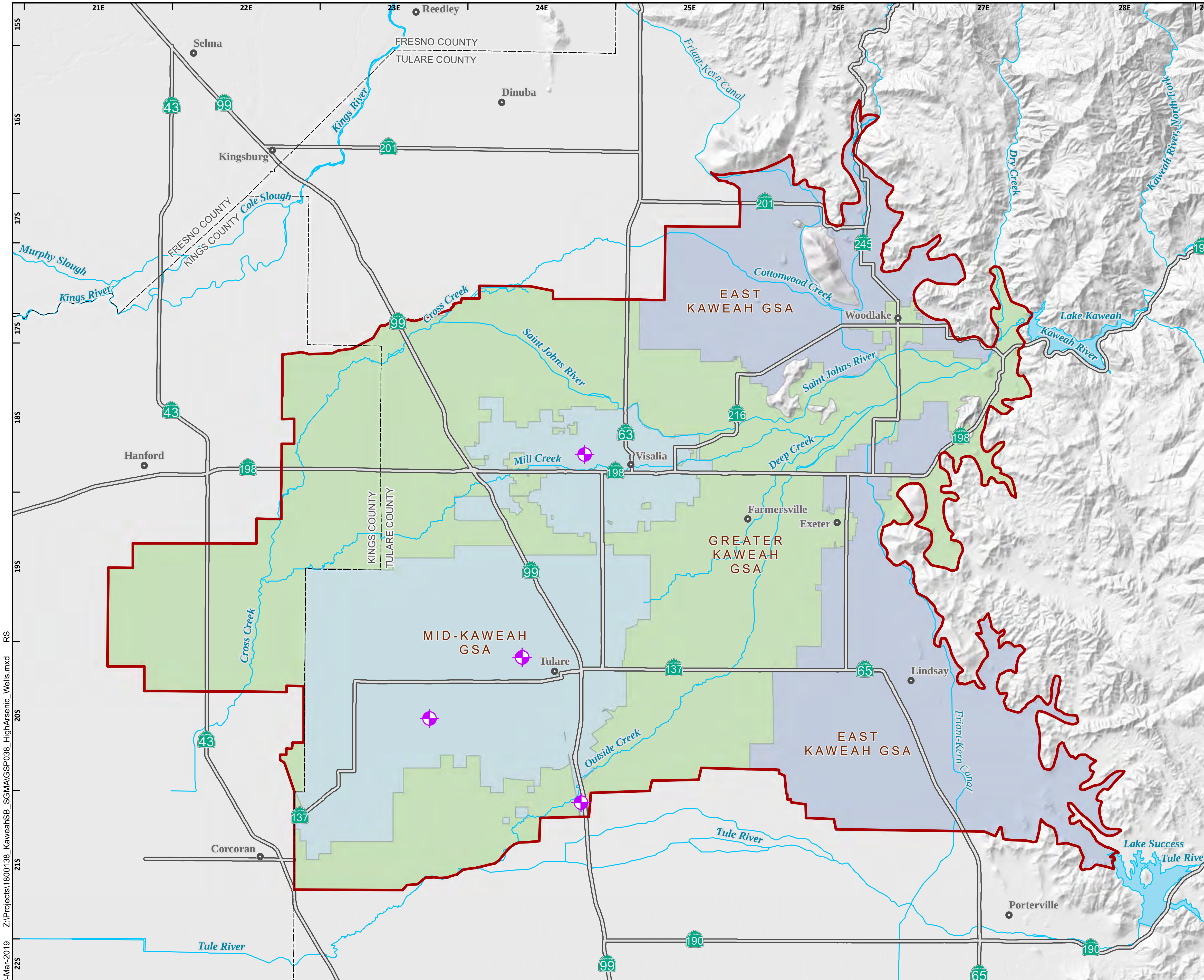
KAWEAH SUBBASIN HIGH ARSENIC WELLS



- Arsenic Concentrations 5-10 ppb, or Increasing Trends

GSA Boundaries

- East Kaweah GSA
- Greater Kaweah GSA
- Mid-Kaweah GSA
- Kaweah Subbasin Boundary

All Other Features

- Highway
- Waterway
- Lake

0 2 4 8
Miles

N

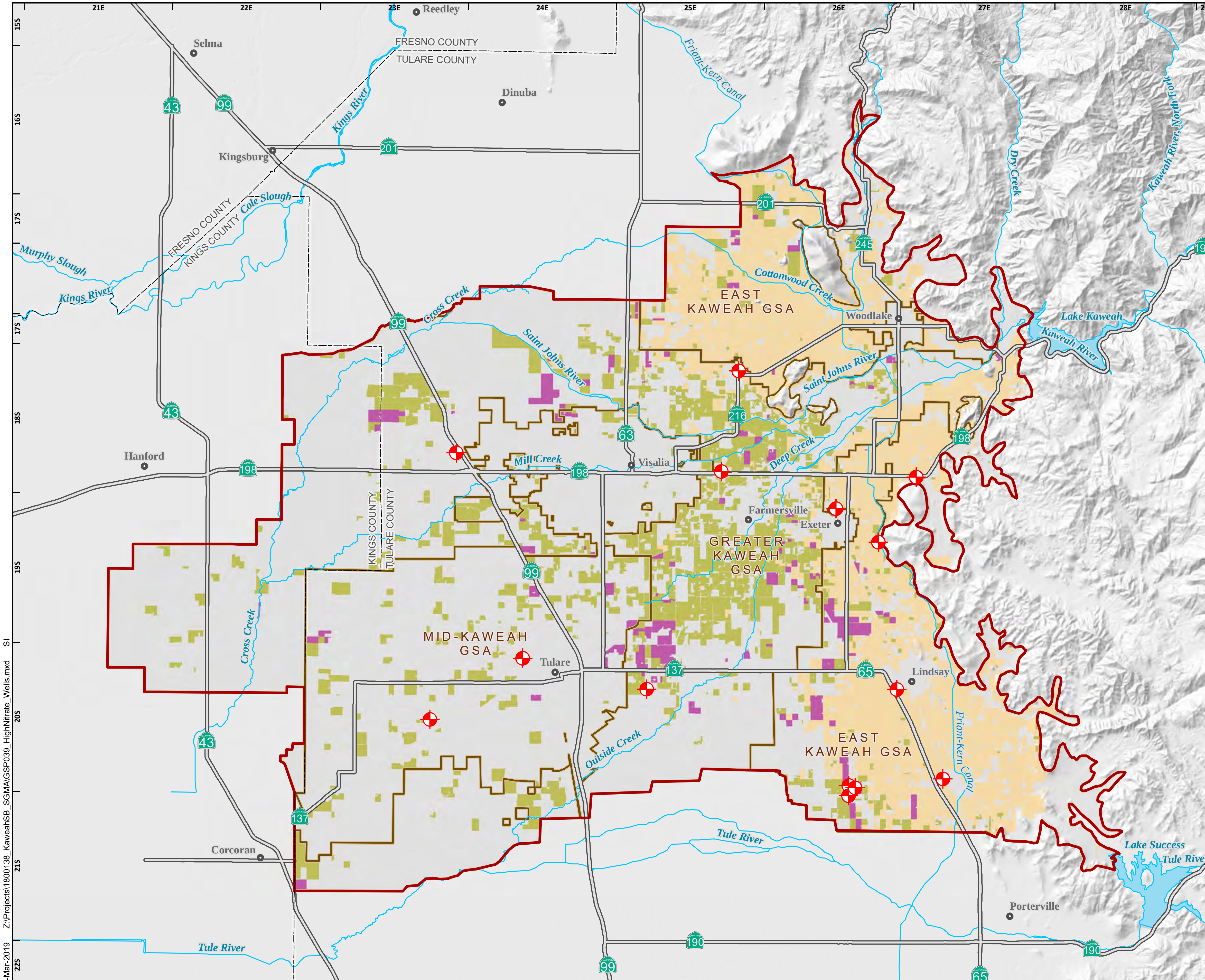
Kaweah Subbasin
Groundwater Sustainability Plan
Tulare County, California

Kaweah Subbasin

GEI Consultants
GSI Water Solutions, Inc.

MARCH 2019 **DRAFT** FIGURE 68

KAWEAH SUBBASIN HIGH NITRATE WELLS



Nitrate Concentrations 5-10 ppm, or Increasing Trends
Kaweah Subbasin GSA
Kaweah Subbasin Boundary

Land Use

Citrus and Subtropical
Deciduous Fruits and Nuts
Vineyard

All Other Features

Highway
Waterway
Lake

0 2 4 8
Miles

Kaweah Subbasin
Groundwater Sustainability Plan
Tulare County, California

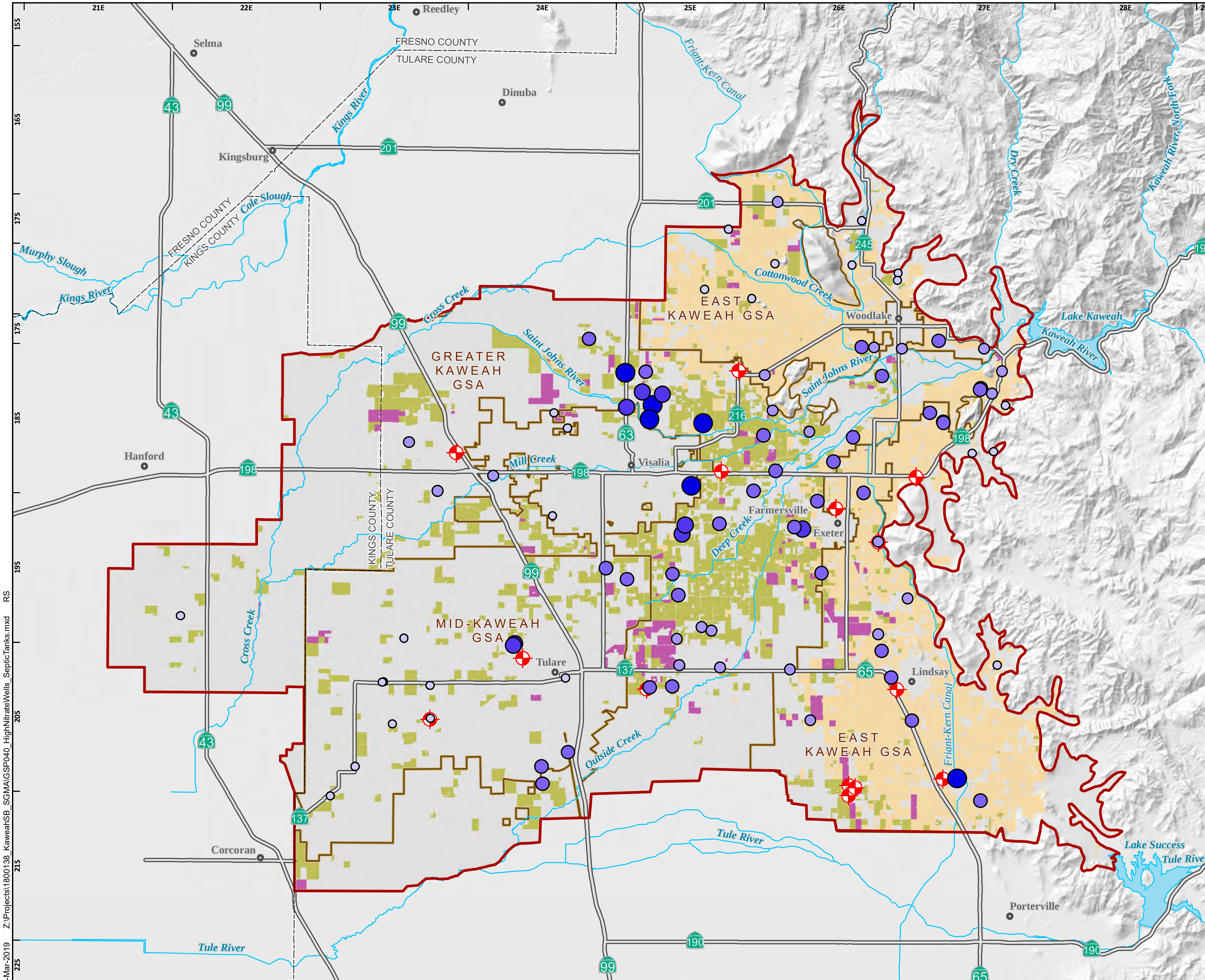
Kaweah Subbasin

GEI Consultants
GSI Water Solutions, Inc.

MARCH 2019 DRAFT FIGURE 70

Z:\Projects\1800138_KaweahSB_SGMA\GSP039_HighNitrate_Wells.mxd
12-Mar-2019

KAWEAH SUBBASIN HIGH NITRATE WELLS AND SEPTIC TANKS



Nitrate Concentrations 5-10 ppm, or Increasing Trends

Kaweah Subbasin GSA

Kaweah Subbasin Boundary

USGS Study Septic Tank Density per 500 meters

- 0.9 to 3.7
- >3.7 to 6.4
- > 6.4 to 10.6
- >10.6 to 15.4
- >15.4 to 35.9

Land Use

- Citrus and Subtropical
- Deciduous Fruits and Nuts
- Vineyard

All Other Features

- Highway
- Waterway
- Lake

0 2 4 8
Miles

N

Kaweah Subbasin
Groundwater Sustainability Plan
Tulare County, California

Kaweah Subbasin

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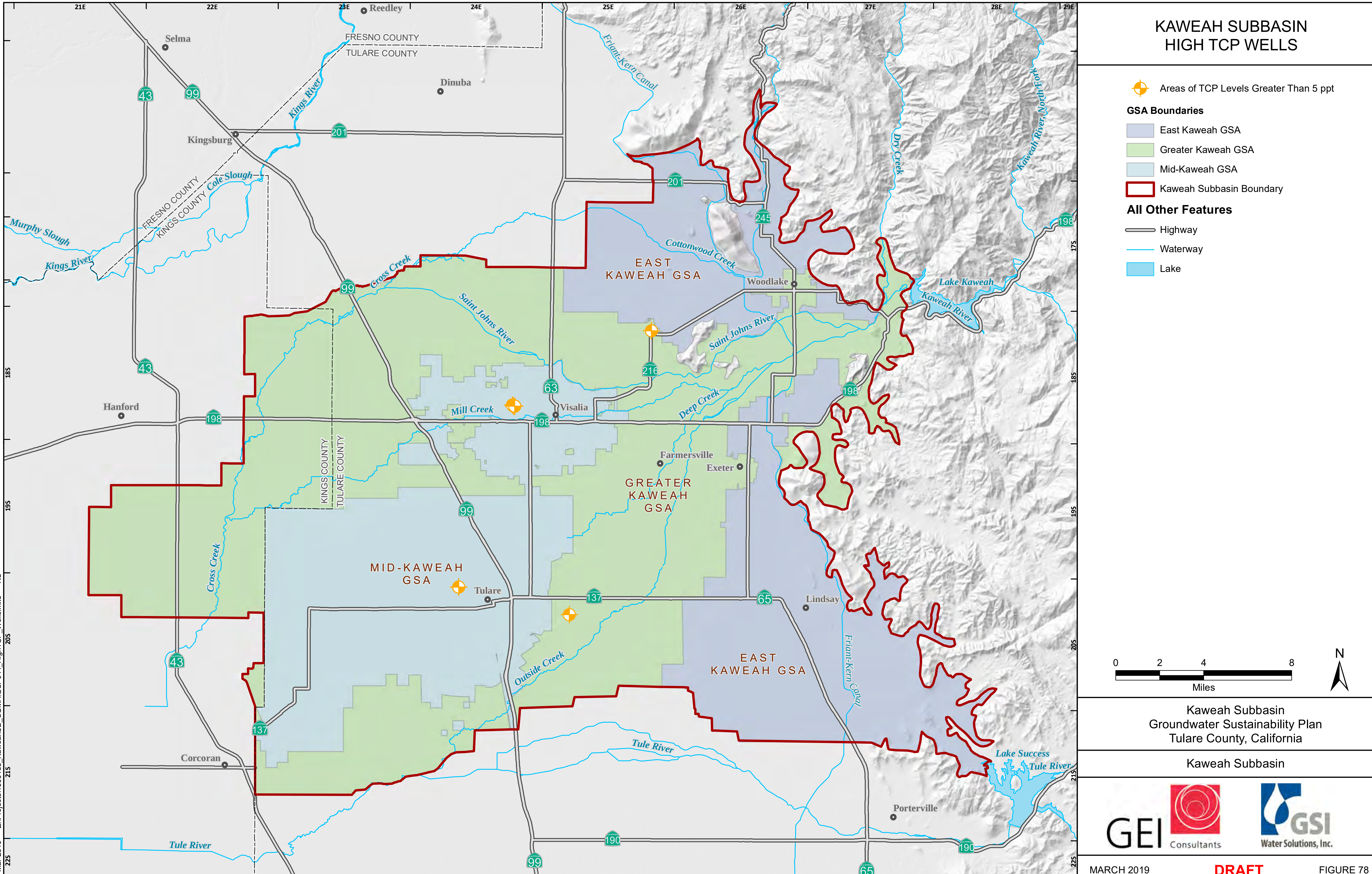
MARCH 2019 **DRAFT** FIGURE 71

Z:\Projects\1800138_KaweahSB_SGMA\GSP040_HighNitrateWells_SepticTanks.mxd RS
12-Mar-2019

KAWEAH SUBBASIN
HIGH TCP WELLS



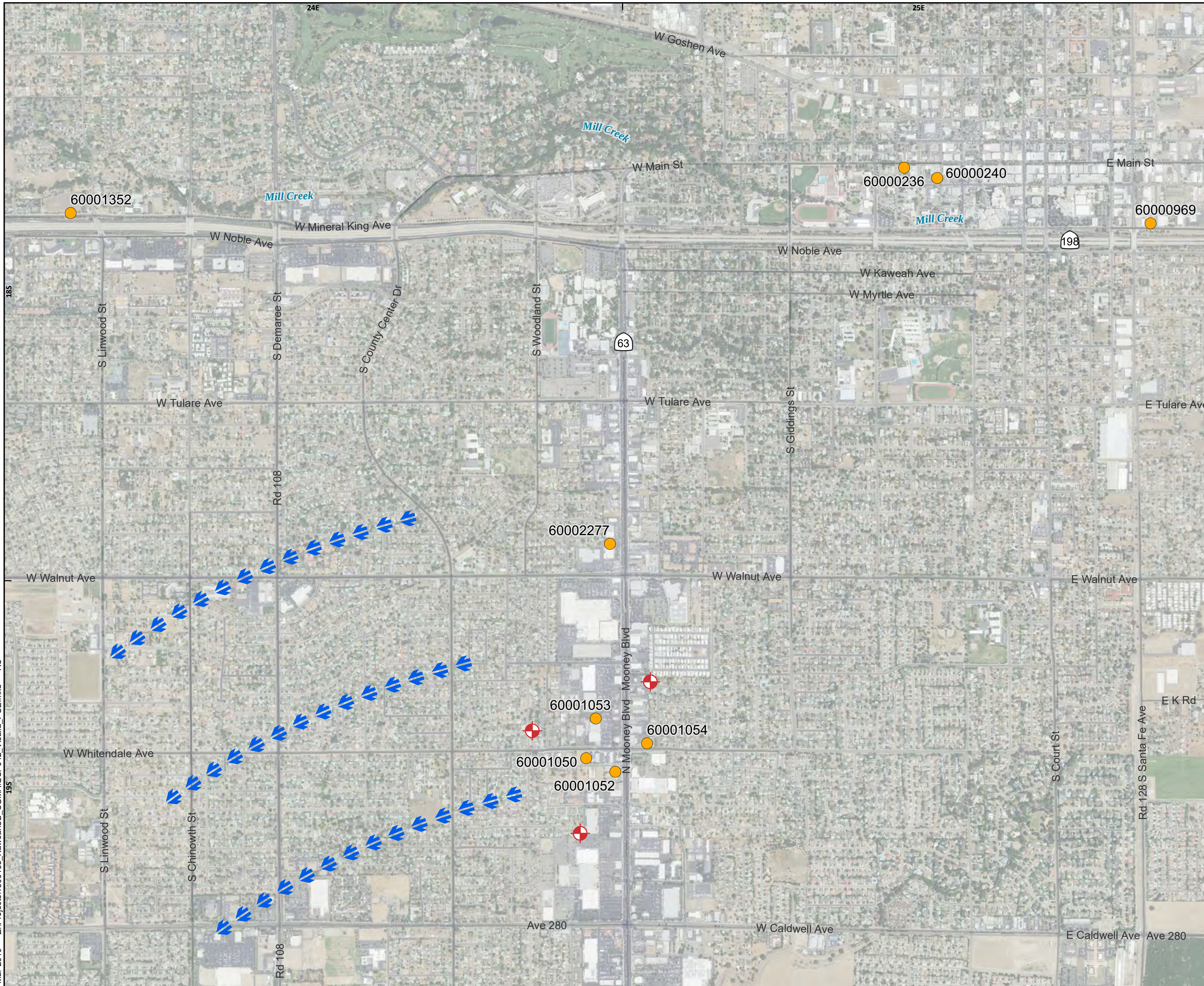
Kaweah Subbasin
Groundwater Sustainability Plan
Tulare County, California

Kaweah Subbasin

GEI Consultants
GSI Water Solutions, Inc.

MARCH 2019 **DRAFT** FIGURE 78

Z:\Projects\1800138_KaweahSB_SGMA\GSP041_HighTCP_Wells.mxd RS
12-Mar-2019



KAWEAH SUBBASIN
VISALIA CITYWIDE PCE PLUME

Kaweah Subbasin
Groundwater Sustainability Plan
Tulare County, California

Kaweah Subbasin

GEI Consultants

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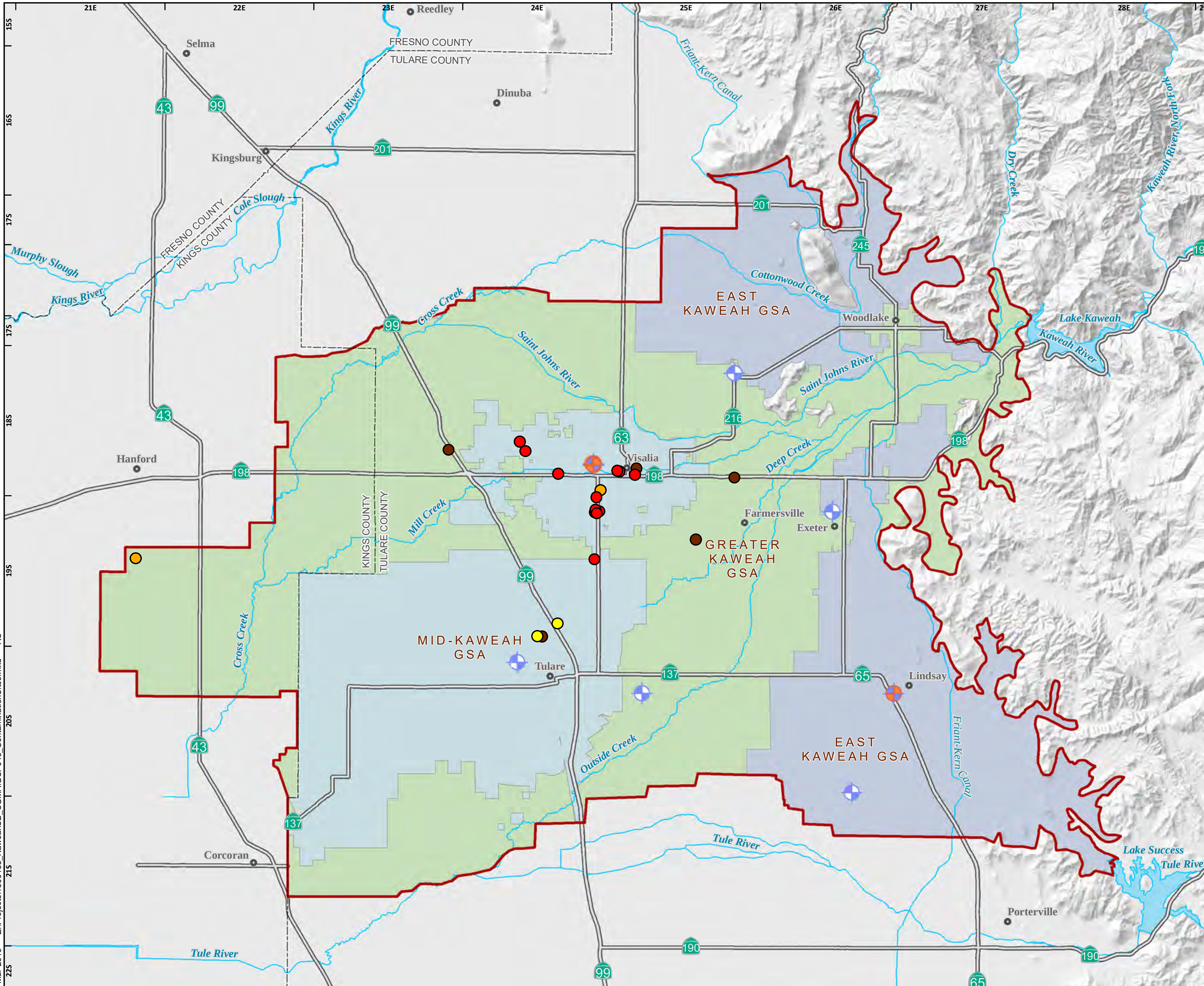
MARCH 2019 **DRAFT** FIGURE 79

KAWEAH SUBBASIN CONTAMINATION SITES



Increased or Elevated PCE Area
Well with DBCP Detected

Contamination Site
Gasoline
Arsenic
Pesticide/Herbicide
VOC

GSA Boundaries
East Kaweah GSA
Greater Kaweah GSA
Mid-Kaweah GSA
Kaweah Subbasin Boundary

All Other Features
Highway
Waterway
Lake

0 2 4 8
Miles
N

Kaweah Subbasin
Groundwater Sustainability Plan
Tulare County, California

Kaweah Subbasin

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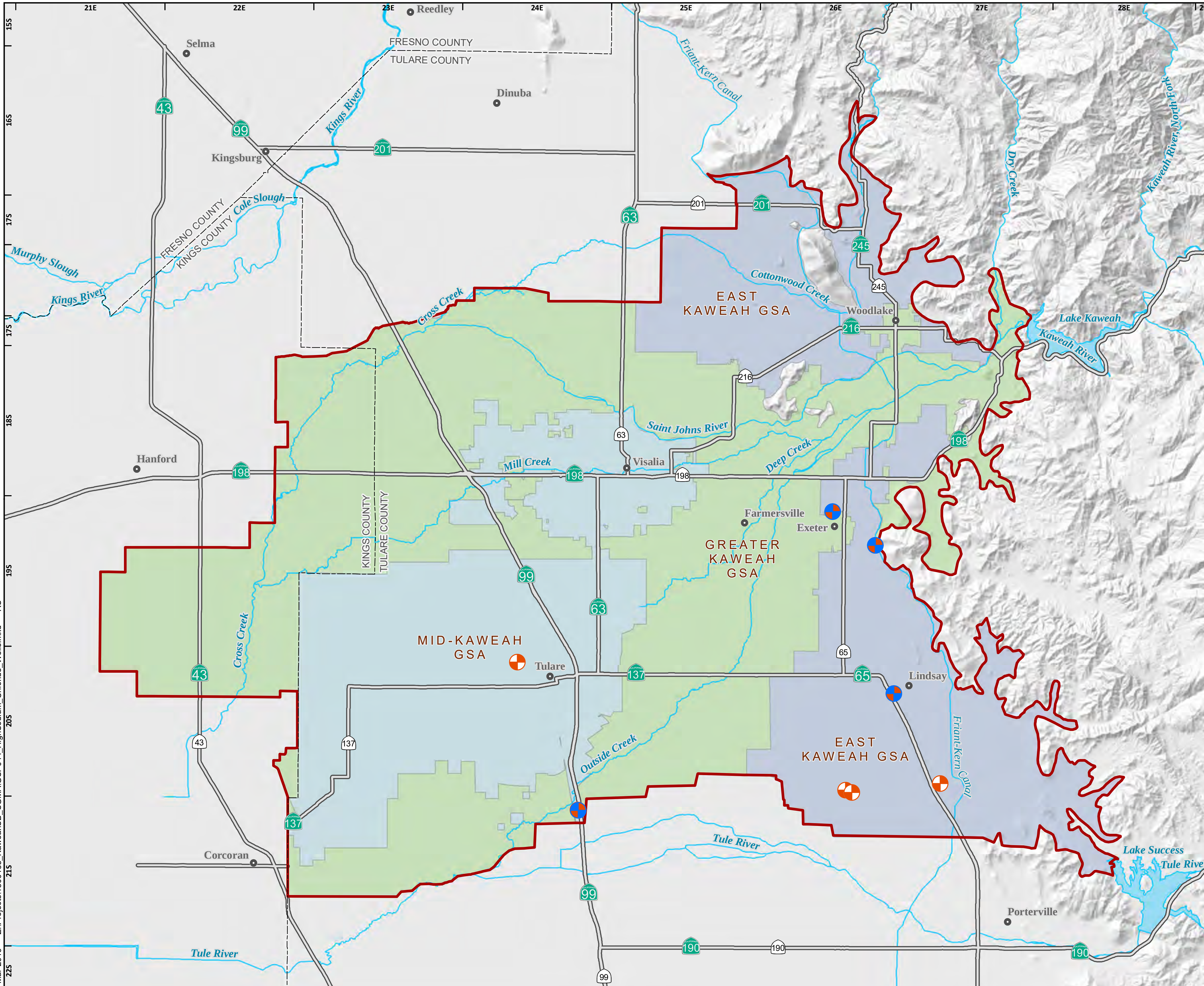
MARCH 2019 **DRAFT** FIGURE 80

Z:\Projects\1800138_KaweahSB_SGMA\GSP043_ContaminationSites.mxd RS
12-Mar-2019

KAWEAH SUBBASIN
HIGH SODIUM AND CHLORIDE WELLS



Kaweah Subbasin
Groundwater Sustainability Plan
Tulare County, California

Kaweah Subbasin

GEI Consultants
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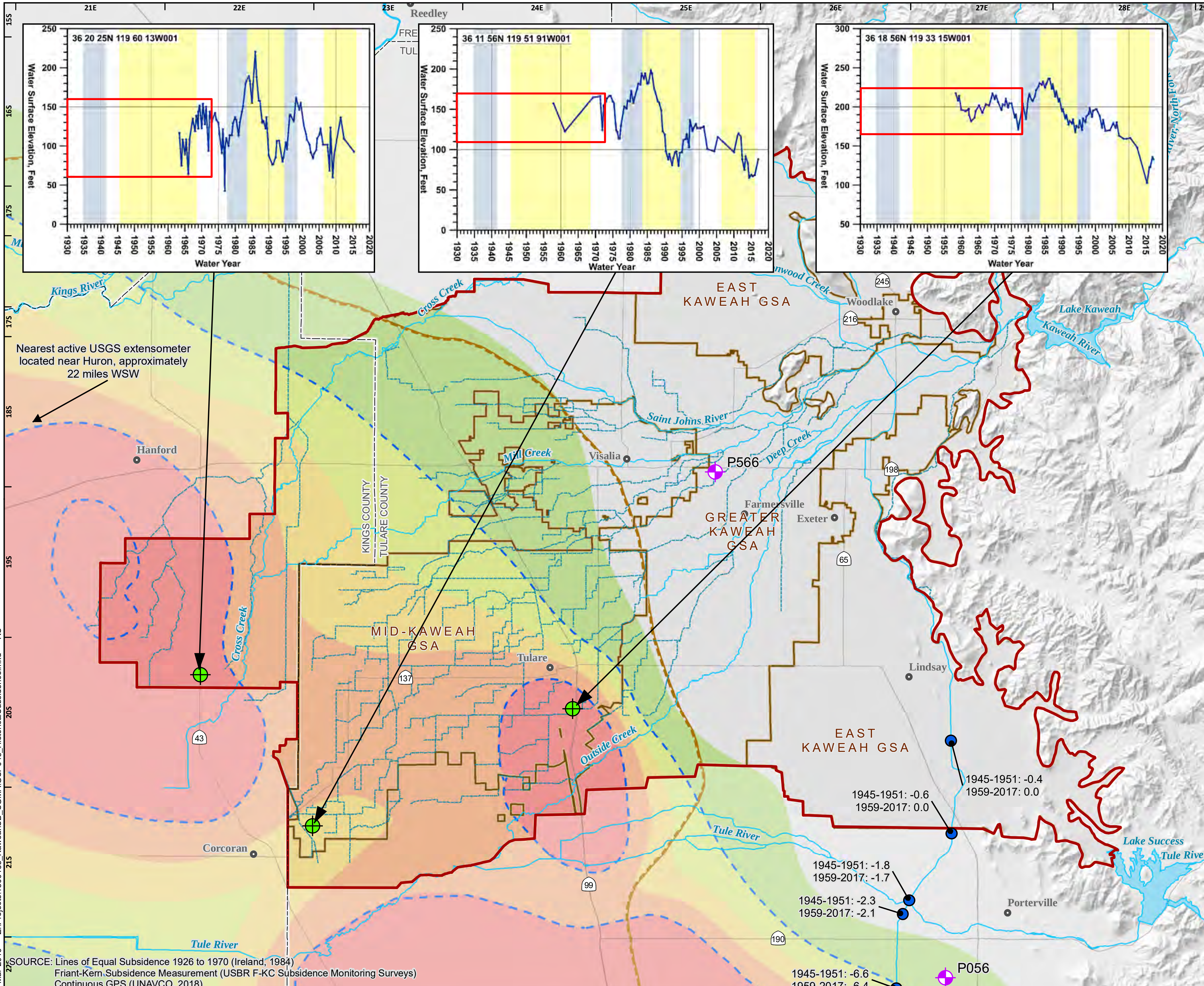
MARCH 2019 **DRAFT** FIGURE 81

HISTORICAL CUMULATIVE SUBSIDENCE (1926 TO 1970)



Kaweah Subbasin
Groundwater Sustainability Plan
Tulare County, California

Kaweah Subbasin

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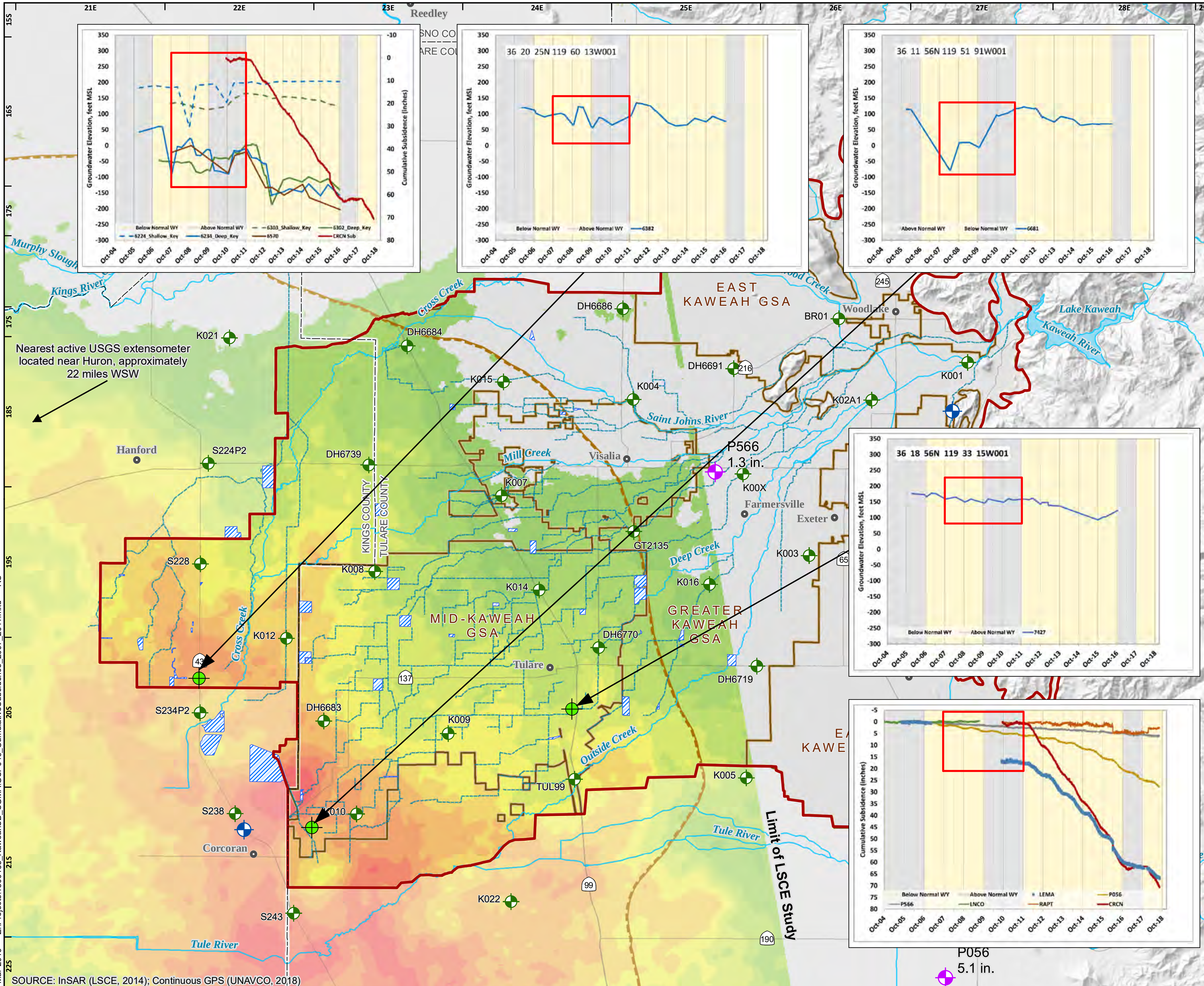
MARCH 2019 **DRAFT** FIGURE 84

CUMULATIVE SUBSIDENCE JANUARY 2007 TO MARCH 2011



SOURCE: InSAR (LSCE, 2014); Continuous GPS (UNAVCO, 2018)

Z:\Projects\1800138_KaweahSB_SGMA\GSP046_CumulativeSubsidence_2007_2011.mxd RS 12-Mar-2019

- Casgem Well with Plotted Hydrograph
- Continuous GPS Station
- SOPAC Location
- Land Surface Elevation Monitoring Station
- Recharge Basin
- Approximate Extent of Corcoran Clay
- Kaweah Subbasin GSA
- Kaweah Subbasin Boundary

Interferometric Synthetic Aperture in Inches (InSAR)

- Limit of LSCE Study
- 0 to 3
- 3 to 6
- 6 to 9
- 9 to 12
- 12 to 15
- 15 to 18
- 18 to 21
- 21 to 24
- 24 to 27
- 27 to 30

All Other Features

- Highway
- Waterway
- Minor Canal
- Lake

0 2 4 8 Miles

N

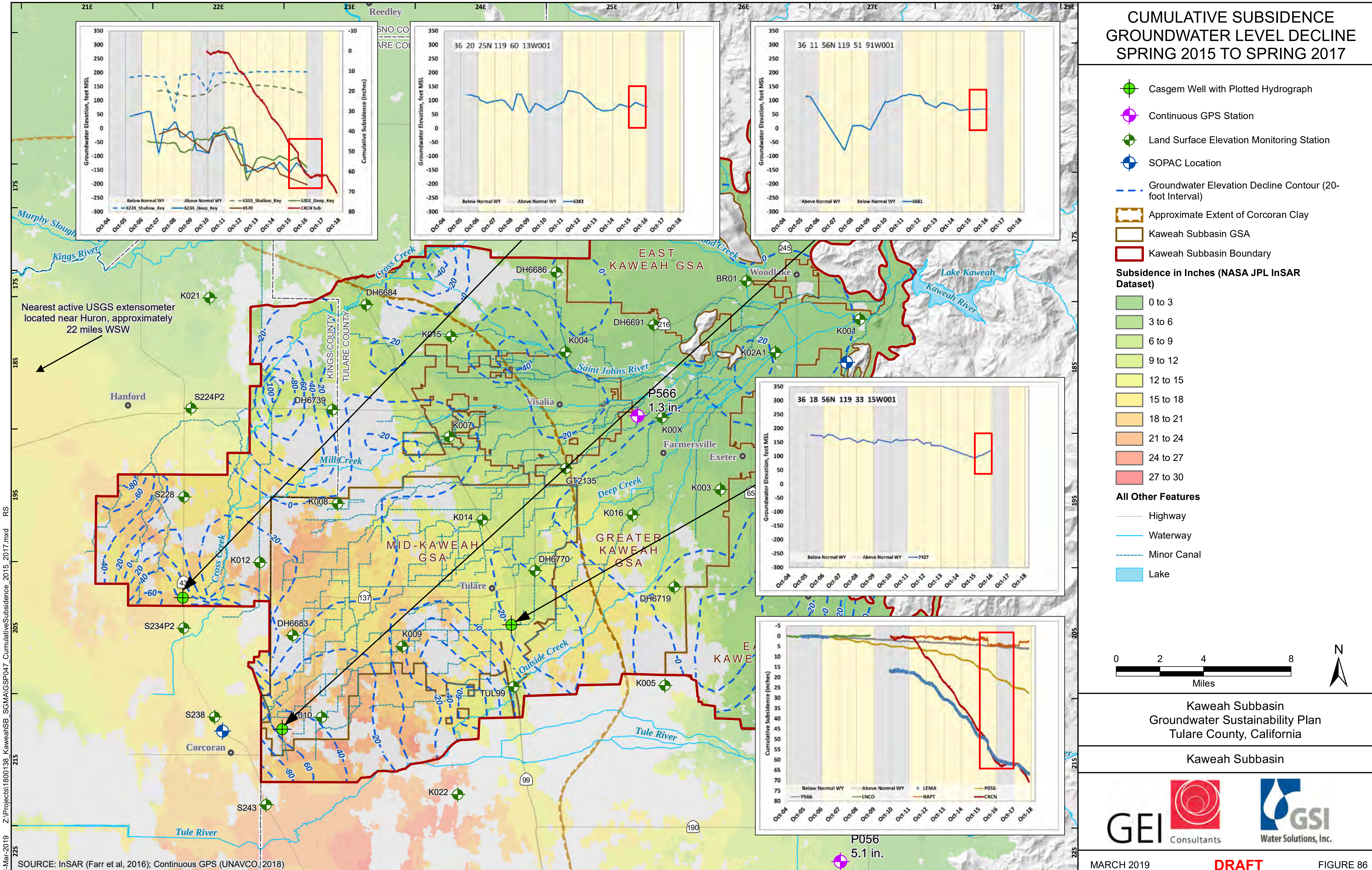
Kaweah Subbasin
Groundwater Sustainability Plan
Tulare County, California

Kaweah Subbasin

GEI Consultants

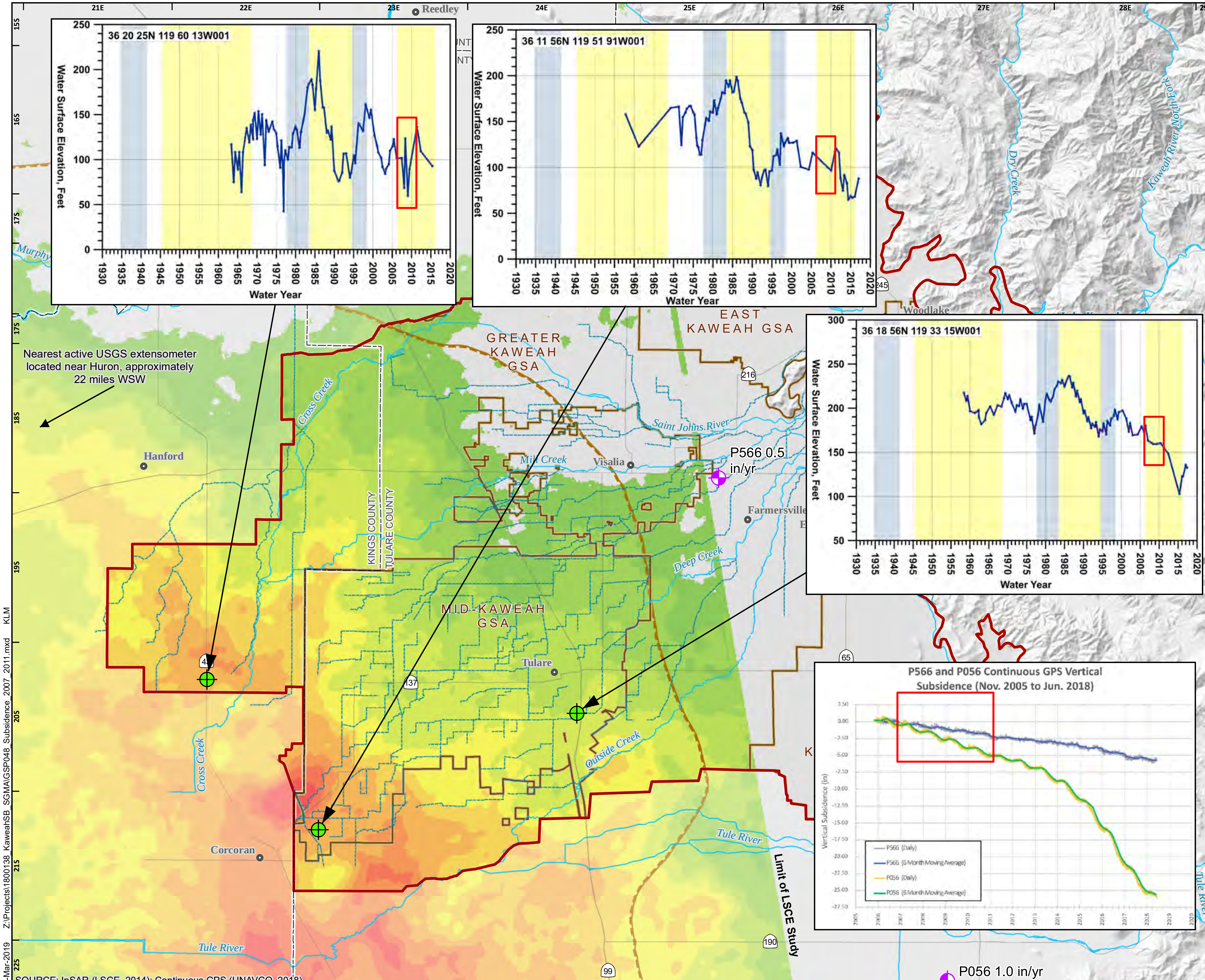
GSI Water Solutions, Inc.

