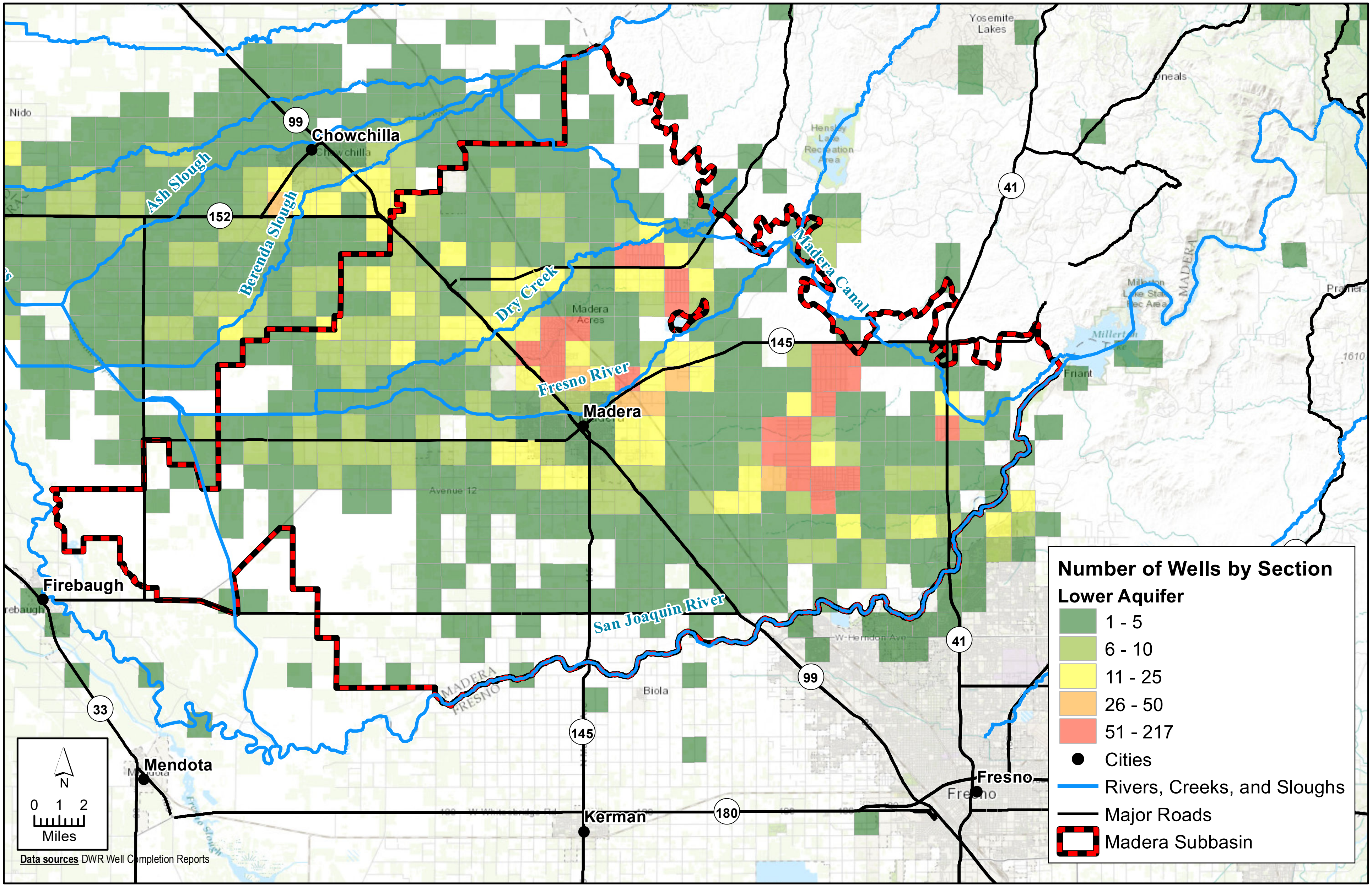
Madera Subbasin Wells by Depth Zone: Upper Aquifer (from DWR WCR data)

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



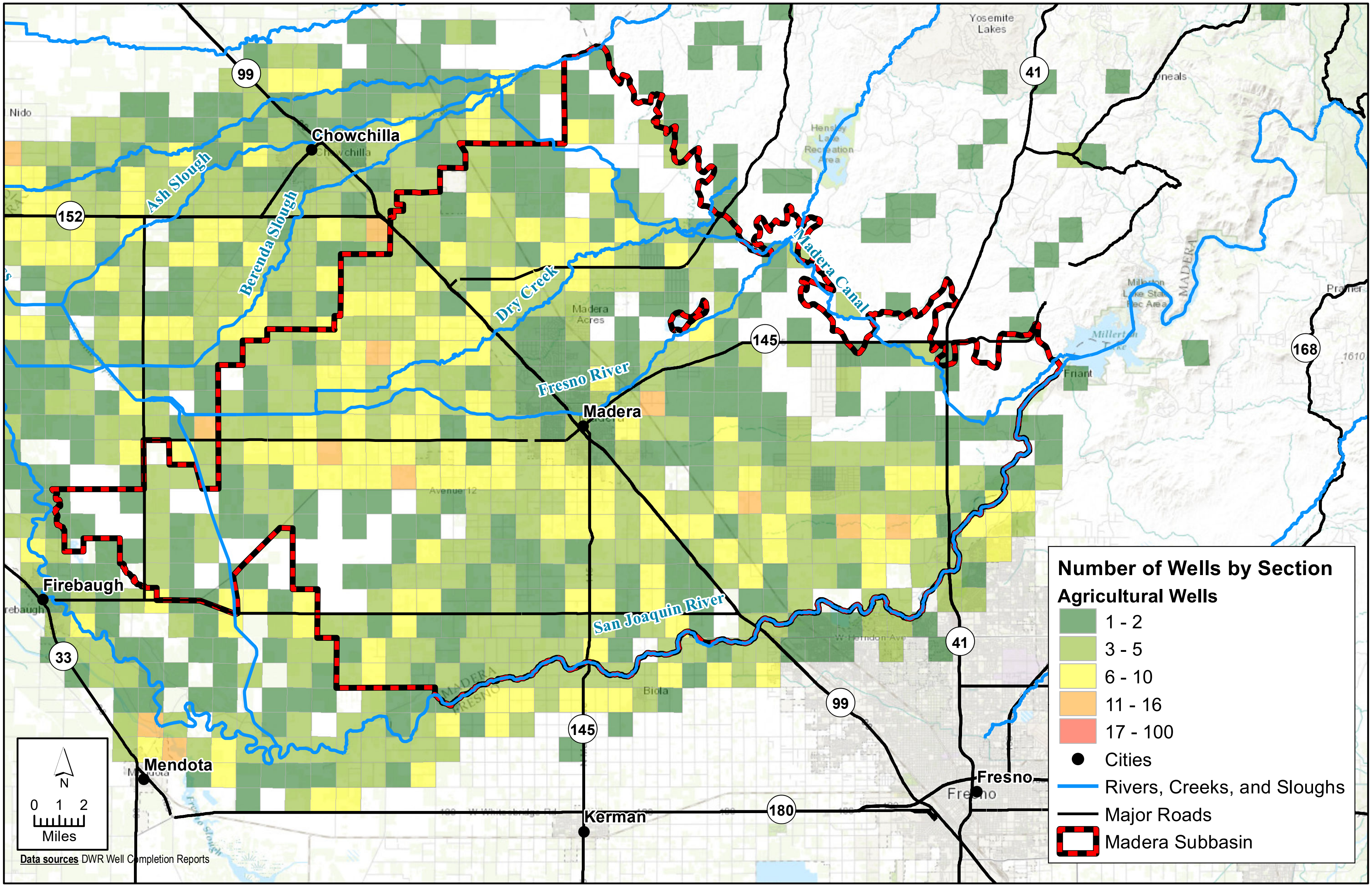
X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Appendix F Madera Subbasin WCRs By Section_Depth_Lower.mxd

DAVIDS ENGINEERING, INC

LUHDORFF & SCALMANINI CONSULTING ENGINEERS

Madera Subbasin Wells by Depth Zone: Lower Aquifer (from DWR WCR data)

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



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DAVIDS ENGINEERING, INC

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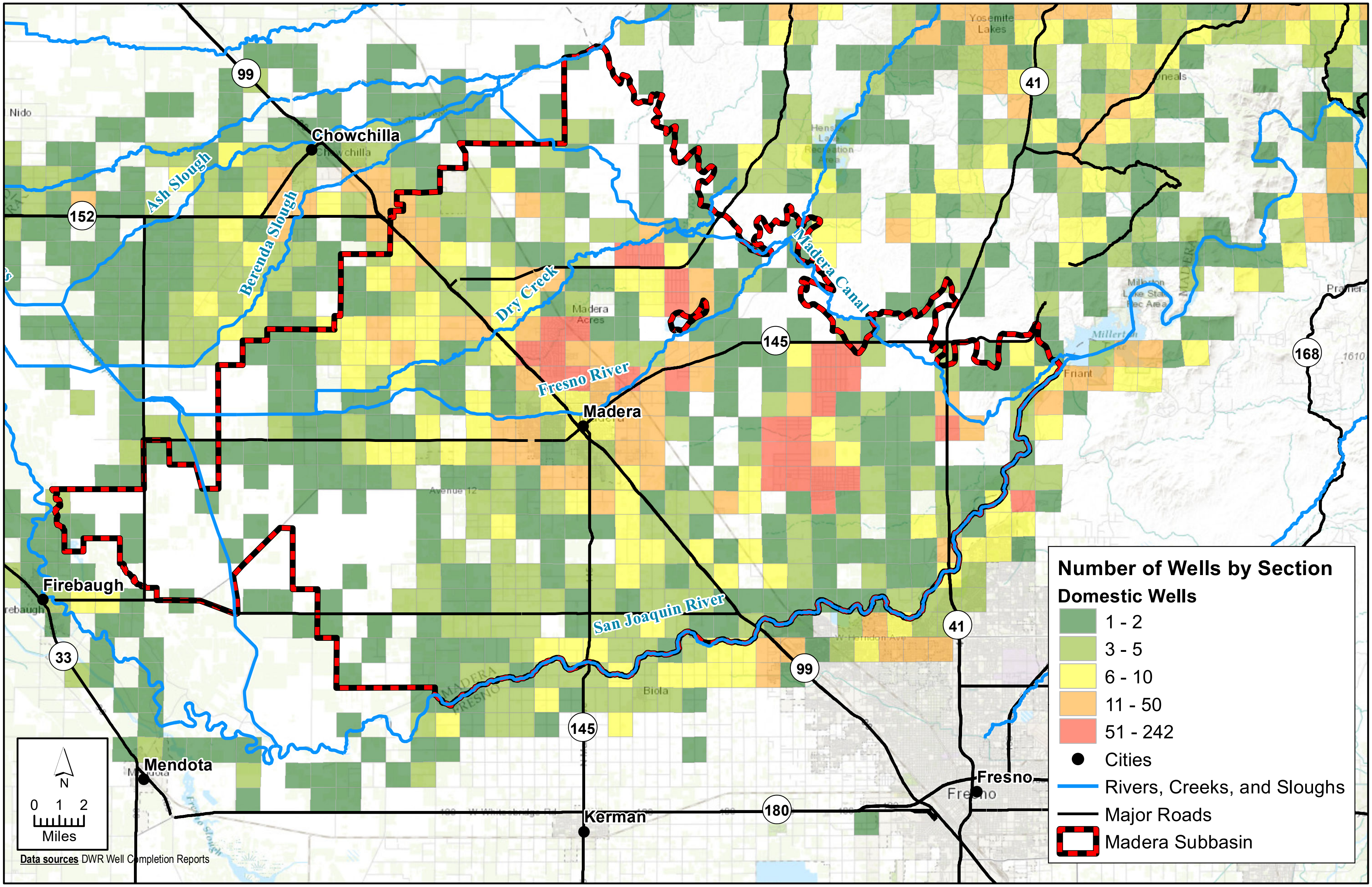
Madera Subbasin Wells By Use: Agricultural (from DWR WCR data)