MARCH 2019 **DRAFT** FIGURE 85



CUMULATIVE SUBSIDENCE
GROUNDWATER LEVEL DECLINE
SPRING 2015 TO SPRING 2017
Casgem Well with Plotted Hydrograph
Continuous GPS Station
Land Surface Elevation Monitoring Station
SOPAC Location
Groundwater Elevation Decline Contour (20-foot Interval)
Approximate Extent of Corcoran Clay
Kaweah Subbasin GSA
Kaweah Subbasin Boundary
Subsidence in Inches (NASA JPL InSAR Dataset)
0 to 3
3 to 6
6 to 9
9 to 12
12 to 15
15 to 18
18 to 21
21 to 24
24 to 27
27 to 30
All Other Features
Highway
Waterway
Minor Canal
Lake
Miles
Kaweah Subbasin
Groundwater Sustainability Plan
Tulare County, California
Kaweah Subbasin
GEI Consultants
GSI Water Solutions, Inc.
MARCH 2019
DRAFT
FIGURE 86
Nearest active USGS extensometer located near Huron, approximately 22 miles WSW
EAST KAWEAH GSA
MID-KAWEAH GSA
GREATER KAWEAH GSA
P566 1.3 in.
P056 5.1 in.
36 20 25N 119 60 13W001
36 11 56N 119 51 91W001
36 18 56N 119 33 15W001
Groundwater Elevation, feet MSL
Cumulative Subsidence (inches)
Below Normal WY
Above Normal WY
SOURCE: InSAR (Farr et al, 2016); Continuous GPS (UNAVCO, 2018)
12-Mar-2019 Z:\Projects\1800138_KaweahSB_SGMA\GSP047_CumulativeSubsidence_2015_2017.mxd RS

ANNUAL RATE OF SUBSIDENCE (JANUARY 2007 TO MARCH 2011)



Continuous GPS Station

Casgem Wells with Plotted Hydrograph

Approximate Extent of Corcoran Clay

Kaweah Subbasin Boundary

Kaweah Subbasin GSA

Interferometric Synthetic Aperture in Inches per Year (InSAR)

- Limit of LSCE Study
- 0 to 0.75
- .75 to 1.5
- 1.5 to 2.25
- 2.25 to 3
- 3 to 3.75
- 3.75 to 4.5
- 4.5 to 5.25
- 5.25 to 6
- 6 to 6.75
- 6.75 to 7.5

All Other Features

- Highway
- Waterway
- Minor Canals
- Lake

0 2 4 8
Miles

N

Kaweah Subbasin
Groundwater Sustainability Plan
Tulare County, California

Kaweah Subbasin

GEI Consultants

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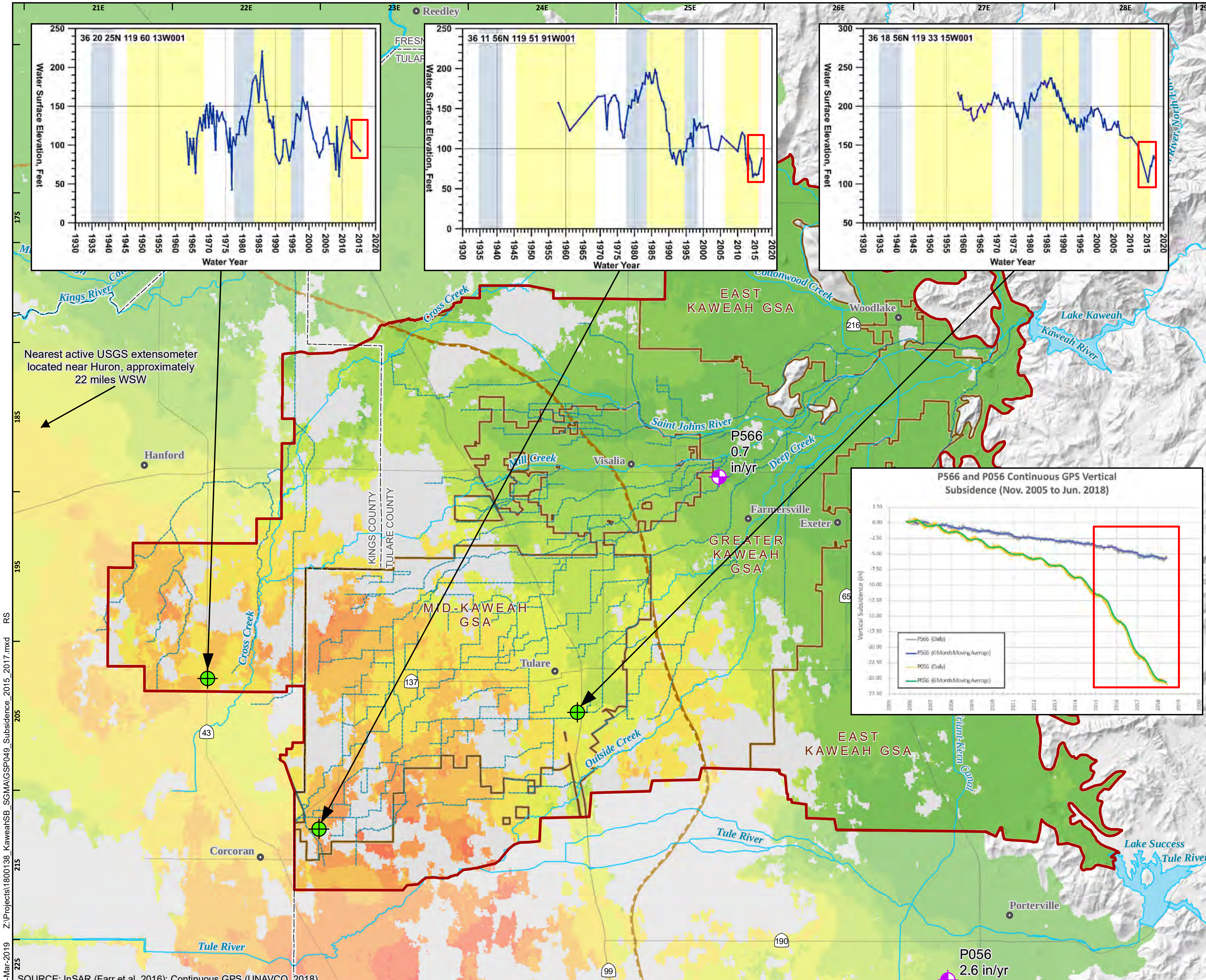
MARCH 2019 **DRAFT** FIGURE 87

ANNUAL RATE OF SUBSIDENCE (SPRING 2015 TO SPRING 2017)



Continuous GPS Station

Casgem Well with Plotted Hydrograph

Approximate Extent of Corcoran Clay

Kaweah Subbasin GSA

Kaweah Subbasin Boundary

Subsidence in Inches per Year (NASA JPL InSAR Dataset)

- 0 to 1.5
- 1.5 to 3
- 3 to 4.5
- 4.5 to 6
- 6 to 7.5
- 7.5 to 9
- 9 to 10.5
- 10.5 to 12
- 12 to 13.5
- 13.5 to 15

All Other Features

- Highway
- Waterway
- Minor Canal
- Lake

0 2 4 8
Miles

N

Kaweah Subbasin
Groundwater Sustainability Plan
Tulare County, California

Kaweah Subbasin

GEI Consultants

GSI Water Solutions, Inc.

MARCH 2019 **DRAFT** FIGURE 88

Appendix A

Consulting Engineers and Scientists

DRAFT

TECHNICAL MEMORANDUM

TO: Kaweah Sub-Basin Management Team

FROM: GEI Consultants, Inc.; GSI Water Solutions, Inc.

DATE: August 24, 2018

RE: TASK 1 – REVIEW OF EXISTING KAWEAH SUB-BASIN GROUNDWATER MODELS AND APPROACH FOR MODEL DEVELOPMENT TO SUPPORT GSPs

Introduction

Early in 2017, the GEI Consultants, Inc. (GEI) and GSI Water Solutions, Inc. (GSI) teams prepared a Technical Memorandum (TM) to evaluate the groundwater models available for use in development of the Groundwater Sustainability Plans (GSP) for the three Groundwater Sustainability Agencies (GSA) in the Kaweah Sub-Basin (Sub-Basin). That TM, dated March 8, 2017, presented the significant comparative details of three numerical groundwater flow models that cover the Sub-Basin, including:

- Kaweah Delta Water Conservation District (KDWCD) Groundwater Model,
- Central Valley Hydrologic Model (CVHM), and
- California Central Valley Groundwater-Surface Water Simulation Model (C2VSim) coarse grid and fine grid variants.

The March 2107 TM identified the water budget from the most recent update of the KDWCD Water Resources Investigation (WRI) as an accounting "model", but it is essentially a water accounting analysis that uses water consumption and soil moisture models. It is not a three-dimensional, numerical groundwater flow model, but is a valuable analysis that will be used as primary inputs to the groundwater model. The March 2017 TM recommended use of the KDWCD Groundwater Model as the preferred tool for Sustainable Groundwater Management Act (SGMA) applications based upon its relative ability to address the potential model needs cited in SGMA regulations. Model selection criteria used in the TM included: model availability; cost of development and implementation; regulatory acceptance; suitability for GSP-specific analyses; and relative abilities to assess Sub-Basin water budget components, future undesirable results, and impacts of future management actions and projects.

More recently, the Kaweah Management Team, consisting of the East Kaweah, Greater Kaweah, and Mid-Kaweah Groundwater Sustainability Agencies (EKGSA, GKGSA, and MKGSA) approved a scope of work to develop a Sub-Basin wide numerical groundwater model to support GSP development and implementation. Efforts related to groundwater model development and use of the calibrated tool were generally defined within three tasks, as follows:

1. Task 1 – Perform a technical assessment of existing groundwater models that cover the Kaweah Sub-Basin, with emphasis on the KDWCD Model, and develop an approach to update and revise the selected source model as required to support the objectives of the GSP.
2. Task 2 – Perform model revisions and updates for the selected groundwater model as documented in Task 1, with a focus on supporting GSP objectives.
3. Task 3 – Apply the updated model predictively for each GSA and cumulatively for the entire Sub-Basin to simulate future conditions, with and without potential management actions and projects proposed to support GSP implementation.

This TM documents the results of Task 1. GEI and GSI (the Modeling Team), as part of supporting Sub-Basin SGMA compliance, have evaluated the existing KDWCD Groundwater Model for update to simulate the entire Sub-Basin and relevant adjacent areas. The following presents technical details and performance aspects of the KDWCD Model and proposes a general approach for utilizing the model to support development of the GSP. Specifics of this approach may change over the course of model development as dictated by data constraints and improved conceptualization provided by the updated Sub-Basin Basin Setting developed through the Management Team. This TM and associated analyses satisfies Task 1 requirements, including:

- Perform a detailed evaluation of the existing KDWCD groundwater model inputs and outputs, including test runs and simulations, comparisons with water budget data, and a general comparison with regional C2VSim and CVHM models.
- Develop a plan to move forward with the model update, including assessment of status of required hydrogeologic data, updates to model area, parameters, fluxes, spatial framework, stress periods, validation periods, and calibration periods and general approach for the model domain.
- Prepare a TM summarizing the path forward for modeling support of the GSP, including technical coordination with adjacent basin GSA representatives regarding groundwater modeling methods and assumptions.

Additionally, the Modeling Team will present the key findings of this TM in a workshop for representatives of the Sub-Basin GSAs. This working session will allow GSA representatives to better understand the model design and capabilities as well as provide a forum for discussion of current, future, and outstanding data as well as planning needs for model development and predictive simulations.

After submittal of this proposed modeling approach and path forward, the Modeling Team will execute the recommended actions described in this document. Once updated, the Modeling Team is recommending adoption of the name Kaweah Sub-Basin Hydrologic Model (KSHM) for this new SGMA tool to differentiate it from the previous modeling efforts and to reflect the fact that it includes complex hydrologic analyses in addition to groundwater flow.

Comparison with Regional Modeling Tools

The Modeling Team previously performed a cursory review of pertinent aspects affecting the efficient use of the three major groundwater modeling tools that cover the Sub-Basin. This TM is built upon that analysis and includes a more in-depth assessment of the newly released beta version of the C2VSim model provided by the California Department of Water Resources (DWR). Although the results of the March 2017 analysis were reinforced with findings from this review, the Modeling Team also looked at the datasets contained within these valuable, regional modeling tools to see if they may be of use in the development of the KSHM.

Central Valley Hydrologic Model

CVHM is an 11-layer model that covers the entire Central Valley. It has a spatial resolution of one square mile and includes both a coupled lithologic model and Farm Process module (model) that are used to estimate hydraulic parameters and agricultural groundwater demand and recharge, respectively. The CVHM was previously deemed not to be a viable modeling alternative for the Sub-Basin analyses by the Modeling Team due to several factors. Most significant of these is the fact that the model data is only current to 2009, well before the SGMA-specified accountability date of 2015. The model resolution is also not suitable to reflect all water budget components at the precision required to assess past and current groundwater responses to water management within each GSA. The CVHM is also not suitably calibrated nor reflective of the hydrostratigraphy in the Sub-Basin and does not match the higher resolution and more accurate crop and related groundwater pumping estimates produced by Davids Engineering, Inc. (Davids Engineering) time-series analysis of evaporation and applied water estimates for the KDWCD; soon to be provided for the entire Sub-Basin through water year 2017. Lastly, the use of the Farm Process is cost prohibitive, given the fact that it would have to be rigorously calibrated to the evapotranspiration and deep percolation estimates already provided by the Davids Engineering analysis.

California Central Valley Groundwater-Surface Water Simulation Model (C2VSim)

The DWR-supported C2VSim Fine Mesh Beta Version was assessed in greater detail as part of the development of this modeling approach. Like CVHM, the C2VSim fine mesh does not include the high resolution of crop demands and surface water deliveries that are in the existing KDWCD model and can be easily updated with the KSHM. It also does not have the element resolution, flexibility to change fluxes, cost savings, and GSA-level accuracy of a sub-regional model designed to incorporate the highest resolution and locally accurate consumptive use and recharge information available. The Modeling Team assessed model layering, significant water budget components, storage change, and groundwater level elevation changes used in C2VSim relative to KDWCD monitoring well locations. The previous KDWCD model produced a better match for the data and estimates from the WRI, and at a significantly higher resolution. Simulated storage change within the Sub-Basin was greater than that estimated by C2VSim by over 20,000 acre-feet per year (AFY); without documentation of how the quantification of water budget components was performed. Calibration of regional flow directions and gradients were reasonable but not as accurate nor locally refined as that observed with the KDWCD modeling efforts.

The beta version of the C2VSim model is not currently considered to be calibrated in a quantitative sense, and no documentation is publicly available to assess the resolution or accuracy of the model inputs for the Sub-Basin. Because of our analysis and comparison of the C2VSim Fine Mesh Beta Model with the water budget and groundwater conditions from the WRI and the draft Basin Setting; the C2VSim was deemed to be a viable source of regional information to supplement development of the KSHM. However, relative to a modeling approach using the KSHM, the C2VSIM model would not provide a more accurate or cost-efficient option for satisfying SGMA regulations.

KDWCD Model Assessment and Review with Respect to an Updated Model

The KDWCD Groundwater Model was originally developed by Fugro Consultants, Inc. (Fugro) under the direction and sponsorship by KDWCD. Model development was documented in the report "*Numerical Groundwater Flow Model for the Kaweah Delta Water Conservation District, Final Report*" (April 2005). The objective of the model was to simulate the water budget estimates as refined under the WRI in 2003 and evaluate calibrated groundwater elevations, and modeled fluxes to and from adjacent sub-basins.

In May 2012, the KDWCD model was expanded to the east and southeast by Fugro to include the service areas of the Cities of Lindsay and Exeter, and adjacent irrigation districts, including: the Lewis Creek Water District; some unincorporated land and significant portions of Exeter Irrigation District, Lindmore Irrigation District, and Lindsay-Strathmore Irrigation District. The purpose of this effort was to update only the geographic extent, and it did not include updates to the simulation period or the calibration. The model was intended to be updated, refined, and improved in the coming years to provide a rigorously calibrated model over this larger extent, but this proposed work was not performed prior to initiation of SGMA and GSP development efforts.

Modeling Code and Packages

The KDWCD model was developed using MODFLOW 2000. MODFLOW, developed and maintained by the United States Geological Survey (USGS), is one of the most commonly used groundwater modeling codes in the world and is considered an industry standard. The pre- and post-processing of groundwater model data was performed using Groundwater Vistas, a third-party graphical user interface (GUI) that is among the most commonly used software in the groundwater industry to facilitate the use of MODFLOW.

The previous two KDWCD model variants used the following MODFLOW modules, or "packages":

- Well Package (WELL)
- Recharge Package (RCH)
- General Head Boundary (GHB) Package

MODFLOW utilizes large text files of numerical values as input files that provide the model with the values of various physical parameters and fluxes; all incorporated into the three-dimensional (3D) model structure. Much of the pre-processing and spatial organization of the data used to develop the MODFLOW input files was accomplished by Fugro using customized FORTRAN routines, as well as a geographic information system (GIS). Because of more recently available evapotranspiration and applied water estimates from Davids Engineering, the use of these FORTRAN routines is no longer necessary; providing a significant cost and time savings.

A summary of the construction and implementation of various water budget components into these model packages is discussed in following sections.

Model Extent and Discretization

The spatial extent of the current KDWCD model is presented in Figure 1. The figure displays the original model extent as well as the expanded extent to the east from the 2012 update. The model extends approximately twelve miles from east to west and 7.5 miles from north to south. It is composed of uniform 1,000 foot by 1,000-foot model cells for each layer.

There are some areas of the Sub-Basin that are not currently within the model domain (Figure 1), including much of what is now the EKGSA area. To evaluate the entire Sub-Basin area, in support of SGMA, it will be necessary to expand the model area to include all of the areas within the Sub-Basin. The updated model must also have shared boundaries and shared buffer zones with all adjacent groundwater sub-basins, as well as an evaluation of subsurface inflow and outflow (underflow) between the sub-basins. Figure 2 shows the proposed, expanded model grid for the new KSHM extent.

Model Layers

The KDWCD model is vertically discretized into three layers as shown on hydrogeologic cross sections shown on Figures 3, 4, and 5. These hydrogeologic cross sections show the principal aquifers, aquitard, and associated geologic units located throughout the Sub-Basin. Layer 1 represents the unconfined, basin sediments from the ground surface down to the Corcoran Clay in the western portion of the model domain or deeper; also including some older Quaternary alluvial deposits in the eastern portion of the domain. Layer 2 represents the Corcoran Clay, which is the primary aquitard in the Sub-Basin, where it is present in the western portion of the domain. In the eastern portion of the model area, where the Corcoran Clay pinches out, Layer 2 is simply represented with a minimal thickness and hydraulic parameters comparable to those of Layer 1. Layer 3 represents the largely confined basin sediments below the Corcoran Clay, where it is present, and deeper unconsolidated sediments to the east of the occurrence of this regional confining unit.

Although some of the regional models covering large areas of the Central Valley (i.e., CVHM and C2VSim) have a more highly discretized vertical layering, the Modeling Team believes that the three-layer conceptual model represented in the KDWCD model is likely suitable for the primary modeling objectives that support GSP development.

Model Simulation Time Periods

The KDWCD model was originally set up with 38 6-month stress periods to simulate the 19-year (calendar) calibration period of 1981 through 1999. Water budget components as documented in the 2003 WRI were used as input into the model and spatially distributed to the degree feasible given the spatial resolution and precision of the data sources and model grid.

It is likely that, after any recommended changes to the KDWCD model are implemented into the KSHM, the Modeling Team will calibrate the model through water year 2017 and perform validation simulations to confirm that the previous calibration developed with the historic WRI information is a suitable starting point the new simulation period. After validation, additional model refinements and updates can proceed to further improve the predictive capabilities of the KSHM using the aforementioned recent, high-resolution datasets as well as updated Basin Setting information.

Model Parameters

- **Hydraulic Conductivity/Transmissivity.** Hydraulic conductivity values are documented in the 2005 Model Report as well as in previous iterations of the WRI and conform with industry-standard literature values for the types of aquifer materials encountered at these depth intervals. Calibrated, horizontal hydraulic conductivities for Layer 1 (upper, unconfined aquifer) range from 50 feet/day (ft/d) to 235 ft/d, with the highest values in the southwest portion of the model area. Horizontal hydraulic conductivities for the portion of Layer 2 representing the Corcoran Clay were set at 0.024 ft/d. In the eastern area of Layer 2, where the Corcoran Clay pinches out, hydraulic conductivity values range from 50 to 150 ft/d and are essentially equal to the values assigned to the same area in Layer 1. Horizontal hydraulic conductivities for Layer 3 range from 25 ft/d to 125 ft/d. This distribution of hydraulic conductivity is consistent with previously published estimates from both the WRI and industry-standard literature estimates for the lithologies encountered.
- **Vertical hydraulic conductivity.** Vertical hydraulic conductivity in the model is set to a ratio of the estimated horizontal hydraulic conductivity, or an anisotropy ratio of 1:1. This essentially means that the vertical hydraulic conductivity of the Corcoran Clay was assumed to be equal to its horizontal conductivity and was apparently based upon the extensive perforation of the Corcoran Clay and other aquifer units by fully penetrating wells. This perforation of the regional aquitard allows for greater hydraulic connection between the upper and lower aquifer units. The Modeling Team will assess the validity of this anisotropy ratio during the validation simulation and adjust where merited.
- **Storage Parameters.** Specific yields in the unconfined aquifer (Layer 1) range from approximately 8% to 14%. Storage coefficients for the confined areas were set at an order of magnitude of approximately 1×10^{-4}. The storage coefficients used for the unconfined and the confined portions of the model are typical of those found in the basin and documented in the WRI as well as other commonly referenced literature for large basin fill valleys.

Current Model Boundary Packages and WRI Water Budget Components

As mentioned previously, the current KDWCD model uses three MODFLOW packages: WELL, RCH, and GHBs. A discussion of how those packages are used follows below.

- **Well Package (WELL).** As currently constructed, the KCWCD model represents the following WRI water budget components; which were calculated outside of the model Groundwater Vistas graphical user interface (GUI) using GIS and a FORTRAN routine that are unavailable to the Modeling Team. The flux values specified in the WELL package input files are essentially "lumped" fluxes representing the sum of the following water budget components:
  - Well pumpage (outflow)
  - Rainfall-based recharge (inflow)
  - Irrigation return flows (inflow)
  - Ditch loss (inflow)
  - Recharge basins (inflow)

The compilation of multiple water budget components into a single MODFLOW package makes tracking and assessment of the individual water budget components from model simulations difficult. Additionally, this model flux accounting approach and design makes evaluation of possible changes in the water budget because of management actions, changes in water demand or availability, and groundwater projects problematic. Because of this lumping of separate water budget components, every cell in Layer 1 is represented in the WELL Package. This makes the exact validation of the test runs and verification of the calibration with the WRI challenging. Without access to the spatial and temporal distributions of all water budget components utilized by Fugro, it is not possible to re-create the exact WELL package input file. However, the gross water budget inflow, outflow and storage values from the earlier WRI's match those simulated by the model and were reproduced by the Modeling Team.

- **Recharge Package (RCH).** The natural stream channels of the St. John's and the Lower Kaweah Rivers are represented in the model using the MODFLOW RCH Package. The RCH package applies a flux (ft/yr) in the surficial (shallowest) cells at the location where applied. The natural seepage flux values (or groundwater recharge) applied to the model correspond to the values of stream infiltration spatially estimated for these rivers and documented in the WRI.
- **General Head Boundaries (GHB).** The KDWCD model has GHBs assigned to all cells on the exterior perimeter of the model, as seen on Figure 1. GHBs are commonly used to represent the edges of a model domain within a larger aquifer extent. Reference heads (groundwater elevations) and "conductance" terms for adjacent aquifers just outside the model domain are used by this package to calculate fluxes in and out across the boundary. The Modeling Team generally agrees with the use of GHBs in the north, south, and west portions of the Sub-Basin. However, we propose the removal of the GHBs along the eastern portion of the sub-basin at the Sierra Nevada mountain front. Conceptually, the eastern model boundary, especially with the expansion and inclusion of the EKGSA area, is not a head-dependent boundary, but a flux-dependent one based on mountain front recharge and seepage from natural drainages and streams adjacent to relatively impermeable material. Thus, this boundary will be better represented using a no-flow condition coupled with a recharge or prescribed underflow component.

Previous WRIs have included estimates of inflow and outflow across the study boundaries, and comparisons between modeled and calculated values vary significantly both spatially and by magnitude. However, there are several variables that directly impact estimated underflow values that have not been sufficiently constrained, due to the focus of previous work being on the interior of the KDWCD area. Recently updated basin conditions, improved understanding of appropriate regional groundwater conditions adjacent to the Sub-Basin and use of an expanded model area will significantly improve the certainty of these underflow estimates.

Model Calibration. Calibration of the KDWCD model for the historic simulation period of 1981-1999 is discussed in the April 2005 model report. These include charts of observed versus modeled water levels for three different time periods and transient hydrographs for 30 target well locations. The density of calibration targets was deemed adequate by the Modeling Team for a model of this area and with the resolution of the model input datasets. Detailed calibration statistics are not documented in the report, but qualitative inspection of the hydrographs indicates that the calibration is adequate for future use in predictive simulations. Additionally, an open-source and industry-standard parameter estimation and optimization algorithm and code (PEST) was used to enhance model calibration. This is a common and robust industry practice that typically improves model calibration statistics.

Adequacy of the KDWCD Groundwater Model for GSP Development

Layering scheme. The 3-layer model layering scheme incorporated into the KDWCD model was deemed adequate by the Modeling Team for use in GSP analyses, and likely does not need significant revision prior to use. This decision was based upon the agreement of the model layers with the hydrogeologic conceptual model for the Sub-Basin as well as the ability of the previous model to simulate historic fluctuations in groundwater elevations over an extensive spatial extent and temporal period. However, should the refinement of the lithologic and stratigraphic understanding of the basin and identification of specific pumping intervals require additional vertical resolution, both Layer 1 and Layer 2 can be split into two layers to improve the model's ability to match and describe key vertical gradients and changes in groundwater level elevations and pressures near prominent pumping centers. At present, this vertical refinement is not required nor supported by data.

Model area. The model area will need to be expanded so that the entire Sub-Basin is included in the model. In addition, at the request of and in coordination with the technical groups for both Kaweah and adjacent sub-basins, a buffer zone will be included outside the defined Sub-Basin boundaries so that adjacent models will overlap and share model input and monitoring data. This overlap will assist in reconciling differences between the direction and magnitude of groundwater gradients along sub-basin boundaries. The preliminary extent of this buffer zone is proposed to be approximately 3 miles; however, this value will be revised in areas based on of the estimated locations of pervasive groundwater divides or apparent hydrologic boundaries.

Cell size. The 1,000 feet square cell size appears to be adequate for the data density for most model inputs. However, due to improvements in computing speed and power, the Modeling Team recommends initially using a smaller cell size of 500 feet square to 1) accommodate improvements in assigning real world boundaries to the model grid, and 2) leverage the improved resolution of crop demand and evapotranspiration data available for this effort.

Parameters. Hydraulic conductivity and storage parameters will remain unchanged at the start of model revisions and calibration scenarios. These will be adjusted if the Modeling Team determines it is necessary during the model validation run or if model calibration standards require parameter refinements.

Stress Periods. The previous temporal discretization of the model incorporated 6-month stress periods. To appropriately characterize seasonal rainfall, surface water delivery and pumping patterns; one-month stress periods should be adopted for predictive simulations. This decision will be finalized after review and conditioning of the input groundwater demand and recharge datasets.

With these revisions to the model framework and geometry of the KDWCD model to support the development of the KSHM will be adequate for use to support GSP analyses. The following section summarizes additional, recommended revisions to the organization of the model inputs, parameters, boundary conditions, and MODLFOW packages.

Proposed Revisions to KDWCD Groundwater Model and Model Approach

The Modeling Team concludes that the KDWCD model is suitable to support GSP development if the following revisions and refinements to the model are performed to develop the KSHM. As mentioned above, once updated, the Modeling Team is recommending adoption of the name Kaweah Sub-Basin Hydrologic Model for this new SGMA tool. This nomenclature is based upon that fact that this model incorporates more than simply a groundwater model in the final analysis. It also incorporates crop demand/evapotranspiration (with precipitation modeling) and applied water models.

The Modeling Team recommends that the relationships between the water budget components, as defined in the WRI (December 2003, revised July 2007), and the MODFLOW modeling packages currently available, be re-organized such that lumping of different water budget components within single MODFLOW packages is minimized. Some degree of aggregation may be unavoidable, but efforts will be made to apply unique water budget components from the updated WRIs and associated water budget components to more appropriate and recent MODFLOW packages. Additionally, we will utilize features of MODFLOW and Groundwater Vistas that allow for tracking of unique components within a single model package when possible. The current and proposed revised conceptual assignments of water budget components to MODFLOW packages are summarized below.

A major change and advantage of this effort relative to previous modeling work involves the availability and use of time-series evapotranspiration and applied water estimates from 1999 through water year 2017, provided by Davids Engineering. This data set uses remote sensing imagery from Landsat satellites to estimate agricultural water demand throughout the Sub-Basin at a very high resolution (approximately 30 meters). This information was not available for previous model builds, and its use will not only improve the understanding and accuracy of agricultural water requirements relative to the previous land use and soil moisture balance calculations that have been used, but also enhance the spatial calibration and predictive capability of the updated and expanded KSHM. The Davids Engineering dataset also includes estimates of deep percolation of applied water and precipitation. During the review of the KDWCD model and development of this modeling approach, the Modeling Team performed testing of the use of this dataset and was able to readily develop crop requirements and associated pumping estimates at a resolution even finer than the proposed model resolution.

Well Pumping. Groundwater pumpage will be the dominant water budget component represented in the WELL package. Other, more limited fluxes may also be used to represent mountain front fluxes or other unforeseen fluxes that are specified but do not have a specific package that is appropriate. All pumpage will be coded within the WELL package input files to identify the pumping by source, use, or entity. Municipal wells will be specifically located and simulated when well permits and required data reports are accessible and provide data specific to each well. Agricultural well pumpage will likely be spatially averaged, or "spread across", irrigated areas because of the uncertainty associated with irrigation well location, construction, and monthly or seasonal pumping rates.

Precipitation-based recharge. The Modeling Team proposes to represent this water budget component using the Recharge package.

Natural channel infiltration. Infiltration of surface water in the natural stream channels of the St. John's and the Lower Kaweah Rivers is currently assigned to the Recharge Package. The Modeling Team proposes to maintain this data in the recharge package along the spatial location of the courses of the rivers. If deemed appropriate and more beneficial the latest version of the Stream Package (SFR2) may be used for localized reaches of continuously flowing water, where gages do not adequately monitor seepage that can be applied directly as recharge. The Stream package calculates infiltration (inflow) to the aquifer based on defined parameters regarding bed geometry and vertical conductivity, and this will likely involve some iterative re-definition of STREAM package components to accurately portray the calculated water budget component flux. Native evapotranspiration (ET), where relevant, will be subtracted from either the precipitation or natural channel infiltration modules. The inclusion of natural, riparian ET will be addressed specifically upon finalization of the water budget for the Sub-Basin.

Man-made channel recharge. (i.e., ditch and canal loss). This is currently incorporated with four other water budget components as a single summed value in the Well Package. The Modeling Team proposes to represent this water budget component using either the Recharge package or another Type 3 boundary condition type, such as a prescribed stage above land surface. Should another more advanced MODFLOW module prove to more effective in simulating this flux, it will be utilized, and the reasoning documented in the model development log.

Irrigation Return Flows. Irrigation return flows are the component of the water budget that infiltrates into the subsurface due to over-watering of crops. This is currently incorporated with four other water budget components as a single summed value in the WELL Package. The Modeling Team proposes to represent this water budget component using the Recharge package, but to differentiate it from precipitation-based recharge within Groundwater Vistas by assigning zone identifiers that are different from the rainfall-based recharge.

Artificial Recharge Basins. This is currently incorporated with four other water budget components as a single summed value in the WELL Package. Recharge basins are likely to be a common management strategy to help achieve sustainability in the Sub-Basin. As such, the model should be able to individually represent each recharge basin. These could be represented in the Recharge Package or other more sophisticated module if specifically merited.

Lateral Model Boundaries. These are currently simulated using the GHB Package. We will maintain this concept, but the locations of the GHBs will be moved to locations beyond the edge of the Sub-Basin up to the extent of the expanded model area. Assigned reference heads for the GHB cells will be based on observed groundwater elevations from historic groundwater elevation maps. GHB head assignments for predictive runs may be lowered over time if current trends indicate declining water levels over the next 20-40 years. These head assignments will be finalized in consultation and coordination with adjacent sub-basin technical groups as well as any regional modeling or State-derived predictive information.

Mountain Front Recharge. Currently, a GHB is assigned to the eastern edge of the Sub-Basin, along the front of the Sierra Nevada foothills. The modeling team will remove this GHB and represent mountain front recharge using the Recharge Package. Conceptually, mountain front recharge is not a head-dependent boundary, but a specified flux-dependent boundary.

Calibration Period and Validation Period. As discussed previously, the original model was calibrated to a 19-year calibration period using 6-month stress periods. The Modeling Team suggests that upon completion of the KSHM model, a validation run simulating the time period of 1999-2017 be made to assess that the model is still adequately calibrated. Upon assessment of the validation simulation, the KSHM will undergo the calibration process using both qualitative and quantitative measures, such as parameter estimation software (PEST), to produce the final calibrated simulation modeling tool to be used to refine the Sub-Basin water budget and be used for predictive simulations. Moving forward, the updated groundwater model for the Kaweah Sub-Basin will begin in 1999 and continue to be updated as new GSP updates are required and deemed necessary by the GSAs. This new start date is due to the substantially increased accuracy and spatial resolution of water budget features, primarily crop demand and surface water deliveries that result in agricultural pumping estimates, beginning with the first year that high quality satellite imagery and associated evapotranspiration/soil moisture balance models were provided by Davids Engineering. This modeling effort can be updated in the future with newer and more accurate local and regional data from neighboring GSAs to benefit required SGMA reporting, refinements, and optimization of the GSPs within the Sub-Basin.

Predictive Simulations. Predictive simulations through the SGMA timeframe of 2040 and beyond will be performed using the same monthly stress period interval and will be developed using the projected climate dataset provided by DWR. Correlations between this climatic projection and previously quantified groundwater demands and surface water deliveries will be developed to produce a suitable baseline predictive simulation that will serve as a starting point for assessing the impacts of various adaptive management actions and groundwater projects. Simulations will be performed for individual GSAs, but also the cumulative effects of future groundwater management in the Sub-Basin will be assessed relative to the baseline predictive simulation.

Collaboration with Neighboring Sub-Basins

The Modeling Team will be collaborating with neighboring sub-basin technical representatives during the update and application of the KSHM, with permission from the Kaweah Sub-Basin GSAs. The purpose for this coordination is to accomplish the following objectives:

- Receive input from GSAs' representatives on modeling tools and approaches in adjacent basins.
- Exchange data and information for consistency between tools.
- Agree on boundary conditions including both gradients and heads located at and outside of the boundaries of the Sub-Basin.
- Ensure that the KSHM integrates well, to the extent possible, with adjacent tools that our approaches for Kaweah Sub-Basin will not result in conflicting boundary conditions or water budgets.

The Modeling Team recommends that inter-basin model coordination meetings begin in August of 2018 and continue until the simulations required for use in developing the draft GSP is are completed. We anticipate the need for four (4) focused meetings on this approximate schedule:

1. KSHM Approach Meeting – Mid September 2018
2. KSHM Update Meeting – Late October 2018
3. KSHM Model Baseline Run and Boundary Flux Meeting – Late November 2018
4. KSHM Model Simulation Results Meeting – January 2019

The Modeling Team attended one meeting with the Tulare Lake Sub-Basin modeling group on June 15th, 2018 to facilitate data transfer between the two modeling efforts and improve agreement and conceptual consistency between the Sub-Basins. Upon request from the Kaweah Sub-Basin managers and committees, the Modeling Team will continue to collaborate and improve consensus with adjacent modeling groups to improve model agreement and sub-regional consistency between calibrated and predictive simulations. The Modeling Team is also prepared to develop and share baseline predictive simulation results with neighboring basins and accept in-kind data sharing to further improve predictive accuracy and understanding on adaptive management and project options and collaboration. These activities will be approved by GSA representatives prior to the Modeling Team sharing any information or data.

Conclusions and Recommendations Regarding Model Updates

In general, the Modeling Team believes that the KDWCD model provides an adequate precursor model that will be suitable for use in GSP development if the following revisions and updates are incorporated.

Groundwater Vistas Version 7 will be the processing software package utilized. We will maintain MODFLOW as the basic code and will update to MODFLOW-USG or MODFLOW-NWT to take advantage of advances in numerical solution techniques that are available in these updated MODFLOW revisions.

1. **Extent**. The model will need to be expanded to fill the area between the general head boundary of the current model and the Sub-Basin boundary shown in Figure 1 to include the entire area of the Kaweah Sub-Basin.
2. **Layers.** The model layering scheme depicting two water-bearing layers above and below the Corcoran Clay is suitable for the objective of supporting the GSP development.
3. **Historical Simulations.** The KDWCD model has been calibrated to the 1981-1999 hydrologic period. Based on inspection of the hydrographs presented in the 2005 modeling report and the 2012 Model update report, observed water levels are adequately simulated to consider this model effectively calibrated. The objective is to have a model suitable to simulate projected management actions through the entire Sub-Basin. No changes will be made to the inputs to the 1981-1999 run. Therefore, it is already calibrated to that period. We are just re-organizing the assignment of water budget components to different MODFLOW packages from 1999-2017, and beyond. Monthly stress periods will be used.
4. **Assignment of water budget components to MODFLOW Packages.** The Modeling Team proposes to revise the conventions used in the current KDWCD model. This will be the most involved part of the model revision. The updated water budget values that have been generated by the GSA will continue to be the primary input as far as flux values go. However, we propose to organize them into more readily identifiable currently available MODFLOW packages to help with the analyses of potential water budget changes that may correspond to management actions in the future.
5. **Recharge Components.** Spatial distribution of such water budget components as percolation of precipitation, irrigation return flow, recharge basins, etc., will be updated based on the most currently available data.
6. **Model Parameters**. Hydraulic conductivity (horizontal and vertical) and storage coefficient will initially stay unchanged during the validation period simulation. If the calibration target hydrographs for the validation period indicate that a suitable match is retained between observed and modeled water levels, the existing parameters will be retained.
7. **Flow Boundaries.** In areas where the current GHB boundaries are within the Kaweah Sub-Basin, they will be expanded approximately 1-2 miles, or at locations of any likely groundwater divides from the Sub-Basin boundary on the north, south, and west sides of the Sub-Basin. The assigned heads for these GHBs for the 1999-2017 verification run will be based on published groundwater elevations in the vicinity as depicted in contour maps published by DWR. Seasonal variability in assigned GHB heads can be incorporated.
8. **No-Flow Boundaries.** The eastern GHB along the base of the Sierra foothills will be removed. Instead, the flux in the Recharge Package will be increased along this boundary to represent mountain front recharge. The flux volume from the GHB will be evaluated, and this flux volume will be approximated using the Recharge Package.

Estimated Schedule of Model Update Activities

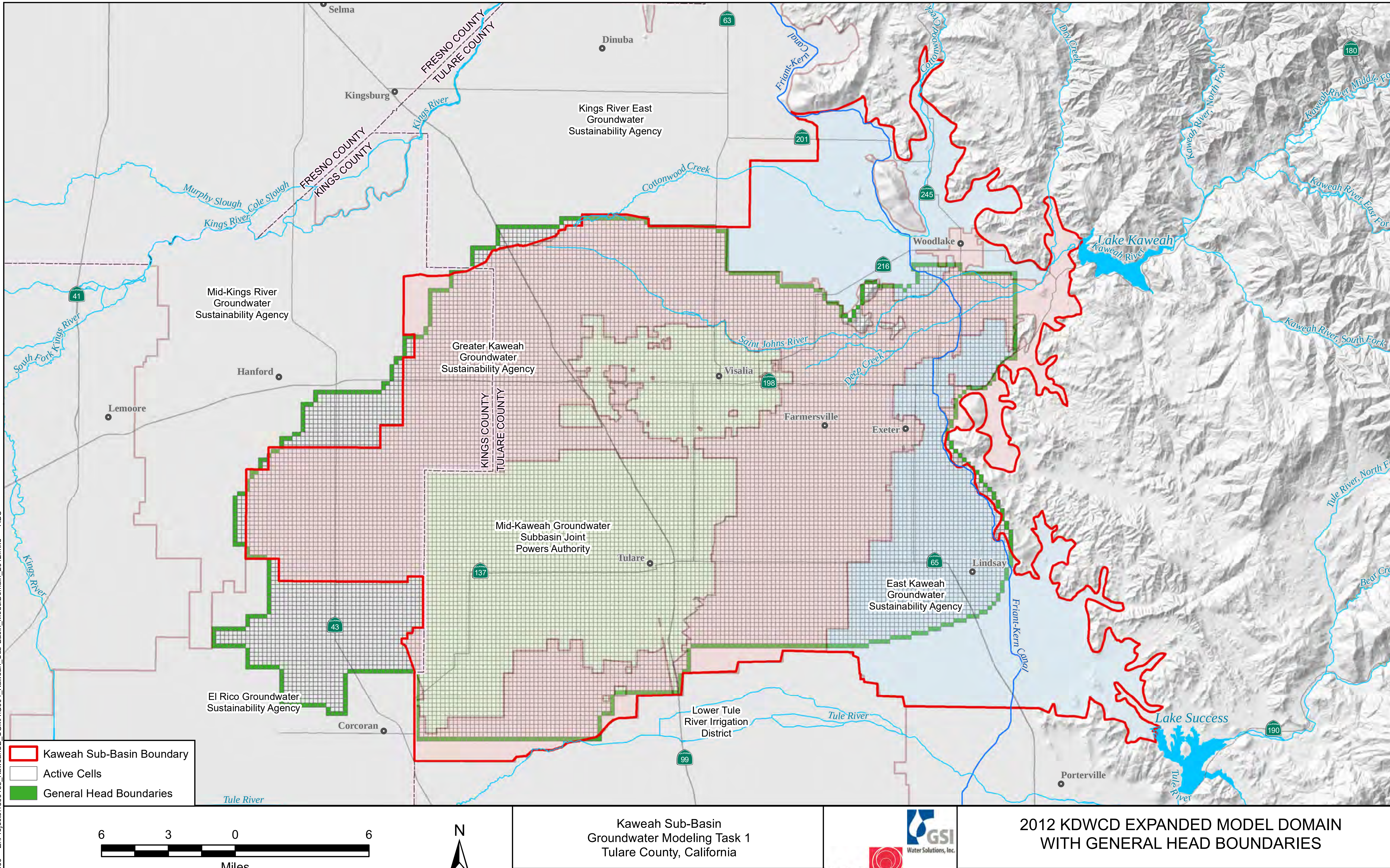
The Modeling Team proposes the following schedule for the major groundwater model update activities. Estimated timeframes for key inter-basin model coordination meetings and updates are also included in the following table to provide a more comprehensive schedule and to facilitate meeting planning. Specific model development and simulation tasks may shift to earlier or later timeframes, but it is the intention of the Modeling Team to comply with the overall schedule and satisfy deadlines for the final deliverable of the calibrated modeling tool and associated predictive scenarios. Should information not be available to the Modeling Team in time to use them in development of the calibrated model simulation or predictive simulations, the data will either not be included, or the schedule may be adjusted to accommodate their inclusion, per guidance from Sub-Basin GSA leadership.

Updates and presentations on the status of the groundwater modeling efforts will occur at regular intervals during Coordinated Sub-Basin and individual GSA meetings, per the scope of work for the groundwater modeling task order.

Table 1: Anticipated Schedule of Groundwater Model Update Activities

Modeling Activity	Estimated Completion Timeframe
Refinement and expansion of model domain and boundary conditions	Early September 2018
Update water budget with Davids Engineering and EKGSA data	Early September 2018
Development of calibration targets	Mid-September 2018
Parameterization of model layers	Mid-September 2018
Refinement of groundwater fluxes	Mid-September 2018
Inter-basin KSHM Approach Meeting (inter-basin)	Mid-September 2018
Adjust boundary conditions, fluxes, and parameters using any new adjacent basin data	Late September 2018
Initiate Formal Calibration Process	Early October 2018
Inter-basin KSHM Update Meeting	Late October 2018
Complete initial calibration process	Early November 2018
Calibration and model refinements and preparation for predictive simulations	Late November 2018
Inter-basin KSHM Calibrated Model and Boundary Flux Meeting	Late November 2018
Develop predictive baseline scenario – Sub-Basin level –	Early December 2018
Develop GSA specific predictive simulations	Mid December 2018
Cumulative Sub-Basin simulations	Early January 2019

LIST OF FIGURES



Kaweah Sub-Basin
Groundwater Modeling Task 1
Tulare County, California

Kaweah Sub-Basin

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2012 KDWCD EXPANDED MODEL DOMAIN WITH GENERAL HEAD BOUNDARIES

AUGUST 2018 | DRAFT | FIGURE 1

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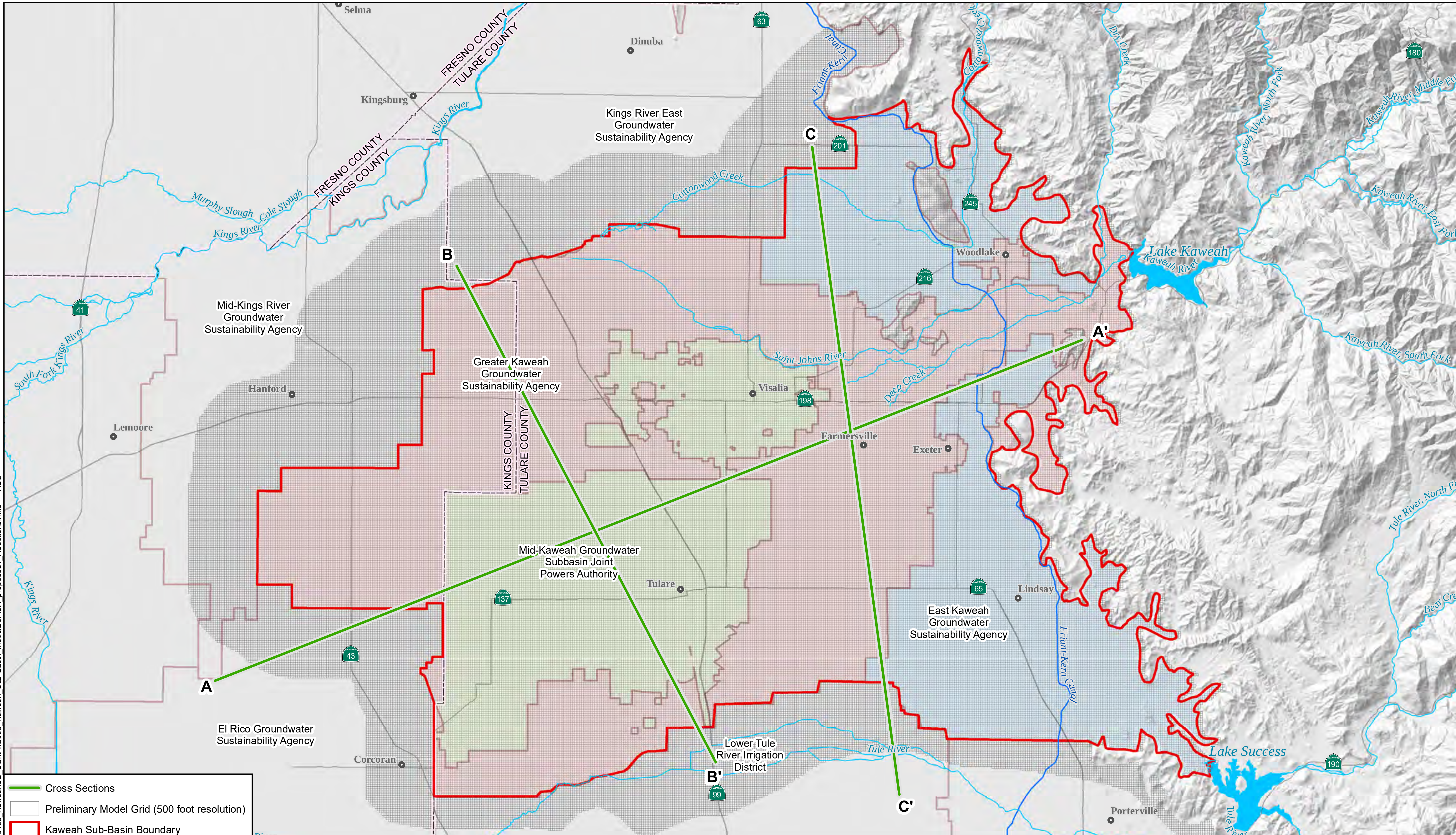

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Kaweah Sub-Basin
Groundwater Modeling Task 1
Tulare County, California

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PRELIMINARY KSHM GRID EXTENT AND RESOLUTION
INCLUDING BUFFER ZONES
AND CROSS SECTION LOCATIONS

AUGUST 2018 DRAFT FIGURE 2

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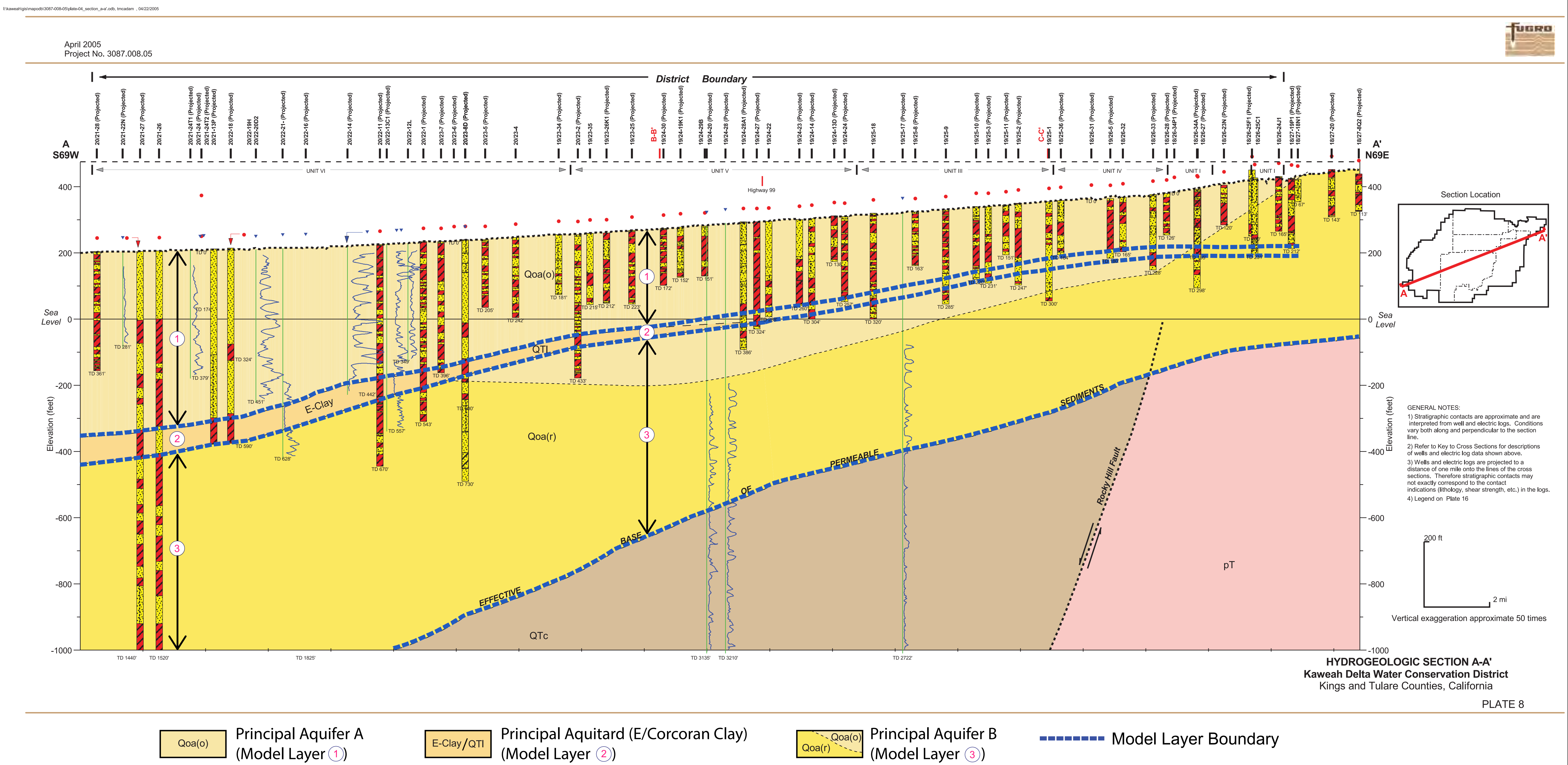

SOURCE: Numerical Groundwater Flow Model for the Kaweah Delta Water Conservation District (April 2005) Prepared for: Kaweah Delta Water Conservation District by Fugro West, Inc.

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Kaweah Sub-Basin
Groundwater Modeling Task 1
Tulare County, California

Kaweah Sub-Basin

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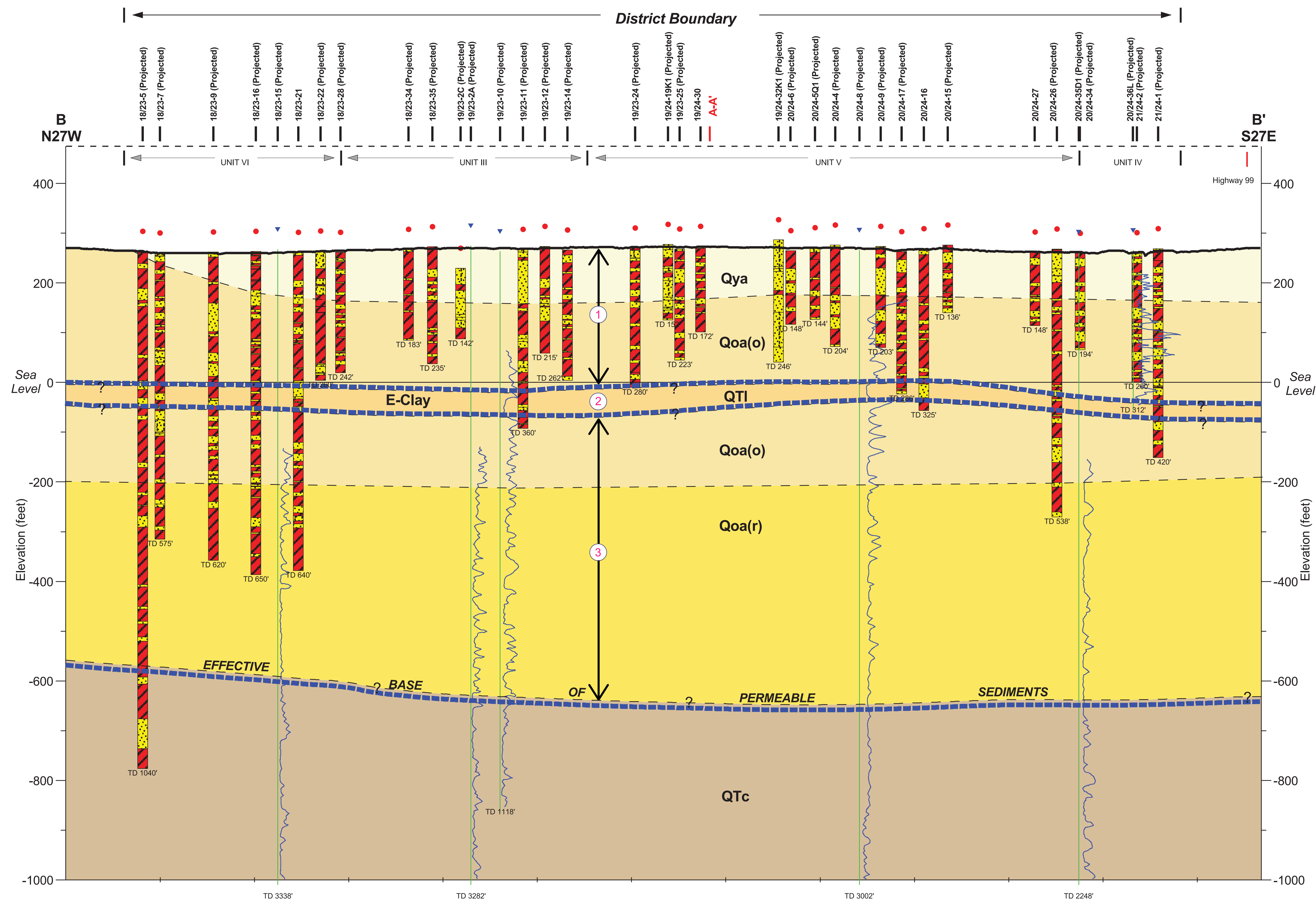
Model Layering Scheme along Hydrogeologic Cross Section A-A'

AUGUST 2018 | DRAFT | FIGURE 3

April 2005
Project No. 3087.008.05



GENERAL NOTES:

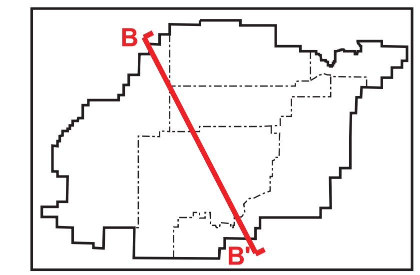
1) Stratigraphic contacts are approximate and are interpreted from well and electric logs. Conditions vary both along and perpendicular to the section line.

2) Refer to Key to Cross Sections for descriptions of wells and electric log data shown above.

3) Wells and electric logs are projected to a distance of one mile onto the lines of the cross sections. Therefore stratigraphic contacts may not exactly correspond to the contact indications (lithology, shear strength, etc.) in the logs.

4) Legend on Plate 16

Section Location



Model Layer Boundary

Principal Aquifer A (Model Layer 1) — Qya / Qoa(o)

Principal Aquitard (E/Corcoran Clay) (Model Layer 2) — E-Clay/QTI

Principal Aquifer B (Model Layer 3) — Qoa(o) / Qoa(r)

200 ft
2 mi
Vertical exaggeration approximate 50 times

HYDROGEOLOGIC SECTION B-B'
Kaweah Delta Water Conservation District
Kings and Tulare Counties, California

PLATE 9

SOURCE: Numerical Groundwater Flow Model for the Kaweah Delta Water Conservation District (April 2005) Prepared for: Kaweah Delta Water Conservation District by Fugro West, Inc.

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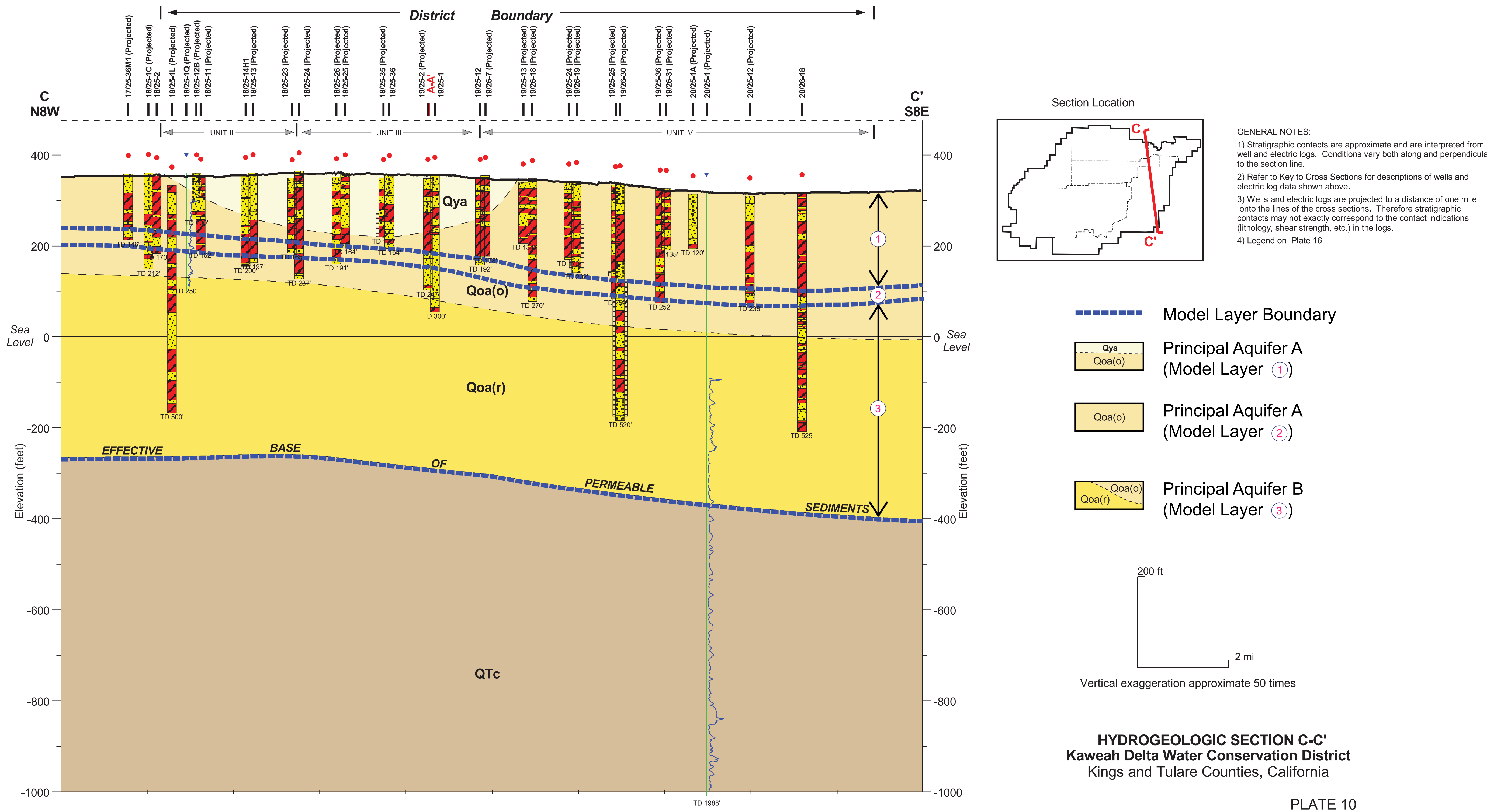
Kaweah Sub-Basin
Groundwater Modeling Task 1
Tulare County, California

Kaweah Sub-Basin

Model Layering Scheme along Hydrogeologic Cross Section B-B'

AUGUST 2018 DRAFT FIGURE 4

April 2005
Project No. 3087.008.05



HYDROGEOLOGIC SECTION C-C'
Kaweah Delta Water Conservation District
Kings and Tulare Counties, California

PLATE 10

SOURCE: Numerical Groundwater Flow Model for the Kaweah Delta Water Conservation District (April 2005) Prepared for: Kaweah Delta Water Conservation District by Fugro West, Inc.

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Kaweah Sub-Basin
Groundwater Modeling Task 1
Tulare County, California

Kaweah Sub-Basin

Model Layering Scheme along Hydrogeologic Cross Section C-C'

AUGUST 2018 DRAFT FIGURE 5

Appendix B

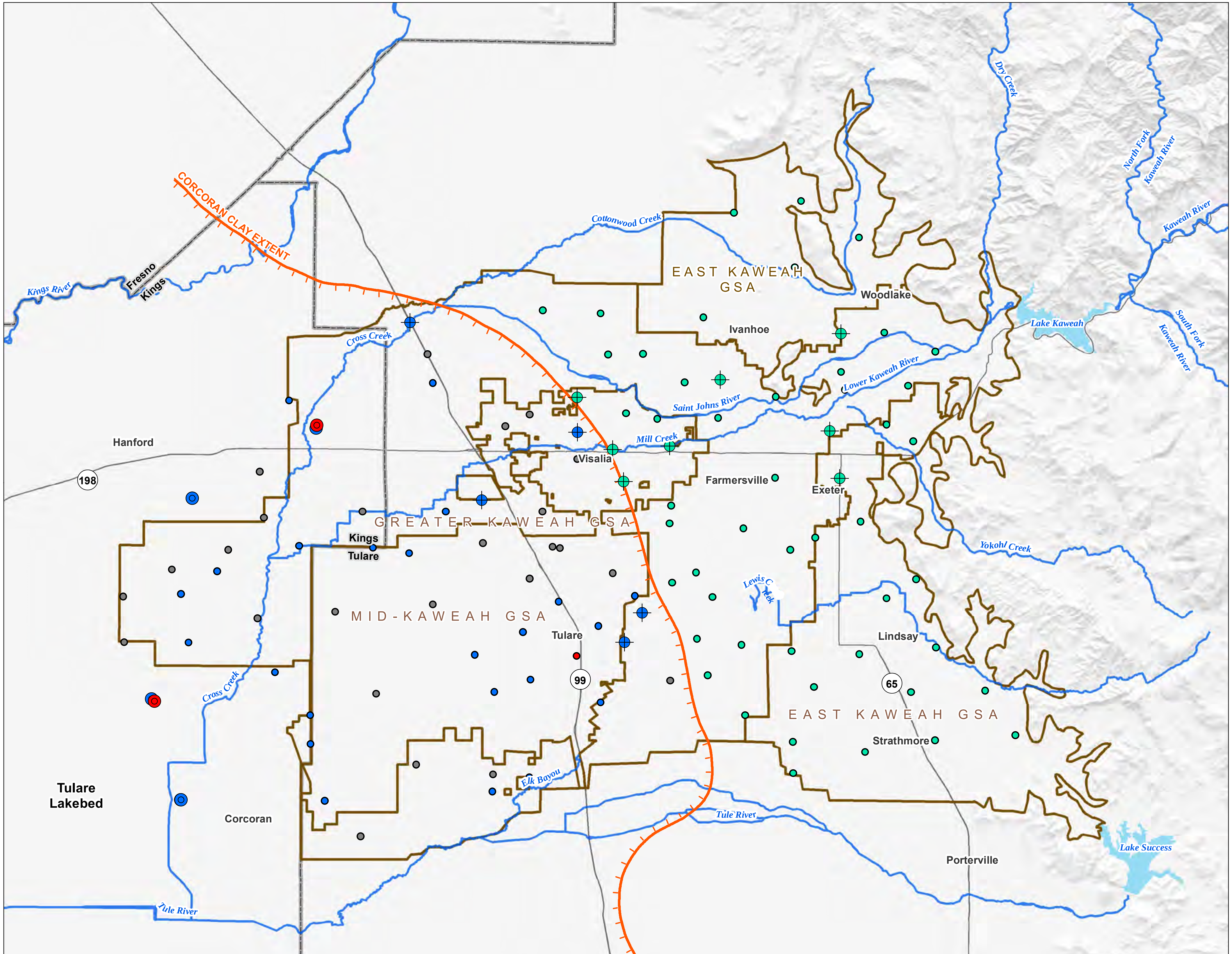


FIGURE X

Key Well Locations

Kaweah Subbasin
Groundwater Sustainability Plan

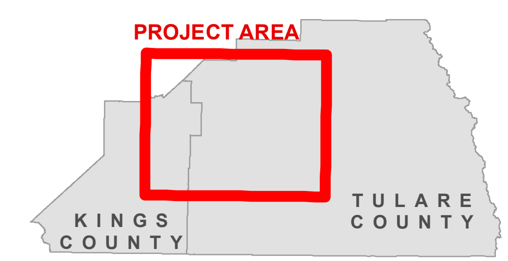
DRAFT

LEGEND

- Lower Aquifer
- Upper Aquifer
- Single Aquifer
- Unknown
- Dedicated Monitoring Well
- Dual Completion Well
- Monitoring Well

All Other Features

- Major Road
- Natural Channel
- Extent of Corcoran Clay (DWR, 1981)
- Kaweah Sub-Basin GSAs
- Counties
- Lake



Date: September 18, 2018
Data Sources: CNRA, DWR, KDWCD, TID, Cal Water

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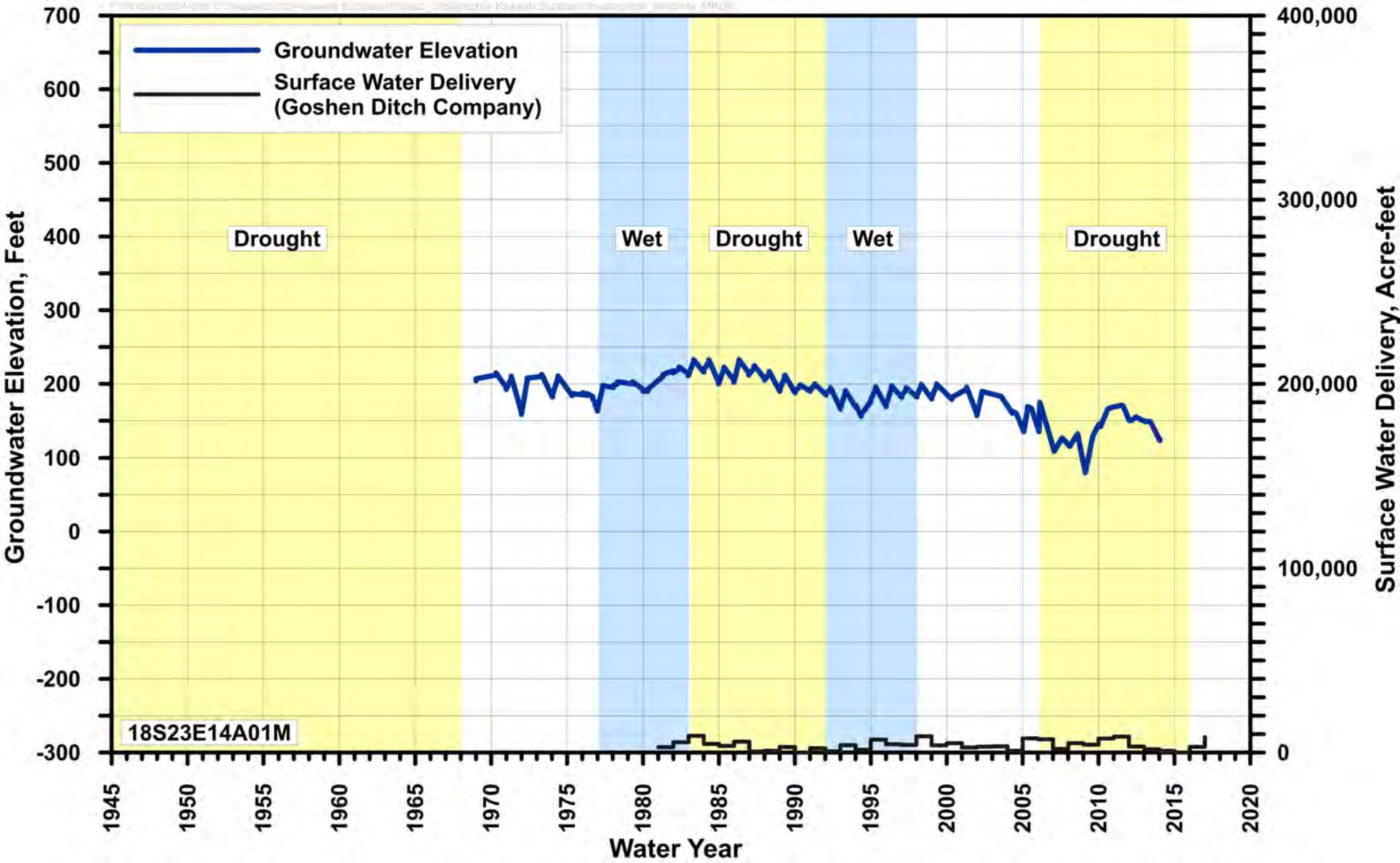
Table _ - Kaweah Sub-basin Key Well Information

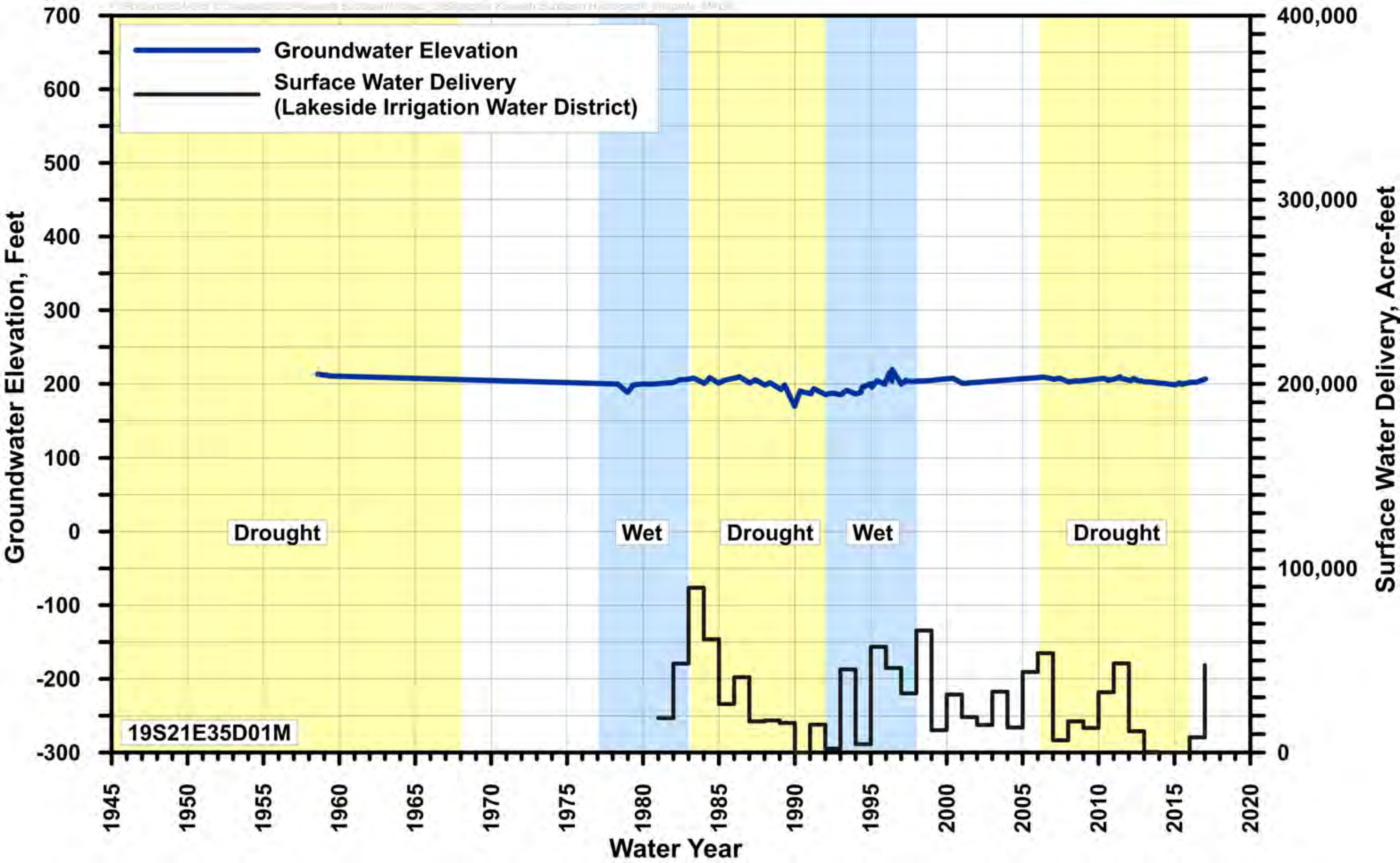
KSB ID	State Well #	CASGEM SITE_CODE	Common Name Well	Water Level Measurement Organization	Water Supply Service Area	GSA	Count of Water Level Measurements	Earliest Measurement Date on Record	Latest Measurement Date on Record	Known Construction? (Y/N)	Dedicated Monitoring Well (Y/N)	Dual Completion Well (Y/N)	Total Depth (Feet)	Top of Screen (Feet)	Bottom of Screen (Feet)	Within the Corcoran Clay? (Y/N)	Reported Ground Surface Elevation (Feet)	Aquifer Screened	LATITUDE	LONGITUDE
KSB-0388	19S21E35D001M	362383N1196704W001		Department of Water Resources	Lakeside Irrigation W.D.	Greater Kaweah GSA	80	Apr-59	Oct-17	N	N	N				y	227	UNK	36.2383	-119.67
KSB-0399	20S21E11D001M	362106N1196685W001		Bureau of Reclamation			52	Sep-76	Oct-17	N	N	N				y	217	UNK	36.2106	-119.669
KSB-0446	20S21E24F901M			Kaweah Delta Water Conservation District	Melga W.D.		23	Feb-06	Oct-17	Y	Y	Y	186	170	186	y	213	UAS	36.176661	-119.648219
KSB-0459	20S21E24F001M	361753N1196460W001		Kaweah Delta Water Conservation District	Melga W.D.		42	Feb-06	Mar-18	Y	Y	Y	700	650	690	y	213	LAS	36.1753	-119.646
KSB-0519	19S22E30D001M	362547N1196341W001		Kaweah Delta Water Conservation District	Lakeside Irrigation W.D.	Greater Kaweah GSA	119	Feb-63	Oct-17	N	N	N				y	230	UNK	36.2547	-119.634
KSB-0531	19S22E31B002M	362400N1196274W001		Bureau of Reclamation	Lakeside Irrigation W.D.	Greater Kaweah GSA	200	Feb-63	Oct-13	Y	N	N		247	271	y	226	UAS	36.24	-119.627
KSB-0532	21S22E07J001M	361158N1196258W001		Kaweah Delta Water Conservation District	Corcoran I.D.		40	Feb-07	Oct-17	Y	Y	Y	775	735	775	y	204	LAS	36.1158	-119.626
KSB-0533	21S22E07J901M			Kaweah Delta Water Conservation District	Corcoran I.D.		20	Oct-07	Oct-17	Y	Y	Y	314	274	314	y	204	UAS	36.115798	-119.625828
KSB-0550	20S22E07A003M	362106N1196216W001		Kings River Conservation District	Lakeside Irrigation W.D.	Greater Kaweah GSA	120	Feb-63	Mar-18	Y	N	N	421	181	421	y	220	UAS	36.2106	-119.622
KSB-0560	19S22E08D002M	362981N1196189W001		Kaweah Delta Water Conservation District	Lakeside Irrigation W.D.		40	Feb-07	Mar-18	Y	Y	Y	700	625	665	y	243	LAS	36.2981	-119.619
KSB-0561	19S22E08D902M			Kaweah Delta Water Conservation District	Lakeside Irrigation W.D.		21	Oct-07	Oct-17	Y	Y	Y	355	315	355	y	244	UAS	36.298133	-119.618932
KSB-0616	19S22E28D001M	362539N1196004W001		Bureau of Reclamation	Lakeside Irrigation W.D.	Greater Kaweah GSA	198	Feb-63	Mar-18	Y	N	N	362	190	360	y	232	UAS	36.2539	-119.6
KSB-0636	19S22E21C001M	362669N1195924W001		Kings County Water District	Lakeside Irrigation W.D.	Greater Kaweah GSA	117	Feb-63	Oct-17	N	N	N				y	237	UNK	36.2669	-119.592
KSB-0718	20S22E03B001M	362256N1195702W001		Department of Water Resources	Lakeside Irrigation W.D.	Greater Kaweah GSA	104	Feb-66	Oct-17	N	N	N				y	232	UNK	36.2256	-119.57
KSB-0721	18S22E34R001M	363142N1195685W001		Bureau of Reclamation	Lakeside Irrigation W.D.		81	Jan-72	Mar-18	N	N	N				y	245	UNK	36.3142	-119.569
KSB-0742	19S22E10R002M	362864N1195654W002		Bureau of Reclamation	Lakeside Irrigation W.D.		85	Oct-61	Oct-17	N	N	N				y	244	UNK	36.2864	-119.565
KSB-0791	20S22E14C001M	361928N1195563W001		Kaweah Delta Water Conservation District	Corcoran I.D.		23	Oct-88	Oct-13	Y	N	N		323	1600	y	225	UAS	36.1928	-119.556
KSB-0818	18S22E24D001M	363572N1195468W001		Department of Water Resources	Kings County W.D.		138	Oct-49	Oct-17	Y	N	N		240	340	y	258	UAS	36.3572	-119.547
KSB-0856	19S22E24B001M	362694N1195393W001		Kaweah Delta Water Conservation District	Kings County W.D.	Greater Kaweah GSA	77	Sep-69	Mar-18	N	N	N	160			y	244	UAS	36.2694	-119.539
KSB-0889	20S22E24R001M	361672N1195299W001		Bureau of Reclamation	Corcoran I.D.	Greater Kaweah GSA	37	Sep-87	Mar-18	Y	N	N	332	196	204	y	227	UAS	36.1672	-119.53
KSB-0890	20S22E36A001M	361497N1195296W001		Bureau of Reclamation	Unincorporated	Greater Kaweah GSA	143	Oct-75	Oct-17	Y	N	N	210	155	206	y	222	UAS	36.1497	-119.53
KSB-0903	18S23E30D901M			Kaweah Delta Water Conservation District	Kings County W.D.	Greater Kaweah GSA	22	Feb-06	Oct-17	Y	Y	Y	154	114	154	y	255	UAS	36.340824	-119.526639
KSB-0905	18S23E30D001M	363426N1195264W001		Kaweah Delta Water Conservation District	Kings County W.D.	Greater Kaweah GSA	39	Feb-06	Mar-18	Y	Y	Y	440	400	440	y	255	LAS	36.3426	-119.526
KSB-0922	21S23E07J001M	361156N1195191W001		Bureau of Reclamation	Tulare I.D.	Mid-Kaweah GSA	171	Aug-58	Oct-17	Y	N	N	428	322	420	y	221	UAS	36.1156	-119.519
KSB-0946	19S23E31R001M	362297N1195121W001		Department of Water Resources	Tulare I.D.	Mid-Kaweah GSA	148	Oct-45	Mar-17	N	N	N				y	245	UNK	36.2297	-119.512
KSB-1031	21S23E21C003M	360942N1194921W001		Department of Water Resources	Unincorporated	Greater Kaweah GSA	82	Feb-63	Oct-17	N	N	N				y	219	UNK	36.0942	-119.492
KSB-1032	19S23E08J001M	362903N1194927W001		Department of Water Resources	Kings County W.D.	Greater Kaweah GSA	146	Oct-49	Mar-17	N	N	N				y	256	UNK	36.2903	-119.493
KSB-1055	19S23E21C001M	362686N1194846W001		Kaweah Delta Water Conservation District	Tulare I.D.	Mid-Kaweah GSA	83	Feb-64	Oct-13	Y	N	N		168	195	y	255	UAS	36.2686	-119.485
KSB-1071	20S23E21B001M	361803N1194813W001		Department of Water Resources	Tulare I.D.	Mid-Kaweah GSA	100	Oct-60	Oct-17	N	N	N				y	241	UNK	36.1803	-119.481
KSB-1161	17S23E34J001M	364049N1194573W001		Kaweah Delta Water Conservation District	Unincorporated	Greater Kaweah GSA	38	Apr-07	Mar-18	Y	Y	N	126	96	126	y	275	UAS	36.4049	-119.457
KSB-1168	19S23E22H001M	362653N1194571W001		Bureau of Reclamation	Tulare I.D.	Mid-Kaweah GSA	129	Oct-52	Mar-16	Y	N	N	331	178	190	y	265	UAS	36.2653	-119.457
KSB-1183	21S23E02A001M	361378N1194513W001		Kaweah Delta Water Conservation District	Elk Bayou D.C.	Greater Kaweah GSA	100	Sep-63	Oct-17	N	N	N				y	238	UNK	36.1378	-119.451
KSB-1214	18S23E02Q001M	363856N1194443W001		Kings County Water District	Unincorporated	Greater Kaweah GSA	144	Feb-52	Mar-18	N	N	N				y	278	UNK	36.3856	-119.444
KSB-1222	18S23E14A001M	363683N1194399W001		Bureau of Reclamation	Goshen D.C.	Greater Kaweah GSA	160	Oct-69	Oct-14	Y	N	N		115	330	y	280	UAS	36.3683	-119.44
KSB-1226	19S23E35H001M	362344N1194396W001		Tulare Irrigation District	Tulare I.D.	Mid-Kaweah GSA	142	Oct-53	Jan-18	N	N	N				y	264	UNK	36.2344	-119.44
KSB-1259	19S23E12L001M	362906N1194304W001		Department of Water Resources	Persian D.C.	Greater Kaweah GSA	144	Sep-69	Oct-13	Y	N	N		192	600	y	275	UAS	36.2906	-119.43
KSB-1359	20S24E07G001M	362042N1194082W001		Tulare Irrigation District	Tulare I.D.	Mid-Kaweah GSA	75	Feb-55	Mar-15	Y	N	N	456	216	456	y	264	UAS	36.2042	-119.408
KSB-1384	19S24E08D002M	362979N1194028W001		Kaweah Delta Water Conservation District	Persian D.C.	Greater Kaweah GSA	29	Apr-07	Mar-18	Y	Y	N	121	91	121	y	287	UAS	36.2979	-119.403
KSB-1389	19S24E17N001M			Tulare Irrigation District	Tulare I.D.	Mid-Kaweah GSA	115	Feb-54	Oct-14	N	N	N				y	287	UNK	36.27166667	-119.4016667
KSB-1425	21S24E08A001M	361219N1193946W001		Kaweah Delta Water Conservation District	Elk Bayou D.C.	Greater Kaweah GSA	109	Oct-51	Mar-18	Y	N	N	520	144	356	y	247	UAS	36.1219	-119.395
KSB-1428	21S24E05H002M	361319N1193938W001		Kaweah Delta Water Conservation District	Elk Bayou D.C.	Greater Kaweah GSA	108	Jan-70	Mar-18	N	N	N				y	250	UNK	36.1319	-119.394
KSB-1431	20S24E17P001M	361819N1193935W001		Department of Water Resources	Tulare I.D.	Mid-Kaweah GSA	128	Feb-56	Oct-17	Y	N	N	229	170	210	y	257	UAS	36.1819	-119.394
KSB-1447			075-01		Unincorporated	Mid-Kaweah GSA	120	Sep-93	Dec-10	N	N	N				y		UNK	36.34244882	-119.3853457
KSB-1506	20S24E04K01M		Well 26		Unincorporated	Mid-Kaweah GSA	114	Mar-92	Feb-18	Y	N	N	720	300	720	y	280	UAS	36.21798677	-119.371617
KSB-1526	18S24E22E001M			Kaweah Delta Water Conservation District	St. Johns W.D.	Mid-Kaweah GSA	9	Mar-12	Oct-17	N	N	N				y	307	UNK	36.34930676	-119.3671998
KSB-1532	19S24E28H001M	362503N1193677W001		Department of Water Resources	Tulare I.D.	Mid-Kaweah GSA	127	Oct-54	Oct-17	N	N	N				y	292	UNK	36.2503	-119.368
KSB-1535	21S24E03L001M	361303N1193665W001		Bureau of Reclamation	Elk Bayou D.C.	Greater Kaweah GSA	126	Feb-53	Oct-17	Y	N	N	325	200	317	y	257	UAS	36.1303	-119.367
KSB-1538	20S24E16H001M	361892N1193667W001		Department of Water Resources	Tulare I.D.	Mid-Kaweah GSA	182	Oct-53	Jan-18	Y	N	N		157	357	y	265	UAS	36.1892	-119.367
KSB-1580	17S24E34B001M	364125N1193588W001		Kaweah Delta Water Conservation District	Unincorporated	Greater Kaweah GSA	208	Sep-30	Mar-14	N	N	N				n	298	SAS	36.4125	-119.359
KSB-1585	19S24E10G001M	362911N1193579W001		Department of Water Resources	Tulare Irrigation Company	Greater Kaweah GSA	115	Oct-56	Oct-17	N	N	N				y	304	UNK	36.2911	-119.358
KSB-1613	19S24E15R001M			Kaweah Delta Water Conservation District	Tulare I.D.	Mid-Kaweah GSA	7	Mar-14	Mar-17	N	N	N				y	306	UNK	36.26949556	-119.3497664
KSB-1628	19S24E35E01M		Well 27		Tulare I.D.	Mid-Kaweah GSA	104	Jul-93	Feb-18	Y	N	N	720	320	720	y	293	UAS	36.23653948	-119.345132
KSB-1634	19S24E23D001M	362689N1193445W001		Department of Water Resources	Tulare I.D.	Mid-Kaweah GSA	139	Oct-36	Jan-18	N	N	N				y	307	UNK	36.2689	-119.345
KSB-1689	18S24E13N001M	363601N1193320W001		Kaweah Delta Water Conservation District	Modoc D.C.	Mid-Kaweah GSA	34	May-08	Mar-18	Y	Y	N	110	70	110	n	321	SAS	36.3601	-119.332
KSB-1690	18S24E25D001M	363391N1193316W001		Kaweah Delta Water Conservation District	Modoc D.C.	Mid-Kaweah GSA	32	May-08	Mar-18	Y	Y	N	123	83	123	n	317	UAS	36.3391	-119.332
KSB-1695	20S24E11J02M		Well 11		Unincorporated	Mid-Kaweah GSA	121	Mar-92	Feb-18	Y	N	N	774	348	756	y	288	LAS	36.20362572	-119.3315452
KSB-1696			025-01		Unincorporated	Mid-Kaweah GSA	393	Jan-71	Apr-18	N	N	N				y		UNK	36.32262819	-119.3314731
KSB-1770	20S24E01H02M		Well 15		Unincorporated	Mid-Kaweah GSA	115	Mar-92	Feb-18	Y	N	N	715	300	700	y	112	UAS	36.22191281	-119.3154621
KSB-1775	17S24E36H003M	364106N1193145W001		Kaweah Delta Water Conservation District	Uphill D.C.	Greater Kaweah GSA	128	Oct-61	Oct-17	N	N	N				n	314	SAS	36.4106	-119.315
KSB-1783	20S24E24H001M	361756N1193140W001		Bureau of Reclamation	Farmers D.C.	Greater Kaweah GSA	160	Feb-69	Oct-16	Y	N	N	355	178	182	y	281	UAS	36.1756	-119.314
KSB-1809	18S25E06P001M			Kaweah Delta Water Conservation District	Unincorporated	Greater Kaweah GSA	4	Mar-16	Oct-17	N	N	N				n	323	SAS	36.386016	-119.308785
KSB-1819	18S25E30Q001M	363286N1193054W001		Kaweah Delta Water Conservation District	Unincorporated	Mid-Kaweah GSA	23	May-08	Mar-17	Y	Y	N	123	83	123	n	326	SAS	36.3286	-119.305
KSB-1830	19S25E30C001M	362539N1193051W001		Department of Water Resources	Tulare I.D.	Mid-Kaweah GSA	167	Oct-54	Oct-17	N	N	N				y	313	UNK	36.2539	-119.305
KSB-1862	19S25E06A001M	363094N1192974W001		Kaweah Delta Water Conservation District	Evans D.C.	Mid-Kaweah GSA	21	May-08	Mar-14	Y	Y	N	124	84	124	n	327	SAS	36.3094	-119.297
KSB-1873	20S25E06R002M	362122N1192962W001		Kaweah Delta Water Conservation District	Farmers D.C.	Greater Kaweah GSA	18	Apr-07	Oct-13	Y	Y	N	125	95	125	y	299	UAS	36.2122	-119.296
KSB-1884			036-01		Unincorporated	Mid-Kaweah GSA	368	Jul-71	Apr-18	N	N	N				n		SAS	36.35027811	-119.2954358
KSB-1903	19S24E36C002M		Well 36		Farmers D.C.	Mid-Kaweah GSA	27	Oct-04	Feb-18	Y	N	N	620	320	620	y	302	UAS	36.24008	-119.2882