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



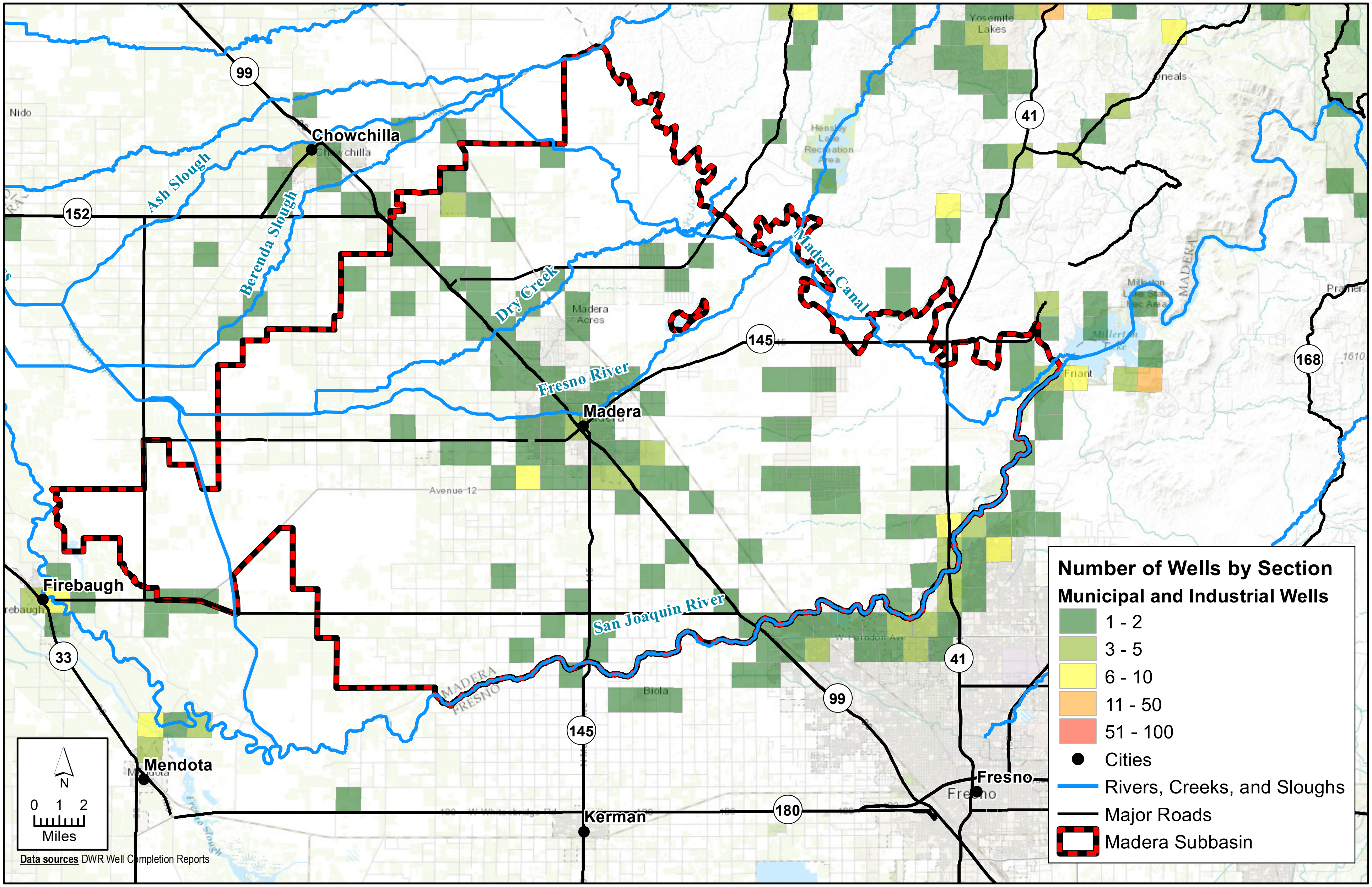
X:\2016\16-119 Madera Co. - Chowchilla & Madera Subbasins SGMA Support\GIS\Maps\FinalMapsForTM\Madera Subbasin\Appendix F Madera Subbasin WCRs By Section_Use_Dom.mxd

DAVIDS ENGINEERING, INC

LUHDORFF & SCALMANINI CONSULTING ENGINEERS

Madera Subbasin Wells By Use: Domestic (from DWR WCR data)

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



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DAVIDS ENGINEERING, INC

LUHDORFF & SCALMANINI CONSULTING ENGINEERS

Madera Subbasin Wells By Use: Municipal and Industrial (from DWR WCR data)

Madera County: Madera Subbasin
SGMA Data Collection and Analysis

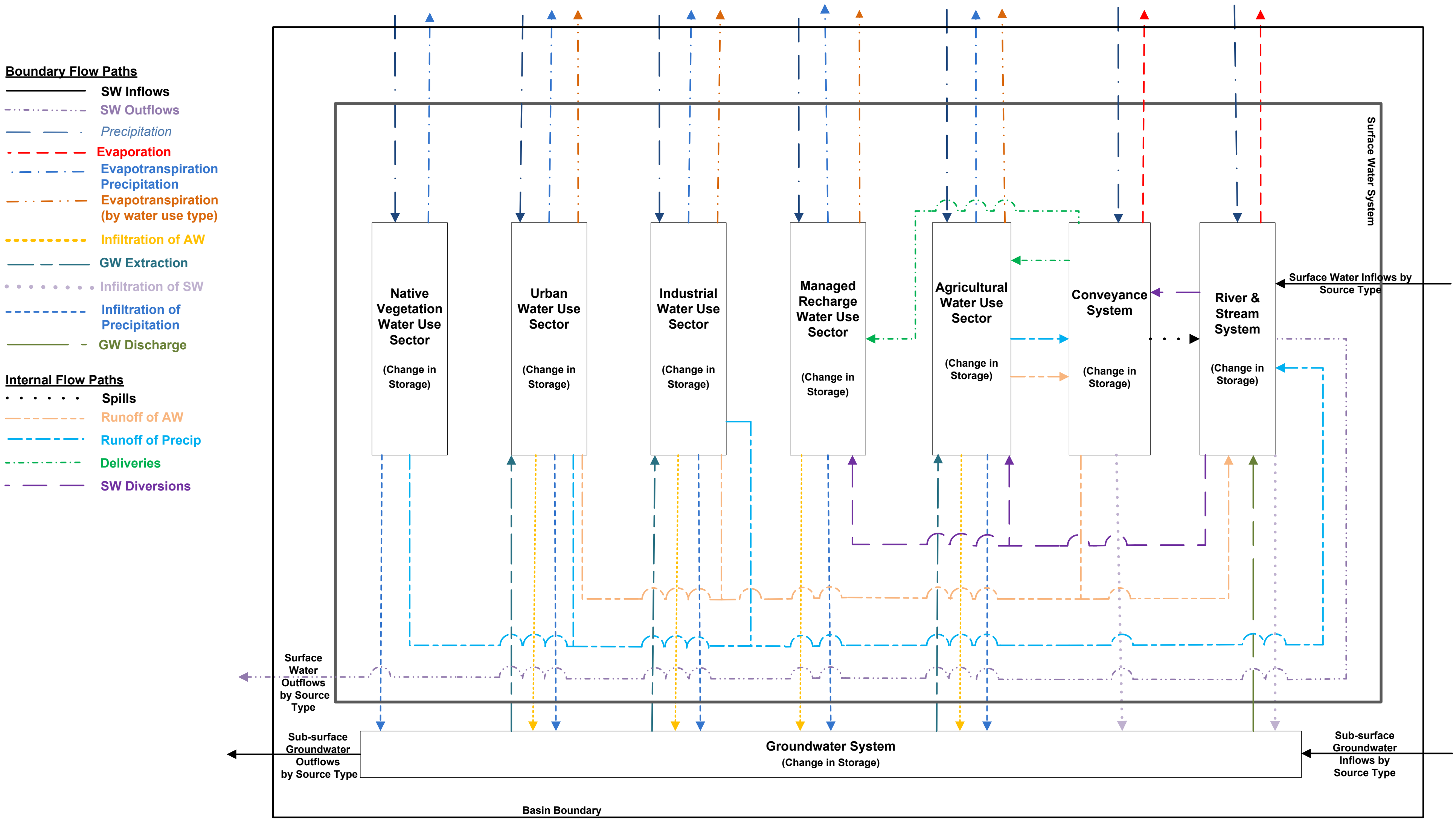
APPENDIX G

CONCEPTUAL WATER BUDGET MODEL SCHEMATICS

SGMA Water Use Sector	DWR Land Use Classes	Area, acres MADERA COUNTY
Agriculture	Agriculture*	207,109
Native Vegetation	Native Vegetation	95,482
Urban	Urban	30,906
Agriculture	Semi agricultural	5,639
Conveyance System/River & Streams	Water Surface	4,658
Industrial	Industrial	2,285
River & Streams	Native Riparian	1,608
Total		347,686