Table _ - Kaweah Sub-basin Key Well Information

KSB ID	State Well #	CASGEM SITE_CODE	Common Name Well	Water Level Measurement Organization	Water Supply Service Area	GSA	Count of Water Level Measurements	Earliest Measurement Date on Record	Latest Measurement Date on Record	Known Construction? (Y/N)	Dedicated Monitoring Well (Y/N)	Dual Completion Well (Y/N)	Total Depth (Feet)	Top of Screen (Feet)	Bottom of Screen (Feet)	Within the Corcoran Clay? (Y/N)	Reported Ground Surface Elevation (Feet)	Aquifer Screened	LATITUDE	LONGITUDE
KSB-1936	18S25E05Q001M	363864N1192834W001		Kaweah Delta Water Conservation District	Mathews D.C.	Greater Kaweah GSA	140	Feb-64	Mar-18	N	N	N	278			n	333	SAS	36.3864	-119.283
KSB-1937	19S25E32J001M	362301N1192828W001		Kaweah Delta Water Conservation District	Farmers D.C.	Greater Kaweah GSA	20	Apr-07	Oct-13	Y	Y	N	115	85	115	y	312	UAS	36.2301	-119.283
KSB-1977			053-01		Unincorporated	Mid-Kaweah GSA	276	Mar-80	Apr-18	N	N	N				n		SAS	36.34705864	-119.2719874
KSB-2014	18S25E28R001M	363309N1192627W001		Kaweah Delta Water Conservation District	Unincorporated	Mid-Kaweah GSA	21	Oct-11	Oct-17	Y	Y	N	100	60	100	n	342	SAS	36.3309	-119.263
KSB-2015	19S25E16A002M	362839N1192634W001		Kaweah Delta Water Conservation District	Unincorporated	Greater Kaweah GSA	140	Oct-50	Mar-18	N	N	N				n	335	SAS	36.2839	-119.263
KSB-2016	20S25E16J002M	361889N1192620W001		Kaweah Delta Water Conservation District	Farmers D.C.	Greater Kaweah GSA	138	Feb-67	Oct-17	N	N	N				y	299	UNK	36.1889	-119.262
KSB-2017	19S25E09H001M	362947N1192617W001		Kaweah Delta Water Conservation District	Unincorporated	Greater Kaweah GSA	133	Oct-61	Oct-17	N	N	N				n	338	SAS	36.2947	-119.262
KSB-2021	19S25E28H001M	362481N1192609W001		Kaweah Delta Water Conservation District	Farmers D.C.	Greater Kaweah GSA	135	Feb-68	Oct-17	N	N	N				n	322	SAS	36.2481	-119.261
KSB-2058	18S25E15C001M	363692N1192520W001		Kaweah Delta Water Conservation District	Unincorporated	Greater Kaweah GSA	175	Oct-41	Oct-17	N	N	N	90			n	348	SAS	36.3692	-119.252
KSB-2089	19S25E27A001M	362544N1192431W001		Kaweah Delta Water Conservation District	Farmers D.C.	Greater Kaweah GSA	137	Feb-68	Oct-17	N	N	N				n	332	SAS	36.2544	-119.243
KSB-2095	20S25E03R001M			Kaweah Delta Water Conservation District	Unincorporated	Greater Kaweah GSA	97	Feb-63	Oct-17	N	N	N				n	308	SAS	36.214539	-119.24285
KSB-2107	17S25E35E001M	364086N1192381W001		Ivanhoe Irrigation District	Ivanhoe I.D.	East Kaweah GSA	169	Mar-53	Mar-14	N	N	N				n	354	SAS	36.4086	-119.238
KSB-2114	20S25E14F004M	361922N1192337W003		Kaweah Delta Water Conservation District	Consolidated Peoples D.C.	Greater Kaweah GSA	118	Feb-68	Oct-17	N	N	N				n	306	SAS	36.1922	-119.234
KSB-2139	19S25E35B002M	362394N1192309W001		Kaweah Delta Water Conservation District	Unincorporated	Greater Kaweah GSA	133	Sep-63	Oct-16	N	N	N				n	327	SAS	36.2394	-119.231
KSB-2147	18S25E23J001M	363478N1192267W001		Kaweah Delta Water Conservation District	Fleming D.C.	Greater Kaweah GSA	136	Sep-63	Mar-15	N	N	N				n	360	SAS	36.3478	-119.227
KSB-2149	18S25E12N001M	363711N1192250W001		Kaweah Delta Water Conservation District	Wutchumna W.C.	Greater Kaweah GSA	21	Apr-07	Mar-13	Y	Y	N	82	52	82	n	397	SAS	36.3711	-119.225
KSB-2175	17S25E01P001M	364718N1192151W001		Bureau of Reclamation	Unincorporated	East Kaweah GSA	355	Dec-31	Oct-10	N	N	N				n	356	SAS	36.4718	-119.215
KSB-2197	20S25E12A001M	362108N1192092W001		Kaweah Delta Water Conservation District	Consolidated Peoples D.C.	Greater Kaweah GSA	130	Feb-66	Oct-16	N	N	N				n	316	SAS	36.2108	-119.209
KSB-2200	19S25E13A002M	362811N1192076W001		Kaweah Delta Water Conservation District	Consolidated Peoples D.C.	Greater Kaweah GSA	156	Oct-61	Mar-18	N	N	N				n	350	SAS	36.2811	-119.208
KSB-2203	20S25E24R001M	361681N1192067W001		Kaweah Delta Water Conservation District	Unincorporated	Greater Kaweah GSA	151	Oct-45	Oct-17	N	N	N	170			n	315	SAS	36.1681	-119.207
KSB-2291	19S26E05C001M	363117N1191842W001		Kaweah Delta Water Conservation District	Unincorporated	Greater Kaweah GSA	143	Sep-63	Oct-17	N	N	N				n	367	SAS	36.3117	-119.184
KSB-2297	18S26E17L001M	363606N1191837W001		Kaweah Delta Water Conservation District	Unincorporated	Greater Kaweah GSA	166	Oct-50	Mar-18	N	N	N				n	385	SAS	36.3606	-119.184
KSB-2322	19S26E20A001M	362683N1191728W001		Bureau of Reclamation	Unincorporated	Greater Kaweah GSA	195	Nov-48	Oct-17	N	N	N				n	353	SAS	36.2683	-119.173
KSB-2333	20S26E08H001M	362069N1191723W001		Lindmore Irrigation District	Lindmore ID	East Kaweah GSA	102	Feb-54	Mar-16	N	N	N				n	329	SAS	36.2069	-119.172
KSB-2344	20S26E32A001M	361522N1191706W001		Bureau of Reclamation	Lindmore ID	East Kaweah GSA	270	Oct-45	Mar-16	N	N	N	340			n	335	SAS	36.1522	-119.171
KSB-2345	21S26E04F001M	361333N1191703W001		Bureau of Reclamation	Lower Tule ID	East Kaweah GSA	132	Oct-61	Mar-16	N	N	N				n	343	SAS	36.1333	-119.17
KSB-2354	17S26E21E001M	364388N1191703W001		Bureau of Reclamation	Ivanhoe I.D.	East Kaweah GSA	179	Jan-61	Mar-14	N	N	N				n	397	SAS	36.4388	-119.17
KSB-2369	17S26E04F002M	364788N1191653W001		Stone Corral Irrigation District	Stone Corral I.D.	East Kaweah GSA	98	Feb-62	Mar-16	N	N	N				n	406	SAS	36.4788	-119.165
KSB-2405	20S26E16R001M	361853N1191551W001		Bureau of Reclamation	Lindmore ID	East Kaweah GSA	182	Sep-61	Mar-16	Y	N	N	492	210	485	n	338	SAS	36.1853	-119.155
KSB-2411	19S26E16J002M	362756N1191545W001		Bureau of Reclamation	Unincorporated	East Kaweah GSA	186	Oct-61	Mar-18	N	N	N	131			n	366	SAS	36.2756	-119.154
KSB-2466	18S26E27B001M	363403N1191434W001		Kaweah Delta Water Conservation District	Unincorporated	Greater Kaweah GSA	30	Apr-07	Mar-18	Y	Y	N	29	9	29	n	394	SAS	36.3403	-119.143
KSB-2507	19S26E03A001M	363115N1191358W001		Kaweah Delta Water Conservation District	Exeter I.D.	East Kaweah GSA	28	Apr-07	Mar-18	Y	Y	N	90	60	90	n	402	SAS	36.3115	-119.136
KSB-2513	18S26E02D002M	363990N1191352W001		Kaweah Delta Water Conservation District	Ivanhoe I.D.	East Kaweah GSA	38	Apr-07	Oct-17	Y	Y	N	69	39	69	n	422	SAS	36.399	-119.135
KSB-2519	18S26E10J001M	363755N1191353W001		Department of Water Resources	Unincorporated	Greater Kaweah GSA	233	Oct-51	Mar-13	Y	N	N	140	57	87	n	408	SAS	36.3755	-119.135
KSB-2539	18S26E14E001M	363649N1191318W001		Kaweah Delta Water Conservation District	Lindsay-Strathmore I.D.	Greater Kaweah GSA	9	Mar-16	Mar-18	N	N	N				n	404	SAS	36.3649	-119.132
KSB-2588	17S26E14B001M	364568N1191217W001		Bureau of Reclamation	Unincorporated	East Kaweah GSA	115	Nov-48	Mar-07	N	N	N				n	489	SAS	36.4568	-119.122
KSB-2590	20S26E11H001M	362053N1191217W001		Kaweah Delta Water Conservation District	Lindmore ID	East Kaweah GSA	99	Feb-54	Mar-13	N	N	N				n	359	SAS	36.2053	-119.122
KSB-2593	19S26E11R001M	362853N1191209W001		Exeter Irrigation District	Exeter I.D.	East Kaweah GSA	107	Oct-50	Mar-16	N	N	N				n	394	SAS	36.2853	-119.121
KSB-2618	20S26E35H001M	361461N1191165W001		Lindmore Irrigation District	Lindmore ID	East Kaweah GSA	148	Feb-54	Mar-16	N	N	N				n	364	SAS	36.1461	-119.117
KSB-2690	17S26E36R001M	363993N1191028W001		Kaweah Delta Water Conservation District	Sweeney Ditch Area	Greater Kaweah GSA	121	Feb-68	Mar-18	N	N	N				n	427	SAS	36.3993	-119.103
KSB-2696	18S26E24J003M	363438N1191012W001		Bureau of Reclamation	Exeter I.D.	East Kaweah GSA	141	Oct-61	Mar-18	N	N	N				n	432	SAS	36.3438	-119.101
KSB-2697	19S26E25R001M	362389N1191009W001		Bureau of Reclamation	Lewis Creek WD	East Kaweah GSA	178	Jan-70	Mar-16	Y	N	N	290	96	226	n	358	SAS	36.2389	-119.101
KSB-2765	18S27E18A001M			Kaweah Delta Water Conservation District	Unincorporated	Greater Kaweah GSA	4	Mar-16	Oct-17	N	N	N				n	429	SAS	36.367412	-119.084864
KSB-2769	20S27E18R001M	361822N1190831W001		Lindmore Irrigation District	Lindmore ID	East Kaweah GSA	113	Nov-52	Mar-16	N	N	N				n	412	SAS	36.1822	-119.083
KSB-2773	18S27E30H001M	363338N1190817W001		Exeter Irrigation District	Exeter I.D.	East Kaweah GSA	82	Feb-62	Mar-16	N	N	N	213			n	456	SAS	36.3338	-119.082
KSB-2790	19S27E29D001M	362506N1190795W001		Lindsay-Strathmore Irrigation District	Lindsay-Strathmore ID	East Kaweah GSA	99	Oct-49	Mar-16	N	N	N	200			n	388	SAS	36.2506	-119.08
KSB-2822	18S27E05J001M	363880N1190651W001		Bureau of Reclamation	Unincorporated	Greater Kaweah GSA	237	Oct-61	Mar-18	Y	N	N	98	24	79	n	447	SAS	36.388	-119.065
KSB-2823	20S27E29R001M	361533N1190645W001		Lindmore Irrigation District	Lindmore ID	East Kaweah GSA	125	Oct-61	Oct-11	N	N	N				n	403	SAS	36.1533	-119.065
KSB-2826	20S27E08A001M	362094N1190645W001		Lindsay-Strathmore Irrigation District	Lindsay-Strathmore ID	East Kaweah GSA	130	Oct-36	Mar-16	N	N	N				n	403	SAS	36.2094	-119.065
KSB-2895	20S27E15R001M	361833N1190278W001		Lindsay-Strathmore Irrigation District	Lindsay-Strathmore ID	East Kaweah GSA	108	Feb-52	Mar-16	N	N	N	200			n	468	SAS	36.1833	-119.028
KSB-2927	20S27E25N001M	361564N1190048W001		Lindsay-Strathmore Irrigation District	Lindsay-Strathmore ID	East Kaweah GSA	139	Feb-52	Mar-16	N	N	N				n	478	SAS	36.1564	-119.005



Groundwater Elevation
Surface Water Delivery
(Goshen Ditch Company)
Drought
Wet
Drought
Wet
Drought
18S23E14A01M
700
600
500
400
300
200
100
0
-100
-200
-300
Groundwater Elevation, Feet
400,000
300,000
200,000
100,000
0
Surface Water Delivery, Acre-feet
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Water Year



Groundwater Elevation
Surface Water Delivery
(Lakeside Irrigation Water District)
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
Drought
Wet
Drought
Wet
Drought
19S21E35D01M
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
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1950
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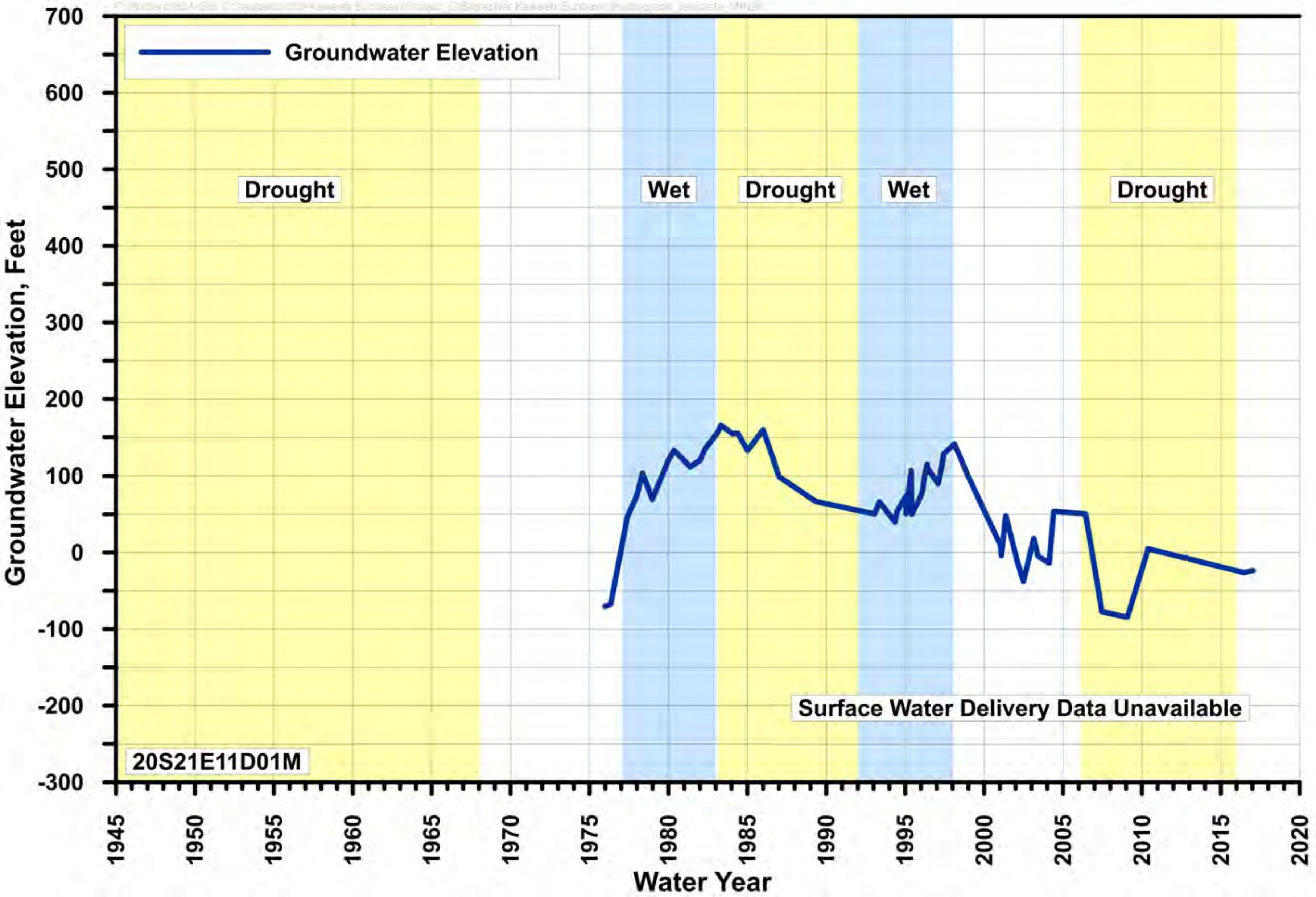
2015
2020



Groundwater Elevation
Drought
Wet
Drought
Wet
Drought
Surface Water Delivery Data Unavailable
20S21E11D01M
Groundwater Elevation, Feet
700
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500
400
300
200
100
0
-100
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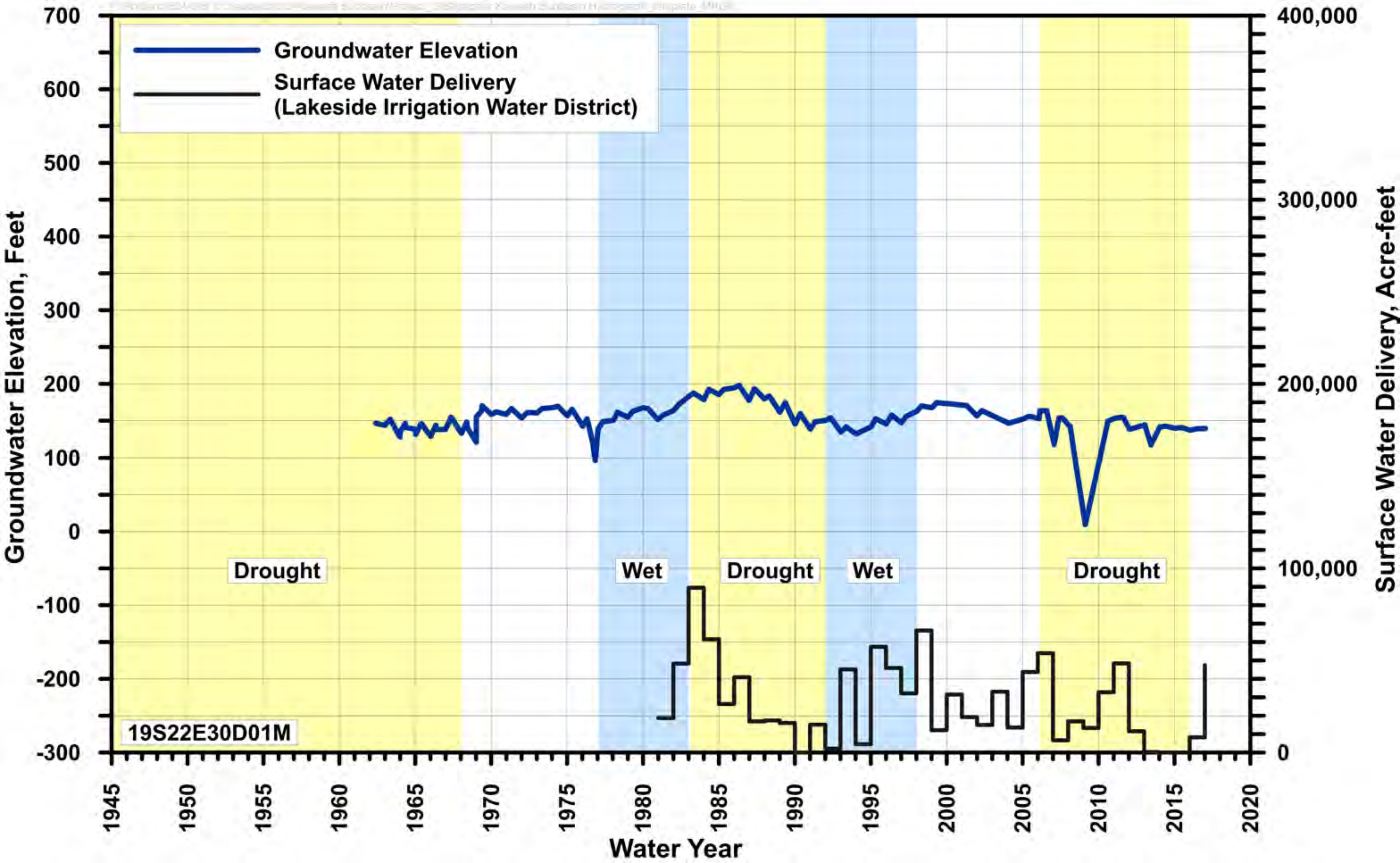
2010
2015
2020
Water Year


Groundwater Elevation
Surface Water Delivery
(Lakeside Irrigation Water District)
Drought
Wet
Drought
Wet
Drought
19S22E30D01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
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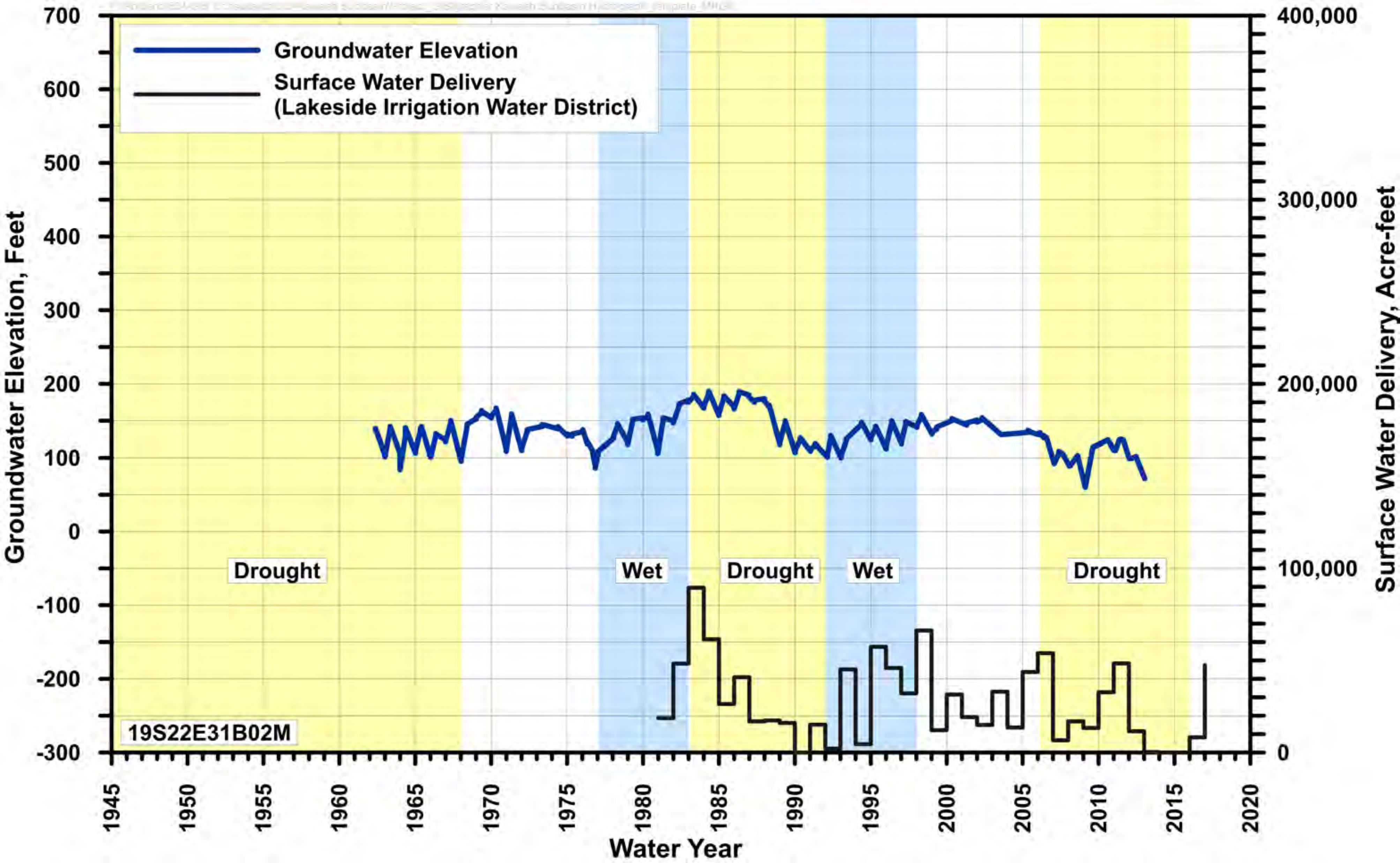
2020



Groundwater Elevation
Surface Water Delivery
(Lakeside Irrigation Water District)
Drought
Wet
Drought
Wet
Drought
19S22E31B02M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
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1950
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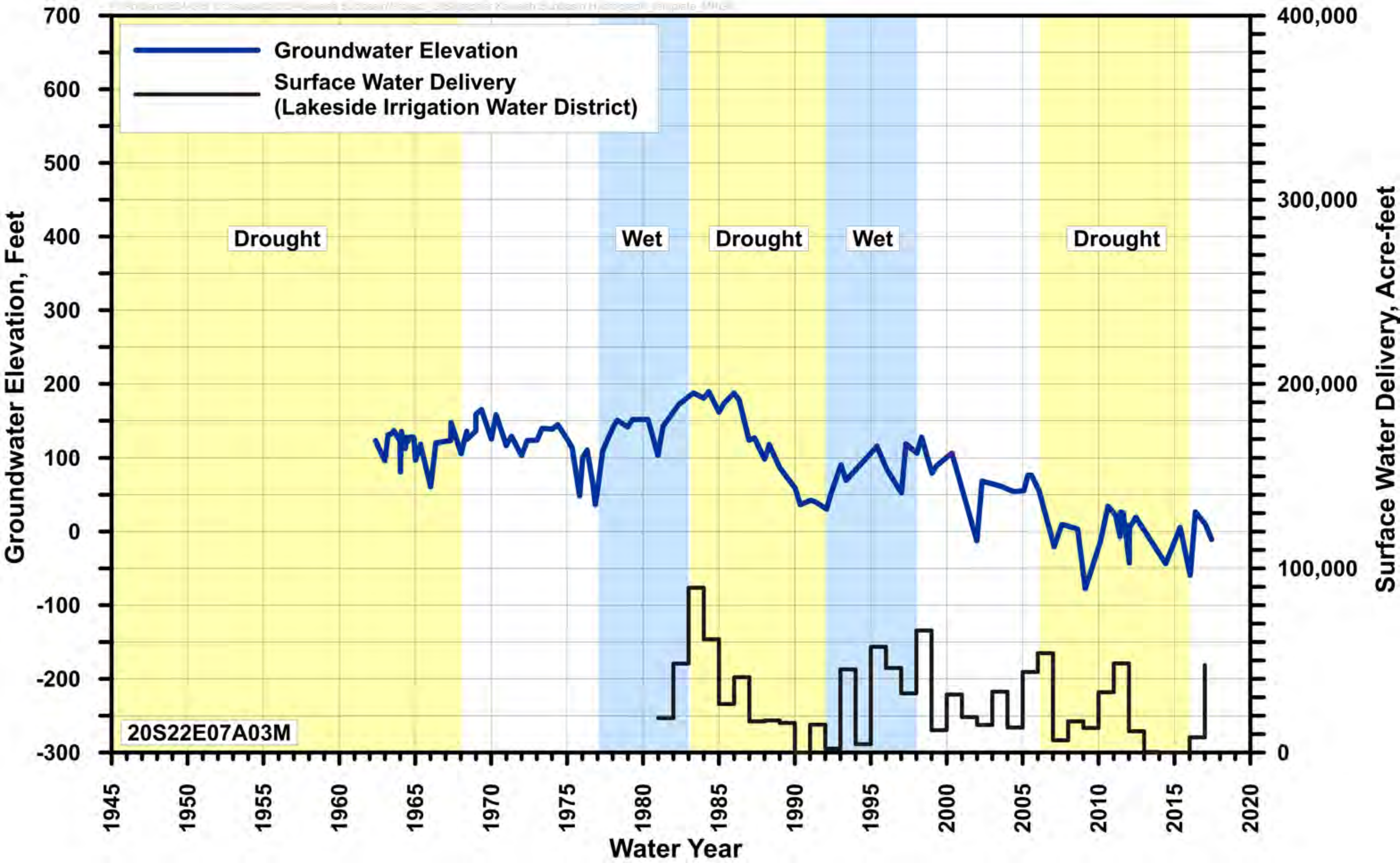

Groundwater Elevation
Surface Water Delivery
(Lakeside Irrigation Water District)
Drought
Wet
Drought
Wet
Drought
20S22E07A03M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
100,000
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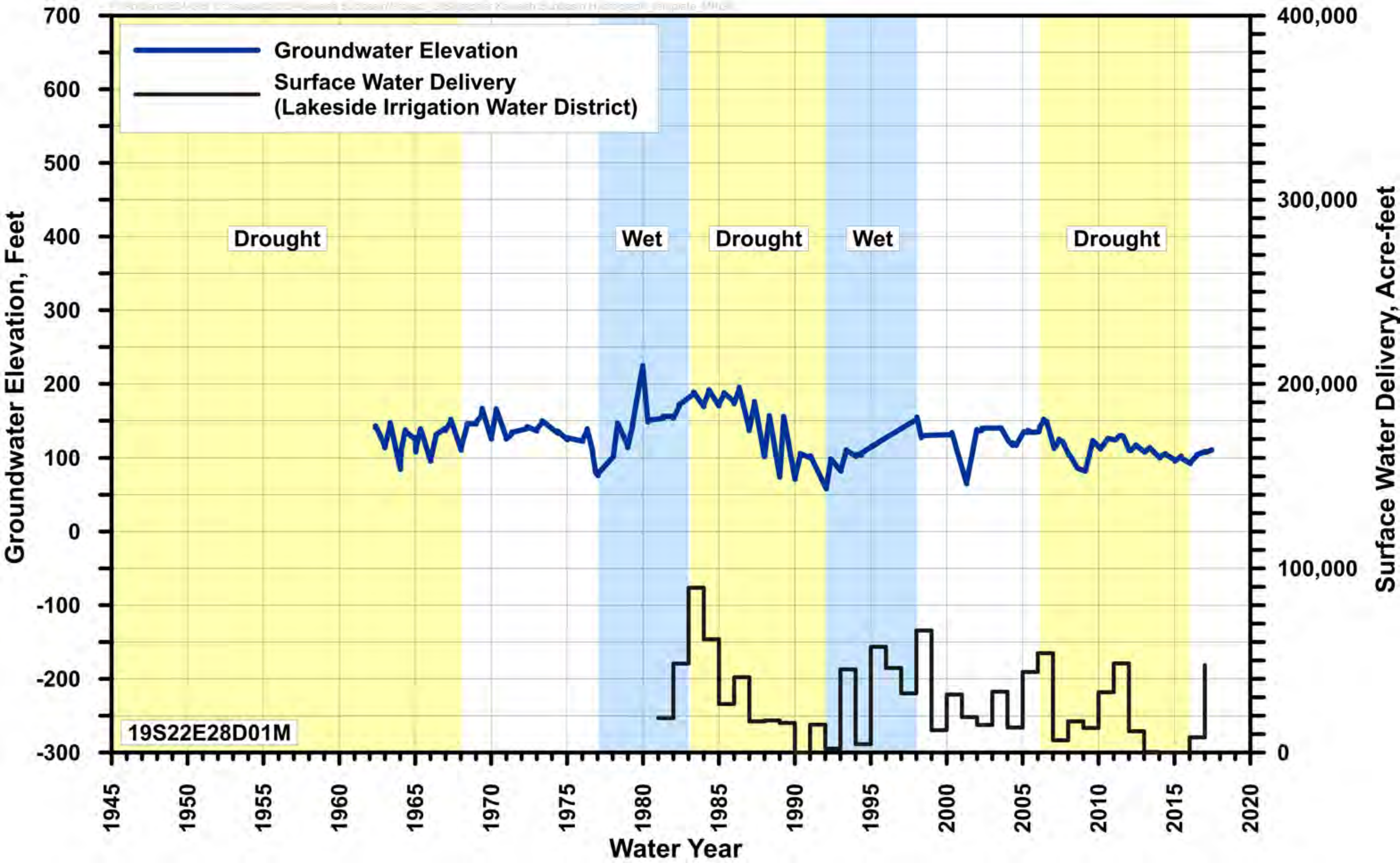
Groundwater Elevation
Surface Water Delivery
(Lakeside Irrigation Water District)
Drought
Wet
Drought
Wet
Drought
19S22E28D01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
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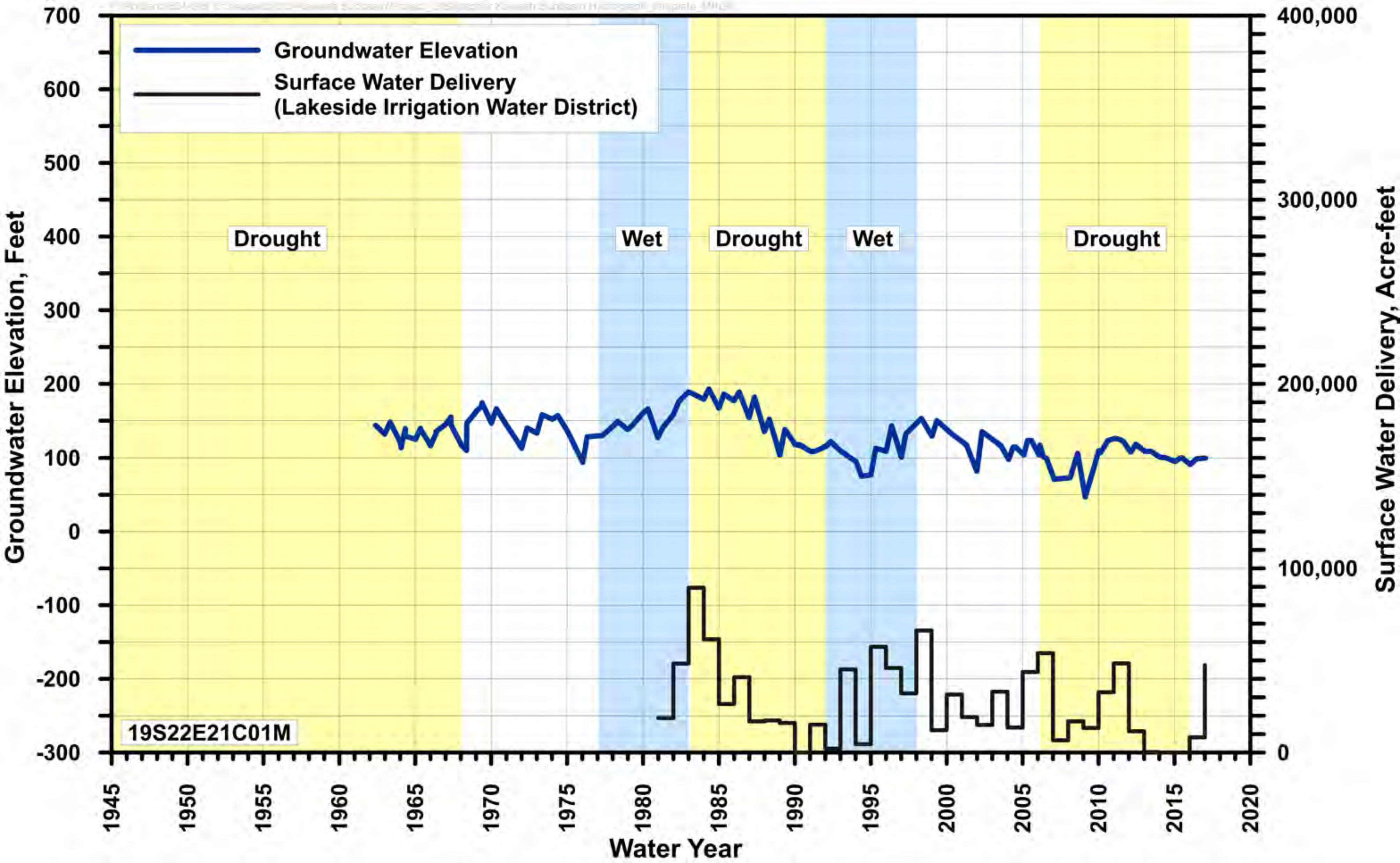
2020



Groundwater Elevation
Surface Water Delivery
(Lakeside Irrigation Water District)
Drought
Wet
Drought
Wet
Drought
19S22E21C01M
Groundwater Elevation, Feet
700
600
500
400
300
200
100
0
-100
-200
-300
Surface Water Delivery, Acre-feet
400,000
300,000
200,000
100,000
0
1945
1950
1955
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1995
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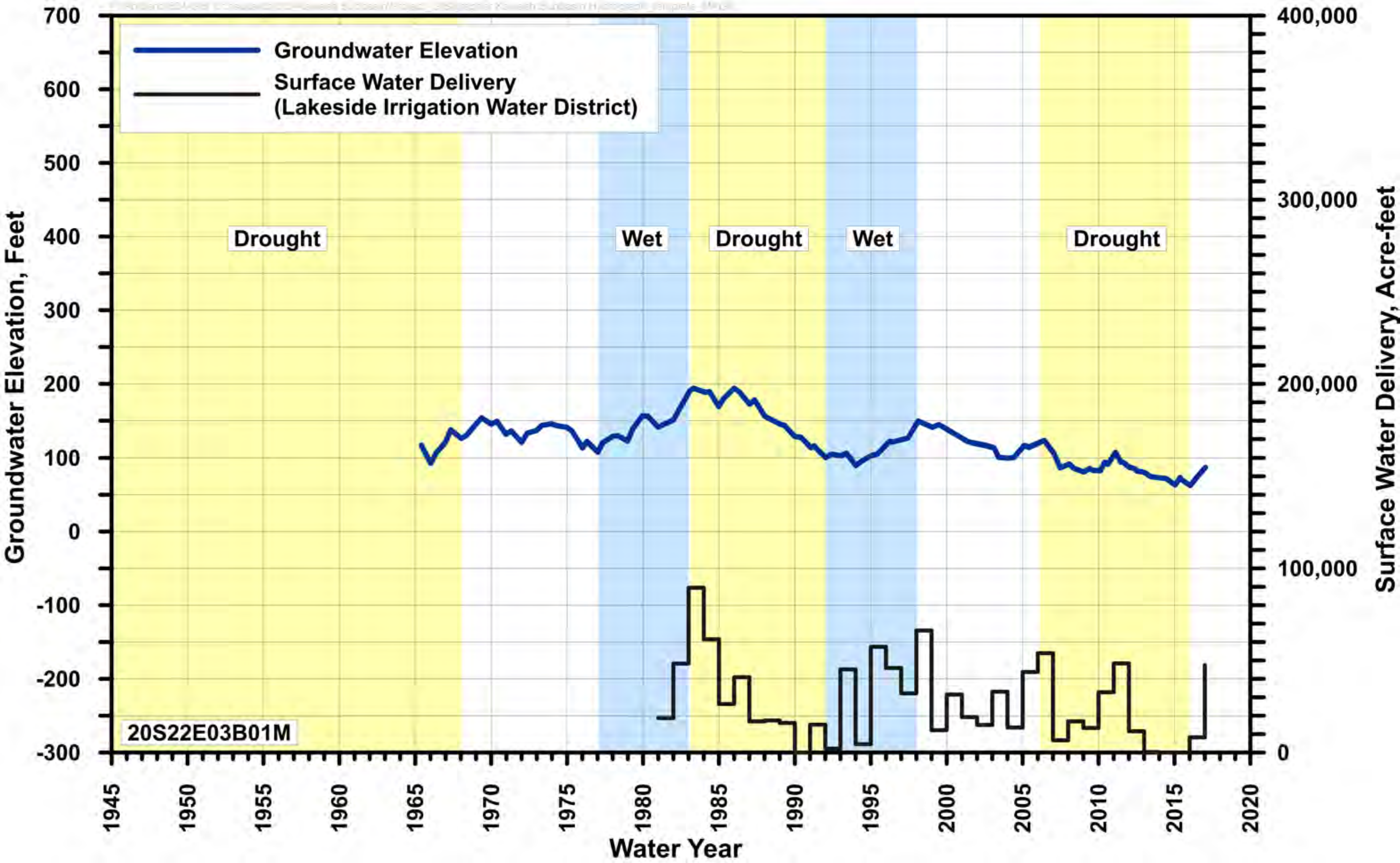
2005
2010
2015
2020
Water Year



Groundwater Elevation
Surface Water Delivery
(Lakeside Irrigation Water District)
Drought
Wet
Drought
Wet
Drought
20S22E03B01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
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1945
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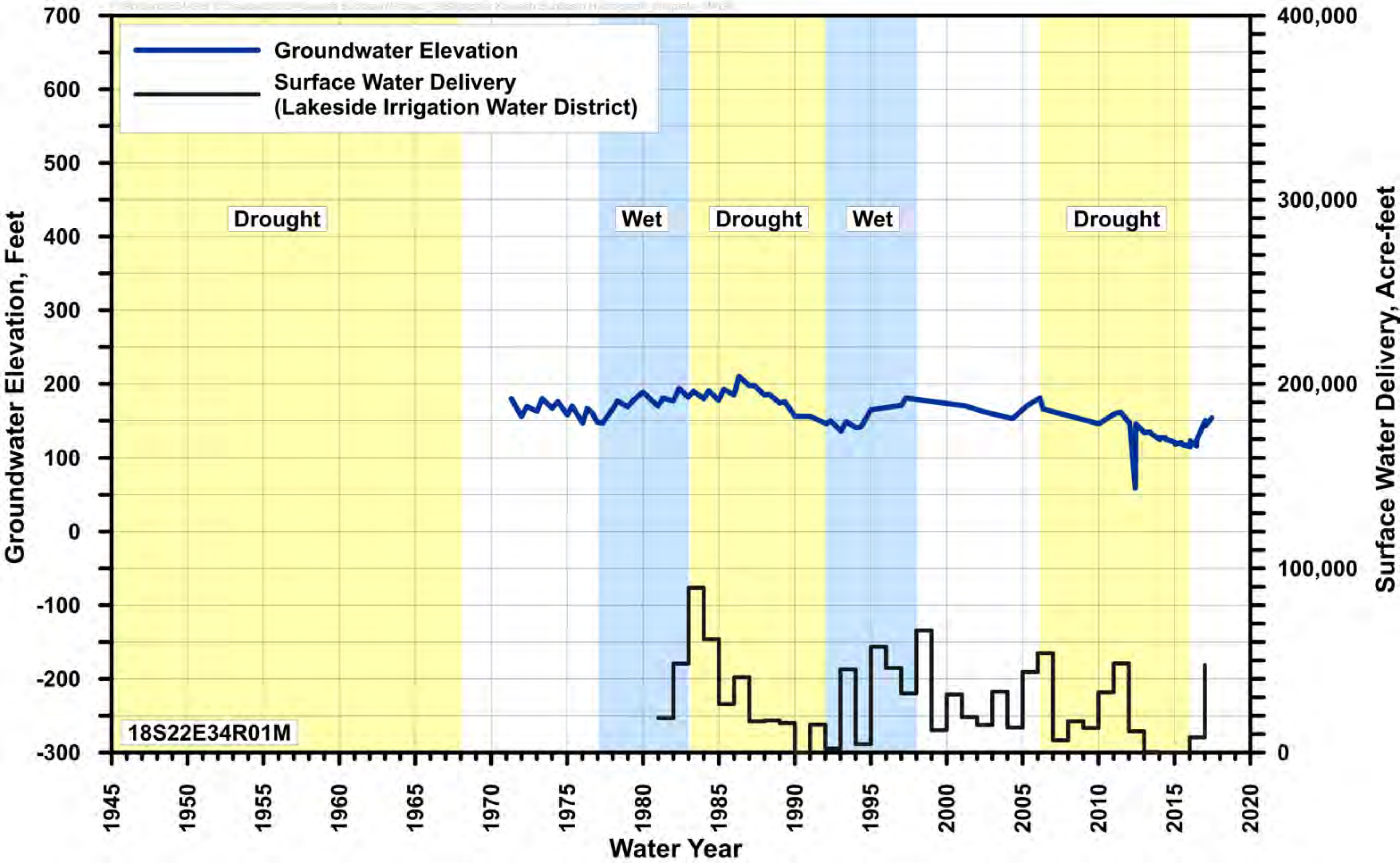

Groundwater Elevation
Surface Water Delivery
(Lakeside Irrigation Water District)
Drought
Wet
Drought
Wet
Drought
18S22E34R01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
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1945
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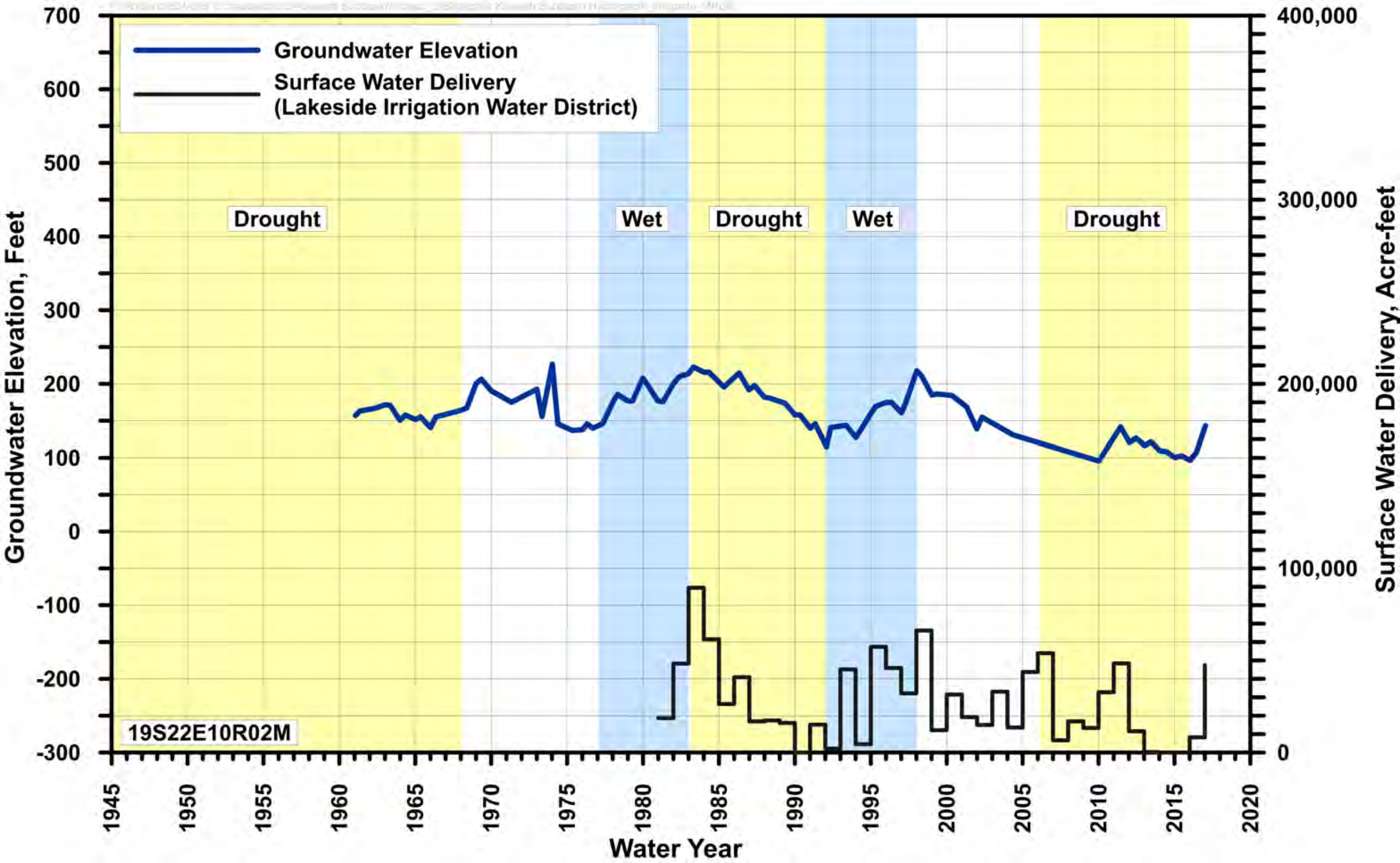

Groundwater Elevation
Surface Water Delivery
(Lakeside Irrigation Water District)
Drought
Wet
Drought
Wet
Drought
19S22E10R02M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
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1945
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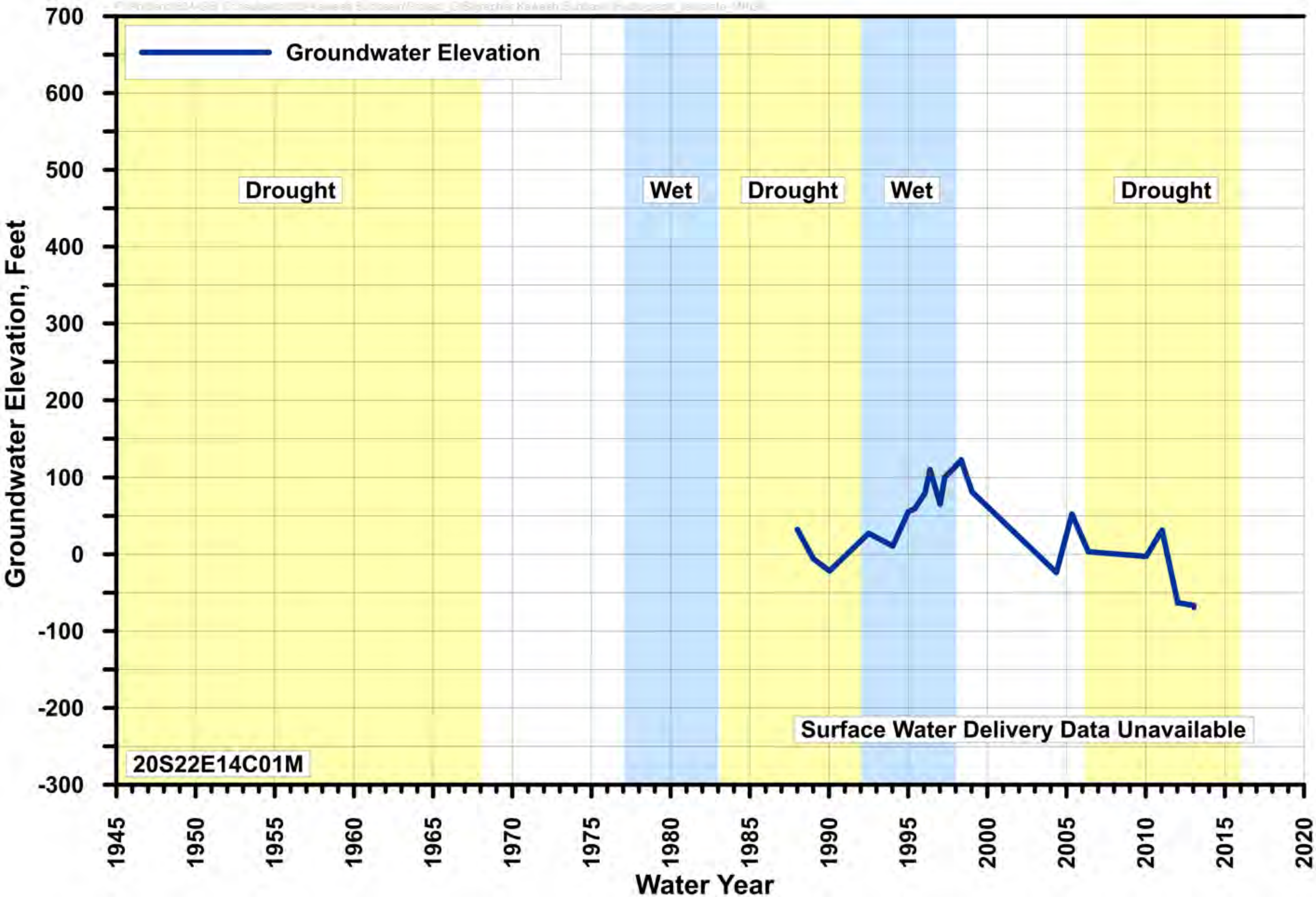

Groundwater Elevation
Drought
Wet
Drought
Wet
Drought
Surface Water Delivery Data Unavailable
20S22E14C01M
Groundwater Elevation, Feet
700
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500
400
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200
100
0
-100
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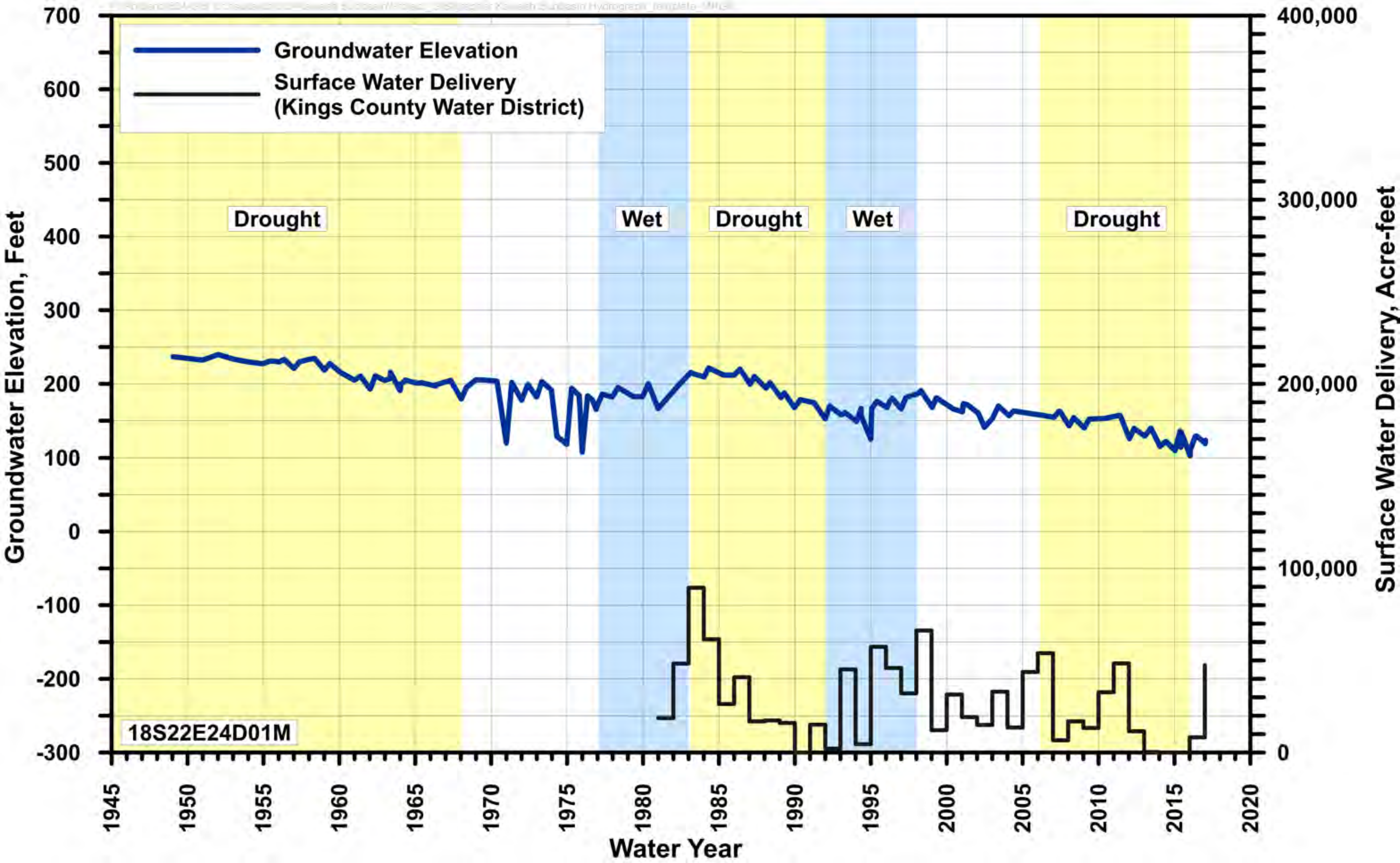
2015
2020
Water Year



Groundwater Elevation
Surface Water Delivery
(Kings County Water District)
Drought
Wet
Drought
Wet
Drought
18S22E24D01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
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1945
1950
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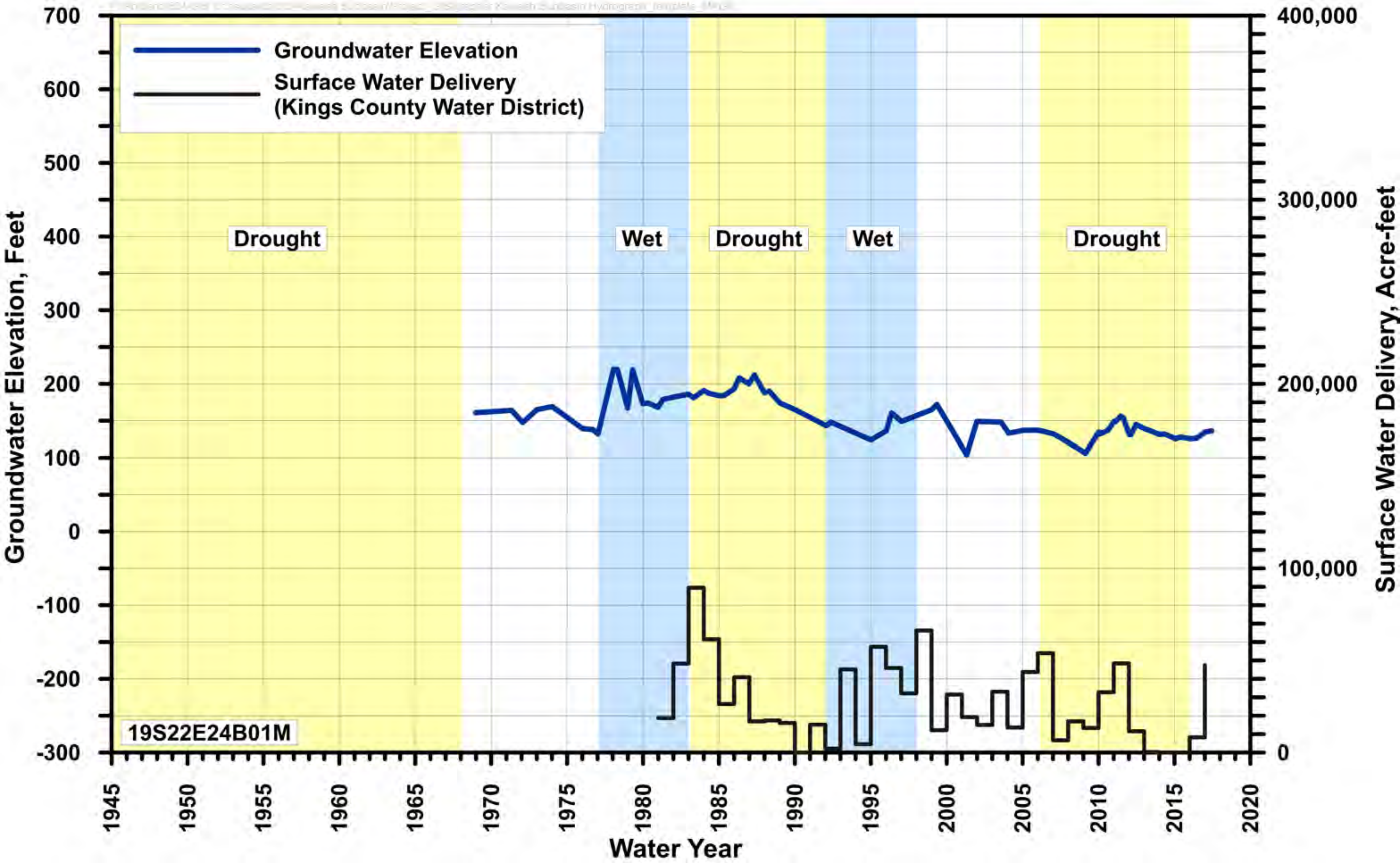

Groundwater Elevation
Surface Water Delivery
(Kings County Water District)
Drought
Wet
Drought
Wet
Drought
19S22E24B01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
100,000
0
1945
1950
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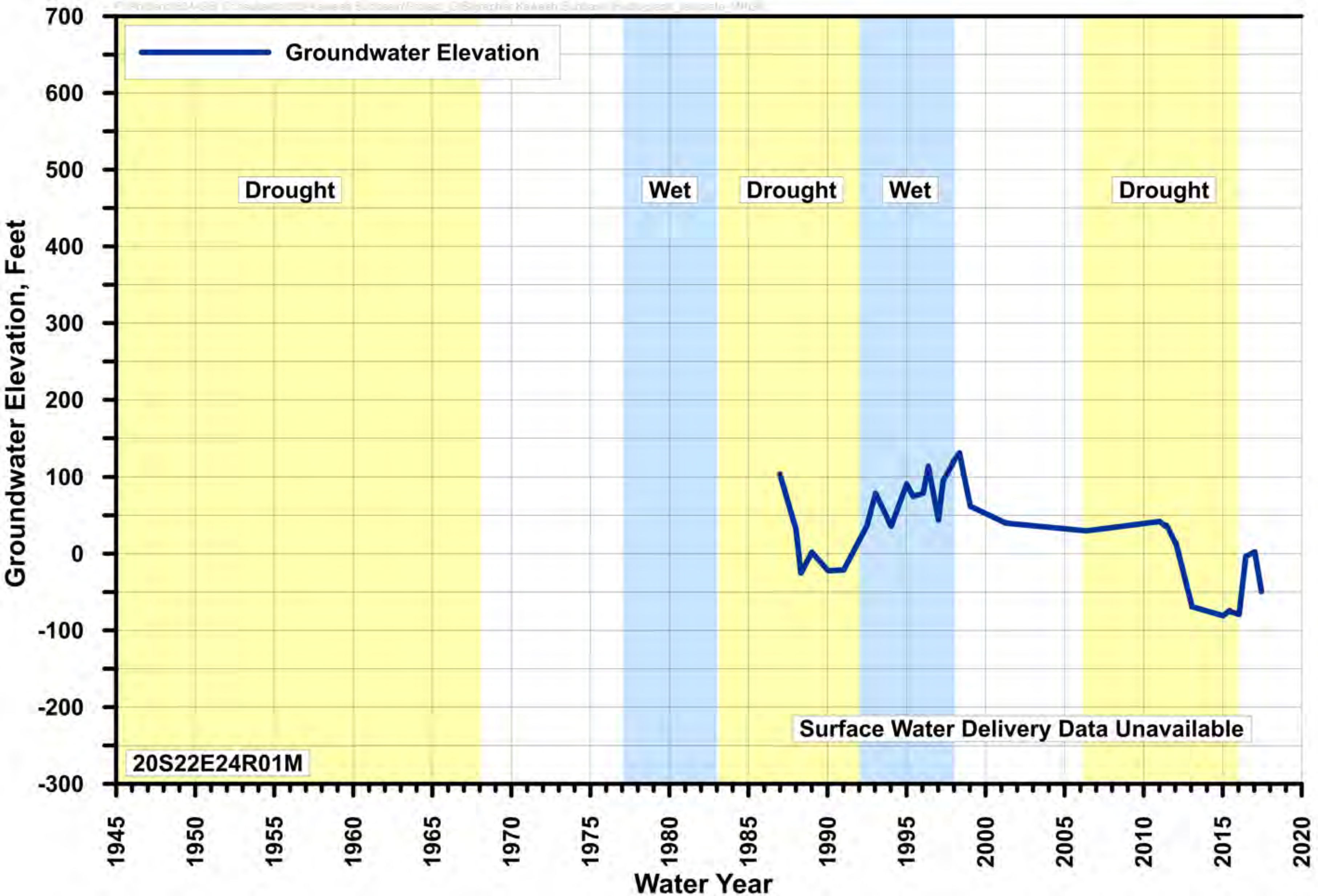

Groundwater Elevation
Drought
Wet
Drought
Wet
Drought
Surface Water Delivery Data Unavailable
20S22E24R01M
Groundwater Elevation, Feet
700
600
500
400
300
200
100
0
-100
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1945
1950
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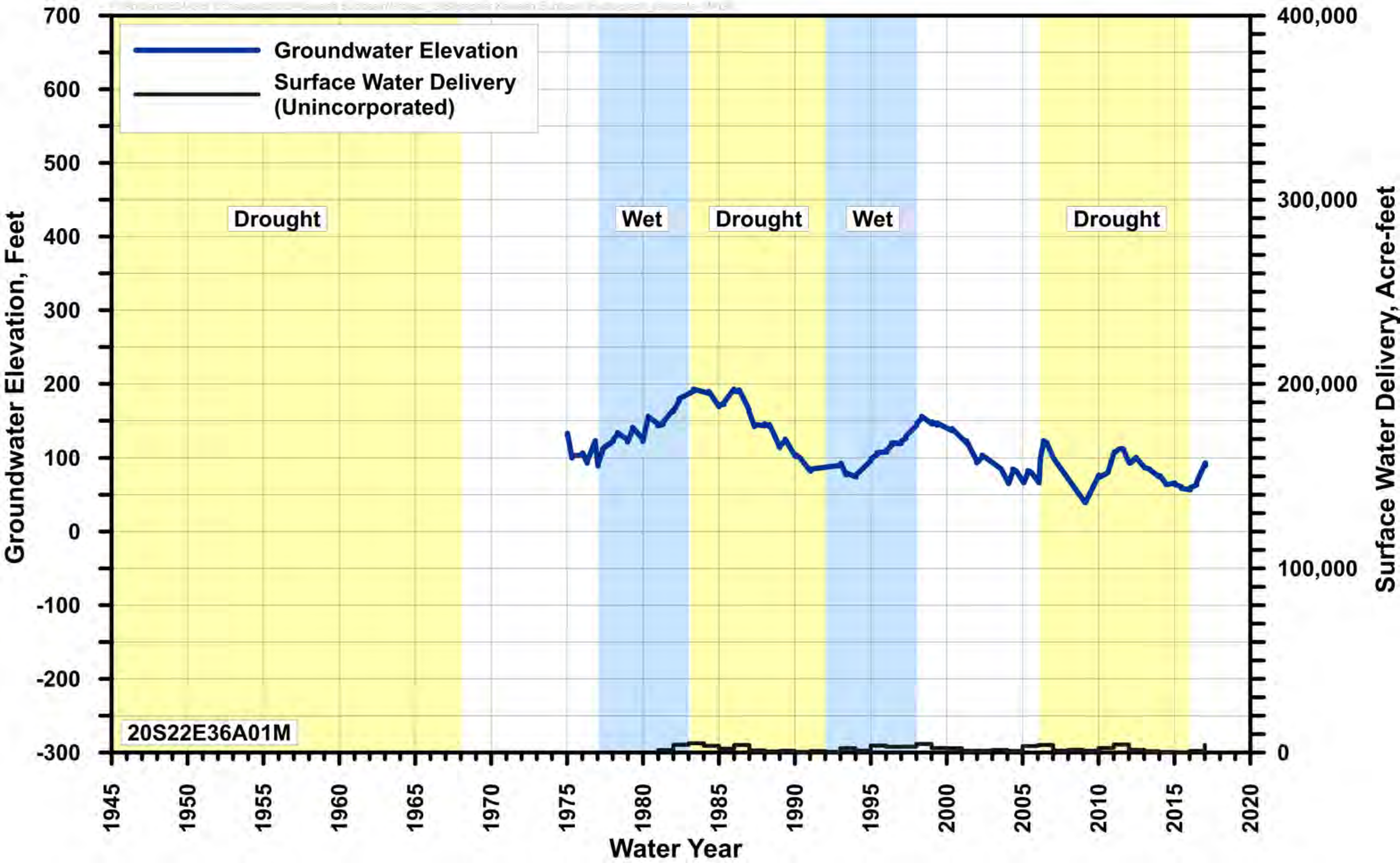
2015
2020
Water Year



Groundwater Elevation
Surface Water Delivery (Unincorporated)
Drought
Wet
Drought
Wet
Drought
20S22E36A01M
Groundwater Elevation, Feet
700
600
500
400
300
200
100
0
-100
-200
-300
Surface Water Delivery, Acre-feet
400,000
300,000
200,000
100,000
0
1945
1950
1955
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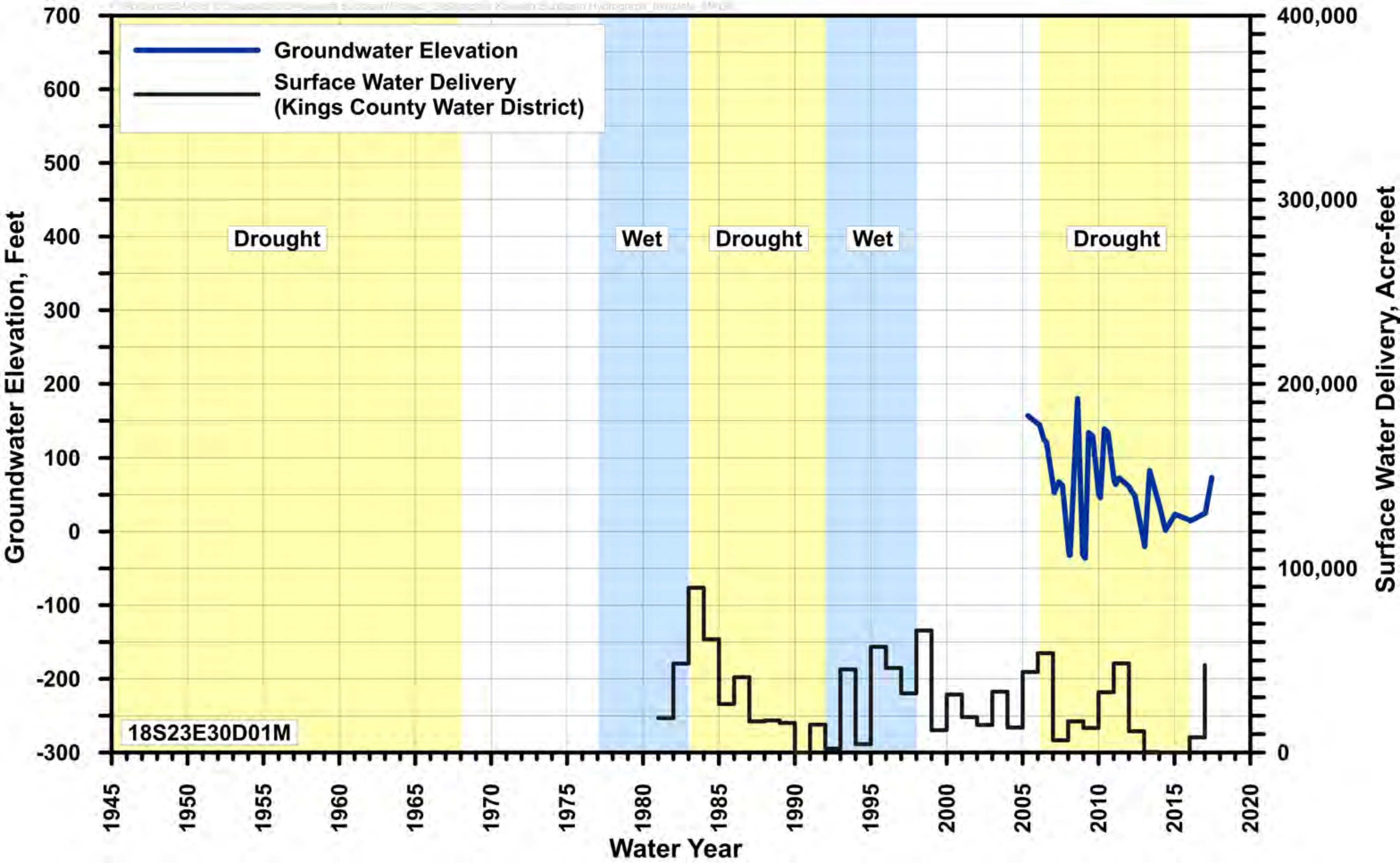
2010
2015
2020
Water Year



Groundwater Elevation
Surface Water Delivery
(Kings County Water District)
Drought
Wet
Drought
Wet
Drought
18S23E30D01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
100,000
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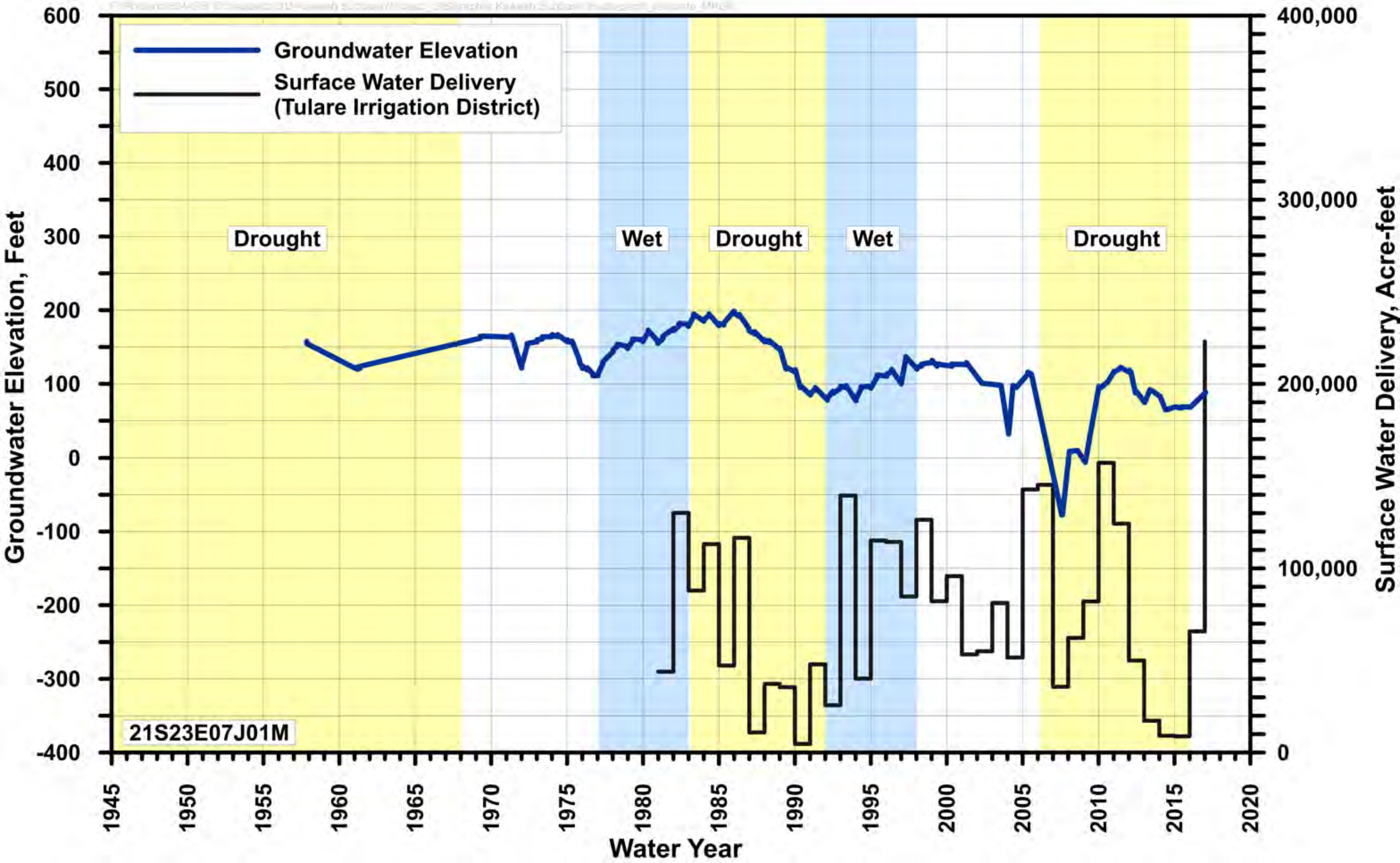

Groundwater Elevation
Surface Water Delivery
(Tulare Irrigation District)
Drought
Wet
Drought
Wet
Drought
21S23E07J01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
600
500
400
300
200
100
0
-100
-200
-300
-400
400,000
300,000
200,000
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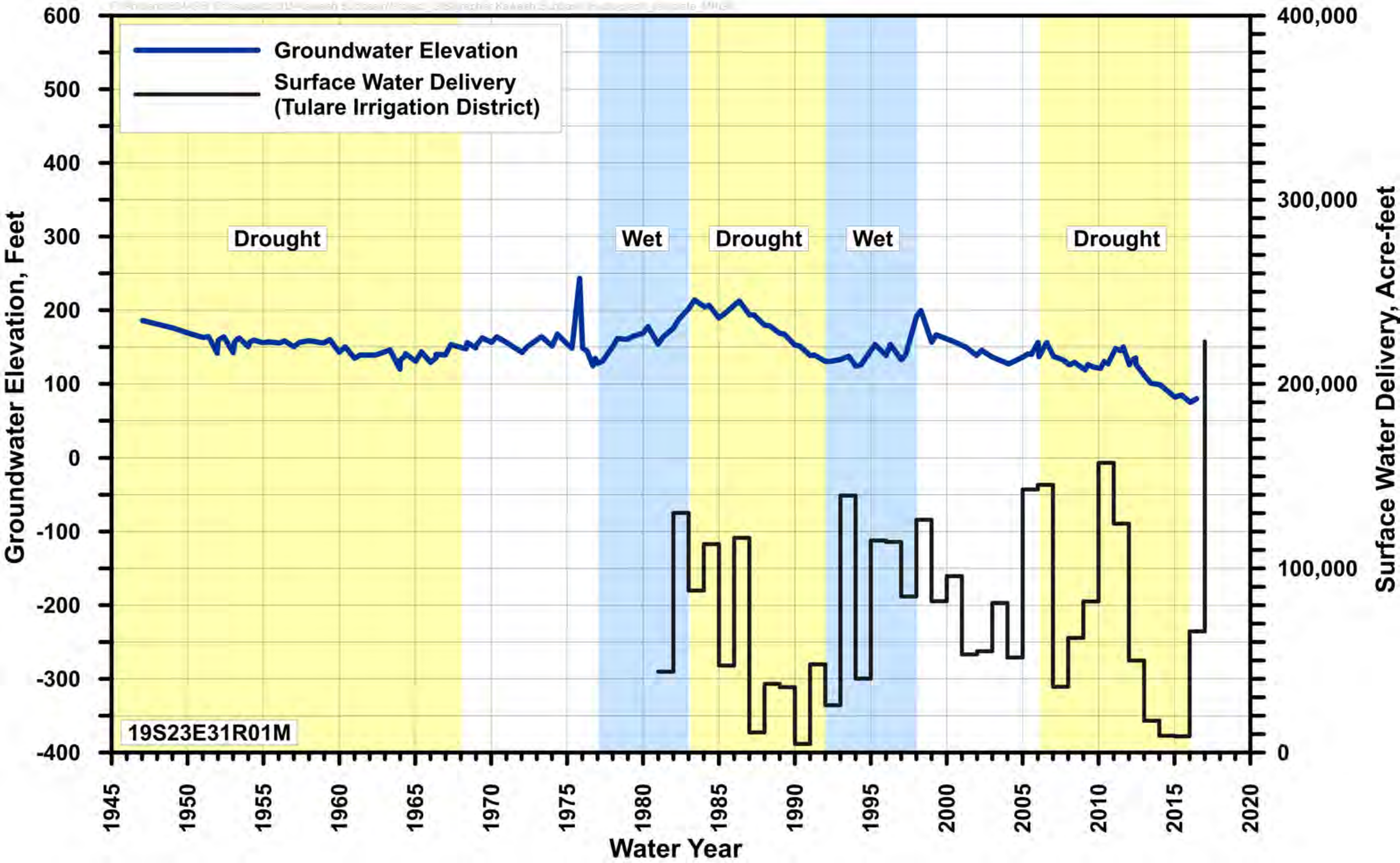

Groundwater Elevation
Surface Water Delivery
(Tulare Irrigation District)
Drought
Wet
Drought
Wet
Drought
19S23E31R01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
600
500
400
300
200
100
0
-100
-200
-300
-400
400,000
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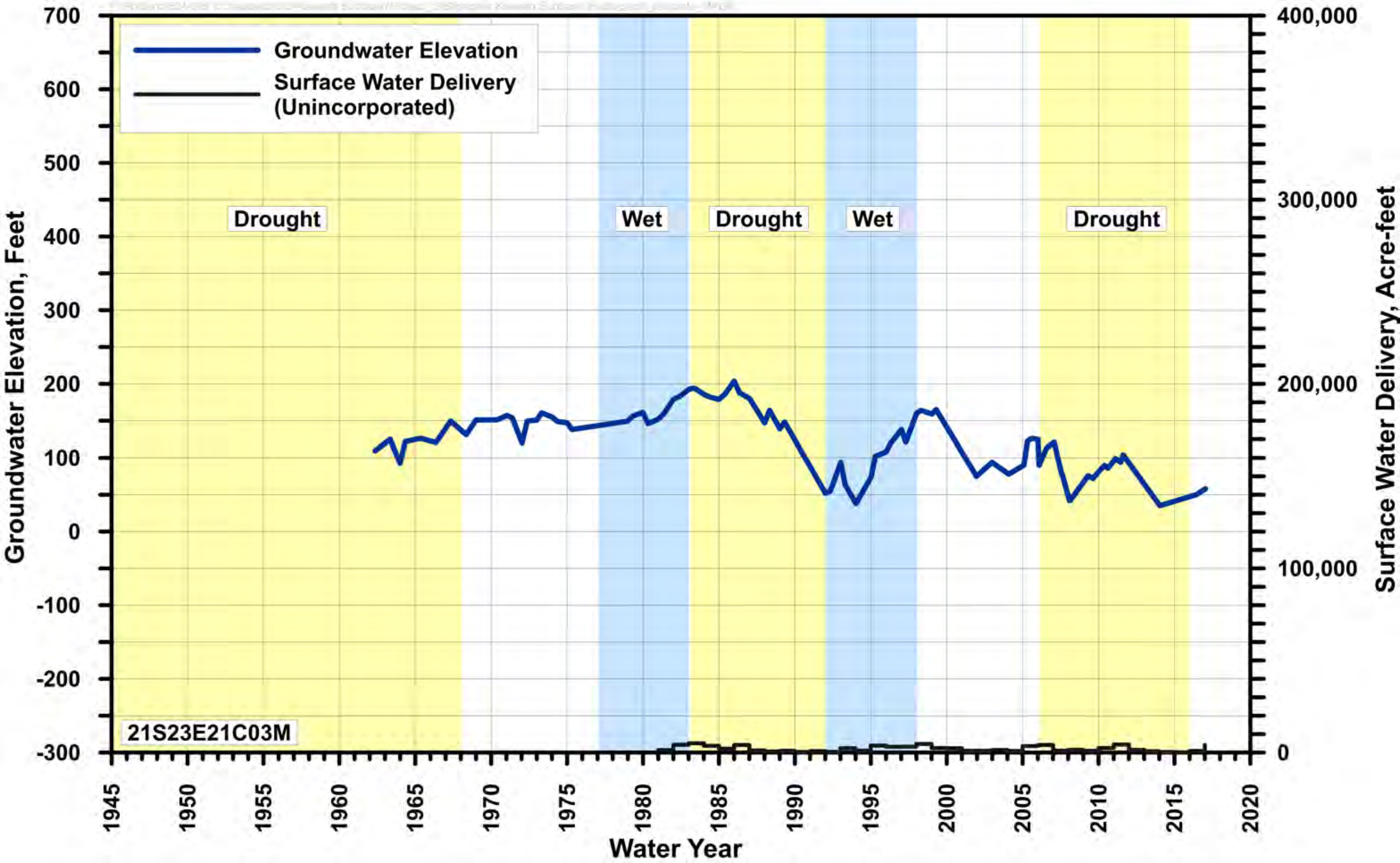

Groundwater Elevation
Surface Water Delivery
(Unincorporated)
Drought
Wet
Drought
Wet
Drought
21S23E21C03M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
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-100
-200
-300
400,000
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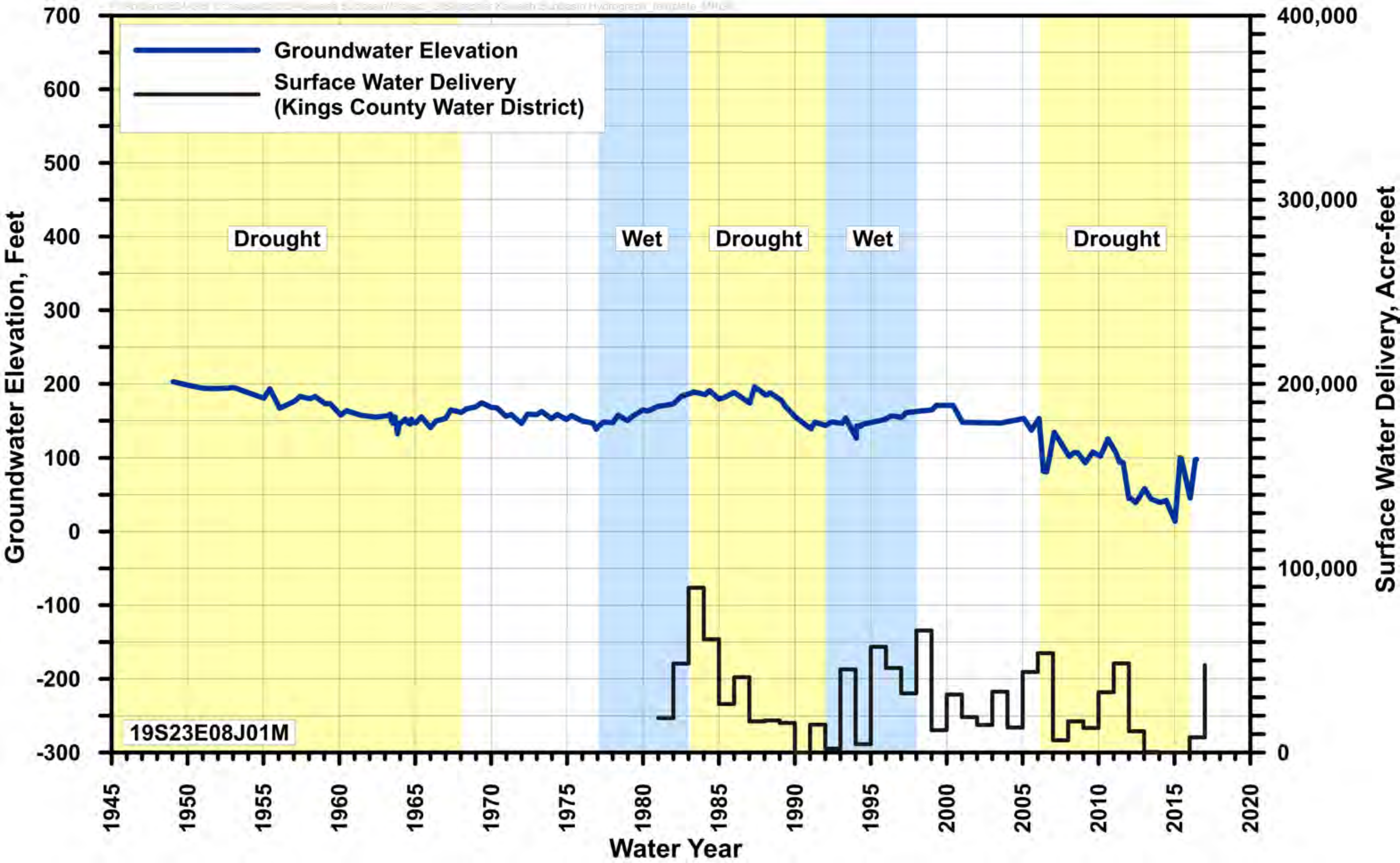

Groundwater Elevation
Surface Water Delivery
(Kings County Water District)
Drought
Wet
Drought
Wet
Drought
19S23E08J01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
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-100
-200
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400,000
300,000
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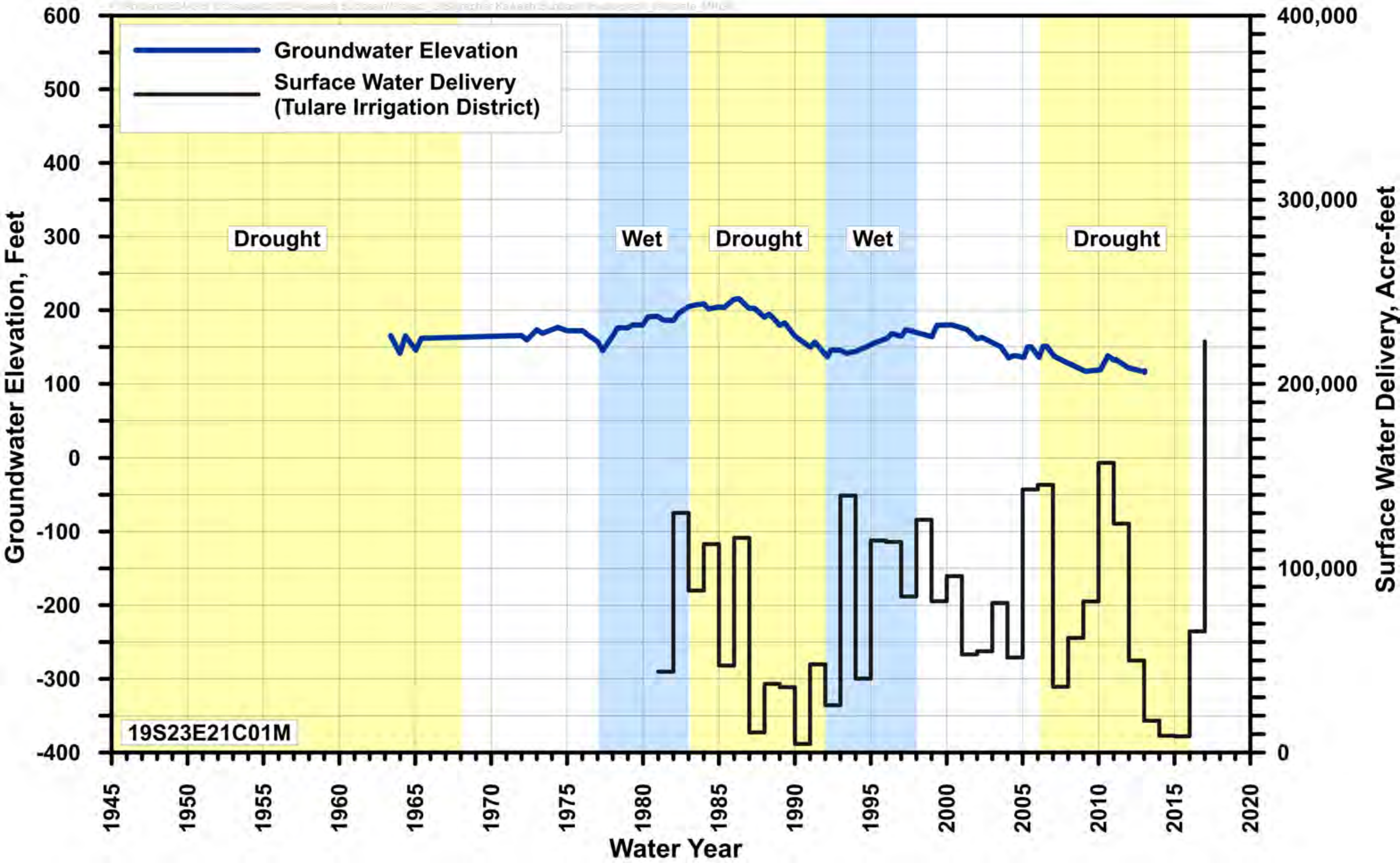

Groundwater Elevation
Surface Water Delivery
(Tulare Irrigation District)
Drought
Wet
Drought
Wet
Drought
19S23E21C01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
600
500
400
300
200
100
0
-100
-200
-300
-400
400,000
300,000
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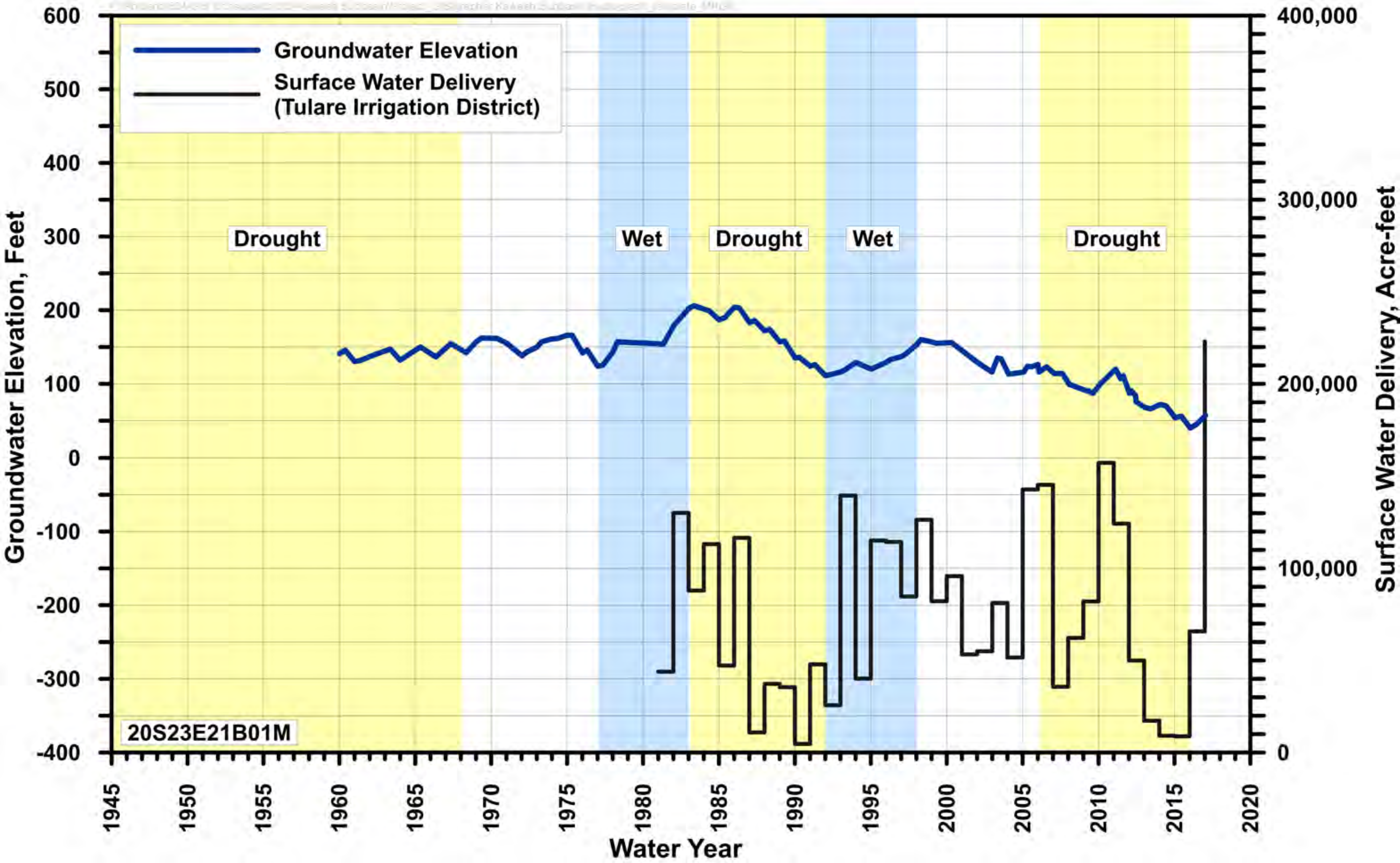
Groundwater Elevation
Surface Water Delivery
(Tulare Irrigation District)
Drought
Wet
Drought
Wet
Drought
20S23E21B01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
600
500
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300
200
100
0
-100
-200
-300
-400
400,000
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1945
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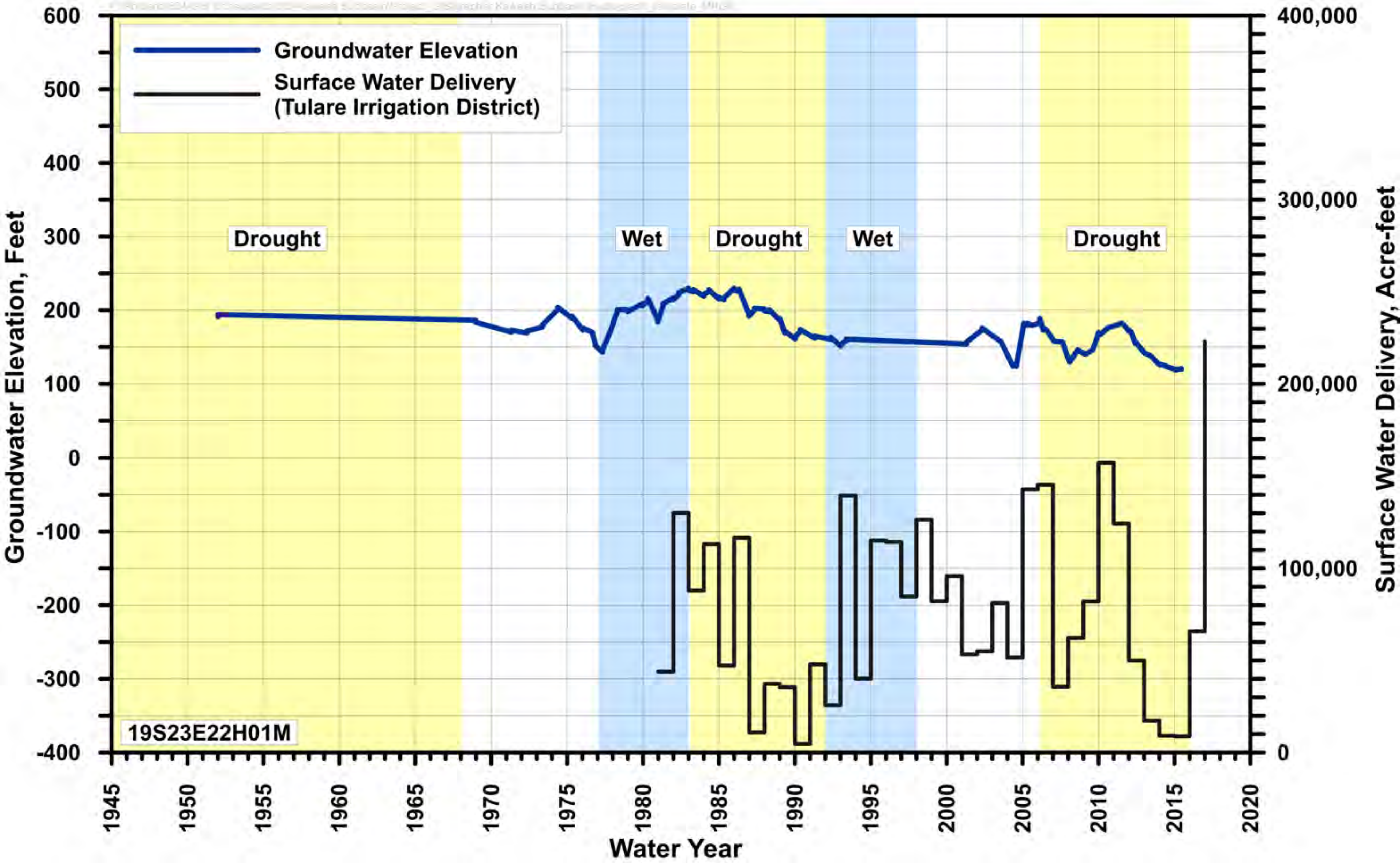
2020