*Native Pasture NOT included

**NOT including "...stream course or watercourse vegetation."

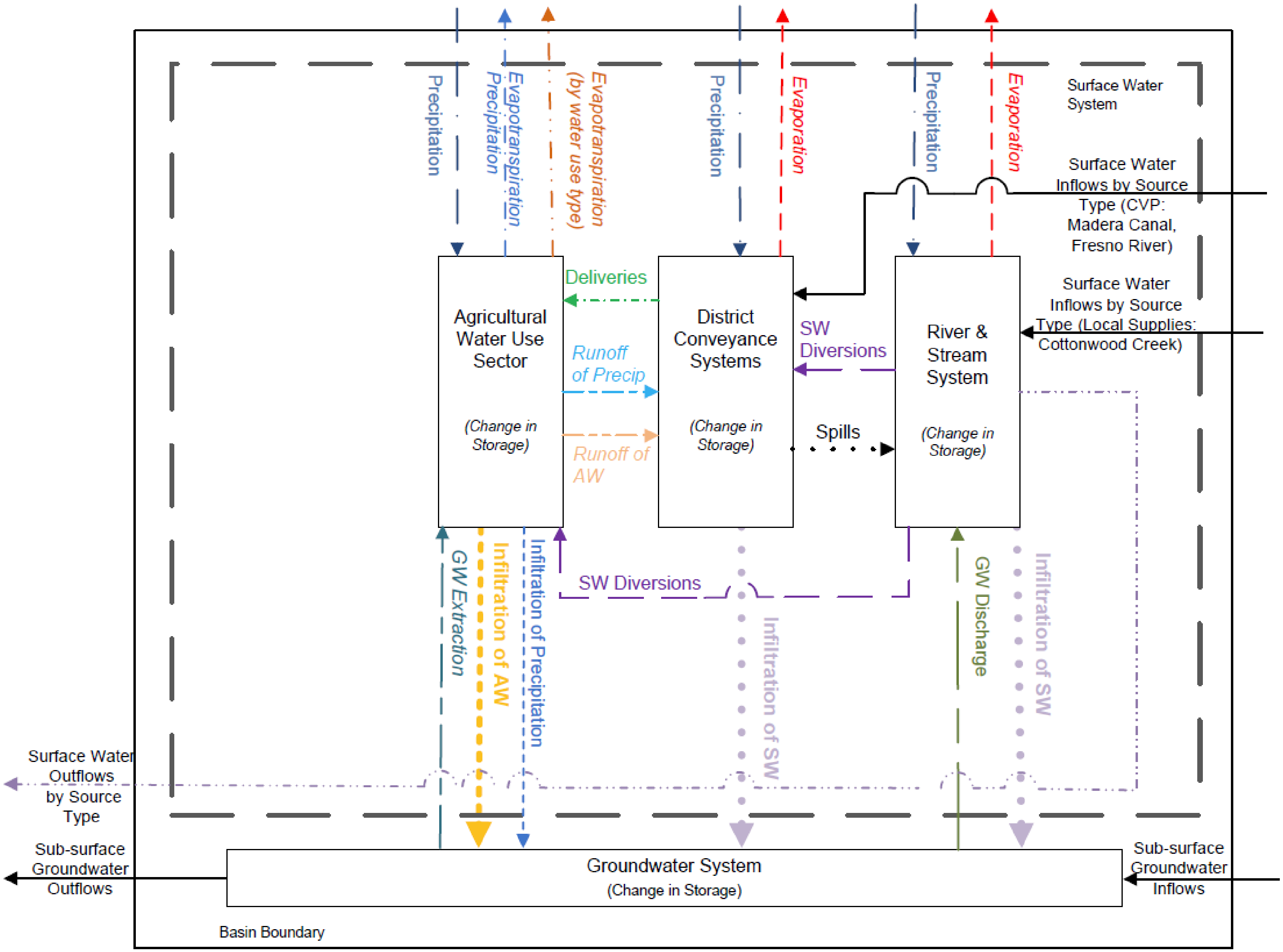


DAVIDS ENGINEERING, INC

LUHDORFF & SCALMANINI CONSULTING ENGINEERS

Conceptual Water Budget Schematics

Madera County: Madera Subbasin
SGMA Data Collection and Analysis

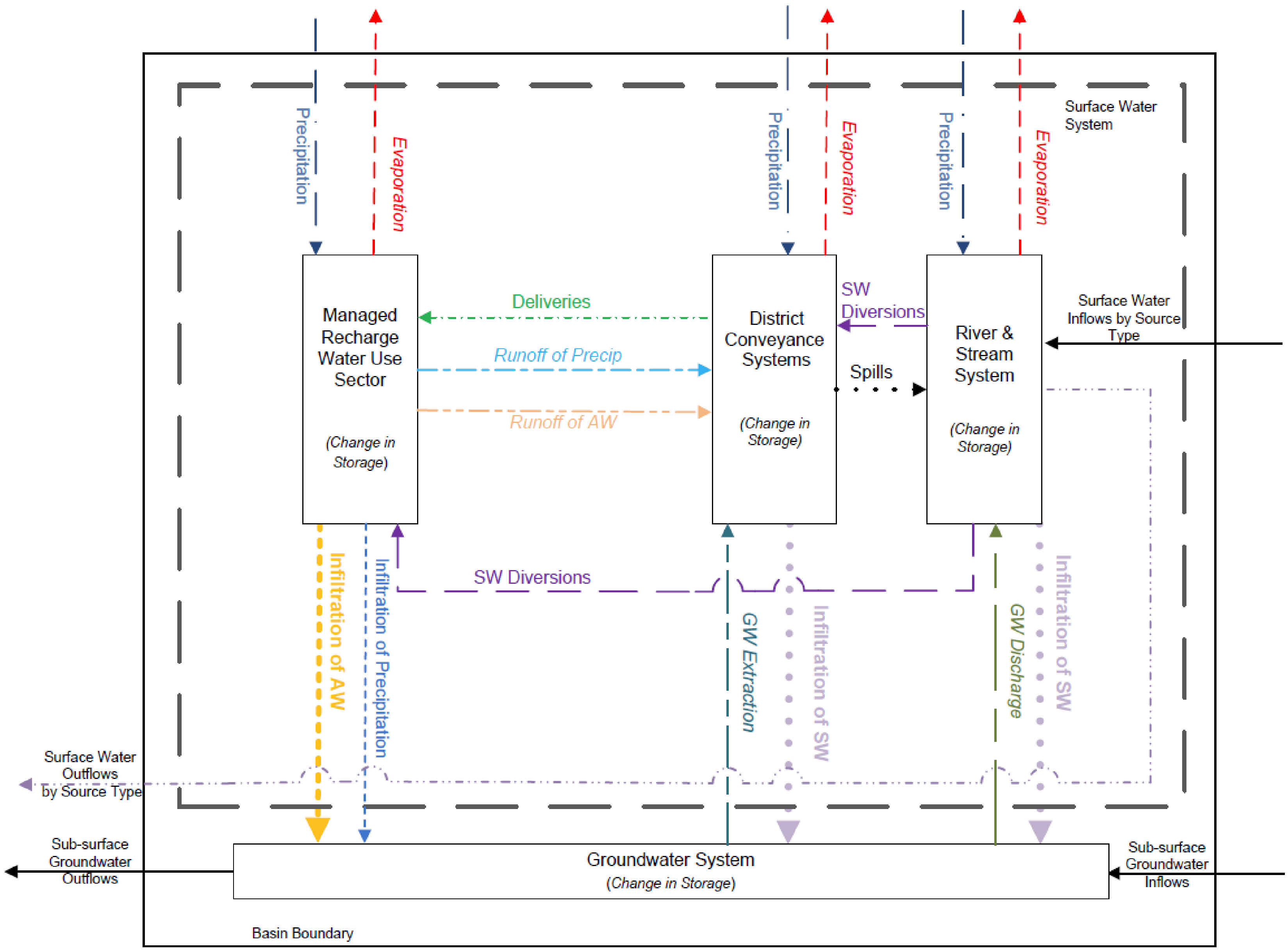


Bold Flow Paths are Closure Term
Italics Flow Path is an Estimate

DAVIDS ENGINEERING, INC
LUHDORFF & SCALMANINI CONSULTING ENGINEERS

Conceptual Water Budget Schematics

Madera County: Madera Subbasin
SGMA Data Collection and Analysis

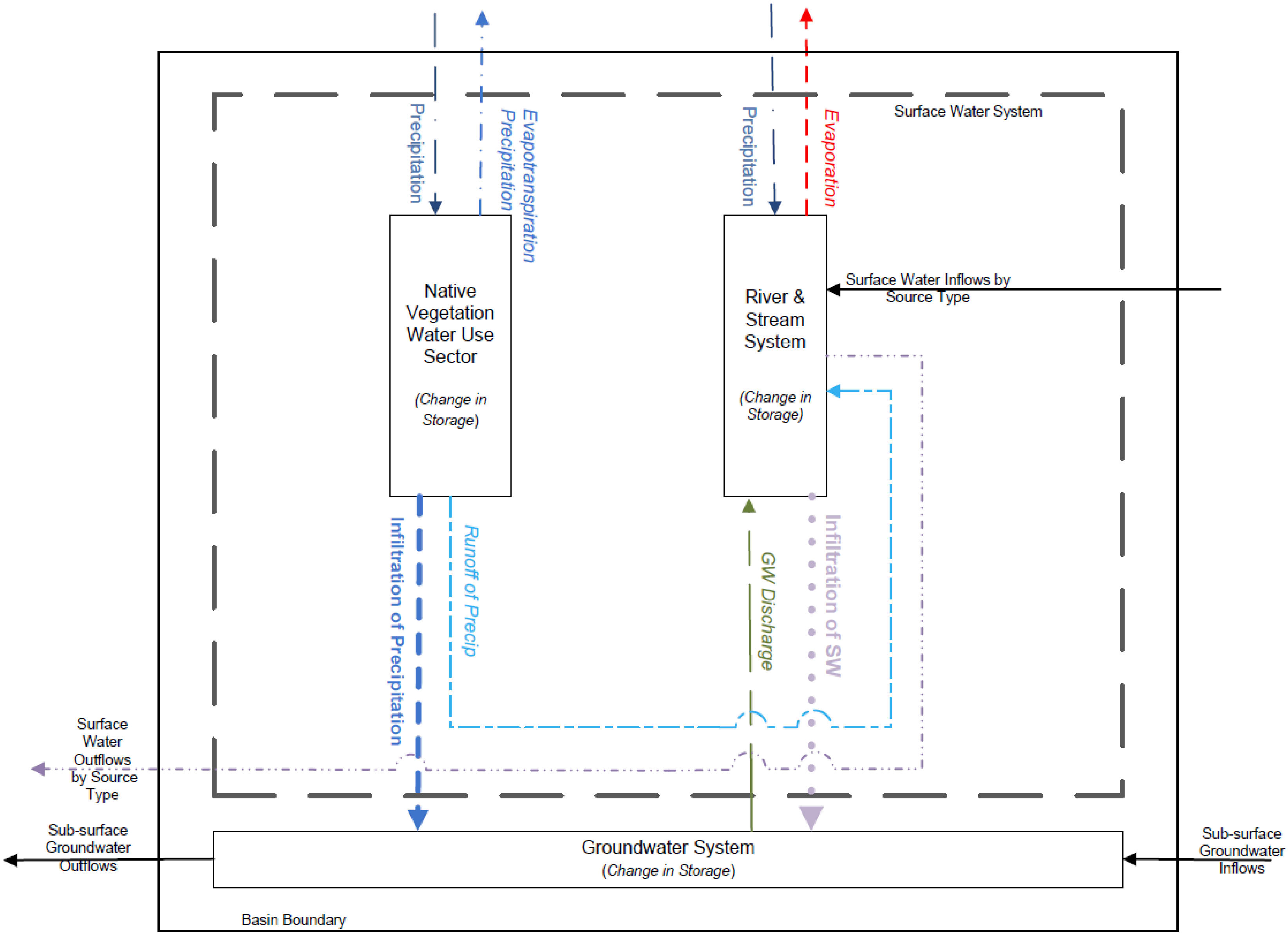


Bold Flow Paths are Closure Term
Italics Flow Path is an Estimate

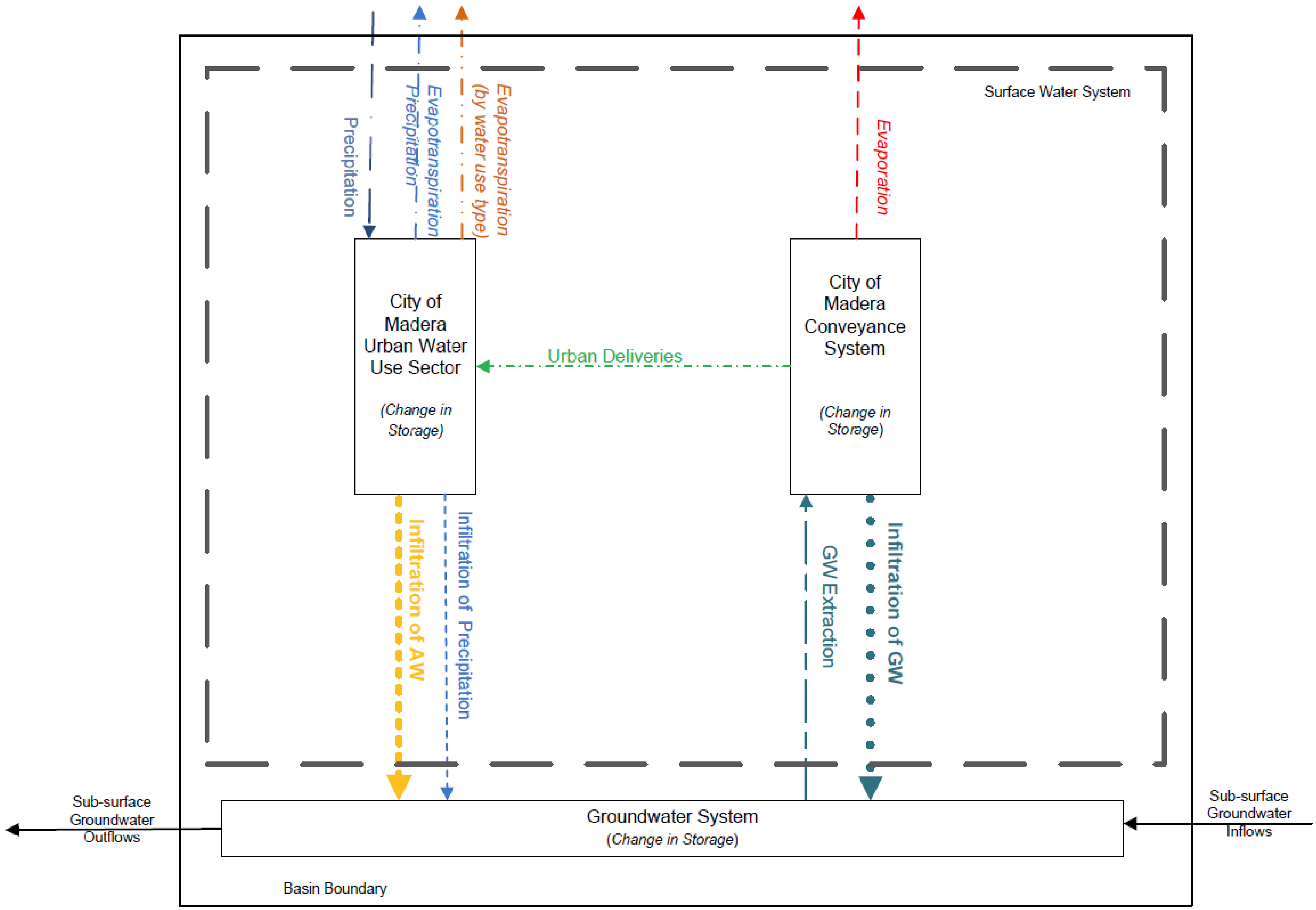
DAVIDS ENGINEERING, INC   LUHDORFF & SCALMANINI CONSULTING ENGINEERS

Conceptual Water Budget Schematics

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



Bold Flow Paths are Closure Term
Italics Flow Path is an Estimate

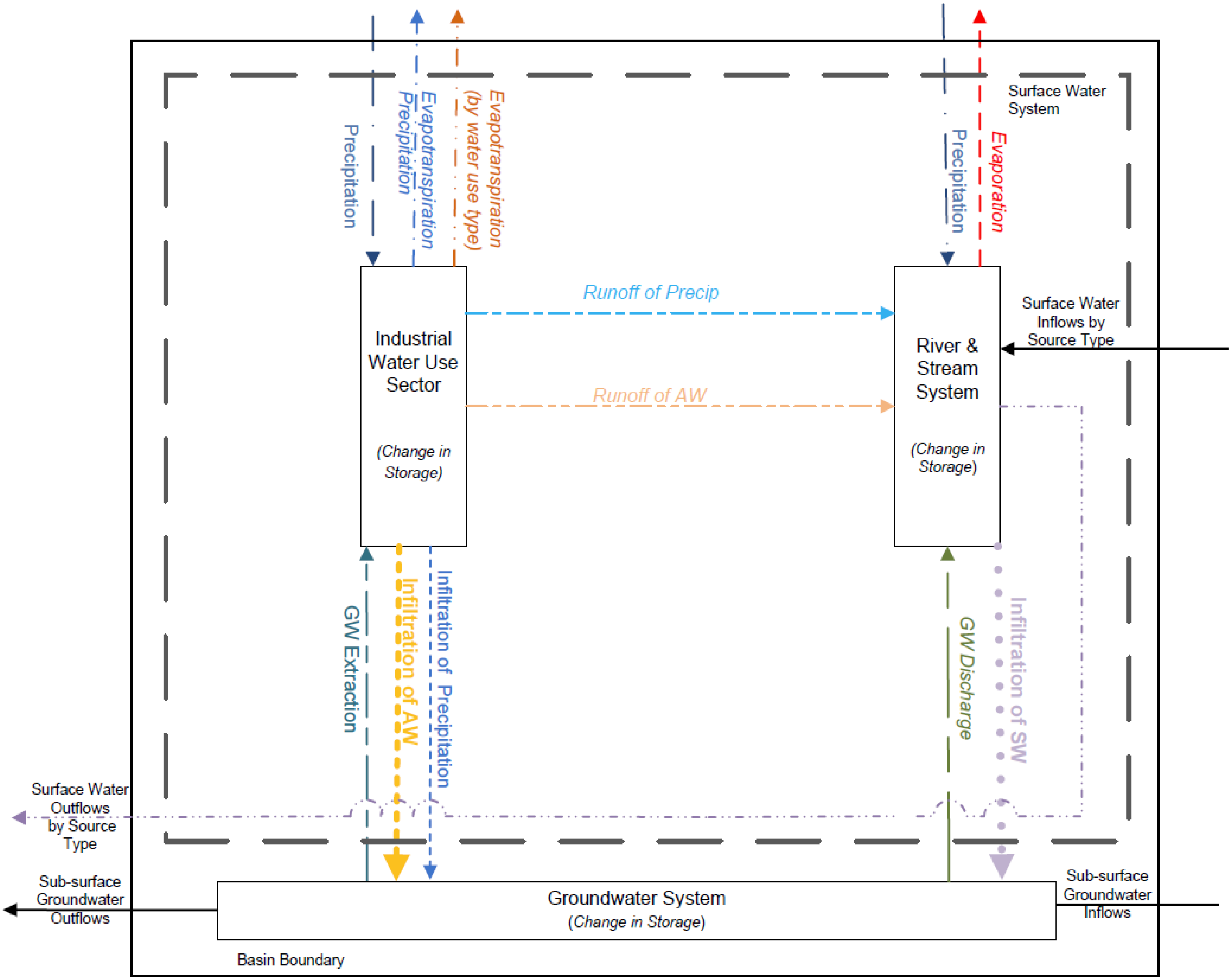


Bold Flow Paths are Closure Term
Italics Flow Path is an Estimate

DAVIDS ENGINEERING, INC
LUHDORFF & SCALMANINI CONSULTING ENGINEERS

Conceptual Water Budget Schematics

Madera County: Madera Subbasin
SGMA Data Collection and Analysis



Bold Flow Paths are Closure Term
Italics Flow Path is an Estimate

APPENDIX H

GSP REQUIREMENTS
AND
RELATED DATA GAP ASSESSMENT

GSP Requirements and Related Data Gap Assessment

GSP Regulation Sections	GSP Elements	Data Type Required	Data Gap Assessment	Additional Data Needs	Priority
Article 5 - Plan Contents					
SubArticle 2	**Basin Setting**				
§ 354.14.	**Hydrogeologic Conceptual Model**				
	(a) Each Plan shall include a descriptive hydrogeologic conceptual model of the basin based on technical studies and qualified maps that characterizes the physical components and interaction of the surface water and groundwater systems in the basin.				
	(b) The hydrogeologic conceptual model shall be summarized in a written description that includes the following:				
	(1) The regional geologic and structural setting of the basin including the immediate surrounding area, as necessary for geologic consistency.	Studies describing the general geologic and structural characteristics of subbasin.	Sufficient existing studies have been compiled.	None	
	(2) Lateral basin boundaries, including major geologic features that significantly affect groundwater flow.	Subbasin boundaries and geologic features that occur at basin boundaries.	Sufficient existing studies, maps, and data have been compiled.	None	
	(3) The definable bottom of the basin.	Geologic studies that define depth to bedrock or other relatively impermeable sediments and/or water quality basis for basin bottom.	Sufficient existing studies have been compiled.	None	
	(4) Principal aquifers and aquitards, including the following information:				
	(A) Formation names, if defined.	Studies describing the general geologic and structural characteristics of subbasin.	Sufficient existing studies have been compiled.	None	
	(B) Physical properties of aquifers and aquitards, including the vertical and lateral extent, hydraulic conductivity, and storativity, which may be based on existing technical studies or other best available information.	Studies describing the general geologic and structural characteristics of subbasin; geologic cross-sections; DWR well logs; existing and local data for aquifer testing.	Existing studies provide sufficient aquifer property data to meet this requirement; however, groundwater modeling would require additional aquifer property data to define aquifer property zones. The data needed to refine aquifer property zones for the model were compiled in this study.	None	
	(C) Structural properties of the basin that restrict groundwater flow within the principal aquifers, including information regarding stratigraphic changes, truncation of units, or other features.	Studies describing the general geologic and structural characteristics of subbasin; basin specific geologic cross-sections.	Sufficient existing studies, maps, geologic cross-sections, and data have been compiled.	None, but could be refined with additional geologic cross-sections needed for groundwater model.	Low - can refine this element in conjunction with groundwater model development in GSP.
	(D) General water quality of the principal aquifers, which may be based on information derived from existing technical studies or regulatory programs.	Studies describing hydrogeology of subbasin; well specific water quality data.	A significant amount of water quality data have been compiled; however, additional efforts are needed for better definition of aquifer-specific water quality characterization.	Better delineation of water quality in upper versus lower aquifers.	High
	(E) Identification of the primary use or uses of each aquifer, such as domestic, irrigation, or municipal water supply.	Land use data; groundwater pumping data; DWR Well Completion Reports.	Sufficient existing studies, maps, and data have been compiled.	None	
	(5) Identification of data gaps and uncertainty within the hydrogeologic conceptual model				
	(c) The hydrogeologic conceptual model shall be represented graphically by at least two scaled cross-sections that display the information required by this section and are sufficient to depict major stratigraphic and structural features in the basin.	Geologic and hydrogeologic studies that contain existing cross-sections; DWR well logs and geophysical logs.	Existing studies provide sufficient geologic cross-sections to meet this requirement; however, groundwater modeling would require preparation of additional geologic cross-sections. The data needed to prepare those additional geologic cross-sections were compiled in this study.	None, but could be refined with additional geologic cross-sections needed for groundwater model.	Low - can refine this element in conjunction with groundwater model development in GSP.
	(d) Physical characteristics of the basin shall be represented on one or more maps that depict the following:				
	(1) Topographic information derived from the U.S. Geological Survey or another reliable source.	Topographic maps and/or data.	Sufficient data/maps have been compiled.	None	
	(2) Surficial geology derived from a qualified map including the locations of cross-sections required by this Section.	Geologic and hydrogeologic studies that contain surficial geology maps.	Sufficient data/maps have been compiled.	None	
	(3) Soil characteristics as described by the appropriate Natural Resources Conservation Service soil survey or other applicable studies.	Geologic and hydrogeologic studies that contain soil survey maps; soil data from NRCS/SSURGO.	Sufficient data/maps have been compiled.	None	
	(4) Delineation of existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas, including significant active springs, seeps, and wetlands within or adjacent to the basin.	Geologic and hydrogeologic studies that contain maps/data on recharge and discharge areas; soil maps; surficial geology maps and cross-sections; GDE mapping by DWR.	The currently available studies/maps/data have been compiled; however, The Nature Conservancy (TNC) and DWR are nearing completion of mapping for statewide groundwater dependent ecosystems (GDEs) that should be included in this analysis.	Incorporate GDE mapping from TNC/DWR when it becomes available	See 354.16.g
	(5) Surface water bodies that are significant to the management of the basin.	Maps delineating surface water bodies; groundwater contour maps; streamflow data.	Sufficient data/maps have been compiled.	None	
§ 354.16.	**Groundwater Conditions**				
	Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:				
	(a) Groundwater elevation data demonstrating flow directions, lateral and vertical gradients, and regional pumping patterns, including:	Groundwater elevation data	Available data has been compiled from public and local sources.	See Below	See Below
	(1) Groundwater elevation contour maps depicting the groundwater table or potentiometric surface associated with the current seasonal high and seasonal low for each principal aquifer within the basin.	Groundwater elevation data specific to shallow and deep aquifers.	Available data has been compiled from public and local sources. Many wells have unknown construction details, thereby limiting the database specific to each aquifer. This is a data gap requiring further work.	Better delineation of historic/future groundwater elevation contours in upper versus lower aquifers.	High
	(2) Hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers.	Groundwater elevation data specific to shallow and deep aquifers.	Available data has been compiled from public and local sources. Many wells have unknown construction details, thereby limiting the database specific to each aquifer. This is a data gap requiring further work.	Better delineation of historic/future changes in groundwater levels in upper versus lower aquifers.	High
	(b) A graph depicting estimates of the change in groundwater in storage, based on data, demonstrating the annual and cumulative change in the volume of groundwater in storage between seasonal high groundwater conditions, including the annual groundwater use and water year type.	Groundwater elevation data; specific yield; groundwater pumping; climatic data.	Existing studies include total and average annual groundwater storage change over specific time periods for Madera County but not specific to the subbasin. This element would be completed during preparation of the GSP.	None, but additional analysis needed used data compiled for this study.	
	(c) Seawater intrusion conditions in the basin, including maps and cross-sections of the seawater intrusion front for each principal aquifer.	Not applicable to the subbasin.	Not applicable to the subbasin.	Not applicable to the subbasin.	