Groundwater Elevation
Surface Water Delivery
(Tulare Irrigation District)
Drought
Wet
Drought
Wet
Drought
19S23E22H01M
Groundwater Elevation, Feet
600
500
400
300
200
100
0
-100
-200
-300
-400
Surface Water Delivery, Acre-feet
400,000
300,000
200,000
100,000
0
Water Year
1945
1950
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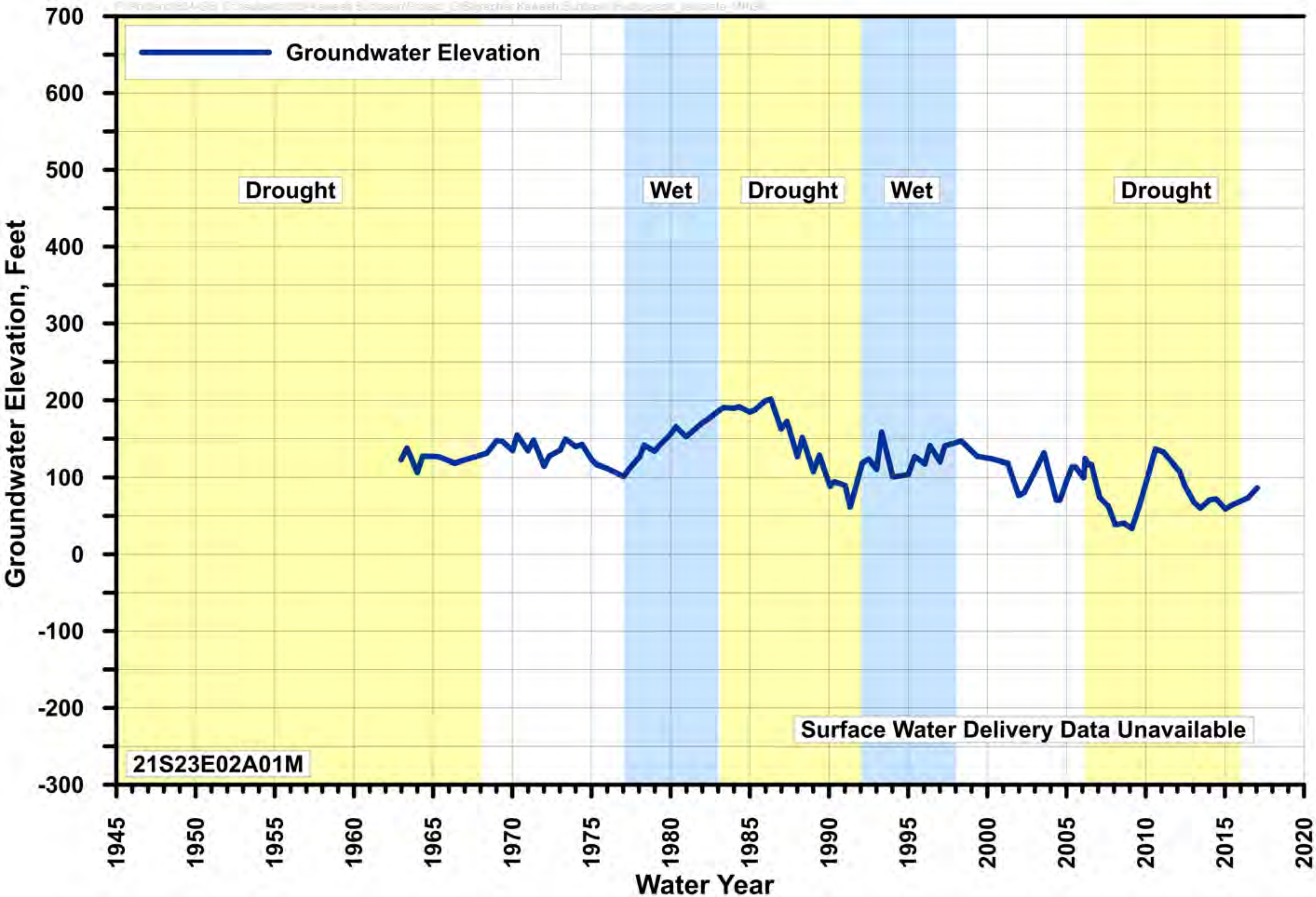
2015
2020



Groundwater Elevation
Drought
Wet
Drought
Wet
Drought
Surface Water Delivery Data Unavailable
21S23E02A01M
Groundwater Elevation, Feet
Water Year
700
600
500
400
300
200
100
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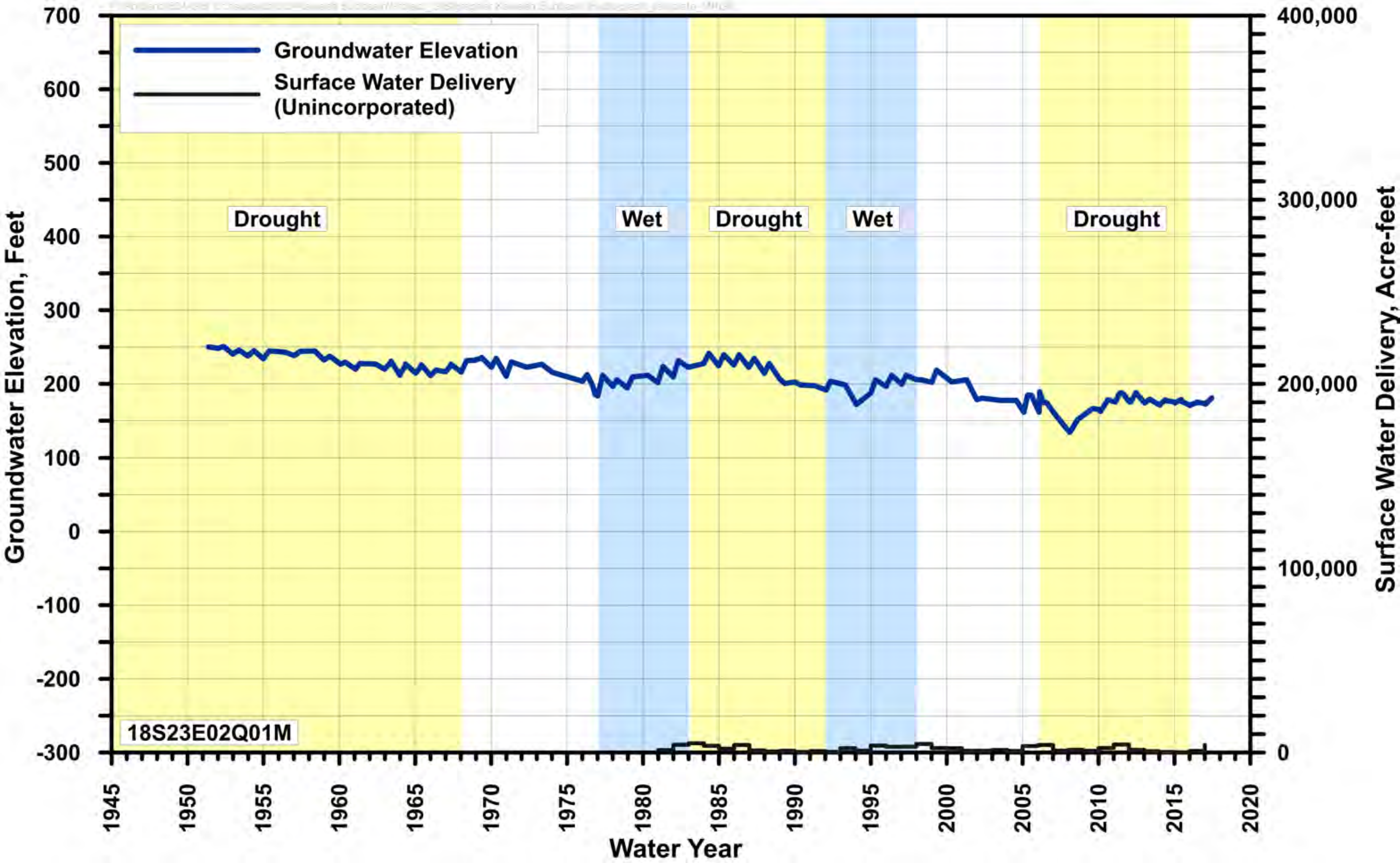

Groundwater Elevation
Surface Water Delivery (Unincorporated)
Drought
Wet
Drought
Wet
Drought
18S23E02Q01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
100,000
0
1945
1950
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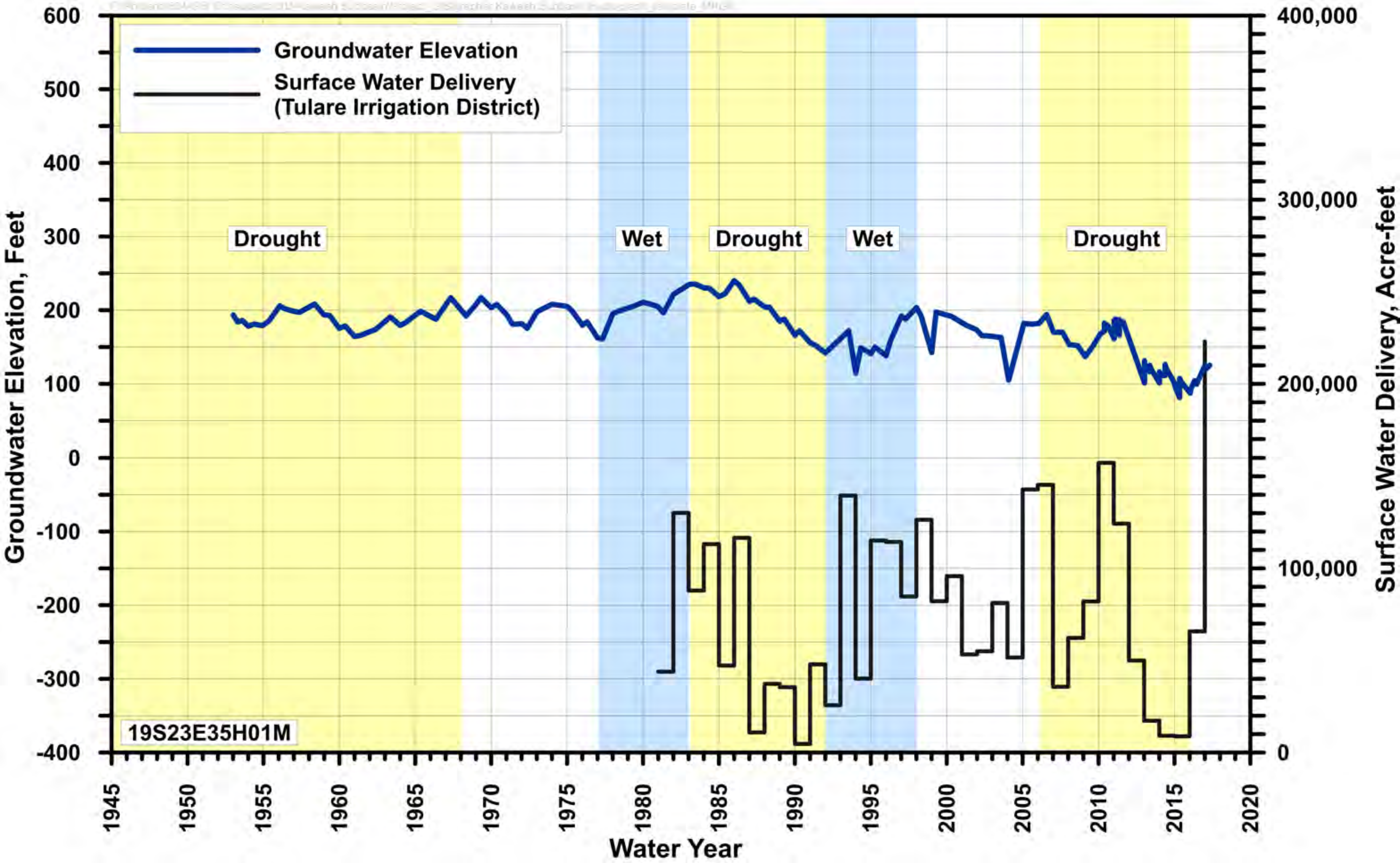
2015
2020



Groundwater Elevation
Surface Water Delivery
(Tulare Irrigation District)
Drought
Wet
Drought
Wet
Drought
19S23E35H01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
600
500
400
300
200
100
0
-100
-200
-300
-400
400,000
300,000
200,000
100,000
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1945
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2005
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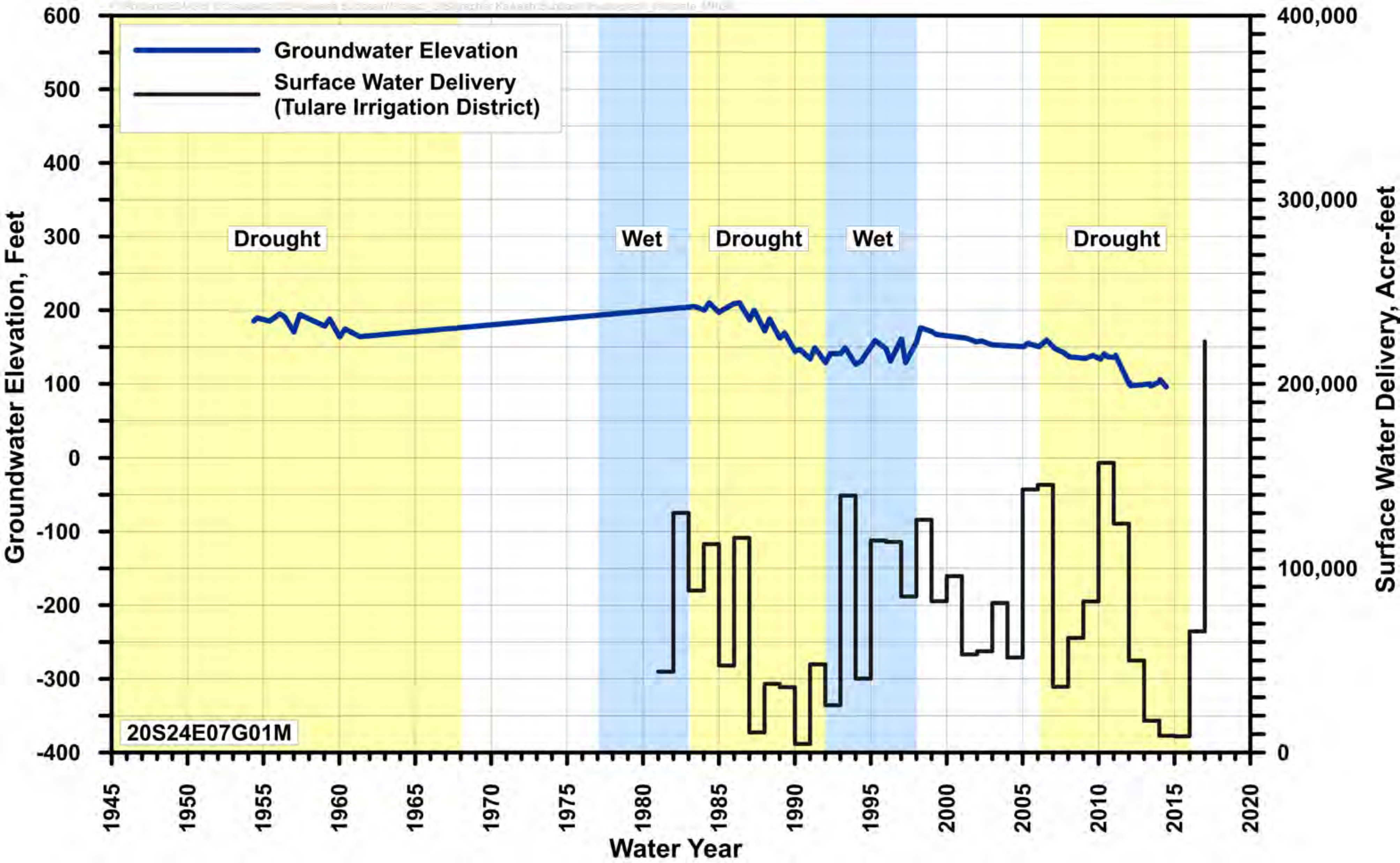
2015
2020



Groundwater Elevation
Surface Water Delivery
(Tulare Irrigation District)
Drought
Wet
Drought
Wet
Drought
20S24E07G01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
600
500
400
300
200
100
0
-100
-200
-300
-400
400,000
300,000
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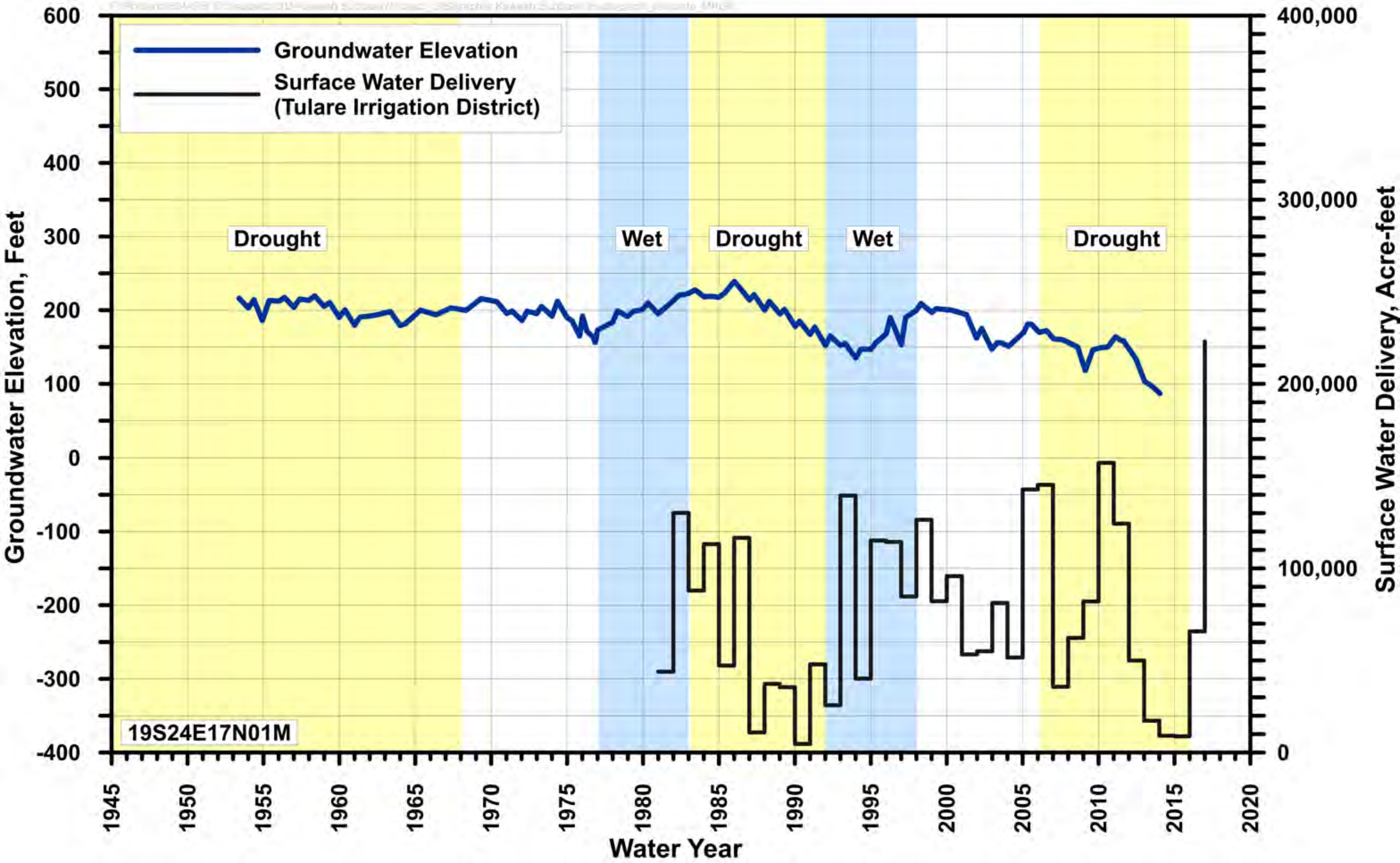

Groundwater Elevation
Surface Water Delivery
(Tulare Irrigation District)
Drought
Wet
Drought
Wet
Drought
19S24E17N01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
600
500
400
300
200
100
0
-100
-200
-300
-400
400,000
300,000
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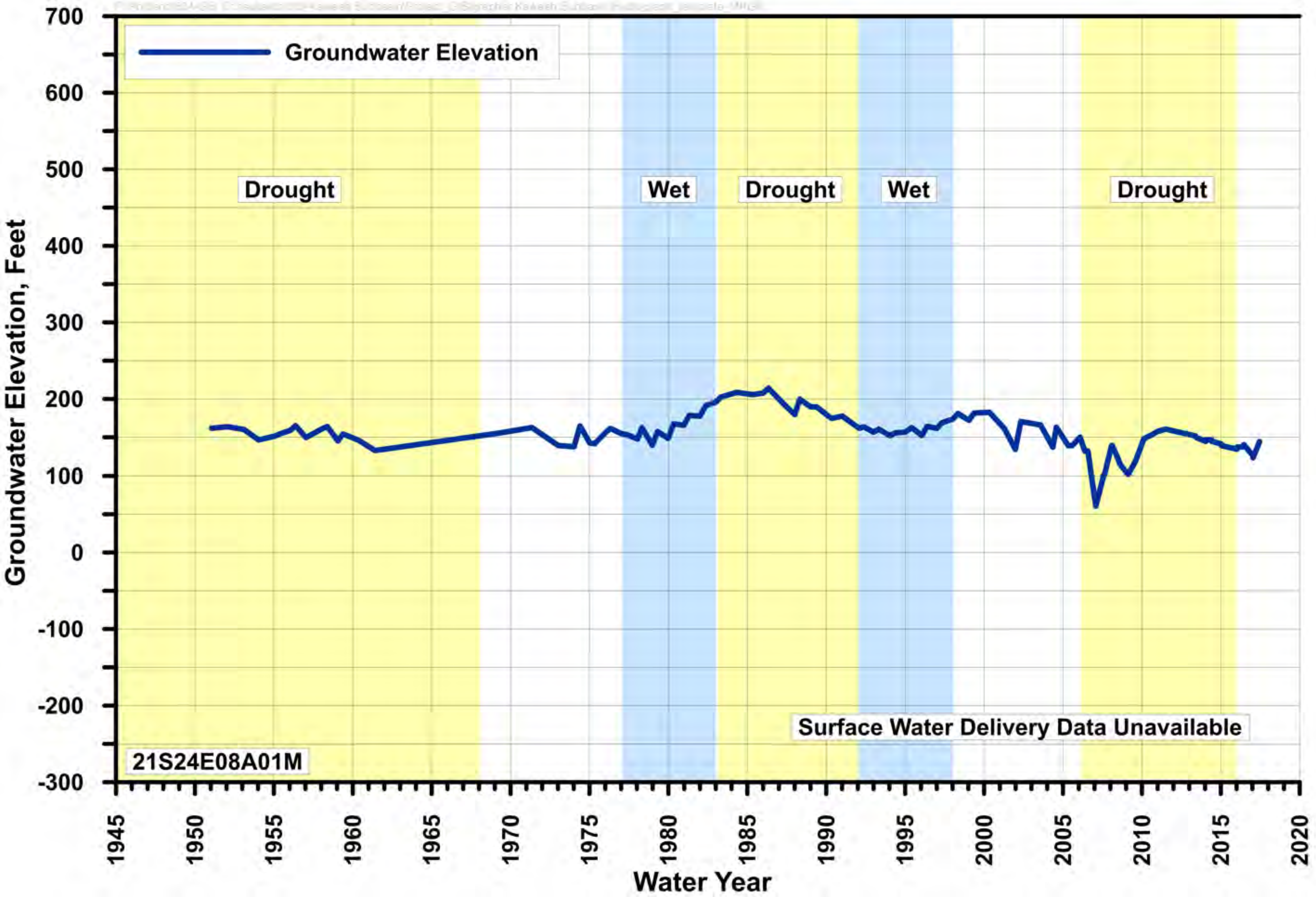

Groundwater Elevation
Drought
Wet
Drought
Wet
Drought
Surface Water Delivery Data Unavailable
21S24E08A01M
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600
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400
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0
-100
-200
-300
Groundwater Elevation, Feet
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1950
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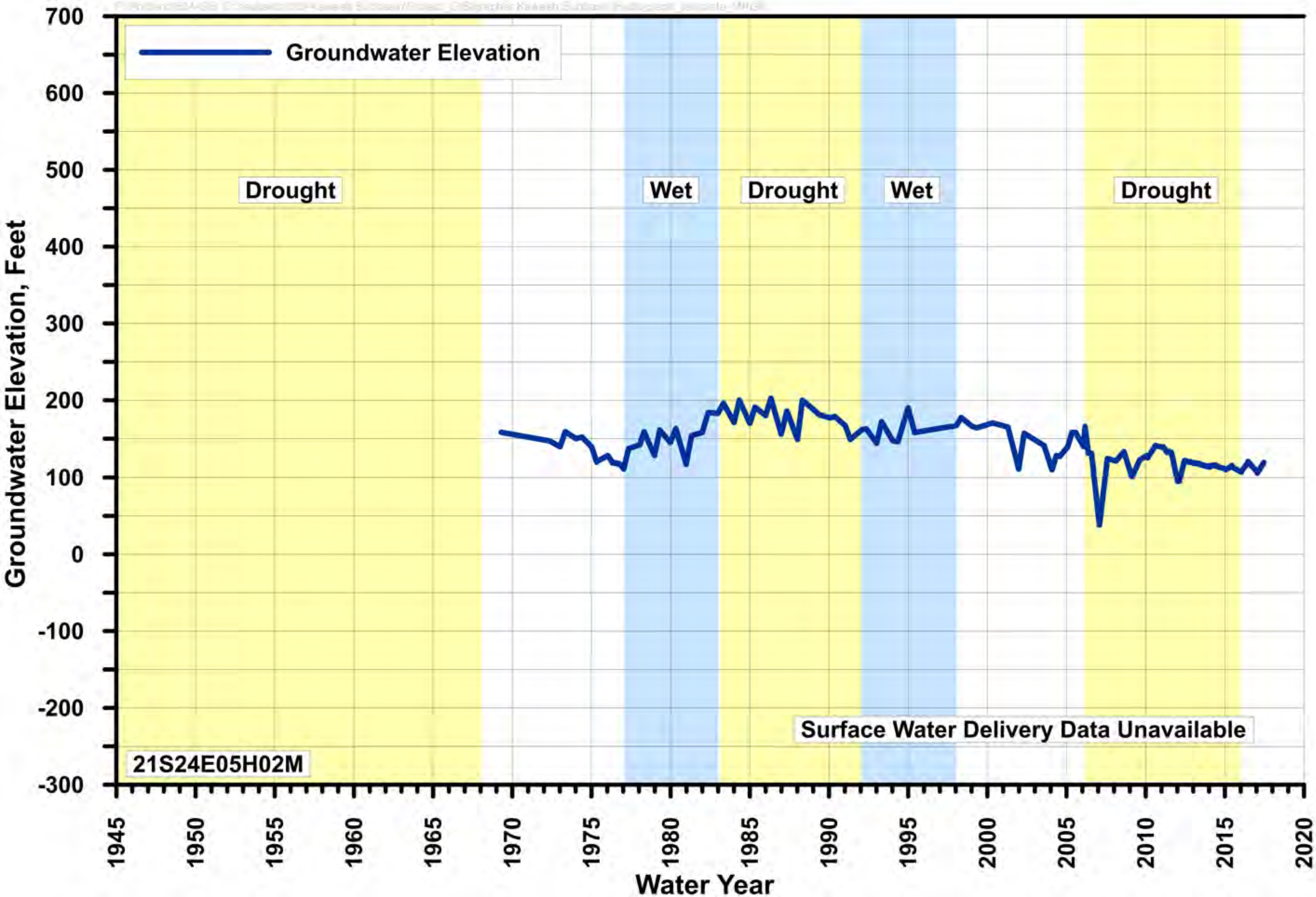
2010
2015
2020
Water Year



Groundwater Elevation
Drought
Wet
Drought
Wet
Drought
Surface Water Delivery Data Unavailable
21S24E05H02M
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700
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200
100
0
-100
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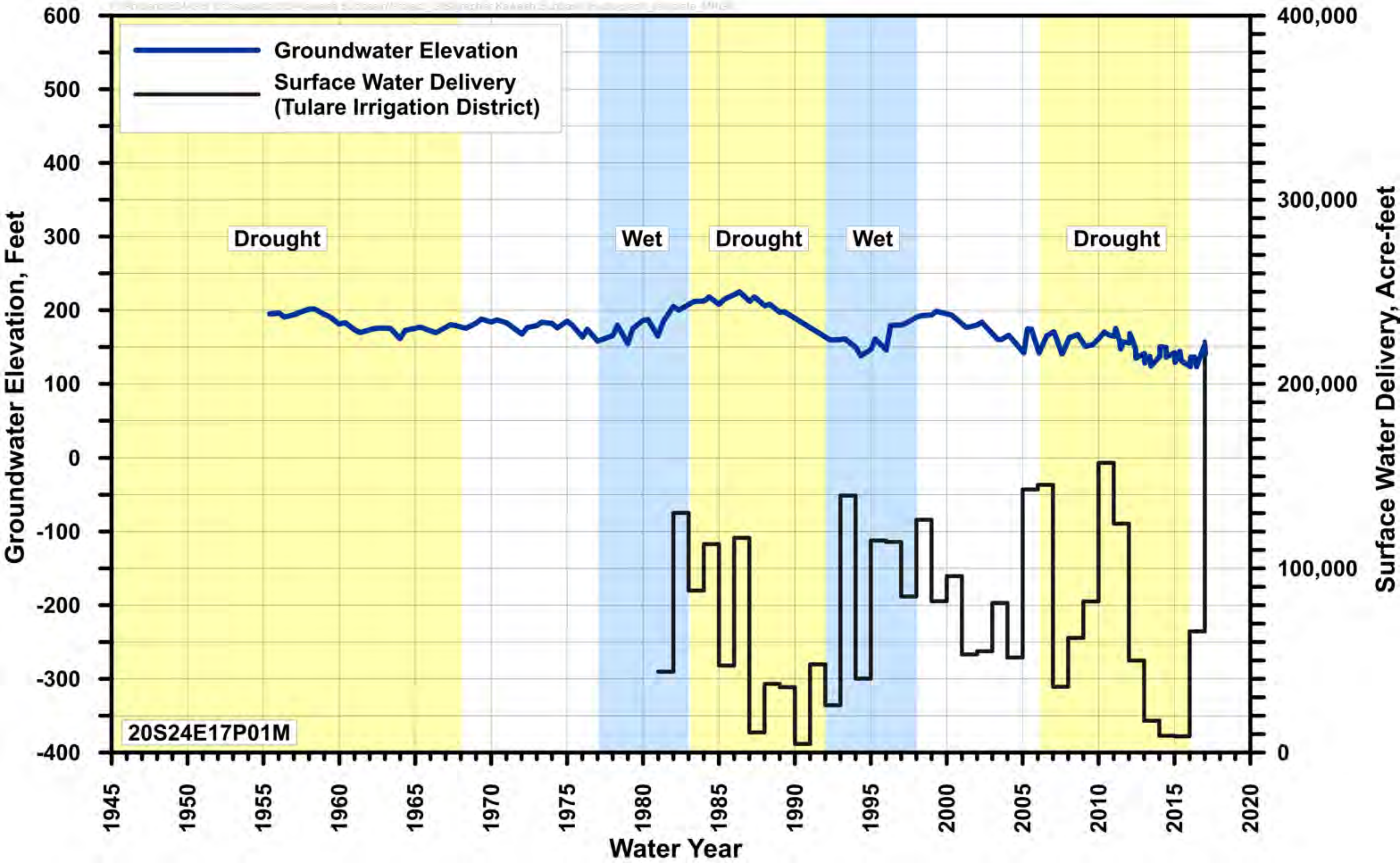
2010
2015
2020
Water Year



Groundwater Elevation
Surface Water Delivery
(Tulare Irrigation District)
Drought
Wet
Drought
Wet
Drought
20S24E17P01M
600
500
400
300
200
100
0
-100
-200
-300
-400
Groundwater Elevation, Feet
400,000
300,000
200,000
100,000
0
Surface Water Delivery, Acre-feet
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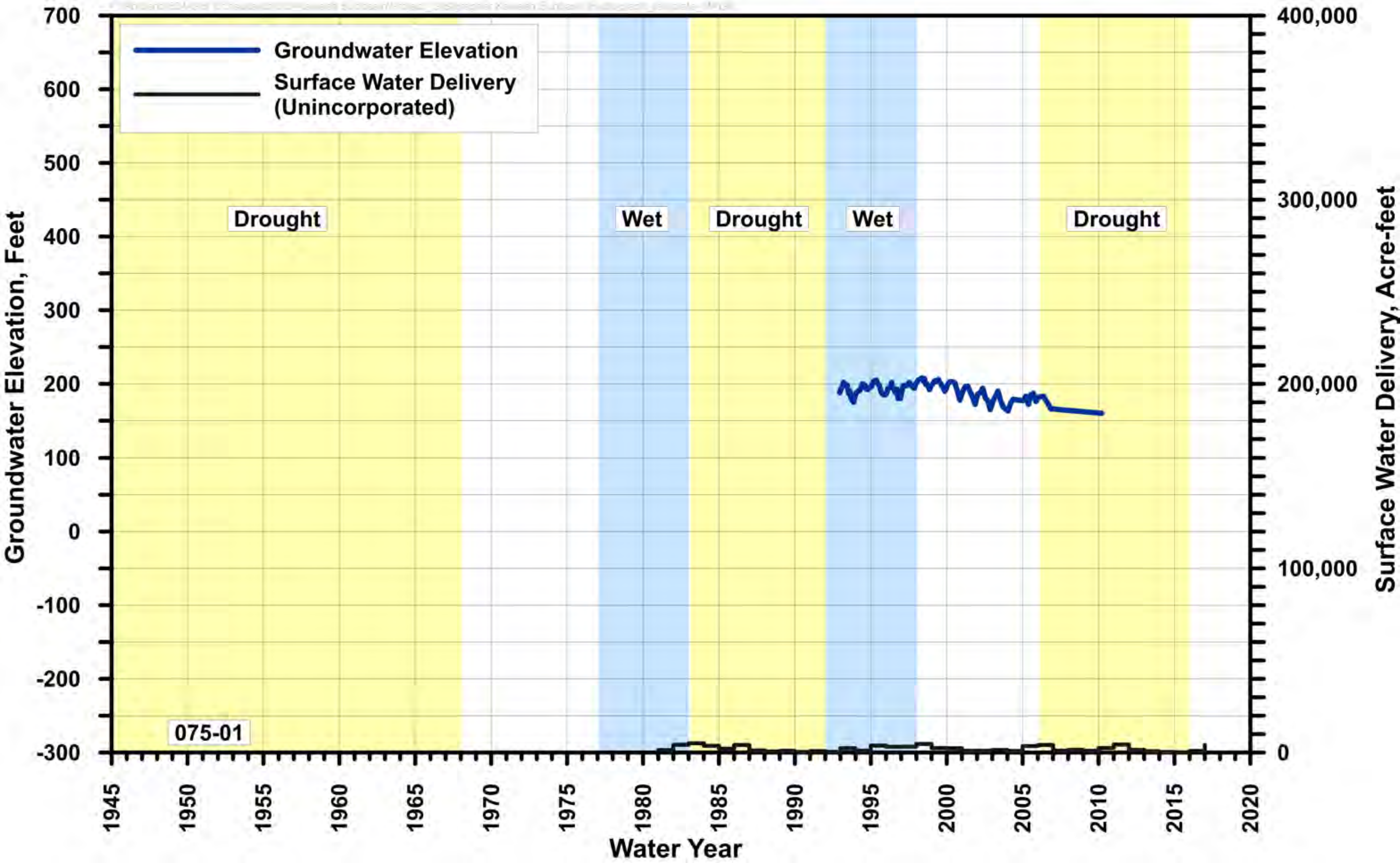
2010
2015
2020
Water Year



Groundwater Elevation
Surface Water Delivery (Unincorporated)
Drought
Wet
Drought
Wet
Drought
075-01
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
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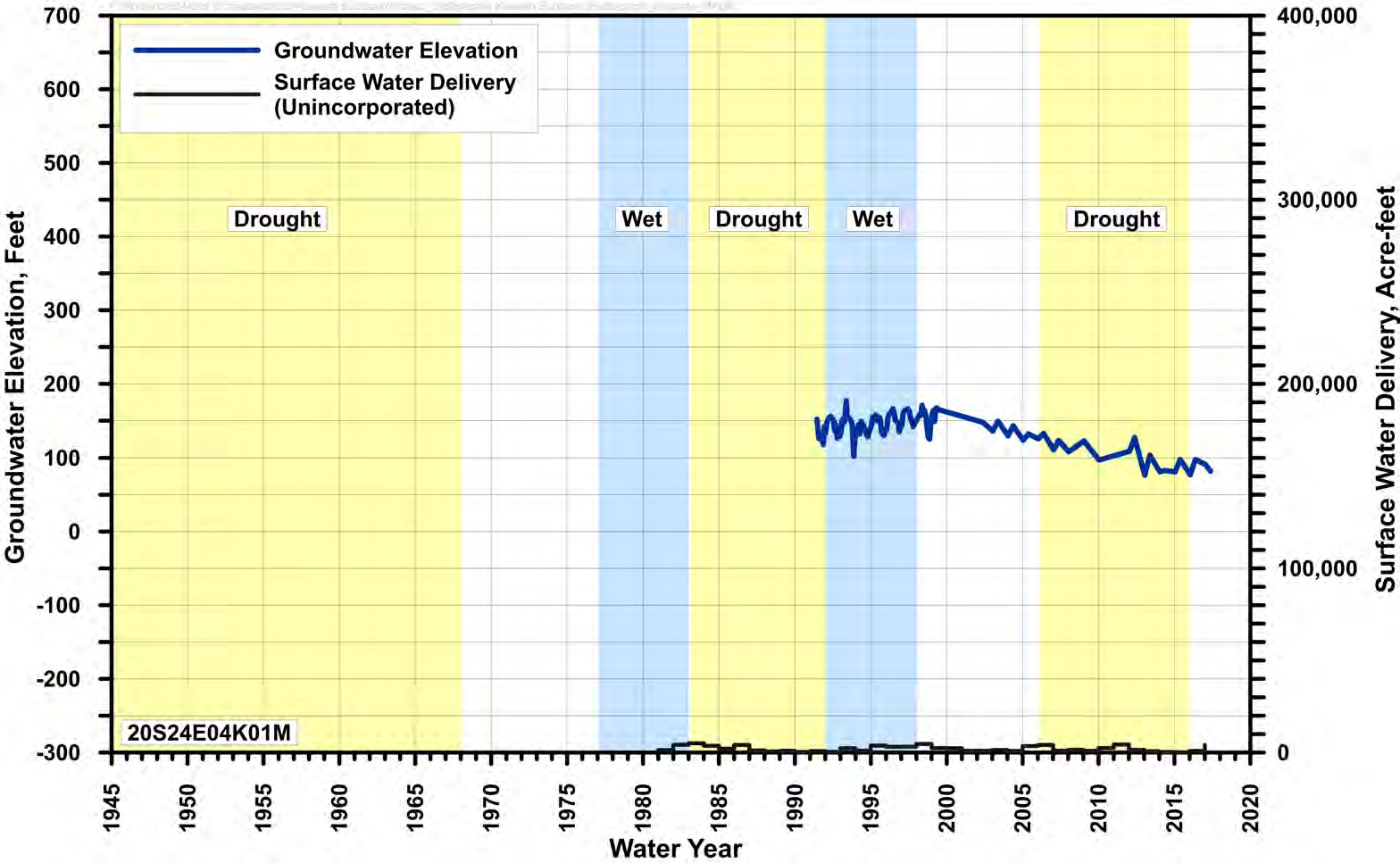
2020



Groundwater Elevation
Surface Water Delivery (Unincorporated)
Drought
Wet
Drought
Wet
Drought
20S24E04K01M
Groundwater Elevation, Feet
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500
400
300
200
100
0
-100
-200
-300
Surface Water Delivery, Acre-feet
400,000
300,000
200,000
100,000
0
Water Year
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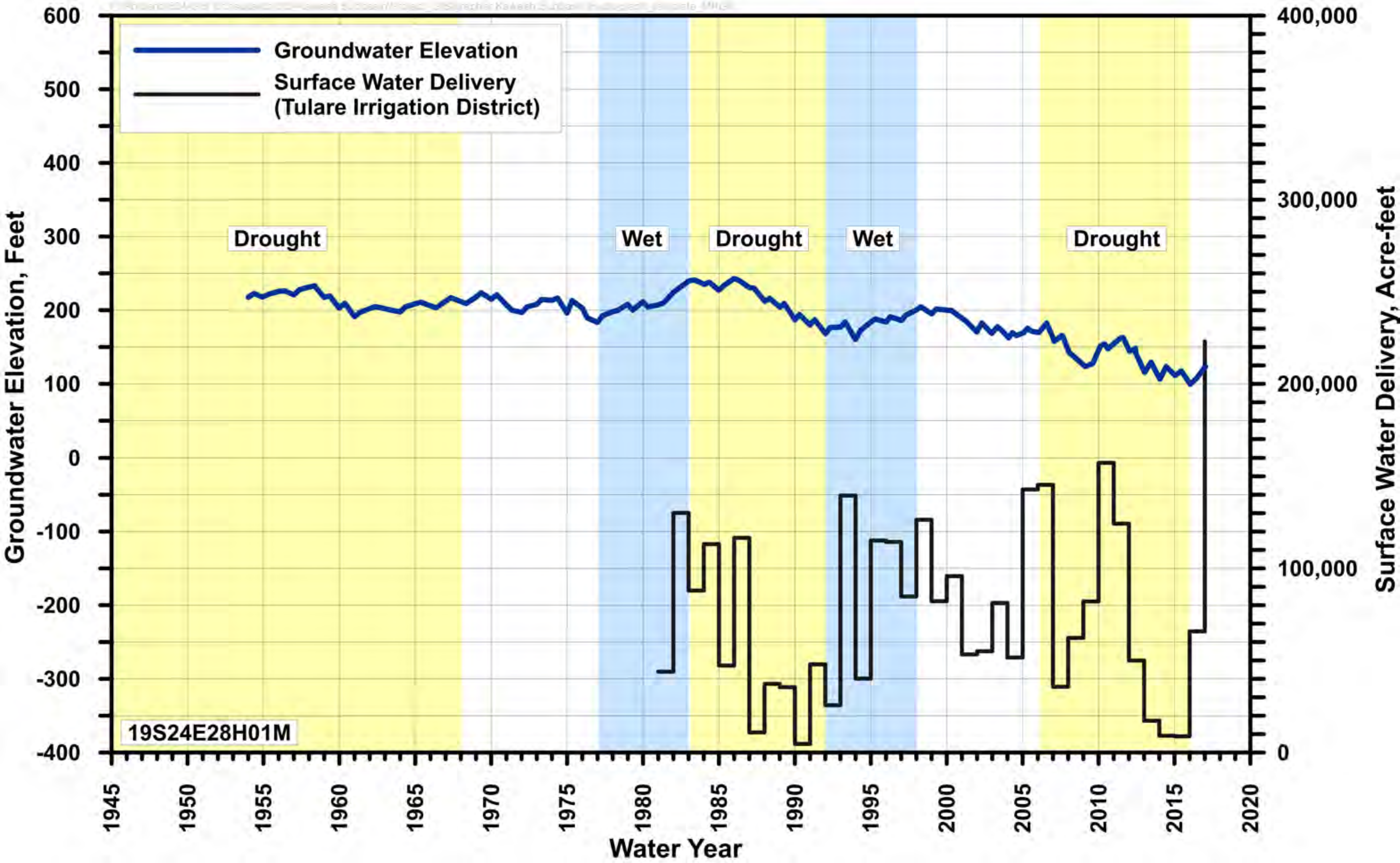
Groundwater Elevation
Surface Water Delivery
(Tulare Irrigation District)
Drought
Wet
Drought
Wet
Drought
19S24E28H01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
600
500
400
300
200
100
0
-100
-200
-300
-400
400,000
300,000
200,000
100,000
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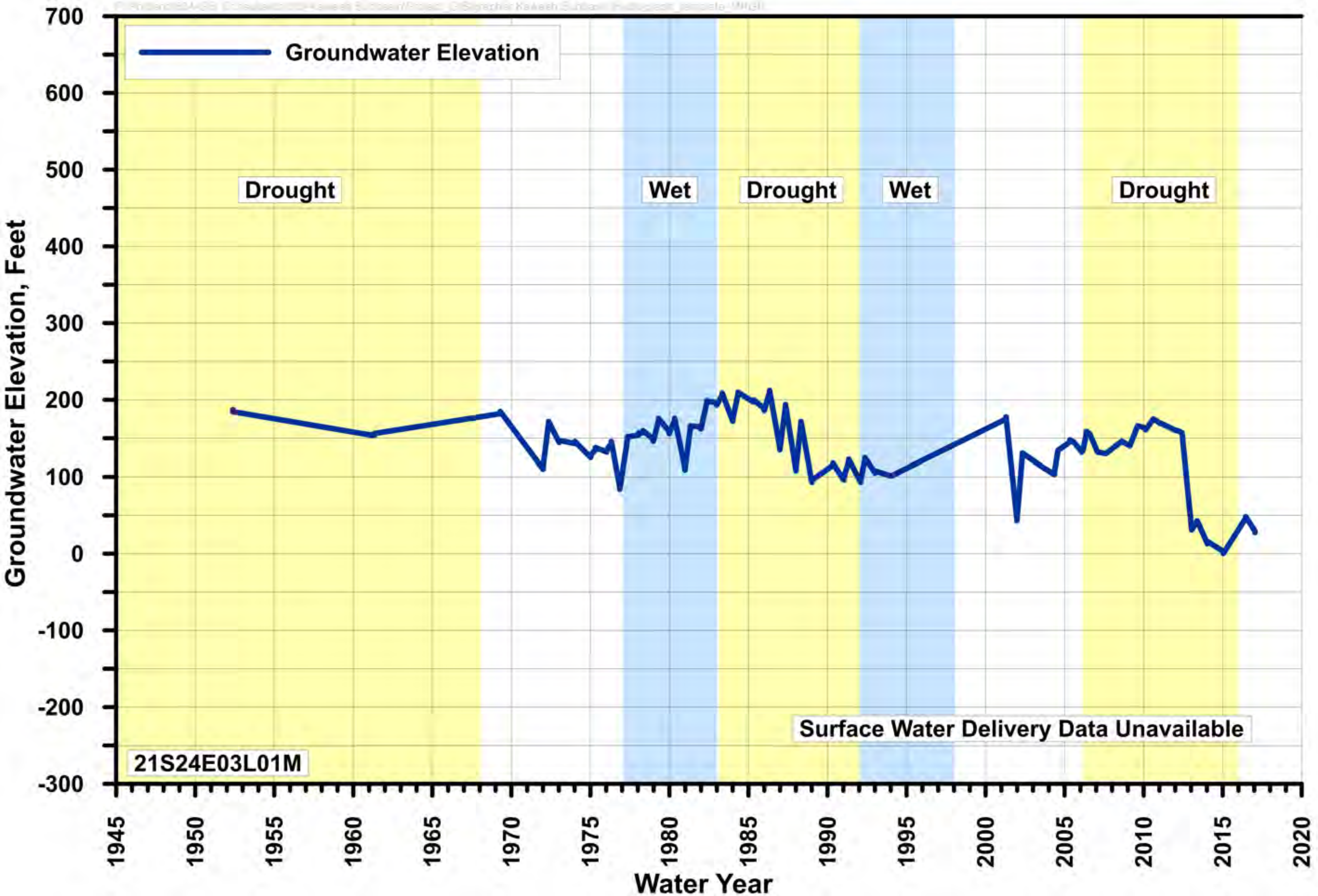