GSP Requirements and Related Data Gap Assessment

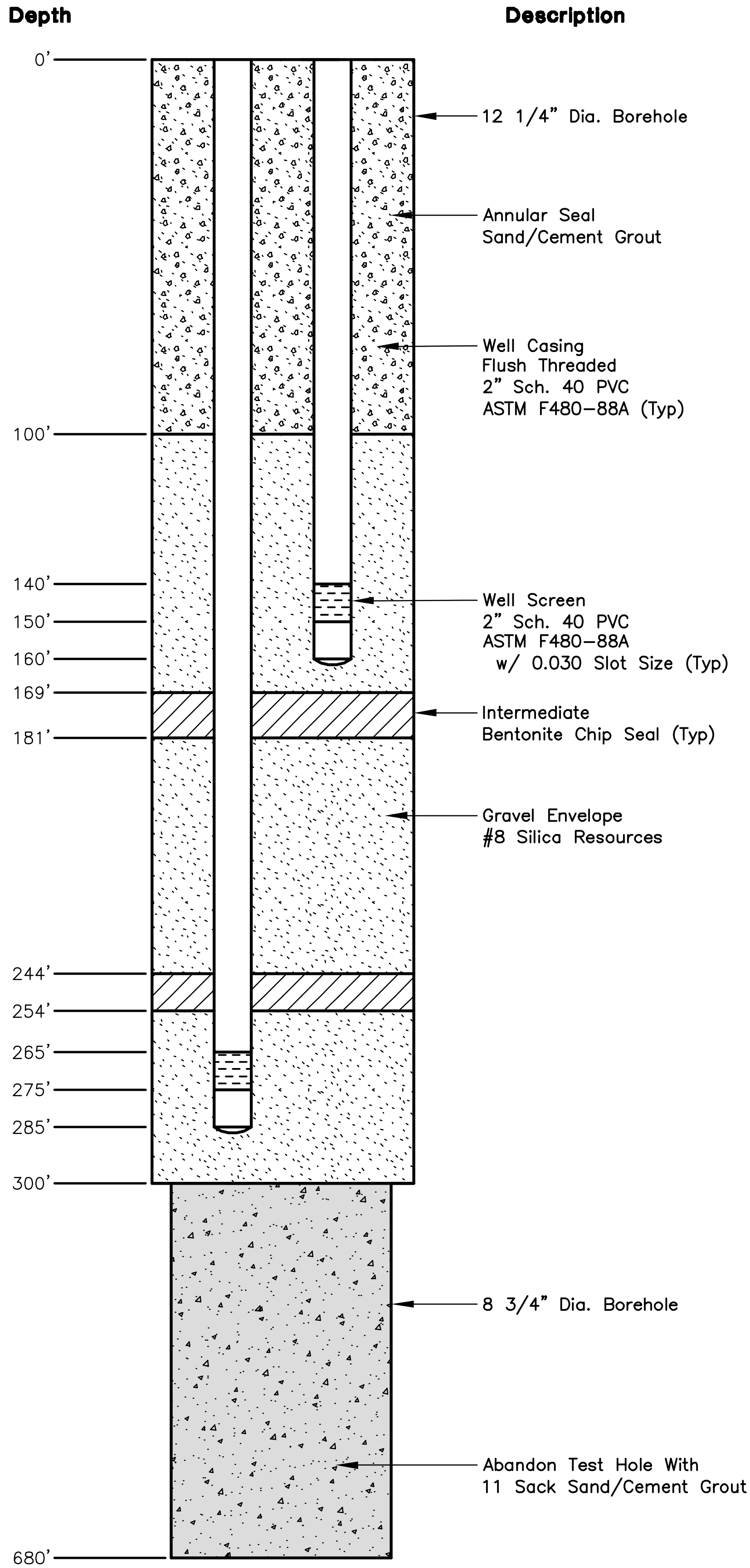
GSP Regulation Sections	GSP Elements	Data Type Required	Data Gap Assessment	Additional Data Needs	Priority
	(d) Groundwater quality issues that may affect the supply and beneficial uses of groundwater, including a description and map of the location of known groundwater contamination sites and plumes.	Groundwater quality data.	Available data has been compiled from public and local sources. Many wells have unknown construction details, thereby limiting the database specific to each aquifer. This is a data gap requiring further work. Data on known groundwater contamination sites/plumes (e.g., UST sites, landfill sites) was not compiled for this study, but is readily available from various sources.	Better delineation of water quality in shallow versus deep aquifers.	High
	(e) The extent, cumulative total, and annual rate of land subsidence, including maps depicting total subsidence, utilizing data available from the Department, as specified in Section 353.2, or the best available information.	Subsidence data.	Sufficient existing studies, maps, and data have been compiled.	None, assuming ongoing land subsidence monitoring by DWR/USGS/USBR	
	(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.	Maps of interconnected surface water bodies; groundwater elevation contour maps; streambed and shallow aquifer characteristics.	Sufficient available studies/maps/data have been compiled for identification. The quantity and timing element may be addressed through groundwater modeling in the GSP. Additional field studies may be required relative to evaluation of streambed properties and monitoring of surface water - groundwater interaction.	Possibly additional field studies to evaluate streambed properties and monitoring installations.	Medium - can be conducted during GSP development.
	(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.	Studies/maps/data delineating groundwater dependent ecosystems (GDEs).	The Nature Conservancy and DWR are nearing completion of their preliminary GDE statewide mapping effort. This database will need to be reviewed for relevant GDEs in the subbasin when it becomes available.	Statewide database being prepared by The Nature Conservancy/DWR.	Medium - can be conducted during GSP development.
§ 354.18.	**Water Budget**				
	(a) 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.				
	(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:				
	(1) Total surface water entering and leaving a basin by water source type.	Surface Water Inflows and Surface Water Outflows by source type for each month for at least last year and 10 years	Sufficient data with QA/QC analysis Surface water outflow data is a major data gap. Seven years of data is available at one outflow site measures combined flows from the three main outflows and is located within approximately 10 miles of the subbasin boundary.	None.	High
	(2) Inflow to the groundwater system by water source type, including subsurface groundwater inflow and infiltration of precipitation, applied water, and surface water systems, such as lakes, streams, rivers, canals, springs and conveyance systems.	Surface Soil Properties, Meteorological (precipitation and reference ET), Land Use, applied water, surface water diversions and surface water inflows and surface water outflows	Sufficient data with QA/QC analysis	None.	Medium - can be conducted during GSP development.
	(3) Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow.	Surface Soil Properties, Meteorological (precipitation and reference ET), Land Use, applied water, surface water diversions and surface water inflows and surface water outflows	Sufficient data with QA/QC analysis	None.	Medium - can be conducted during GSP development.
	(4) The change in the annual volume of groundwater in storage between seasonal high conditions.	Groundwater elevation data; specific yield	See Groundwater Conditions section (354.16b).	See Groundwater Conditions section (354.16b).	
	(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.	Surface Soil Properties, Meteorological (precipitation and reference ET), Land Use, applied water, surface water diversions and surface water inflows and surface water outflows	Sufficient data with QA/QC analysis	None.	Medium - can be conducted during GSP development.
	(6) The water year type associated with the annual supply, demand, and change in groundwater stored.	water year type	Sufficient data	None	Medium - can be conducted during GSP development.
	(7) An estimate of sustainable yield for the basin.	Various, as described in HCM and Groundwater Conditions sections	See HCM and Groundwater Conditions sections	See HCM and Groundwater Conditions sections	See HCM and Groundwater Conditions sections
	(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.	Surface Soil Properties, Meteorological (precipitation and reference ET), Land Use, applied water, surface water diversions and surface water inflows and surface water outflows	Sufficient data with QA/QC analysis	None.	Medium - can be conducted during GSP development.
	(2) Historical water budget information shall be used to evaluate availability or reliability of past surface water supply deliveries and aquifer response to water supply and demand trends relative to water year type. The historical water budget shall include the following:				
	(A) A quantitative evaluation of the availability or reliability of historical surface water supply deliveries as a function of the historical planned versus actual annual surface water deliveries, by surface water source and water year type, and based on the most recent ten years of surface water supply information.	Surface water deliveries for at least last year and 10 years	Sufficient data with QA/QC analysis	None.	Medium - can be conducted during GSP development.
	(B) A quantitative assessment of the historical water budget, starting with the most recently available information and extending back a minimum of 10 years, or as is sufficient to calibrate and reduce the uncertainty of the tools and methods used to estimate and project future water budget information and future aquifer response to proposed sustainable groundwater management practices over the planning and implementation horizon.	Surface Soil Properties, Meteorological (precipitation and reference ET), Land Use, applied water, surface water diversions and surface water inflows and surface water outflows	Sufficient data with QA/QC analysis	None.	Medium - can be conducted during GSP development.

GSP Requirements and Related Data Gap Assessment

GSP Regulation Sections	GSP Elements	Data Type Required	Data Gap Assessment	Additional Data Needs	Priority
	(C) A description of how historical conditions concerning hydrology, water demand, and surface water supply availability or reliability have impacted the ability of the Agency to operate the basin within sustainable yield. Basin hydrology may be characterized and evaluated using water year type.	Surface Soil Properties, Meteorological (precipitation and reference ET), Land Use, applied water, surface water diversions and surface water inflows and surface water outflows	Sufficient data with QA/QC analysis	None.	Medium - can be conducted during GSP development.
	(3) 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:				
	(A) Projected hydrology shall utilize 50 years of historical precipitation, evapotranspiration, and streamflow information as the baseline condition for estimating future hydrology. The projected hydrology information shall also be applied as the baseline condition used to evaluate future scenarios of hydrologic uncertainty associated with projections of climate change and sea level rise.	Precipitation, evapotranspiration, streamflow	Sufficient data with QA/QC analysis	None.	Medium - can be conducted during GSP development.
	(B) Projected water demand shall utilize the most recent land use, evapotranspiration, and crop coefficient information as the baseline condition for estimating future water demand. The projected water demand information shall also be applied as the baseline condition used to evaluate future scenarios of water demand uncertainty associated with projected changes in local land use planning, population growth, and climate.	Surface Soil Properties, Meteorological (precipitation and reference ET), Land Use, applied water, surface water diversions and surface water inflows and surface water outflows and population projections	Sufficient data with QA/QC analysis	None.	Medium - can be conducted during GSP development.
	(C) Projected surface water supply shall utilize the most recent water supply information as the baseline condition for estimating future surface water supply. The projected surface water supply shall also be applied as the baseline condition used to evaluate future scenarios of surface water supply availability and reliability as a function of the historical surface water supply identified in Section 354.18(c)(2)(A), and the projected changes in local land use planning, population growth, and climate.	Surface Water Inflows for each month for at least last year and 10 years	Sufficient data with QA/QC analysis	None.	Medium - can be conducted during GSP development.
	(d) The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget:				Medium - can be conducted during GSP development.
	(1) Historical water budget information for mean annual temperature, mean annual precipitation, water year type, and land use.	mean annual temperature, mean annual precipitation, water year type, and land use	Sufficient data with QA/QC analysis	None.	Medium - can be conducted during GSP development.
	(2) Current water budget information for temperature, water year type, evapotranspiration, and land use.	mean annual temperature, mean annual precipitation, water year type, and land use	Sufficient data with QA/QC analysis	None.	Medium - can be conducted during GSP development.
	(3) Projected water budget information for population, population growth, climate change, and sea level rise.	population, population growth, climate change	Sufficient data with QA/QC analysis	None.	Medium - can be conducted during GSP development.
	(e) Each Plan shall rely on the best available information and best available science to quantify the water budget for the basin in order to provide an understanding of historical and projected hydrology, water demand, water supply, land use, population, climate change, sea level rise, groundwater and surface water interaction, and subsurface groundwater flow. If a numerical groundwater and surface water model is not used to quantify and evaluate the projected water budget conditions and the potential impacts to beneficial uses and users of groundwater, the Plan shall identify and describe an equally effective method, tool, or analytical model to evaluate projected water budget conditions.				
	(f) The Department shall provide the California Central Valley Groundwater-Surface Water Simulation Model (C2VSIM) and the Integrated Water Flow Model (IWFM) for use by Agencies in developing the water budget. Each Agency may choose to use a different groundwater and surface water model, pursuant to Section 352.4.	California Central Valley Groundwater-Surface Water Simulation Model (C2VSIM) and the Integrated Water Flow Model (IWFM)	Localized model lacking	Localize model	Medium - can be conducted during GSP development.

APPENDIX I

TYPICAL MONITORING WELL DESIGN AND CONSTRUCTION SPECIFICATIONS



CAD FILE: C:/Documents and Settings/DavidT.LSCEDOMAIN/Local Settings/Application Data/Autodesk/AutoCAD 2014/R19.1/enu/Template/Typical MW (2).dwt

LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

Typical Monitoring Well

I. SPECIAL PROVISIONS

1.1 GENERAL

1.1.1 ENGINEER

The Engineer for the project is Luhdorff and Scalmanini, Consulting Engineers, 500 First Street, Woodland, California 95695 (Contact: Scott Lewis at (530) 661-0109). The Engineer will act as the Owner's agent with respect to interpretation of the Plans as well as serving as a technical advisor and inspector during drilling and well construction activities. During the course of the Work, the Engineer may advise the Owner as to the quality or acceptability of materials furnished and work performed and as to the manner of performance and rate of progress of the Work. In addition, the Engineer may advise the Owner on questions which arise as to the interpretation of the Plans and Technical Provisions, questions as to the acceptable fulfillment of the contract on the part of the Contractor, and questions as to measurement and payment.

1.1.2 TERMINATION AND ALTERNATIVE WELL

Owner reserves the right to terminate the Work at any time. In such an event, the Contractor shall be paid for work completed at that time in accordance with the prices stated on the BID FORM. The Owner reserves the right to select an alternate site to replace an abandoned test hole or well. If an alternate site is chosen by the Owner, the Contractor shall be paid for the work done on the alternate site in accordance with the unit prices stated on the BID FORM.

1.1.3 PRELIMINARY TEST HOLE AND MONITORING WELL DESIGN

Final quantities for test hole drilling and well construction will be based on actual conditions encountered during the drilling. The Work described in the Plans and Technical Provisions reflects the Owner's preliminary design and may be modified in response to actual subsurface conditions revealed through the drilling operations. All compensation shall be based on actual quantities using unit or lump sum prices stated on the BID FORM.

1.1.4 PERMITS AND NOTIFICATIONS

1. The Contractor shall be responsible for obtaining the necessary permits to perform the contract Work. All permits shall be posted on the drilling rig prior to the start of drilling operations.

2. The permitting agencies are as follows:

____

____

____

3. The Contractor shall notify the Owner and the appropriate regulatory agencies in advance of the commencement and completion of the test holes and well constructions and prior to the placement of surface annular seals.

1.1.5 SERVICES FURNISHED BY THE OWNER

1. The Owner has obtained the necessary legal right-of-ways for the drilling and well construction work.

2. Water for drilling will be made available at no cost to the Contractor at or near each work site. The Contractor is responsible for delivering the water to the drilling site from the assigned water source.

1.1.6 REFERENCE POINTS

The Owner shall stake the location of the test hole.

1.1.7 WORK AREA RESTRICTIONS

A. General -- The Contractor shall protect all existing facilities and shall keep the site clear and open all the time. The Contractor may use, without cost, all open areas on the project site, and as approved by the Owner, for the Work.

B. Coordination With Other Activities -- Contractor is advised that other work by the Owner may be conducted at the project site. The Contractor shall limit all activities to the designated work areas.

C. Work Hours – Operations will be limited to between the hours of __am to __ pm, Monday through Friday, and __ am to __ pm on Saturday. No work shall be undertaken on Sundays or legal holidays.

D. Noise -- Contractor shall adhere to the following noise restriction: drilling activities shall not exceed __ dBA at a distance of __ feet from the equipment.

E. Health and Safety -- Contractor shall provide and adhere to a health and safety plan to address actual or potential hazards associated with the Work. A copy of the Contractor's health and safety form shall be posted at the job site.