Groundwater Elevation
Drought
Wet
Drought
Wet
Drought
Surface Water Delivery Data Unavailable
21S24E03L01M
Groundwater Elevation, Feet
Water Year
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300
200
100
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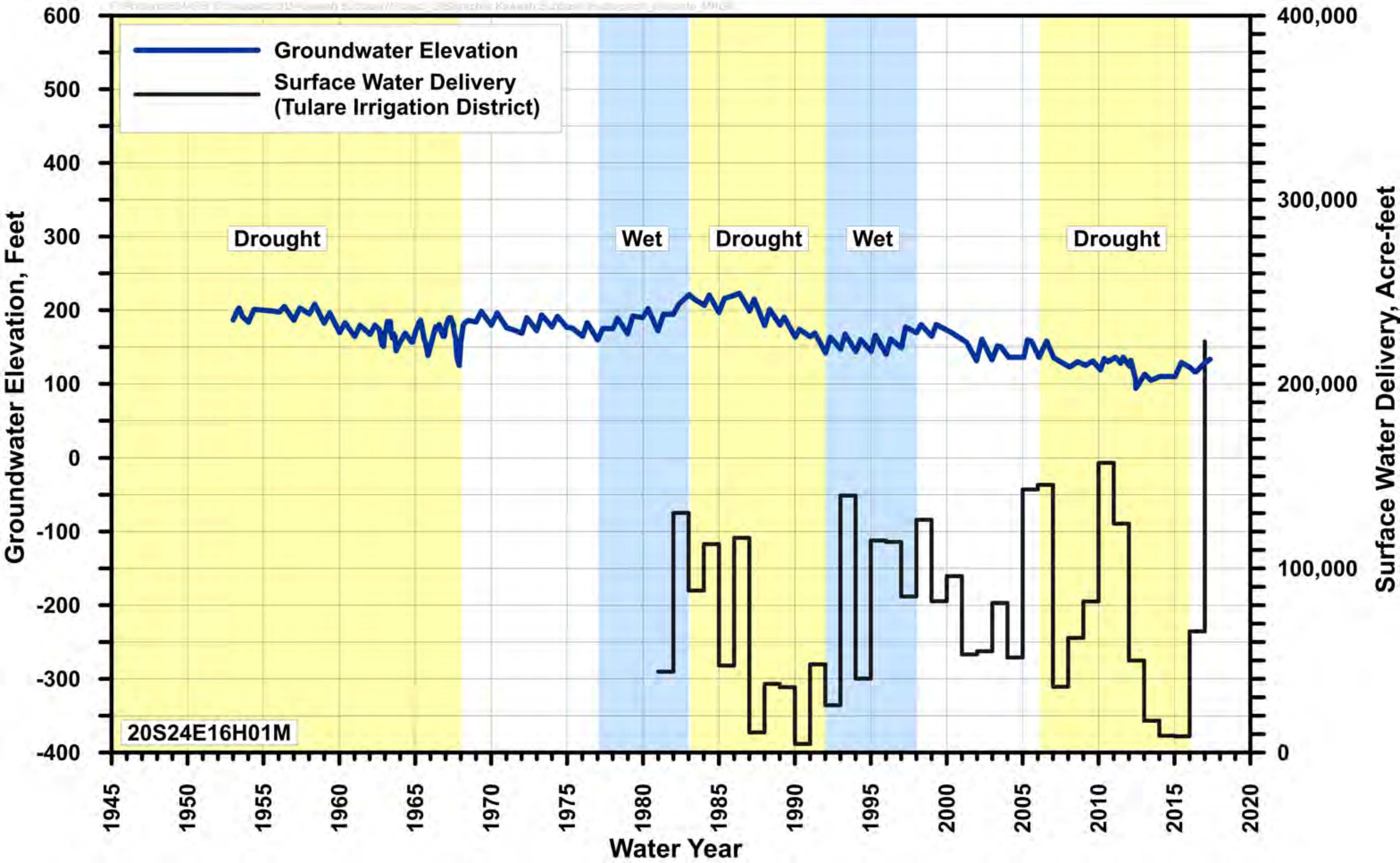
2020



Groundwater Elevation
Surface Water Delivery
(Tulare Irrigation District)
Drought
Wet
Drought
Wet
Drought
20S24E16H01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
600
500
400
300
200
100
0
-100
-200
-300
-400
400,000
300,000
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1945
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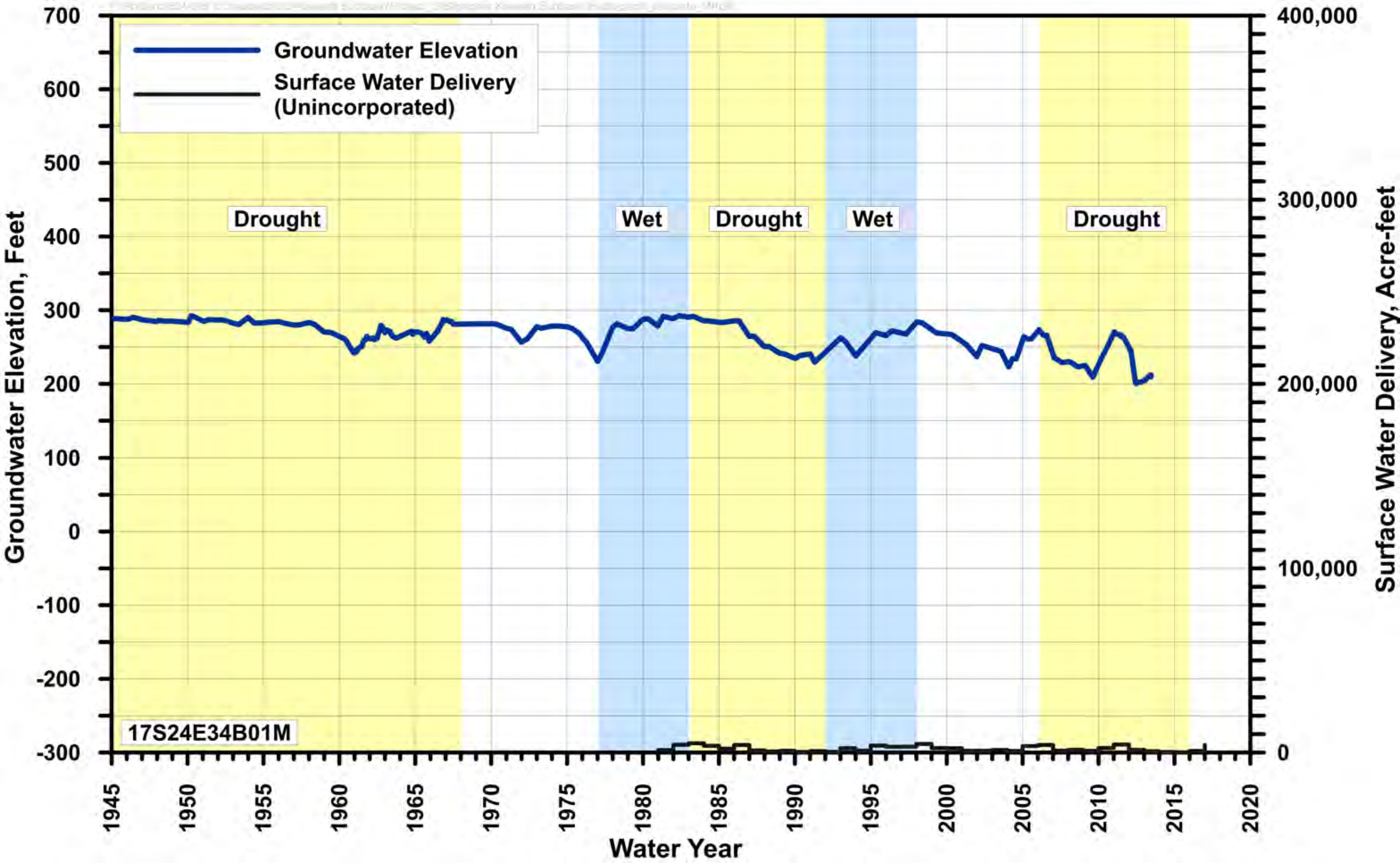
2020



Groundwater Elevation
Surface Water Delivery (Unincorporated)
Drought
Wet
Drought
Wet
Drought
17S24E34B01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
100,000
0
1945
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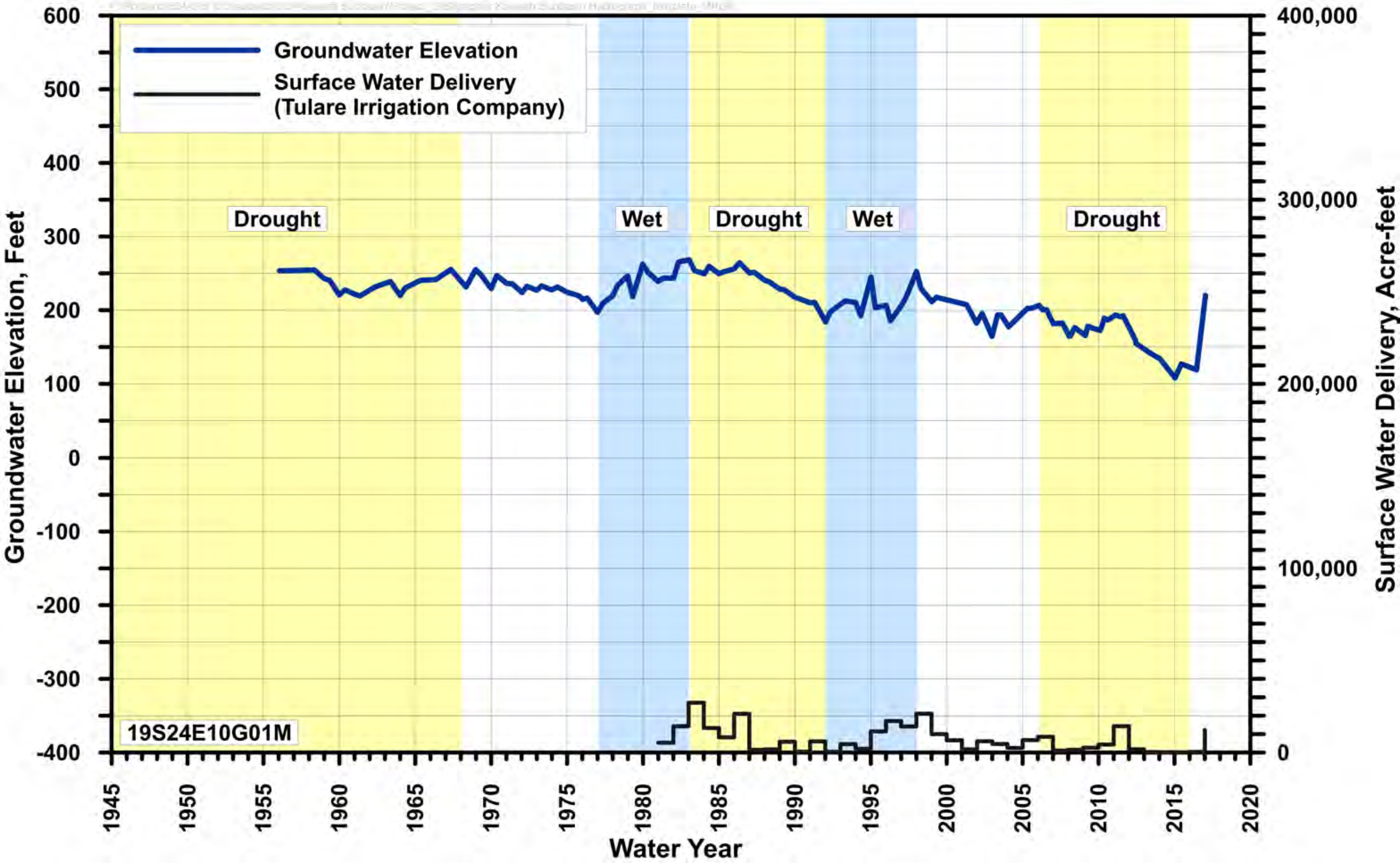
2020



Groundwater Elevation
Surface Water Delivery
(Tulare Irrigation Company)
Drought
Wet
Drought
Wet
Drought
19S24E10G01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
600
500
400
300
200
100
0
-100
-200
-300
-400
400,000
300,000
200,000
100,000
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1945
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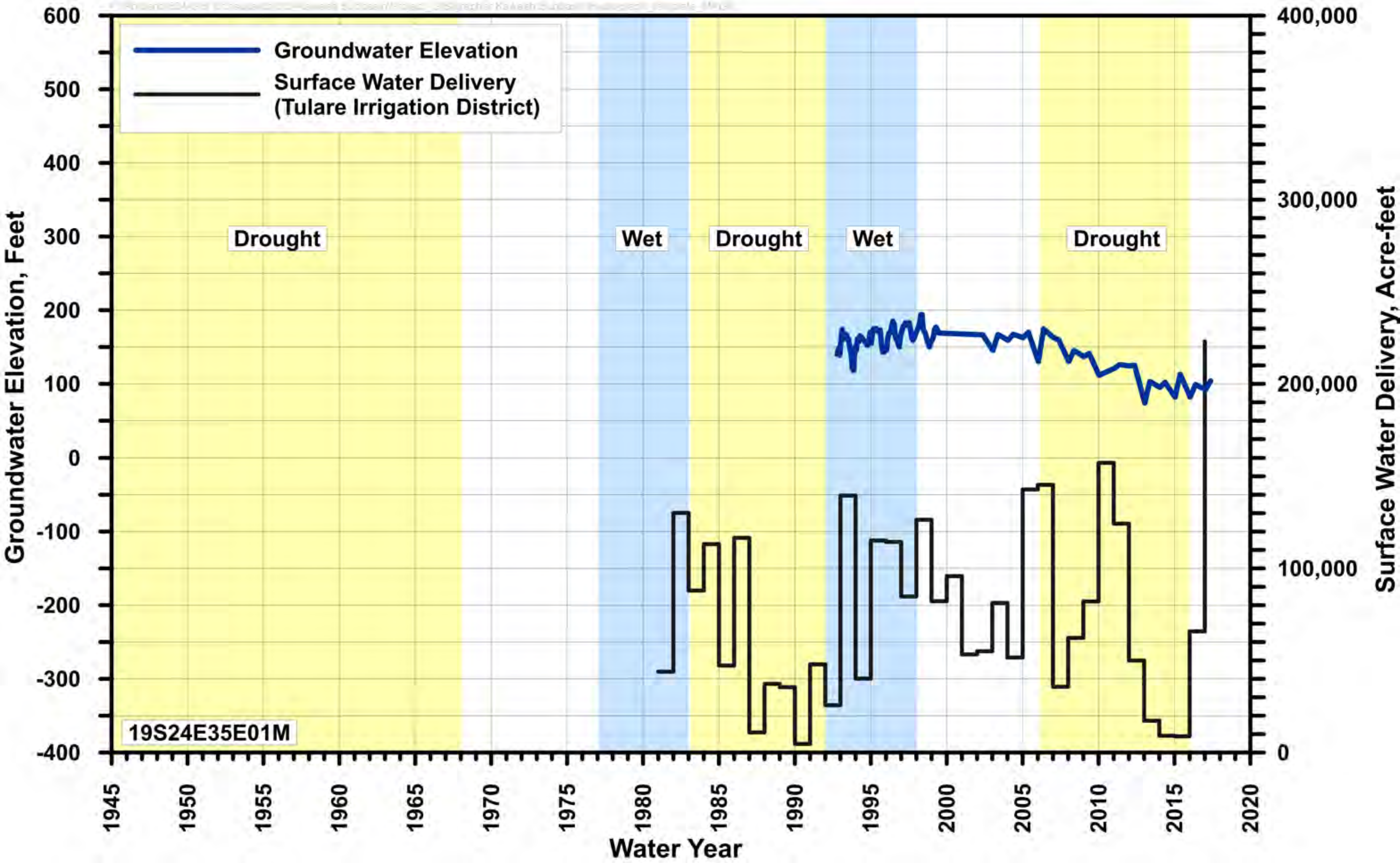
2020


Groundwater Elevation
Surface Water Delivery
(Tulare Irrigation District)
Drought
Wet
Drought
Wet
Drought
19S24E35E01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
600
500
400
300
200
100
0
-100
-200
-300
-400
400,000
300,000
200,000
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1945
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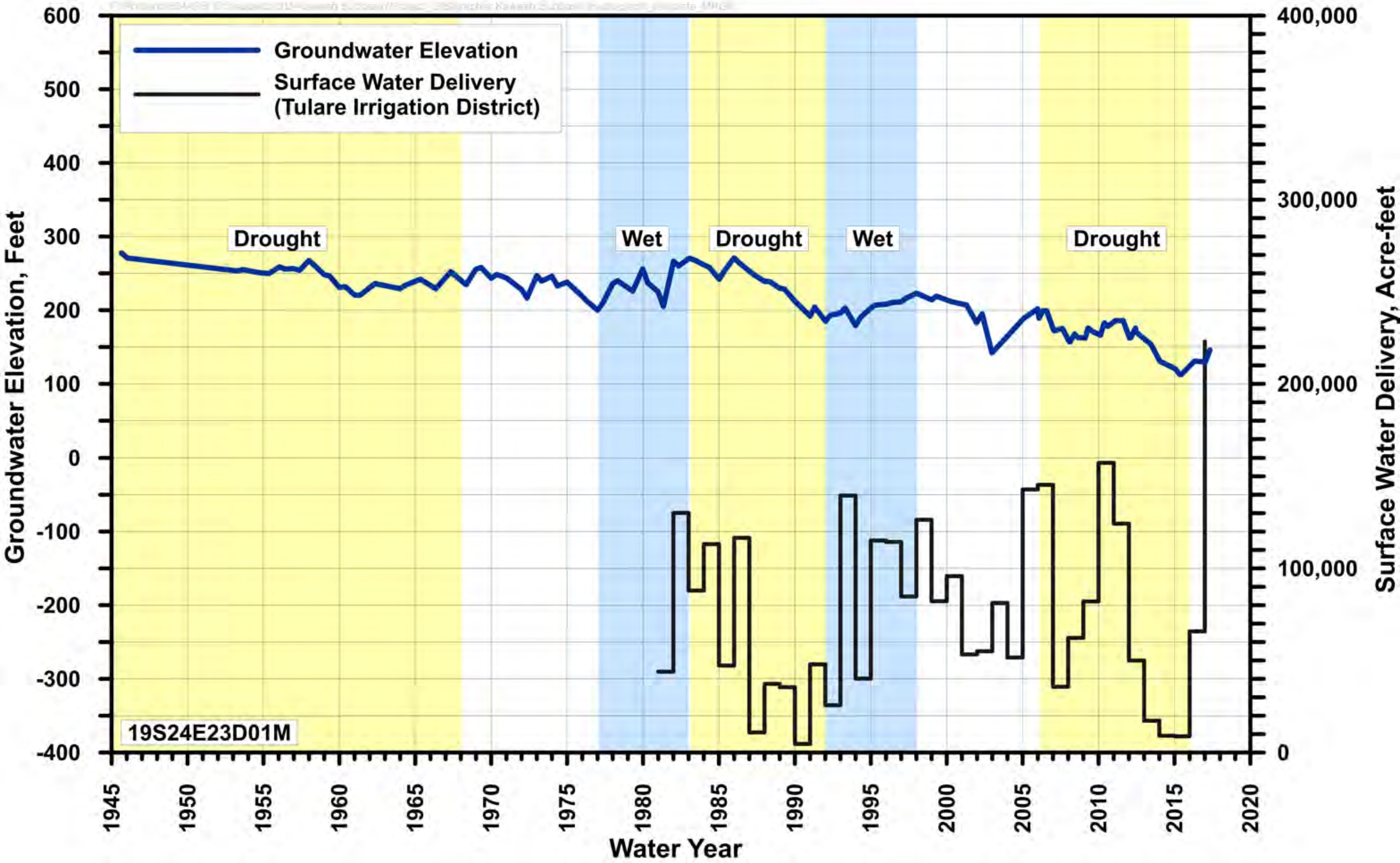
2020



Groundwater Elevation
Surface Water Delivery
(Tulare Irrigation District)
Drought
Wet
Drought
Wet
Drought
19S24E23D01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
600
500
400
300
200
100
0
-100
-200
-300
-400
400,000
300,000
200,000
100,000
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1945
1950
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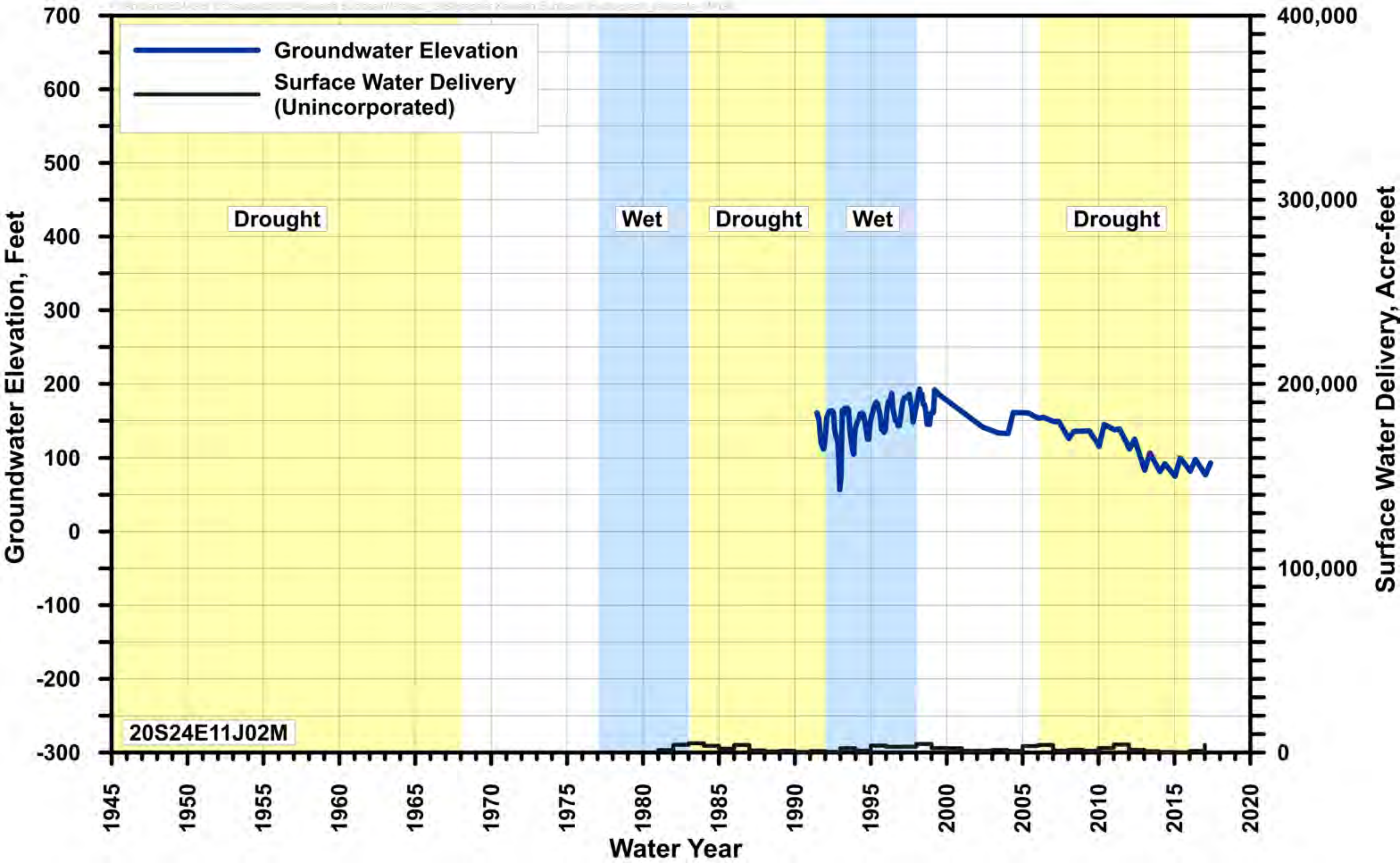
2020



Groundwater Elevation
Surface Water Delivery (Unincorporated)
Drought
Wet
Drought
Wet
Drought
20S24E11J02M
700
600
500
400
300
200
100
0
-100
-200
-300
Groundwater Elevation, Feet
400,000
300,000
200,000
100,000
0
Surface Water Delivery, Acre-feet
1945
1950
1955
1960
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1970
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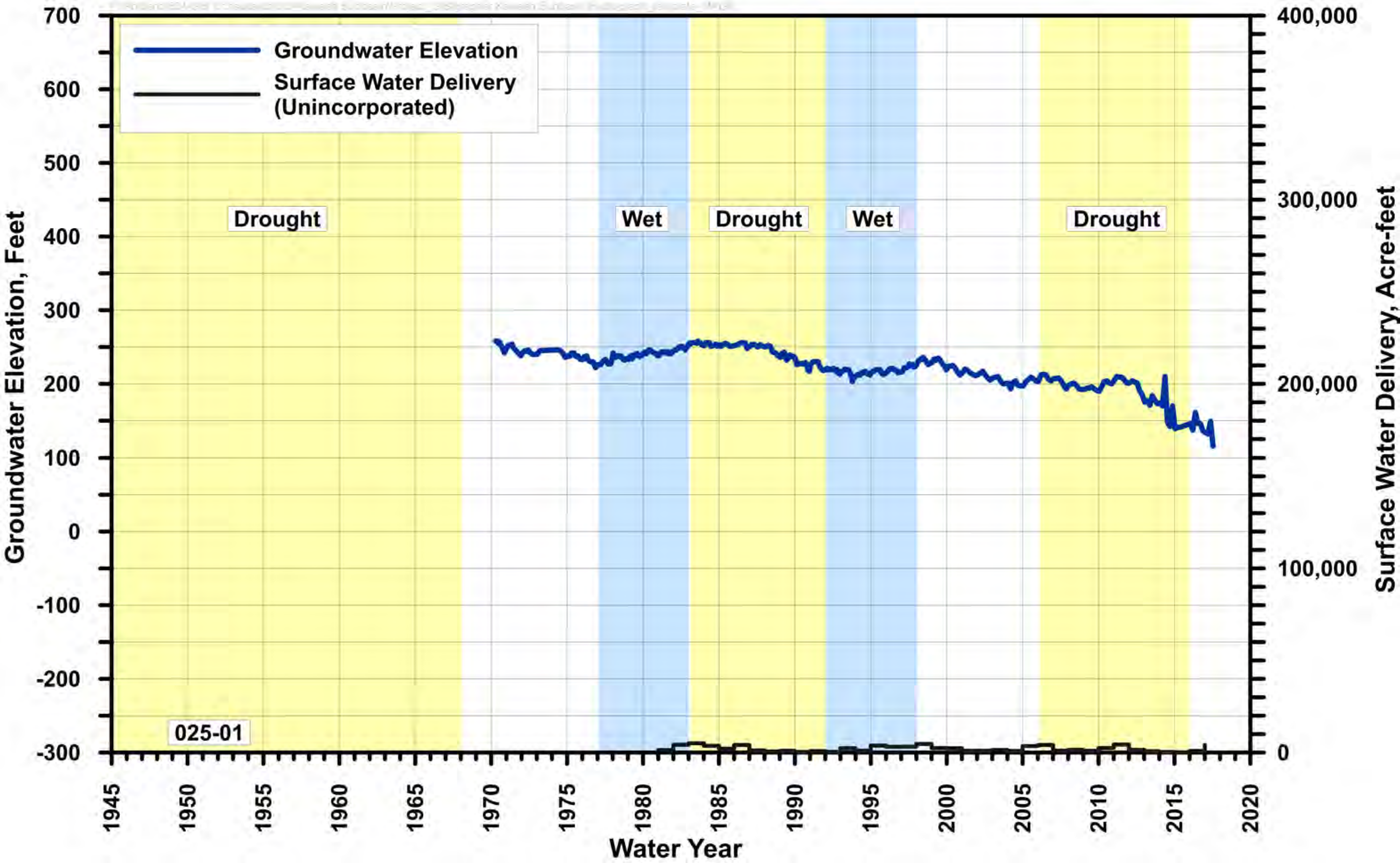
2010
2015
2020
Water Year



Groundwater Elevation
Surface Water Delivery
(Unincorporated)
Drought
Wet
Drought
Wet
Drought
025-01
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
100,000
0
1945
1950
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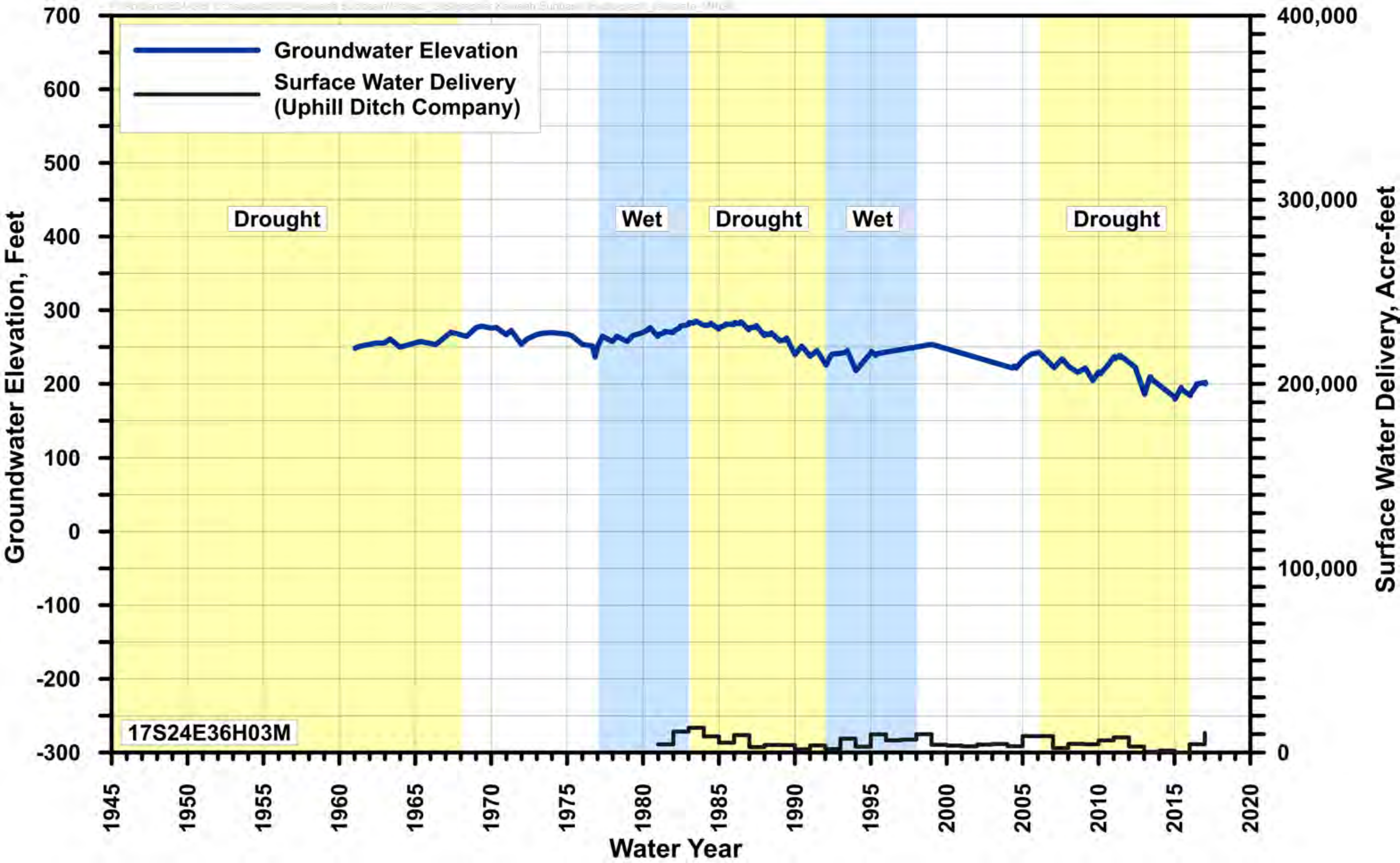
2015
2020



Groundwater Elevation
Surface Water Delivery
(Uphill Ditch Company)
Drought
Wet
Drought
Wet
Drought
17S24E36H03M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
100,000
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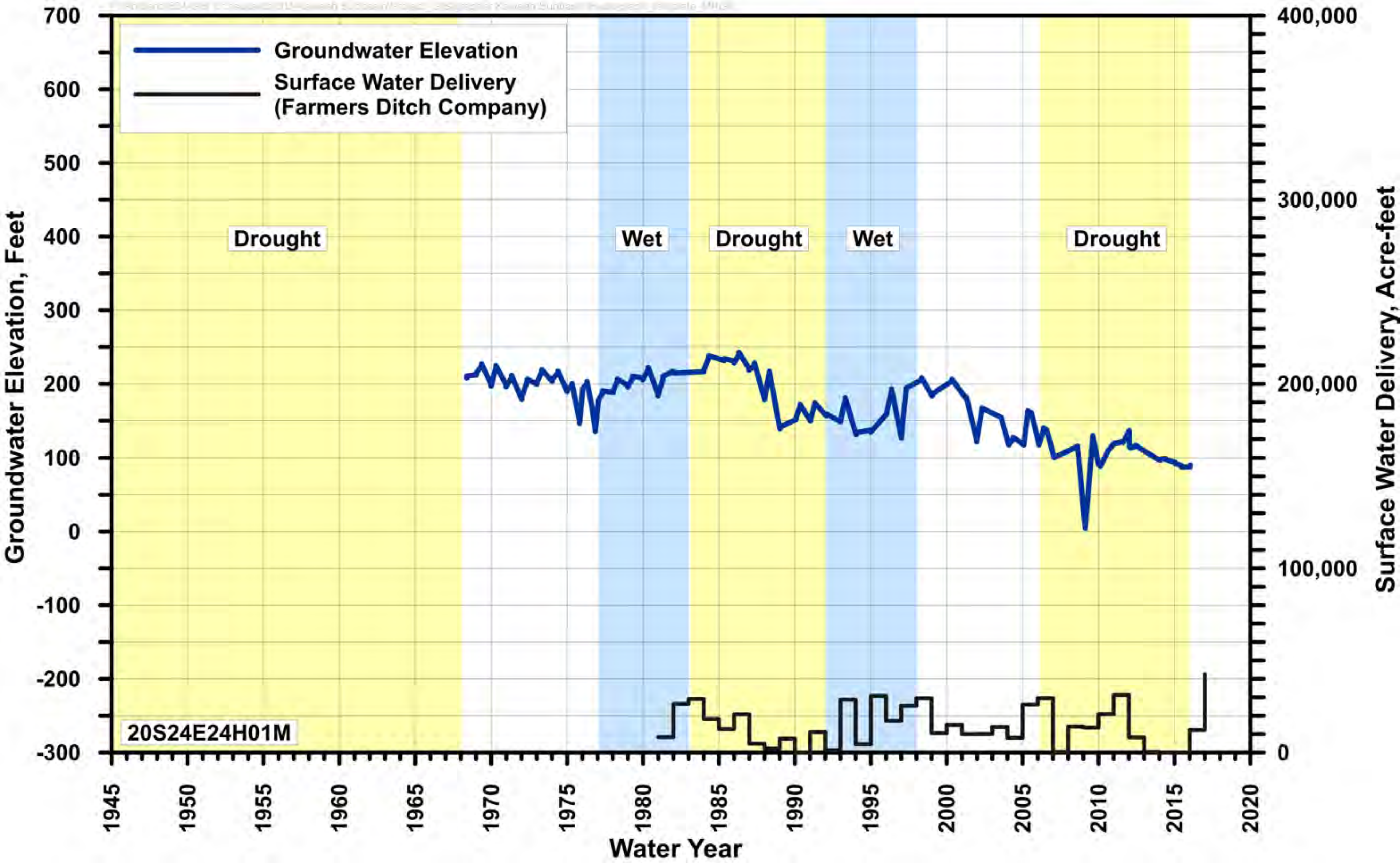
2010
2015
2020



Groundwater Elevation
Surface Water Delivery
(Farmers Ditch Company)
Drought
Wet
Drought
Wet
Drought
20S24E24H01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
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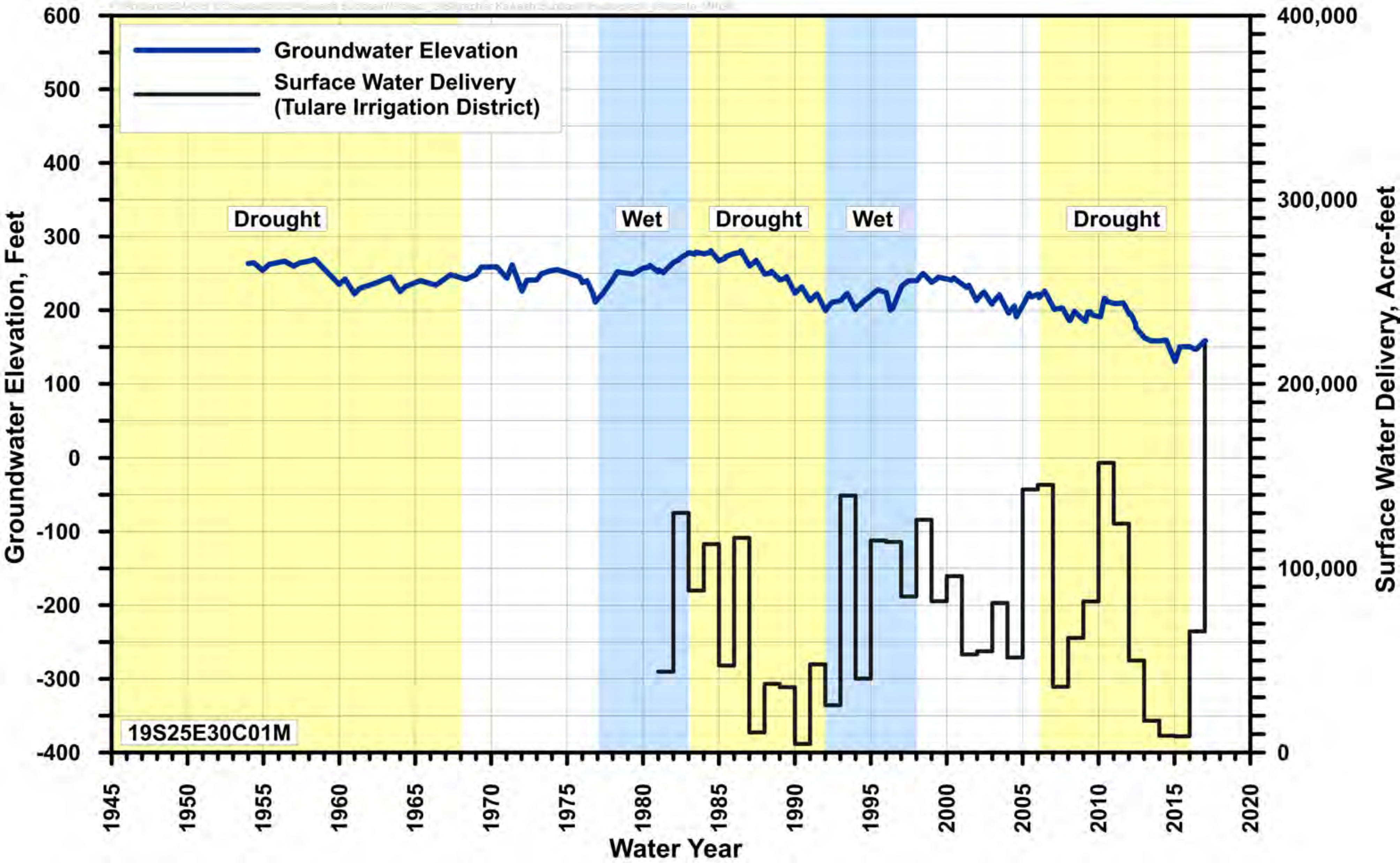
2020



Groundwater Elevation
Surface Water Delivery
(Tulare Irrigation District)
Drought
Wet
Drought
Wet
Drought
19S25E30C01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
600
500
400
300
200
100
0
-100
-200
-300
-400
400,000
300,000
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1945
1950
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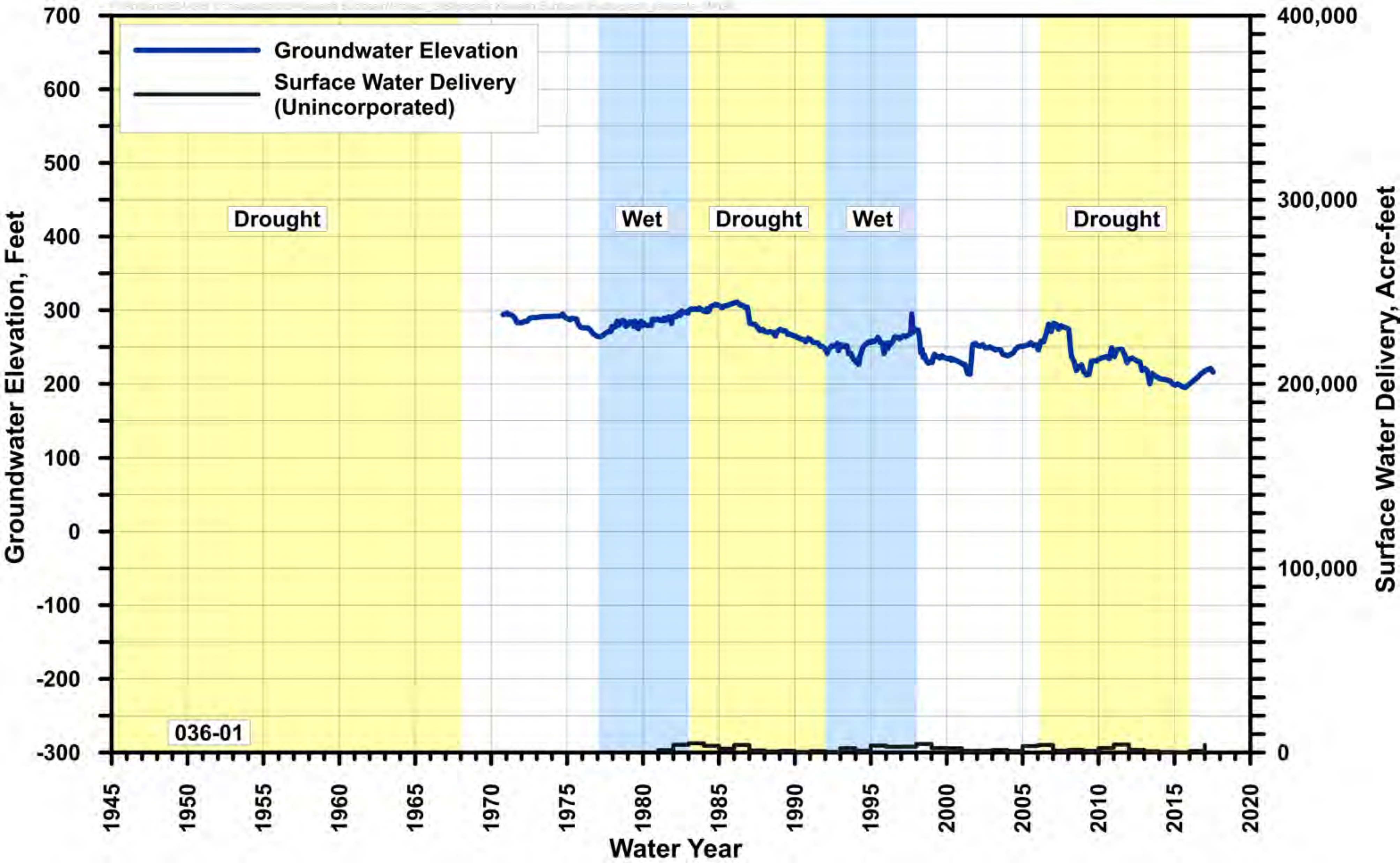
2020