F. Hazardous Materials -- The Contractor shall comply with all government laws, rules and regulations concerning the use of hazardous materials and the disposal of hazardous wastes at the job site, including but not limited to the following:

1. The Contractor shall not bring hazardous materials onto the job site or deliver hazardous materials without providing the Owner, in advance, Material Safety Data Sheets for each hazardous material.

2. All hazardous material shall be stored and used in a safe manner and shall not be stored or used in any vehicular or pedestrian traffic lanes.

3. Any hazardous products, waste or empty containers used or generated shall not be poured down any drain or sewer nor disposed of in any trash container or dumpster.

4. The Contractor will be considered to be the hazardous waste generator and will be responsible for the legal transport and disposal of all hazardous waste. No containers or trash will be left in any building or on any job site.

5. Violation of any of the above methods shall be sufficient cause for the Owner to stop all work. Any expense incurred by the Owner caused by the work stoppage will be borne by the Contractor. These expenses will include all costs to return the job site and all other areas contaminated by the Contractor to a hazard-free condition.

6. The Contractor will be solely responsible for all the costs, including fines and penalties, for the investigation and cleanup of any suspected hazardous materials the Contractor used, left on the job site, or disposed through a municipal drain or sewer, and any damage to property and/or injury to any person.

1.1.8 CONSTRUCTION INSPECTION

The work specified in the Technical Provisions will be inspected by the Owner, or Owner's agent, at various stages of the construction.

1.1.9 SITE SECURITY

The Contractor shall provide suitable means of protecting the borehole(s) from the entrance of foreign objects at all times for the duration of the contract. The Contractor will provide portable fencing surrounding the site.

1.1.10 WATER FOR DRILLING

The Contractor is responsible for delivering the water to the drilling site from the assigned water source. Water for drilling operations will be available from____. The Contractor must comply with any connection and metering requirements set forth by the water supplier

1.1.11 NUISANCE WATER, DEVELOPMENT WATER, AND DRILL CUTTINGS

A. Nuisance Water -- Nuisance water, such as rainfall or surface runoff, may occur at the well sites during the period of construction under this contract. The Contractor shall at all times protect the Work from damage by such waters and shall take all due measures to prevent delays in progress of the Work caused by such waters.

B. Development Water -- During development and testing of the well, the discharge water shall be disposed of in such a manner as to cause the least impact to the site and vicinity.

(Check one)

___ Clean, low turbidity water produced during well development and testing will be discharged in the vicinity of the project site(s) as directed by the Engineer.

___ All water produced during well development and testing will be contained and lawfully disposed of offsite.

C. Drill Cuttings and Development Solids -- The Contractor is responsible for handling of drill cuttings and development solids.

(Check one)

___ Drill cuttings and development solids may be spread at each site as directed by the Engineer.

___ Drill cuttings and development solids shall be contained and lawfully disposed of offsite.

1.1.12 CONTINGENCIES

Materials and/or support services in connection with the Work, which are deemed “extraordinary” or “site-specific”, and not “contemplated” under the Agreement shall be paid for separately.

1.1.13 CONTRACTOR’S INSURANCE

1.1.13.1 Insurance Coverage and Limits

The Contractor will obtain and maintain in force during the period of the contract, including the guarantee period following acceptance, the following insurance coverage with the limits as specified.

A. General Liability Insurance - Comprehensive Form

Coverage

- Premises - Operations
- Explosion and Collapse Hazard
- Underground Hazard
- Products/Completed Operations Hazard
- Contractual Insurance
- Broad Form Property Damage

- Independent Contractors
- Personal Injury

Limits

Bodily Injury - Not less than $300,000 each occurrence and aggregate
Property Damage - Not less than $300,000 each occurrence and aggregate
Personal Injury - Not less than $300,000 aggregate

Bodily injury and property damage may be combined with a limit of $500,000 for each occurrence and aggregate.

B. Automobile Liability Insurance - Comprehensive Form

Coverage

- Owned Vehicles
- Hired Vehicles
- Non-owned vehicles

Limits

Bodily injury and property damage combined - $500,000 each occurrence

C. Excess Liability Insurance - Umbrella Form

Limits

Bodily injury and property damage combined - $2,000,000 each occurrence and aggregate

If the limit of the general liability insurance actually furnished is greater than the specified limit, the limit of the excess liability may be reduced by the amount of the excess, provided that the sum of the limits of the general liability and excess liability insurance will not be less than $2,500,000.

D. Workmen's Compensation and Employer's Liability Insurance

Limits

Workmen's Compensation - Statutory
Employer's Liability - $2,000,000 each accident

All specified insurance will be satisfactory to the Owner as to insurers, form, limits and amounts.

The Contractor will require his subcontractors of every tier to carry similar insurance or will provide otherwise for insurance coverage of its subcontractors.

1.1.13.2 Specific Provisions and/or Endorsements

A. All liability insurance will state that the coverage provided is primary and is not excess or contributing with any insurance maintained by the Owner or any of the named additional insured.

B. All liability insurance will contain a "cross liability" or "severability of interest" clause.

C. All insurance will provide for a thirty-day written notice to the Owner prior to cancellation, termination, alteration or material change of such insurance.

D. Proof of Insurance will be provided on Certificates and Endorsements furnished by the Owner as part of the Contract Documents.

1.1.13.3 Named Additional Insured

The following will be named as additionally insured in the liability insurance:

A. The Owner (____________________________) and each of its officers, employees and agents.
B. Luhdorff and Scalmanini, Consulting Engineers of Woodland, California.

1.1.13.4 Certificates of Insurance

Within 10 days after receipt of the Owner's Notice of Award, the Contractor will deliver to the Owner satisfactory Certificates of Insurance covering all policies that provide the specified insurance coverage on the form provided. Certificates of Insurance will clearly state compliance with all specified requirements. The Certificates will be signed on behalf of the insurer or insurers by an authorized representative.

1.1.13.5 Continuation of Insurance

Should the Contractor fail to maintain these specified insurance coverages, the Owner may, but is not required to, obtain such insurance coverage as is not being maintained. All costs of any such insurance obtained by the Owner will be deducted from any amounts due or which may become due the Contractor.

1.2 MEASUREMENT AND PAYMENT

1.2.1 GENERAL

Direct payment will be made only for the items listed in the proposal. Items of work not listed, but necessary to satisfactorily complete the Work, will not be paid for separately; and all costs in connection therewith shall be considered to be included for payment with the listed items.

1.2.2 ITEM NO. 1a & 1b: MOBILIZATION AND SITE TO SITE MOBILIZATION

A. Measurement: – Mobilization and Site to Site Mobilization for test hole drilling and well construction, satisfactorily completed, will be paid for at the applicable lump sum price stated in the proposal.

B. Payment: -- Mobilization and Site to Site Mobilization will be made at the unit prices stated in the proposal. Such payment will be considered full compensation for mobilizing all labor, material, tools and equipment necessary and incidental to drill the test holes and construct the monitoring wells.

1.2.3 ITEM NO. 2: TEST HOLE DRILLING

A. Measurement: – Test hole drilling will be measured as the number of lineal feet for which drill cuttings and a geophysical log are acquired.

B. Payment: – Payment for test hole drilling will be made on a linear foot basis at the unit price stated in the proposal. Such payment will be considered full compensation for furnishing all labor, material, tools and equipment necessary and incidental to complete the test hole.

1.2.4 ITEM NO. 3: GEOPHYSICAL LOGGING

A. Measurement and Payment: -- Payment for this item shall be considered full compensation for all labor, tools, equipment, insurance and doing all work necessary and incidental to running a geophysical log in the test hole, including standby time. If the Owner requests additional logging runs, in writing, the Contractor shall be paid for the additional logging “at-cost plus 15 percent”.

1.2.5 ITEM NO. 4: BOREHOLE REAMING

A. Measurement: – Borehole reaming will be measured as the number of lineal feet successfully completed for construction of well.

B. Payment: -- Payment for borehole reaming will be made on a linear foot basis at the unit price stated in the proposal. Such payment will be considered full compensation for furnishing all labor, material, tools and equipment necessary and incidental to complete the test hole reaming.

1.2.6 ITEM NOS. 5a, 5b,: WELL CASING AND SCREEN

A. Measurement: – Well casing and screens shall be measured in place to the nearest whole unit of lineal feet satisfactorily installed in the final well.

B. Payment: -- The quantities of well casing and well screen, satisfactorily installed, will be paid for at the applicable unit prices stated in the proposal for each item. Such payment will be considered full compensation for furnishing all labor, material, tools and equipment necessary and incidental to installation.

1.2.7 ITEM NO. 6: GRAVEL ENVELOPE AND INTERMEDIATE SEALS

A. Measurement: – Gravel envelope and intermediate seals will be measured in place to the nearest whole unit of lineal feet of annular space satisfactorily filled in the final well.

B. Payment: -- The quantities of gravel envelope and intermediate seals satisfactorily installed, will be paid for at the applicable unit prices stated in the proposal for each item. Such payment will be considered full compensation for furnishing all labor, material, tools and equipment necessary and incidental to installation.

1.2.8 ITEM NO. 7: ANNULAR SEAL

A. Measurement: – Annular seals will be measured in place to the nearest whole unit of lineal feet of annular space satisfactorily filled in the final well.

B. Payment: -- The quantity of annular seal, satisfactorily installed, will be paid for at the applicable unit prices stated in the proposal for each item. Such payment will be considered full compensation for furnishing all labor, material, tools and equipment necessary and incidental to installation.

1.2.9 ITEM NO. 8: WELL DEVELOPMENT

A. Measurement and Payment: -- The development of the well piezometers, satisfactorily completed, will be paid for at the lump sum price stated in the proposal. Such payment will be considered full compensation for furnishing all labor, material, tools and equipment necessary and incidental to developing the piezometers.

1.2.10 ITEM NO. 9: WELL SURFACE COMPLETION

A. Measurement and Payment: -- The well surface completion, satisfactorily installed, will be paid for at the lump sum price stated in the proposal. Such payment will be considered full compensation for furnishing all labor, material, tools and equipment necessary and incidental to installation of the security completion.

1.2.11 ITEM NO. 10: STANDBY TIME

A. Measurement: – Standby time, ordered by the Owner, will be measured to the nearest one-quarter unit as the number of hours of idle time for drilling equipment and crew.

B. Payment: -- Standby time, ordered and approved by the Owner, will be paid for at the unit price specified in the proposal.

1.2.12 ITEM NO. 11: SITE CLEAN-UP, RESTORATION, AND RECORDS

A. Measurement and Payment: – The site clean-up, restoration, and submission of records satisfactorily completed will be paid for at the lump sum price stated in the proposal. Such payment will be considered full compensation for furnishing all labor, material, tools and equipment necessary and incidental to restore the site to its original condition.

1.2.13 ITEM NO. 12: BOREHOLE ABANDONMENT

A. Measurement: – Abandonment will be measured as the number of lineal feet of borehole required to be destroyed and shall not exceed the number of feet of test hole successfully drilled and approved for payment under Section 2.3.13.

B. Payment: -- Payment for borehole abandonment will be made on a linear foot basis at the unit price stated in the proposal. Such payment will be considered full compensation for furnishing all labor, material, tools and equipment necessary and incidental to destroy the test hole

II. TECHNICAL PROVISIONS

2.1 GENERAL REQUIREMENTS

2.1.1 SCOPE OF WORK

A. Purpose -- The test hole shall serve to evaluate the lithologic character of subsurface formations and aquifers at the candidate well site and to determine characteristics of the aquifer materials through geophysical surveys and measurements. The monitoring well will be used to sample ground water and measure water levels at selected depth horizons. The test hole shall be converted to single or multiple completion monitoring well with up to three, 2-inch diameter piezometers. Piezometers shall be constructed of Schedule 40 PVC casing and screen.

B. Test Hole Drilling and Monitoring Well Construction

1. The Work to be completed under this Contract will consist of furnishing all materials, labor, equipment, fuel, tools, transportation and services for the drilling, sampling and logging of a test hole at the selected site. The test hole shall be converted to a permanent monitoring well. Up to three individual piezometers may be installed in the reamed borehole. In the event that the Owner does not elect to convert the test hole to a monitoring well, the test hole shall be destroyed in the manner specified herein.

2. The project sites are located in ______________________ County, CA.

3. The test hole shall be drilled to a depth of ______ feet bgs. The actual depth of the test hole will depend on the lithology encountered. A driller's log will be prepared to define the lithology encountered during construction, drill cuttings of the formations encountered will be collected, and the test hole will be logged with electric geophysical logging equipment.

5. The minimum diameter of the test hole is 8 ¾-inches. The contractor may drill a larger diameter test hole at his own expense.

4. The final design for the monitoring well will be prepared by the Engineer after evaluating the test hole data.

5. Cuttings, drilling fluids, and development water shall be contained. The Contractor shall dispose of cuttings and fluids at the sites as directed by the Engineer.

C. Preliminary Monitoring Well Design

1. A conceptual, preliminary monitoring well design is depicted in the Plans. Up to three piezometers may be installed in the reamed test hole with a combination of intermediate and surface seals as shown conceptually on the preliminary design. The piezometer assemblies will be equipped with appropriate centralizers to ensure that the screen intervals are adequately spaced from the borehole wall.

2. A graded gravel envelope will be placed between the casing assemblies and the borehole from the bottom of the well to the surface by the tremie pipe method. Intermediate seals, consisting of graded bentonite chips (in saturated zones and sand/cement grout in unsaturated zones), may be specified to isolate screened intervals. A sanitary/annular seal shall consist of a sand/cement grout.

3. At the completion of well development an above-ground surface completion shall be constructed, as directed by the Engineer.

D. Local and State Standards

1. All drilling and well construction activities shall comply with local and State standards. If a conflict arises between the Technical Provisions and regulatory requirements, the Contractor shall immediately notify the Owner and not proceed until the Owner resolves the conflict.

2. It is the Contractor's sole responsibility to satisfy the well permitting requirements.

2.1.2 LOCATION AND LOCAL CONDITIONS

2.1.3 DRILLING FLUID CONTROL PROGRAM

A drilling fluid program shall be employed by the contractor in accordance with the following general conditions.

1. A drilling fluid control program shall be prepared by a qualified, professional drilling fluids engineer and submitted to the Owner for approval. Selection and use of the drilling fluid materials shall be a part of this agreement. The Contractor shall be responsible for maintaining the quality of the drilling fluid to assure protection of water bearing and potential water bearing formations exposed in the borehole, and the ability to obtain reliable representative samples of the formation materials.

2. Material used by the Contractor to prepare the drilling fluid shall be composed of water from an assigned source and drilling additives processed to meet or surpass the specification in the American Petroleum Institute "Std. 13-A for Drilling Fluid Materials". All drilling fluid additives will comply with recognized industry standards and practices and they shall be used as prescribed by the manufacturer. Toxic and/or dangerous substances shall not be added to the drilling fluid.

3. The drilling fluid for the rotary construction shall be made up of high grade bentonite clays or organic polymer additives in common drilling usage in the water well industry, and shall possess such characteristics as required to condition the walls of the borehole to prevent caving of formations and excessive loss of circulation, facilitate removal of the cuttings, and produce an easily removed thin filter cake.

4. In accordance with these Technical Provisions, the Contractor shall submit a drilling fluid program for approval prior to construction. The submittal shall include the recommendations for make-up water conditioning, quantities of clay base, and additives required to maintain a drilling fluid having properties within the ranges specified below for test hole drilling and reaming operations.

The drilling fluid shall be maintained in such a manner as not to exceed the properties specified above for weight, viscosity, and sand content without the approval of the Owner. In addition, the Contractor shall maintain the minimum viscosity of the drilling fluid that will raise cuttings and adequately condition the walls of the holes. At the completion of all drilling operations, the drilling fluid shall be conditioned and meet the following property ranges for well construction.

Property	Direct Circulation Drilling Method
a) Weight:	8.7 –9.3 lbs./gal
b) Marsh Funnel Viscosity:	28 – 35 sec/qt
c) API Filter Cake Thickness:	<3/32
d) Sand Content of Returns:	< 1/2% by volume

5. The drilling rig must be provided with equipment to measure the drilling fluid weight, viscosity, API filter cake, and sand content.

6. The Contractor shall maintain a current log describing the condition of the drilling fluid on the site. The log shall include the following:

a) time, depth and results of all drilling fluid tests;

b) materials added to the system; type, quantity, time, and depth;

c) variances or modifications from approved drilling fluid program (e.g., time, depth, reason, and authorization).

7. Proper control of the drilling fluid must be maintained to the satisfaction of the Owner. The Contractor will be required, at the Contractor's expense, to retain or employ an experienced, qualified drilling fluid, or mud, engineer to supervise and maintain drilling fluid characteristics to the satisfaction of the Owner if such control cannot be accomplished by the Contractor.

8. If at any time the drilling fluid is not in compliance with these Technical Provisions or the recommendations of the drilling fluid engineer, as approved by the Owner, the properties shall be adjusted and the tests rerun until the drilling fluid obtains the specified characteristics. If the specified properties cannot be maintained, the drilling fluid shall be replaced.

9. The Contractor shall provide one complete direct rotary drilling unit with shaker, de-sanding cones, and containment facilities if directed by the Engineer.

2.2 MATERIALS

2.2.1 CERTIFICATES OF COMPLIANCE

If requested by the Owner, the Contractor shall provide certificates of compliance as specified herein.

A. Items Requiring a Certificate of Compliance

1. The Contractor shall submit to the Owner for approval, certificates of compliance for the following materials:

b) Cement Grout Sealing Material

c) Blank Well Casing

d) Well Screen

e) Gravel Envelope Material

2. No material shall be incorporated into the Work until certificates of compliance have been approved in writing by the Owner.

B. Content of Certificates of Compliance

1. Certificates of compliance from the Contractor, suppliers, and/or manufacturers, shall clearly indicate that the material to be delivered to the job site will meet all requirements of the project Technical Provisions. A certificate of compliance shall include, but not be limited to the project title, delivery location, date (or approximate date) of delivery, name of the material with appropriate classification or model numbers, quantity, name of the manufacturers, statement of compliance with all requirements of the Technical Provisions, and the name, title and signature of the certifying

agent.

2. A factory or mill certification (laboratory test report) shall be submitted with the certificates of compliance for all components of the casing assembly. The factory or mill certification shall not be a substitute for the certificate of compliance, unless it contains all information required for a certificate of compliance as described above.

3. Insufficient, incomplete, or unclear certificates will be rejected and the Contractor shall be responsible for all delays caused by any need for re-submittal.

C. New Materials -- All materials provided by the Contractor shall be new.

2.2.2 MATERIALS SPECIFICATIONS

A. Sealing Material -- Sealing material, consisting of sand-cement grout shall be employed for abandonment purposes and surface seal in the well. Bentonite chips as well as sand/cement grout may be employed in the well for intermediate seals and to limit infiltration of cement grout into the gravel envelope.

1. The sealing material shall be composed of a slurry of sand-cement grout. The grout shall consist of a sand-cement mixture in accordance with California Department of Water Resources Well Standards, Bulletin 74-81/Supplement 74-90.

2. The mixture for the surface, or sanitary, seal shall conform to State standards and local ordinances for sanitary seals.

3. The bentonite sealing material shall be a graded chip bentonite with granules ranging from 1/4 inch to 3/8 inch. An approved product for the bentonite seals is "HOLEPLUG" as manufactured by the NL Baroid Division of NL Industries, Inc.

C. Well Casing and Screen Material

1. The PVC well casing and well screen for the monitoring well will be made of ASTM F-480-88A Schedule 40 and Schedule 40 PVC. The ends of each joint shall be threaded and couple with O-ring seals. The blank casing will be 2-inch Schedule 40 PVC, ASTM F480-88a. The well screen shall be fabricated from the same material as the blank casing. The perforations shall be machine cut horizontal slots, with openings of 0.030 inch.

2. The bottom of each PVC casing assembly shall be furnished with PVC threaded, pointed or rounded end cap of the same schedule and size as the casing and the same specifications as described herein.

3. Each casing will be fitted with appropriate centralizers to ensure that the well casings meet the minimum 2-inch separation distance from the borehole wall

4. The top of each casing shall be furnished with a watertight and locking security plug.

D. Gravel Envelope -- All gravel or coarse-grained sand for packing shall be hard, water-worn, and washed clean of silt, fine sand, dirt, and foreign matter (crushed gravel will not be accepted). It shall be well rounded, graded, and selected. The gravel envelope material is specified to be Silica Resources Incorporated (SRI) (Marysville, CA) sand, or equal. Alternative materials are subject to the approval of the Engineer. A description and sieve analysis of gravel packing materials to be delivered to the site must be submitted prior to the use of the material in the Work. The gravel, if stockpiled at the well site, shall be protected and kept free of foreign matter.

2.3 TEST HOLE DRILLING AND MONITORING WELL CONSTRUCTION

2.3.1 MOBILIZATION AND SITE TO SITE MOBILIZATION

A. General

1. Mobilization shall include acquisition of all necessary permits; transportation of personnel, equipment, and operating supplies to and from the site establishment of portable sanitary facilities, preparing a work site sufficient to support equipment and personnel in a safe and workman-like manner, and other preparatory work at the site required by the Contractor for his/her operations.

2. The Contractor shall provide one complete direct rotary drilling unit with shaker, de-sanding cones, and containment facilities if directed by the Engineer. The Contractor shall also provide all tools, accessories, power, fuel, materials, supplies, lighting, necessary to conduct efficient drilling operations. The drilling unit shall be in good condition and of sufficient capacity to perform the specified drilling and well construction.

2.3.3 TEST HOLE DRILLING

A. Scope -- The test hole shall be drilled using the direct rotary method. The hole shall be drilled at a minimum diameter of 8-3/4 inches. The final depth of the test hole will depend location and the lithology encountered while drilling and will be determined by the Engineer. It is anticipated that the test hole will range in depth of _____ to _____ feet.

B. Methods

1. The test hole shall be drilled using the direct circulation rotary drilling method of construction. The drilling fluid for the direct rotary drilling operation shall conform to the specifications in SECTION 2.1.3.

2. The drilling operations shall be conducted using equipment that is adequate to reach the depth and perform the evaluations specified in the Technical Provisions. If, in the opinion of the Engineer, the Contractor's equipment is not capable of satisfactorily performing the specified work, the Contractor, at his/her own expense, shall substitute equipment satisfactory to the Engineer.

3. The Contractor shall take all measures necessary to protect the top portions of the test hole from caving or raveling.

4. The Contractor shall keep records providing the following information:

a) A record of construction activities for each shift.

b) A time drilling log of the test hole recording the time (in minutes) required to drill down each section of drill pipe.

c) A log of drilling bit types and depths of changes.

d) Record of drilling fluid properties at 4-hour intervals during drilling operations. The record shall show drilling fluid weights, Marsh Funnel viscosity, sand content, drilling fluid losses, and any additives used.

e) A drilling log which defines and classifies the type of formations encountered during the drilling. The log will consist of the depth at which each change in formation is encountered, the classification of the material encountered, its color and particle size. Classification of silt, sand, gravel, cobbles, etc. shall be based on the size of material encountered in accordance with the established and accepted geologic standard for classification of these materials. If more than one size of material is encountered in a formation such as "sand and clay", an estimate of the quantity of each shall be recorded, such as "20% sand, 80% clay".

f) All measurements for depths shall be referenced to the existing ground surface at the well site.

5. During the drilling of the test holes, the Contractor shall collect representative samples of the rotary drill cuttings at 10-foot intervals and at formation changes. The Owner may direct the Contractor to collect samples at more frequent intervals if deemed appropriate. The samples collected shall not be washed. They shall be carefully drained of excess drilling fluid but in a manner which will preserve the finer particle size of the sample. Each sample taken shall be preserved in quart-size "Zip-Lock" plastic freezer bags and marked as to date, depth, and well number. The samples shall be properly stored by the Contractor in a manner as to prevent breakage or loss until they are accepted by the Engineer.

6. Upon completion of the test hole drilling, a geophysical log shall be conducted.

2.3.4 GEOPHYSICAL LOGGING

A. Scope -- This item shall consist of conditioning the bore hole and conducting geophysical surveys in the test hole. The geophysical surveys to be run in the test hole are the gamma ray, spontaneous potential and resistivity surveys.

B. Methods

1. The Contractor shall furnish services for logging the test hole. Acceptable geophysical logging service companies are West Coast Logging Services, Boredata, or Pacific Surveys. Borehole geophysical logs, consisting of gamma ray, spontaneous potential (SP) and multiple resistivity, shall be conducted in the test hole.

2. The spontaneous potential survey shall be plotted on a scale of one-inch equal to plus or minus 20 millivolts. The gamma ray survey shall be plotted on a scale of one-inch equal to plus or minus 20 API units. The multiple resistivity survey shall consist of a point resistivity curve and multiple resistivity curves employing 16-inch short normal and 64-inch long normal spacings on a one-inch equal to 20 or 40 ohm scale. All surveys will be plotted on a footage scale of one-inch equal to 20 feet in accordance with the American Petroleum Institute standard.

3. The Contractor is responsible for the integrity of the borehole to assure that the geophysical logging can be successfully conducted. The Contractor shall maintain circulation in the borehole with tools on the bottom of the hole until the logging equipment is on location and prepared to conduct the survey. The logging service company shall obtain a ditch sample of the circulating fluid for calibration of the logs prior to the securing of the circulating pump. Tools shall then be pulled by the Contractor and the logging services immediately commenced. If the logging probe fails to descend to the desired depth, the Contractor, at his/her own expense, shall run the drilling tools to the target depth to recondition the hole.

4. Upon completion of logging operation, the Contractor will deliver four (4) field prints to the Engineer. Four final prints and an electronic ASCII file of the geophysical surveys shall be provided with the final records submittal. The field copies of the electrical log shall be approved by the Owner before the logging service is released from the site by the Contractor.

2.3.5 TEST HOLE REAMING

A. Scope -- This item shall consist of reaming the test holes to the final specified well depth in accordance with the Engineers' design. The drilling and reaming of the borehole will be conducted by the direct rotary drilling method to the depth and diameter specified in the Engineers design. Drilling fluid properties must conform to those specified in SECTION 2.1.3.

B. Methods

1. The test hole shall be reamed to a minimum diameter and depth as specified in the Engineers design. The drilling fluid for the direct rotary drilling operation shall conform to the specifications in SECTION 2.1.3. The Contractor shall be responsible to protect the pilot hole from caving. The Contractor shall exercise caution to ensure that the hole remains straight and plumb during the reaming operations.

2. The Contractor shall keep records providing the following information:

a) A record of construction activities for each shift.

b) A time drilling log of the test hole recording the time (in minutes) required to drill down each section of drill pipe.

c) A log of drilling bit types and depths of changes.

d) Record of drilling fluid properties at 4-hour intervals during drilling operations. The record shall show drilling fluid weights, Marsh Funnel viscosity, sand content, drilling fluid losses, and any additives used.

All measurements for depths shall be referenced to the existing ground surface at the well location.

2.3.6 WELL CASING AND SCREEN

A. Scope -- This item shall consist of furnishing and installing blank casing and well screen as specified in the Owner's final design.

B. Methods

1. A wiper trip shall be conducted to insure that the borehole is open to the total depth prior to running casing.

2. A tremie pipe of a minimum two-inch diameter shall be run into the borehole to the total depth of the casing installation. Circulation by pumping shall be commenced using fluid from the drilling fluid/mud tank of the same viscosity as that in the borehole. Circulation shall continue for a period of sixty minutes prior to casing installation.

3. With the tremie pipe remaining in the borehole, casing installation shall proceed in accordance with the final well design for casing installation furnished by the Owner.

4. The casing assemblies shall be installed to the specified depth supported above the ground surface. The casing shall be capped to insure that foreign particles are prevented from entering the casing.

5. The casing shall be suspended in tension from the surface by means of an appropriate hanger or clamp. The bottom of the casing shall be at a sufficient distance above the bottom of the reamed hole to ensure that none of the casing will be supported from the bottom of the hole.

6. Circulation through the tremie pipe shall continue during the casing installation.

7. If, for any reason, the casing cannot be landed in the correct position or at a depth acceptable to the Owner, the Contractor shall remove the casing, recondition the borehole and reinstall the casing to the specified depth. If the casing cannot be removed from the borehole the contractor shall construct another

well immediately adjacent to the original location and complete the well in accordance with these Technical Provisions at no additional cost to the Owner. The abandoned hole shall be sealed in accordance with these Technical Provisions and in accordance with any laws pertaining to proper well abandonment at no additional cost to the Owner.

8. If any of the casing assembles collapse prior to well completion, the remaining hole shall be abandoned in accordance with these Technical Provisions at no cost to the Owner. A replacement borehole and well shall be drilled and constructed at an adjacent location as directed by the Owner.

2.3.7 GRAVEL ENVELOPE AND INTERMEIDIATE BENTONITE SEALS

A. Scope -- This item shall consist of providing and installing gravel or coarse grained sand opposite the screen intervals and intermediate bentonite or sand/cement seals between the screen intervals, as specified by the Engineer, in the annulus between the casing and screens and the well bore of each well. Intermediate bentonite seals may be used in saturated zones. Sand/cement grout shall be used for intermediate seals in unsaturated zones.

B. Methods

1. Prior to placement of the gravel pack and intermediate seals in the well, the drilling fluid shall be thinned with clean water. Thinning shall be accomplished by reducing the viscosity of the drilling fluid in the sump to a maximum marsh funnel viscosity of 30 seconds and a maximum weight of 8.9 pounds per gallon by the addition of clean water to the sump. The Contractor shall avoid the direct injection of water into the well bore through the tremie pipe in order to prevent unbalancing the fluid consistency in the borehole.

2. Gravel packing and sealing material shall be pumped or gravity fed through the tremie pipe. The gravel pumping system shall consist of a hopper, which will allow for the calculation of the amount of gravel packing material entering the borehole. The Contractor shall provide the Owner with a schematic drawing of the system of gravel placement he intends to employ prior to the installation of casing.

3. The tremie pipe shall be removed in approximately twenty-foot intervals when the gravel in the borehole reaches the tremie pipe.

4. The quantities of gravel placed in the annulus of each well shall not be less than the computed volume of the annulus. A quantity less than the computed value will be judged as an indication of voids, and corrective measures shall be taken by the Contractor.

5. If the volume of gravel installed in the annulus is less than the theoretical volume, the well may be rejected by the Engineer.

6. Gravel packing and bentonite seal placement shall continue uninterrupted until the gravel pack reaches the depth of the surface seal.

2.3.8 ANNULAR SEAL

A. Scope --. This item shall consist of providing and installing a sand/cement grout annular seal in the annulus between the casing(s) and the well bore.

B. Methods

Installation of the annular seal shall conform to State Water Well Standards and the requirements of the well permitting agency.

1) The Contractor shall proceed with sealing operations after the Engineer verifies the depth of the

top of the gravel in the well annulus.

2) The tremie pipe shall be installed no more than 5 feet above the placed gravel envelope before beginning seal placement. The bottom of the tremie pipe shall remain submerged in the sealing material maintaining a positive displacement throughout the sealing process until the grouting material has reached the ground surface.

3) The Contractor shall take measures to ensure that the weight of the cement column does not collapse the well casing during the sealing operation.

4) Well development shall not commence until a minimum of 24 hours after placement of the seal.

2.3.9 WELL DEVELOPMENT

A. Scope -- This item shall consist of airlift pumping and surging of the piezometers. The purpose of well development is to remove drilling fluids and to develop the gravel pack and aquifer to ensure that proper ground-water samples may be obtained from the piezometers.

B. Methods

1. The Contractor shall provide an air compressor, sufficient pipe, and necessary equipment used for pumping that shall be capable of pumping 25 gpm from a static water level of 300 feet during development.

2. The air compressor used during well development shall be fitted with in-line filters to prevent volatile organic compounds from entering the well casings from the compressor. A 0.3 micron pre-filter and a 0.01 micron filter run in series and verified compatible to the Contractor's compressor will be required during all phases of well development. The Contractor shall furnish the Owner with the make and model number of the air compressor to be used and the manufacturer and model number of the proposed filters to be used prior to the construction of the wells.

3. After the placement of the gravel envelope and annular seals has been completed, the gravel envelope shall be cleaned of all fluids, cake, and substances that would impair the flow of water into the well and the quality thereof. Cleaning shall be accomplished by airlift pumping and surging until the gravel has been cleaned and consolidated.

4. Pumping will be done with a minimum 3/8-inch diameter air pipe using the well casing as the eductor pipe. The air compressor and necessary equipment used for pumping shall be capable of pumping 25 gpm from a static water level of 300 feet during development. The pumping operations will be conducted until the well is fully developed and discharging clean ground water.

6. The development shall continue until the well produces water free of sand and the following turbidity guidelines can be achieved after surging the well. For piezometers that produce less than 2 gpm, a turbidity of 10 NTU within two casing volumes of purging. For piezometers that produce at least 2 gpm, a turbidity of 5 NTU must be achieved within two casing volumes of purging.

2.3.11 SURFACE COMPLETION

A. Scope -- This item shall consist of furnishing and installing an above ground or flush mount (vault) surface completion on the Plans and in accordance with State and local standards.

B. Methods

Above Ground Surface Completion

1. The Contractor shall excavate a 5-foot square hole extending 3 inches below the ground surface.

A 5-foot square wood form 6 inches deep shall be placed over the excavation to form the concrete pedestal above the ground surface as shown in the Plans.

2. A protective cover constructed of a steel pipe (riser) with a minimum wall thickness of 3/16 inches and a minimum of 4-1/2 feet long and a locking lid shall be installed over the monitoring well as shown in the plans. The minimum diameter of the riser shall be 8-inches for a single or a dual completion monitoring well and 14-inches for a triple completion monitoring well.

3. The riser shall be suspended above the top of the well such that the top of the riser is 2 feet above grade. A concrete slurry shall then be poured and tamped on top of the annular seal such that the riser is set in concrete. The concrete will be poured and tamped until it is approximately 3 inches below grade. The remaining portion of the excavation and the wood from will then be poured with concrete slurry, tamped and finished with a graded surface which shall slope gently away from the riser.

4. The finished concrete pedestal shall be 9 inches in thickness at 6 inches above grade. The riser set in the center of the pedestal will extend 2 feet above grade. The steel riser shall be painted with a high grade rust resistant paint of a neutral color approved by the Engineer.

Flush Mount Surface Completions

1. At grade (flush mount) well completions will be housed in a traffic rated valve box with a cast iron lid and locking ring. The valve box will be a Morrison Series 519 manhole or approved equal.

2. The Contractor shall excavate a hole large enough to allow for a 6-inch apron of concrete around the manhole at ground surface to a depth of 16-inches to allow for the installation of the specified manhole.

3. The box will centered over the well casing and set flush with existing grade.

4. A concrete slurry shall then be poured and tamped on top of the annular seal and brought to grade level such that the box is set in concrete.

2.3.12 TEST HOLE ABANDONMENT

A. General -- At the Engineer's determination, following completion of geophysical logging operations, the test hole, or a lower portion of the test hole, shall be destroyed in accordance with State and local standards for the construction and destruction of wells and other deep excavations.

B. Methods – Sand/cement grout shall be injected from the bottom of the borehole by means of pumping equipment and a tremie pipe. The tremie pipe may be raised as the grout is placed but the discharge end must be submerged in grout at all times until the grouting is completed. The test hole shall be filled with cement grout to within 5 feet of the ground surface. The balance of the hole shall be filled with native material to the ground surface.

2.3.13 REJECTED BOREHOLE OR WELL

A. General -- No payment will be made for any labor or materials involved in the construction of any borehole or well when such a hole fails to reach the specified or directed final depth and/or diameter for any preventable cause, or when such a test hole fails to meet these Technical Provisions. Such holes will be rejected and shall be replaced as specified herein. Preventable failures include any failure caused by faulty or inadequate drilling equipment, failure caused by negligence or improper drilling operations or techniques, failure caused by the installation of faulty or non-approved materials, or failure caused by improperly protecting drill holes and drilling work from the natural elements, including cave-ins resulting from existing soil conditions.

B. Sealing and Replacement of a Rejected Borehole or Well -- Any rejected borehole or well shall be sealed at no additional cost to the Owner and in accordance with provisions of Section 2.3.12. Any casing remaining in the hole shall be cut off at a depth of five feet and the upper portion thereof removed.

C. Non-Payment for Borehole and Well Abandonment

No payment will be made for the abandonment of a rejected borehole or well. The cost of abandonment shall be borne by the Contractor. Any rejected borehole shall be replaced by another hole adjacent to the first, or at a location as directed by the Owner.

2.3.14 STANDBY TIME

A. Scope

1. During the drilling operations, it may be necessary for the Engineer to perform work or analysis that will require the drilling crew and equipment to stand idle. In such an event, the Engineer shall request the Contractor to cease operations and shall state the anticipated extent or duration thereof. The Contractor shall promptly cease operations.

2. Within 12 hours after the completion of test hole drilling and logging operations, the Owner will provide the final design of the wells. Such time ***will not*** be considered standby time.

2.3.15 RECORDS

A. Scope -- The item consists of preparing final records of the drilling and well construction.

B. Well Completion Records -- Prior to final acceptance of a test hole or well, the Contractor shall prepare and deliver to the Engineer a Driller's Report in the format required by the State of California.

C. Final Prints -- The Contractor shall have prepared, two (2) final prints of the daily tour reports, the drilling logs, and as-built construction drawings.

2.3.16 SITE CLEAN-UP AND RESTORATION

A. Scope -- This item shall consist of restoring the work site to its original condition after work is completed.

B. Methods -- The Contractor shall keep the premises free from accumulations of waste materials, rubbish, and other debris resulting from the Work, and at completion of the Work, he/she shall remove all waste materials, rubbish, and debris from and about the well site as well as all tools, construction equipment, fuel tanks, machinery and surplus materials. The Contractor shall leave the site clean and ready for use by the Owner. The Contractor shall restore to their original condition all temporary work areas. Any cuttings and drilling fluids left on site shall be spread by the Contractor at the site at the direction of the Owner. The Contractor is responsible for any damages to properties adjacent to the sites caused by drilling or construction activities associated with the Work described herein.