Groundwater Elevation
Surface Water Delivery (Unincorporated)
Drought
Wet
Drought
Wet
Drought
036-01
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
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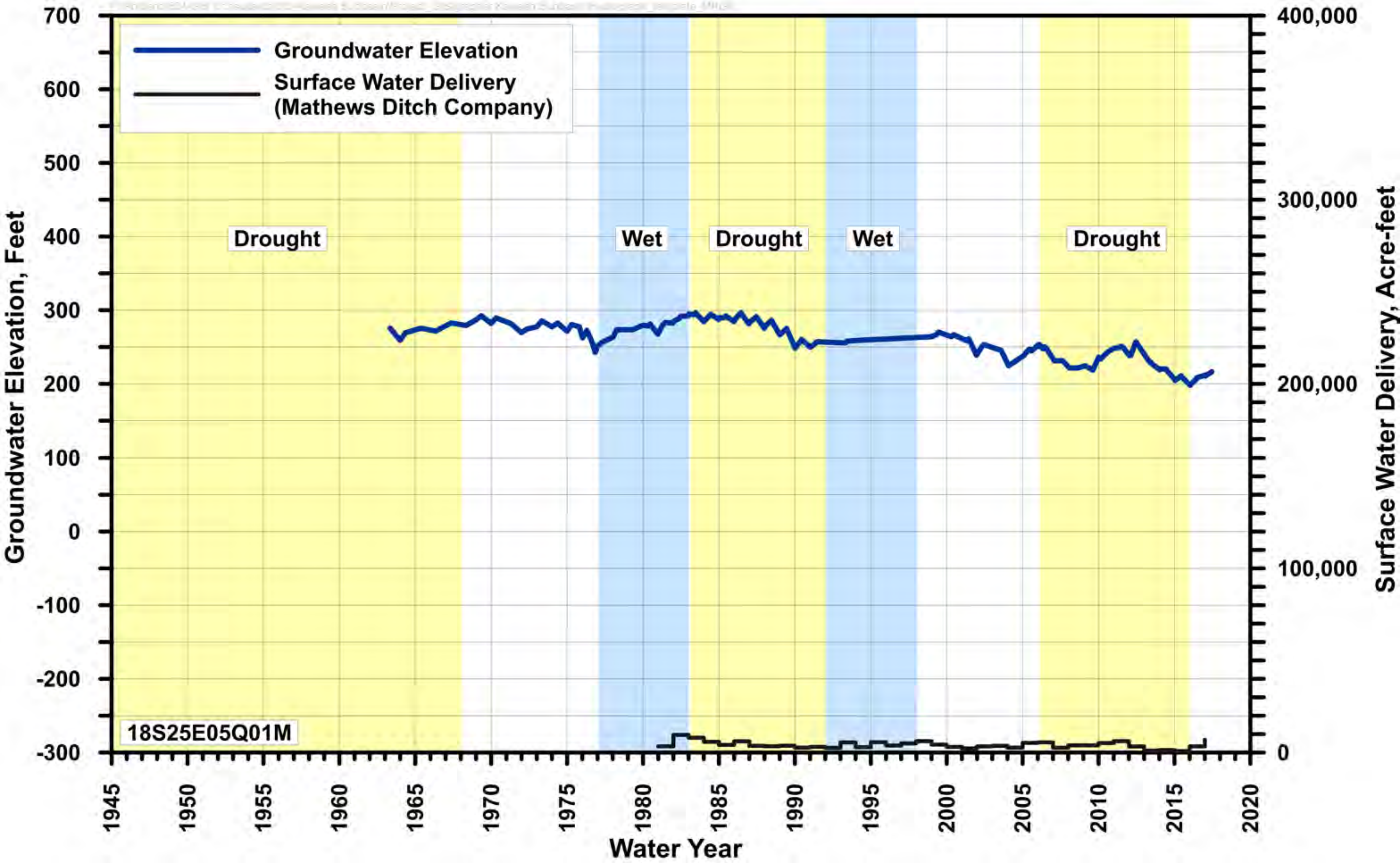
2020



Groundwater Elevation
Surface Water Delivery
(Mathews Ditch Company)
Drought
Wet
Drought
Wet
Drought
18S25E05Q01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
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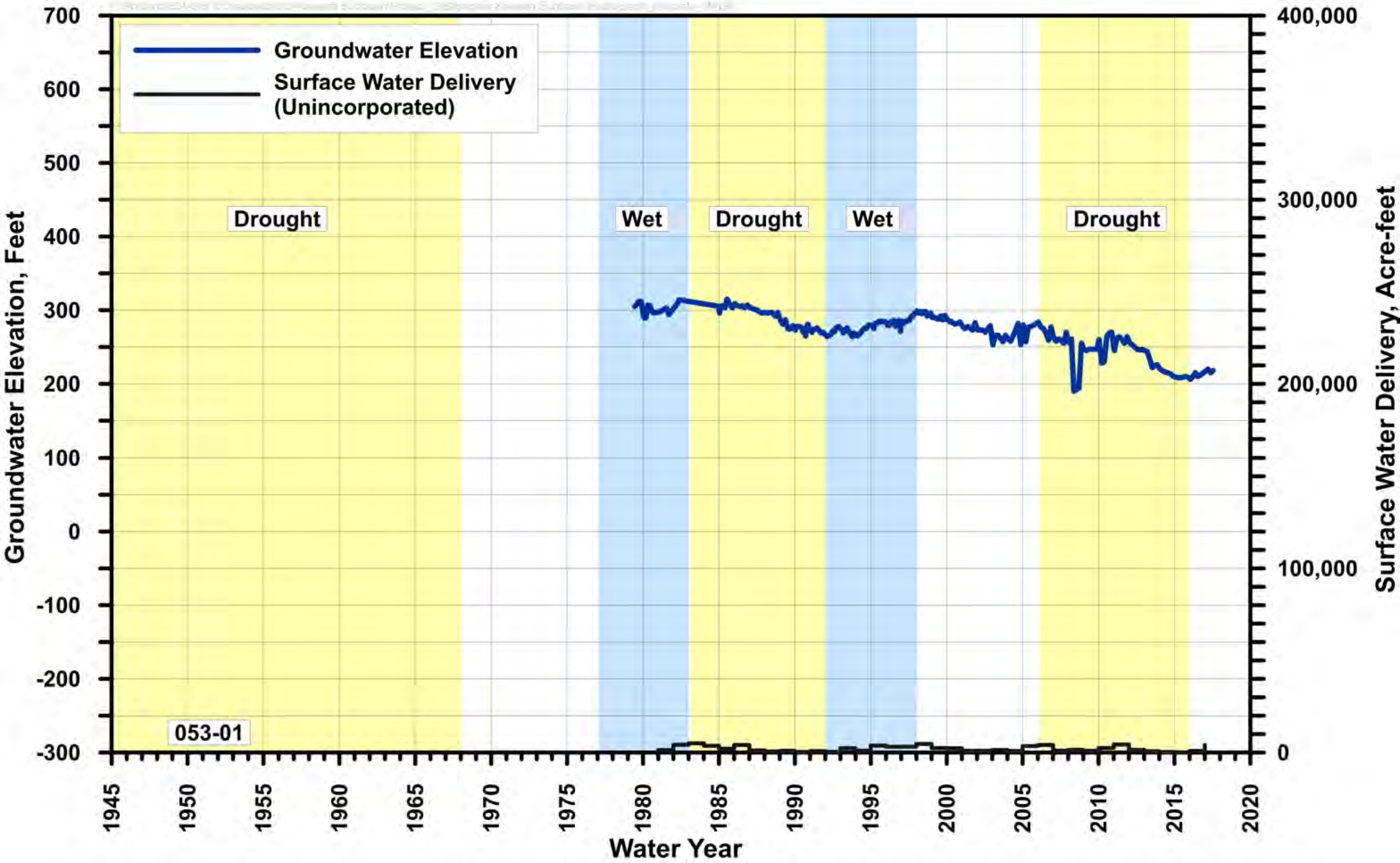
2015
2020



Groundwater Elevation
Surface Water Delivery (Unincorporated)
Drought
Wet
Drought
Wet
Drought
053-01
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
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1950
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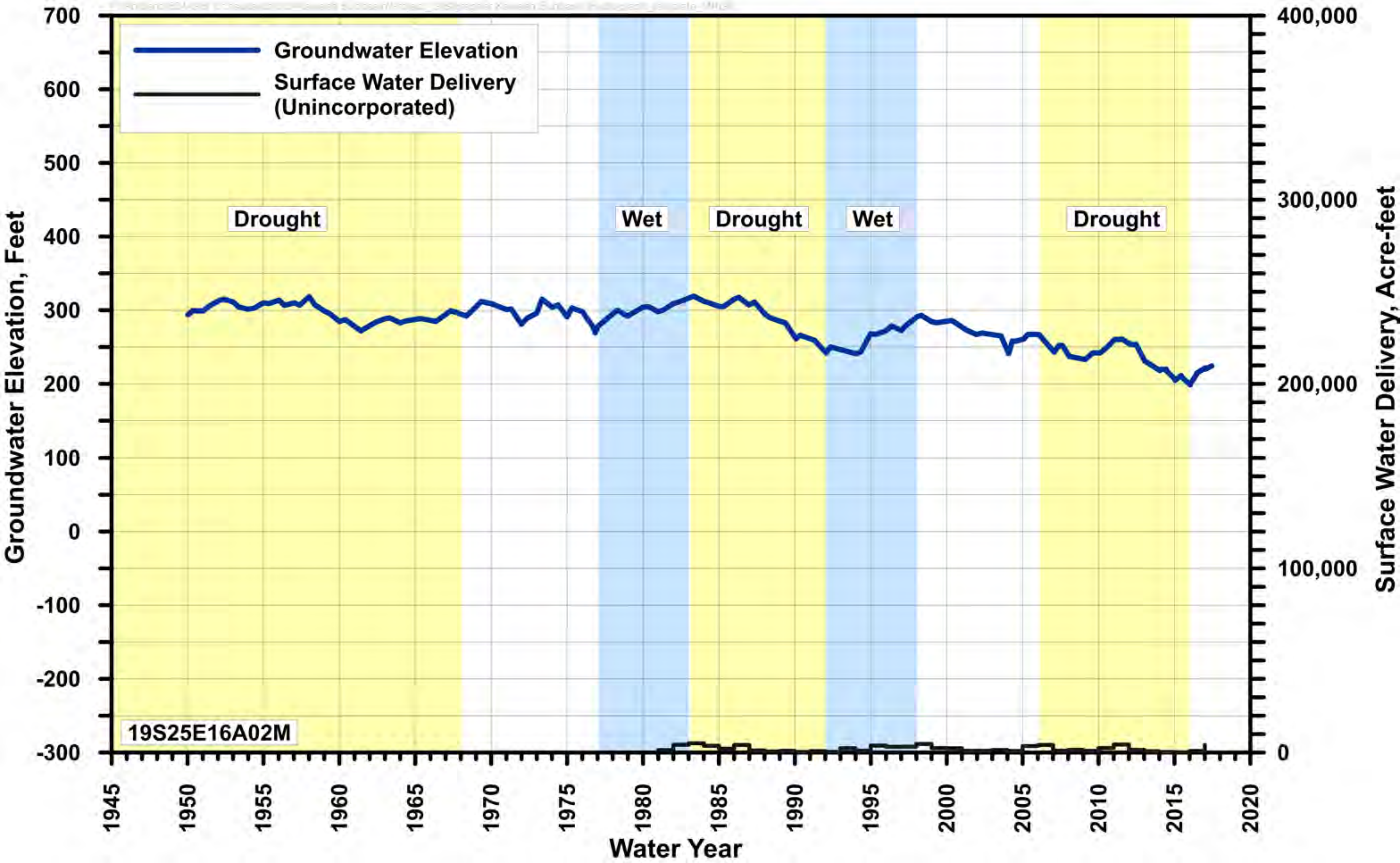
2020



Groundwater Elevation
Surface Water Delivery (Unincorporated)
Drought
Wet
Drought
Wet
Drought
19S25E16A02M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
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1945
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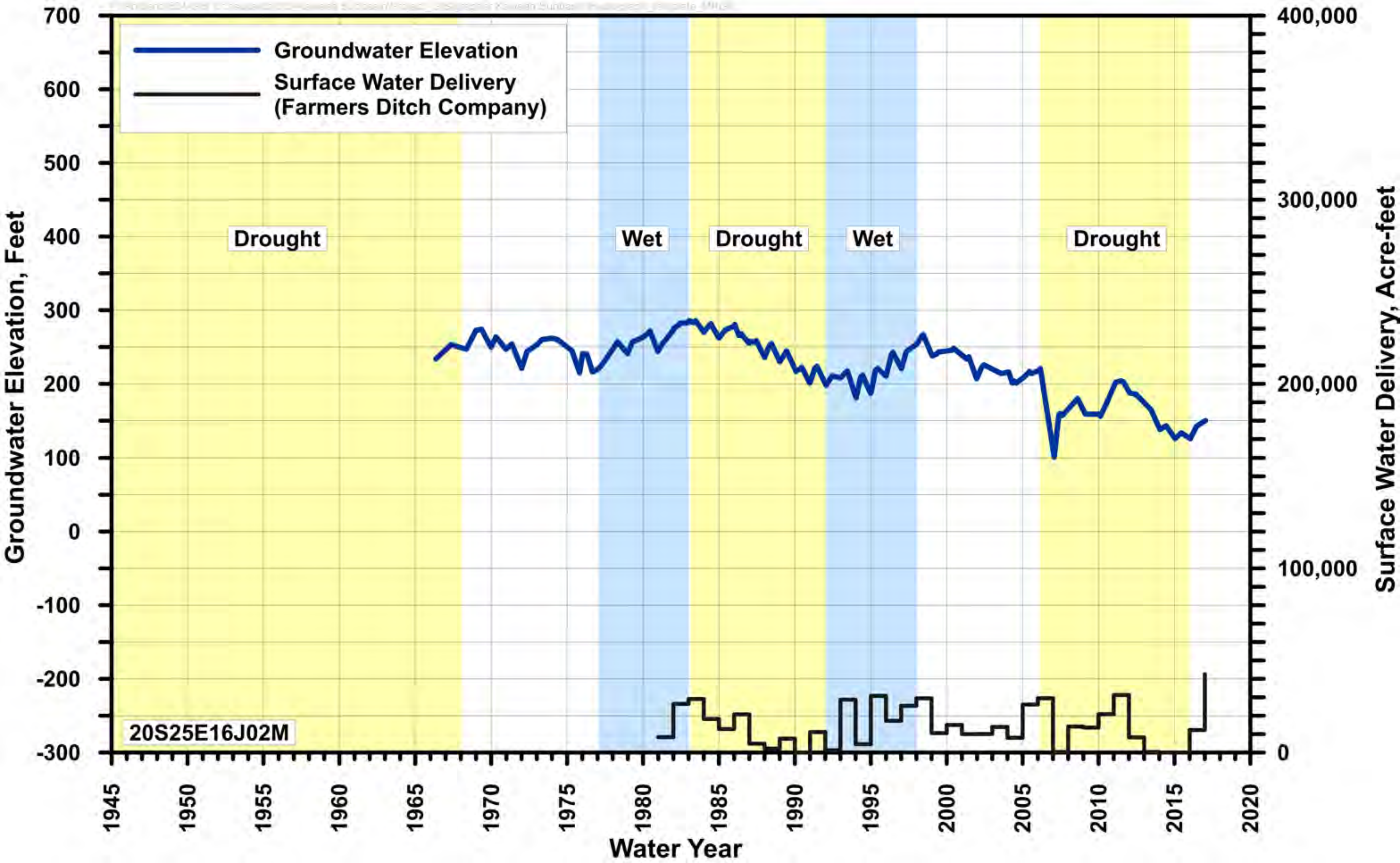

Groundwater Elevation
Surface Water Delivery
(Farmers Ditch Company)
Drought
Wet
Drought
Wet
Drought
20S25E16J02M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
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1945
1950
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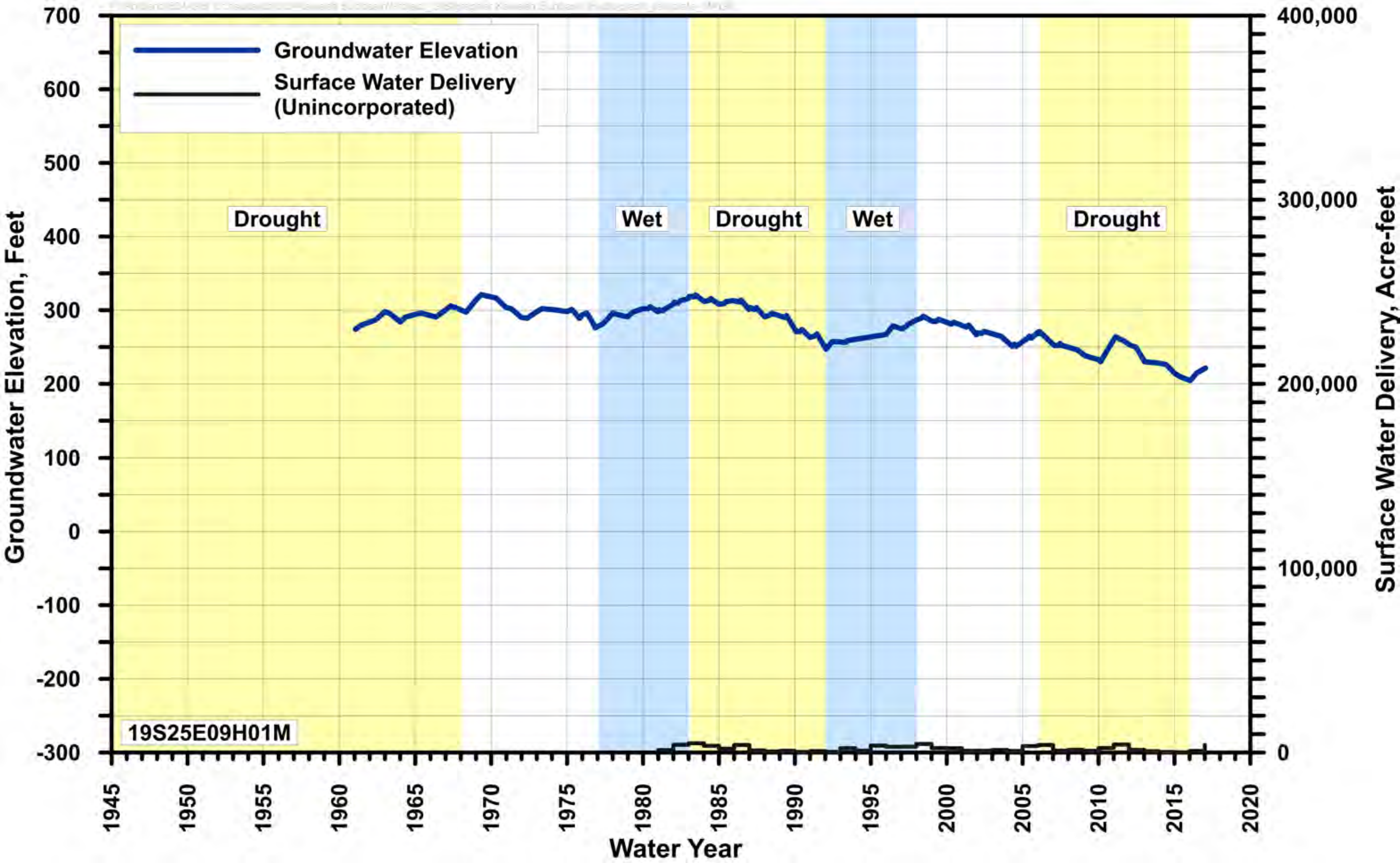
2020



Groundwater Elevation
Surface Water Delivery
(Unincorporated)
Drought
Wet
Drought
Wet
Drought
19S25E09H01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
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1945
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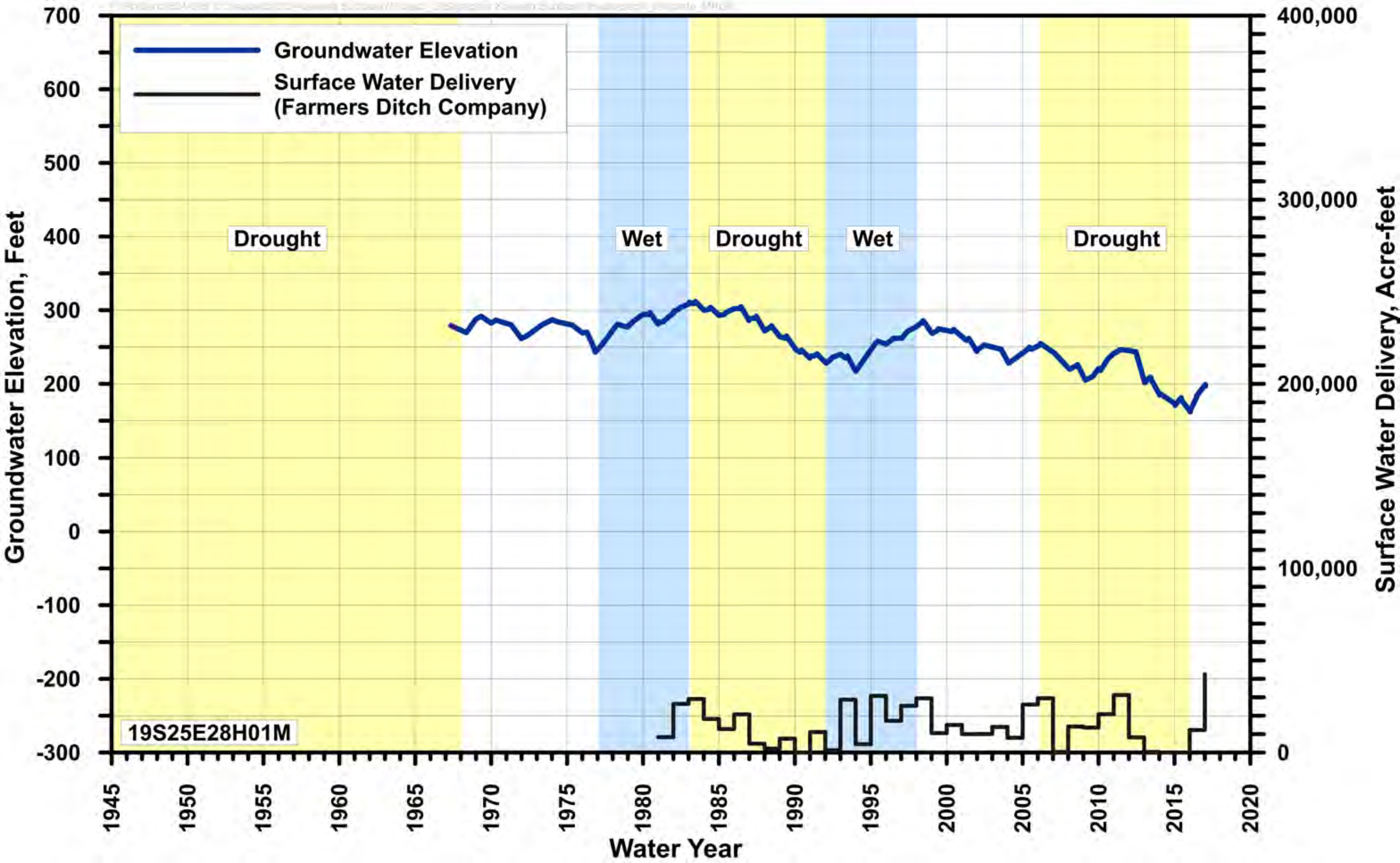
2010
2015
2020



Groundwater Elevation
Surface Water Delivery
(Farmers Ditch Company)
Drought
Wet
Drought
Wet
Drought
19S25E28H01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
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-100
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400,000
300,000
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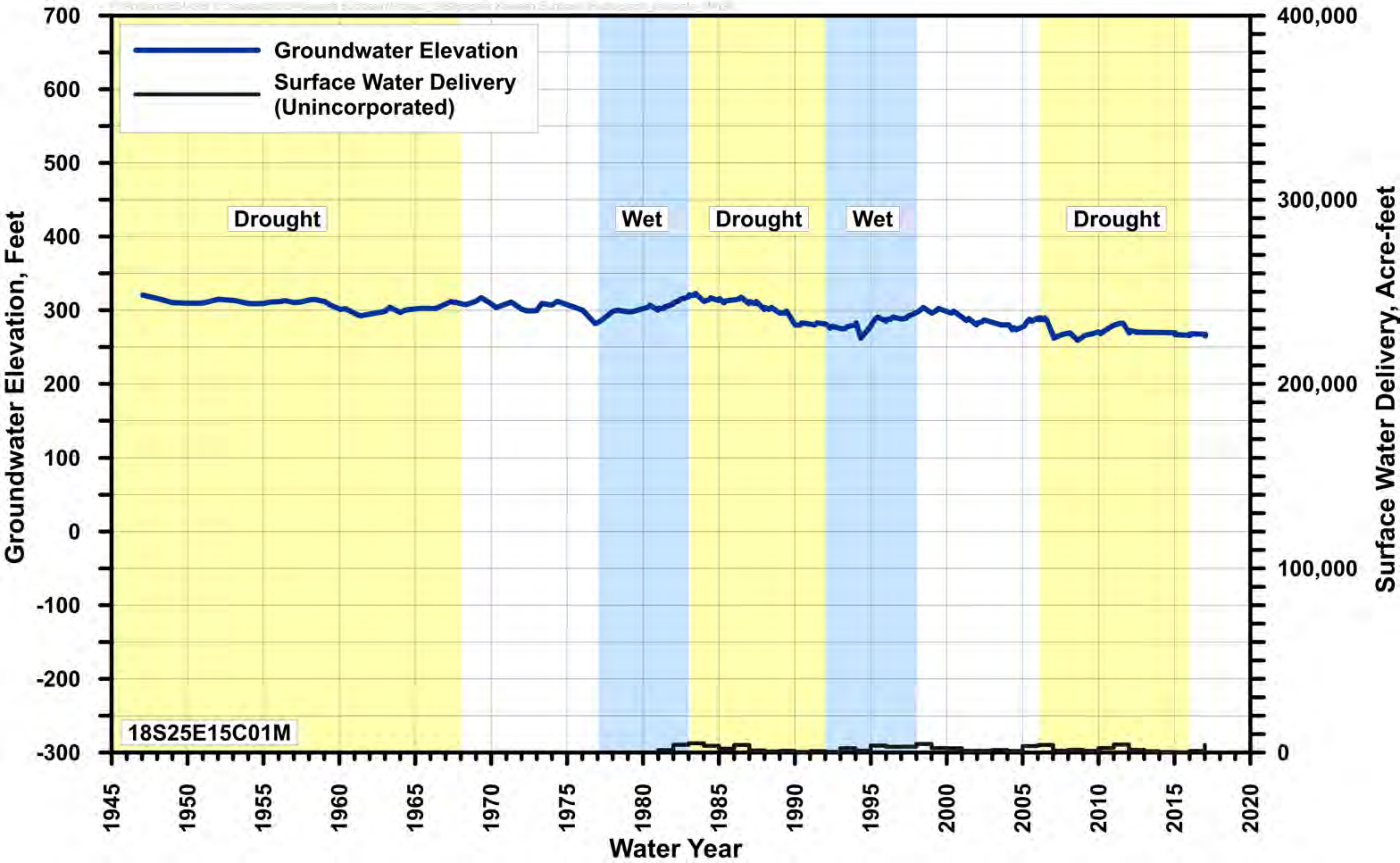
2015
2020



Groundwater Elevation
Surface Water Delivery
(Unincorporated)
Drought
Wet
Drought
Wet
Drought
18S25E15C01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
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300,000
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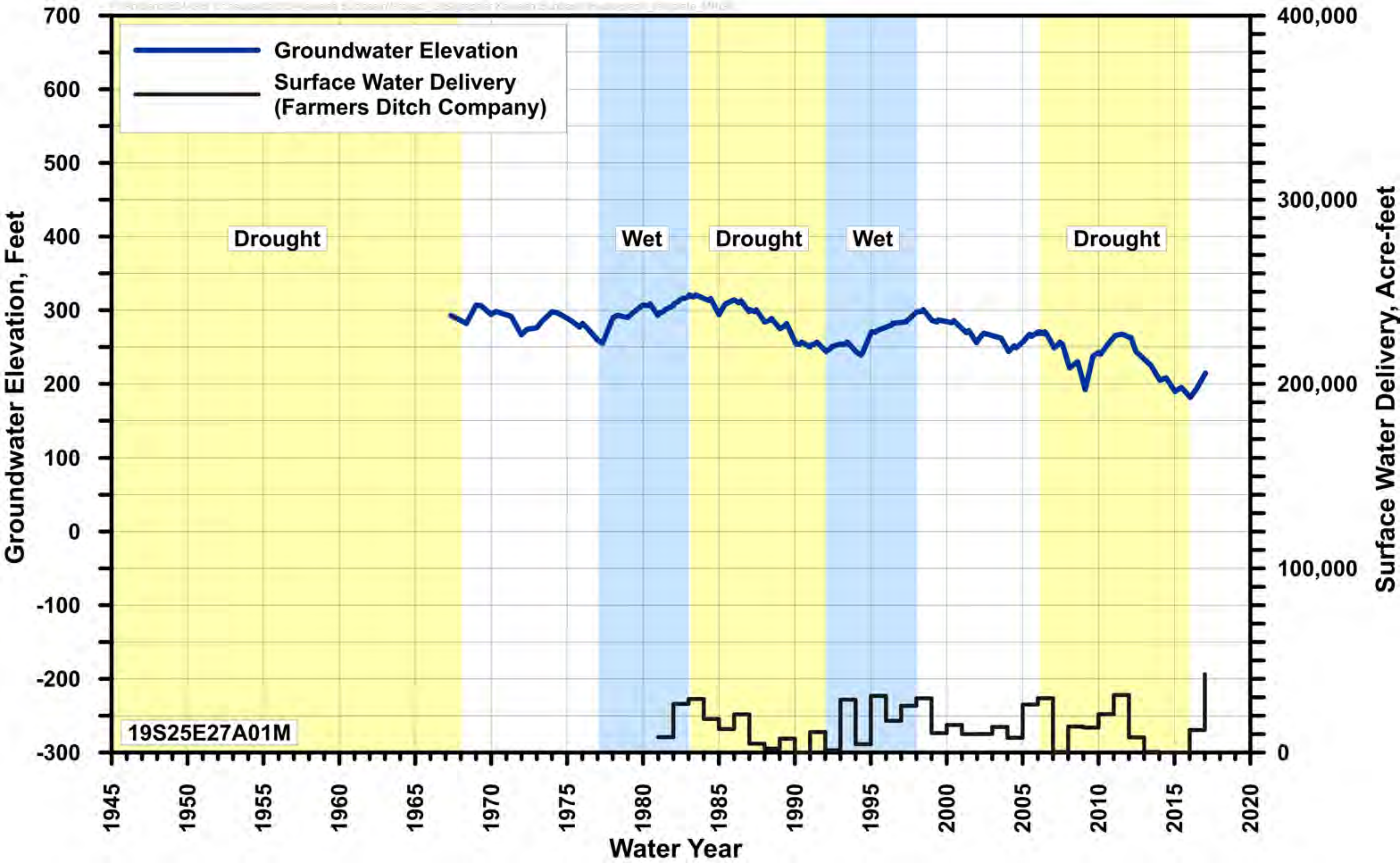
2020



Groundwater Elevation
Surface Water Delivery
(Farmers Ditch Company)
Drought
Wet
Drought
Wet
Drought
19S25E27A01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
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100,000
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1945
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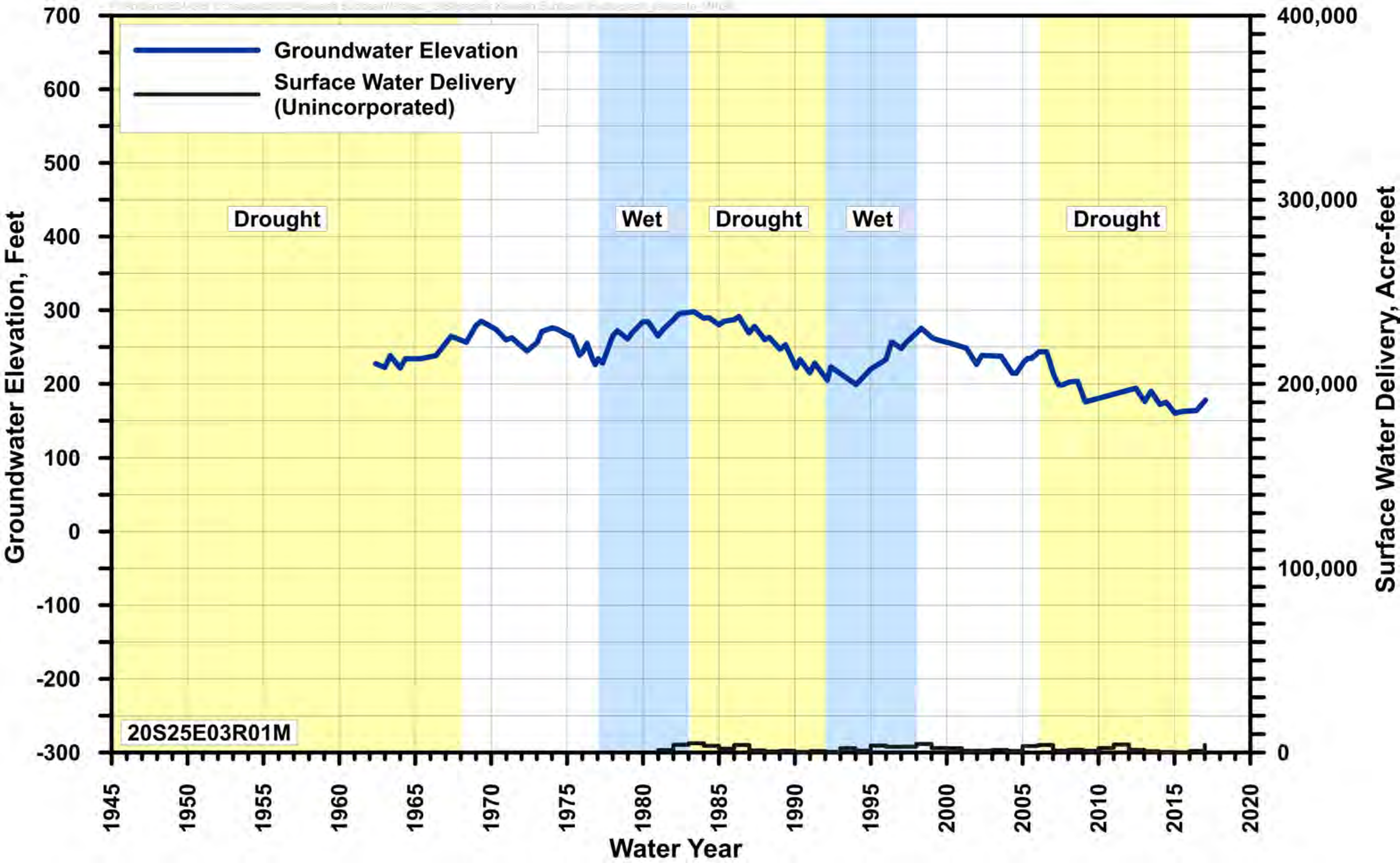
2015
2020


Groundwater Elevation
Surface Water Delivery
(Unincorporated)
Drought
Wet
Drought
Wet
Drought
20S25E03R01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
100,000
0
1945
1950
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1990
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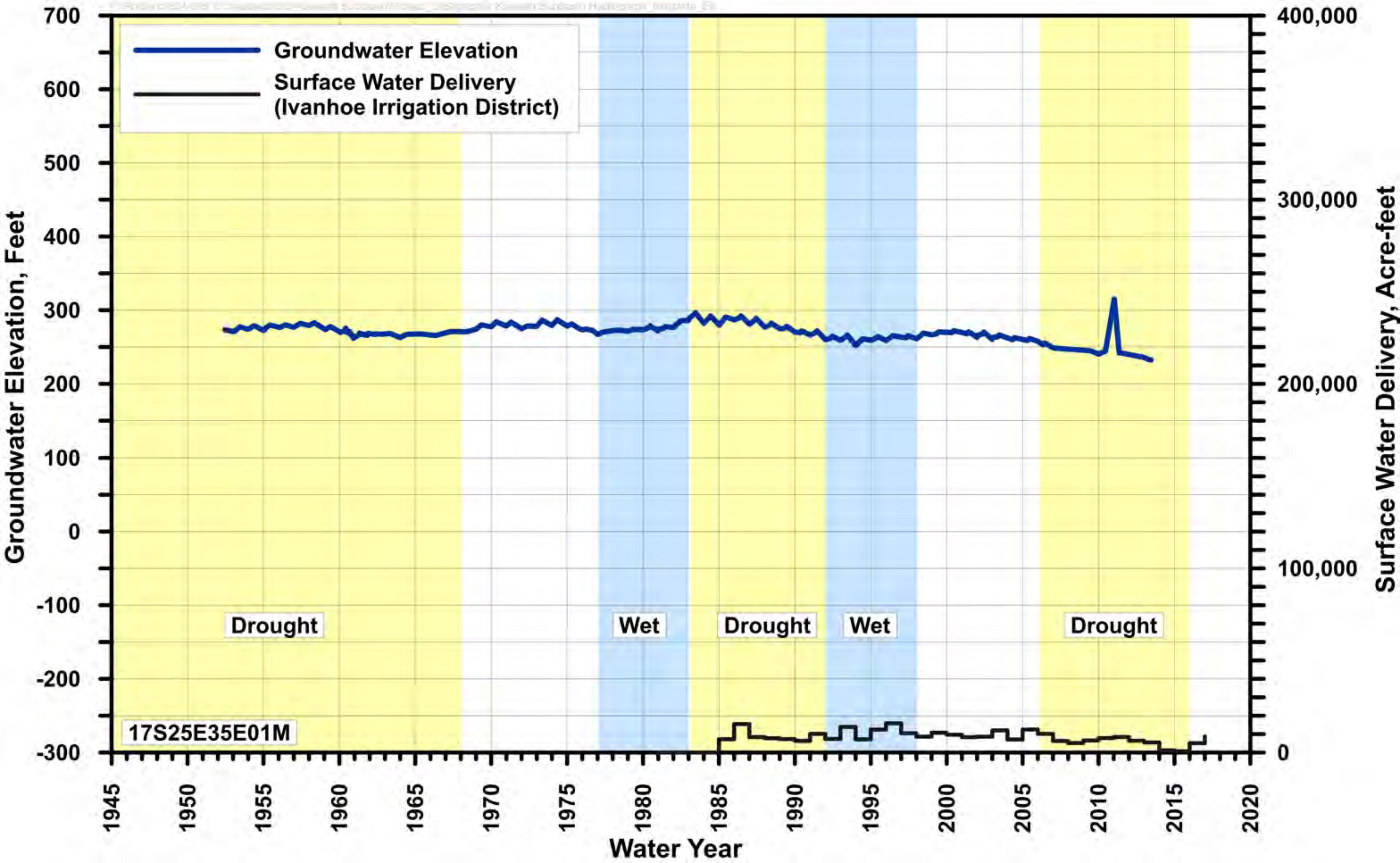
2020



Groundwater Elevation
Surface Water Delivery
(Ivanhoe Irrigation District)
Drought
Wet
Drought
Wet
Drought
17S25E35E01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
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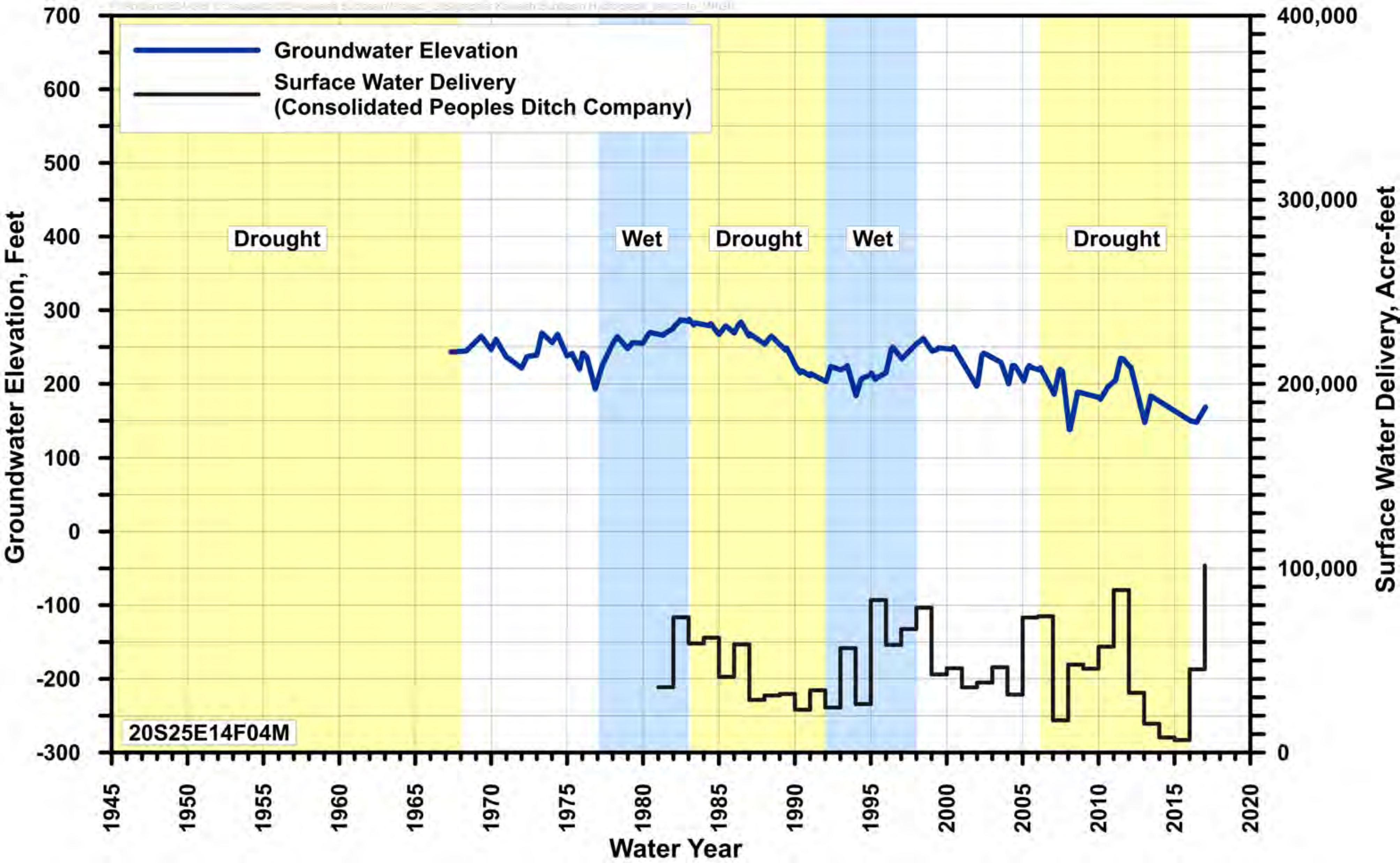

Groundwater Elevation
Surface Water Delivery
(Consolidated Peoples Ditch Company)
Drought
Wet
Drought
Wet
Drought
20S25E14F04M
Groundwater Elevation, Feet
700
600
500
400
300
200
100
0
-100
-200
-300
Surface Water Delivery, Acre-feet
400,000
300,000
200,000
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Water Year
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1950
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1970
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1980
1985
1990
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2015
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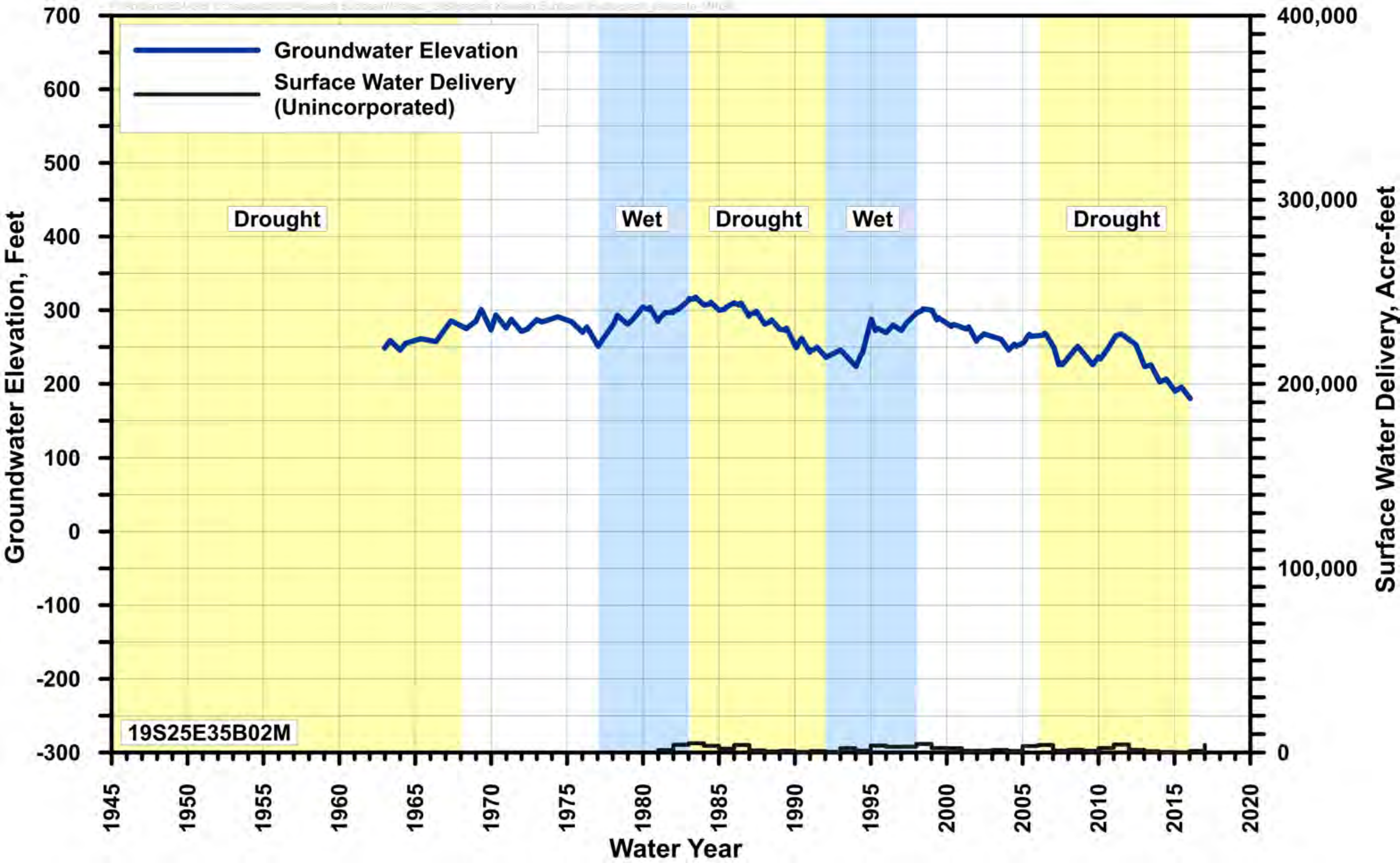

Groundwater Elevation
Surface Water Delivery (Unincorporated)
Drought
Wet
Drought
Wet
Drought
19S25E35B02M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
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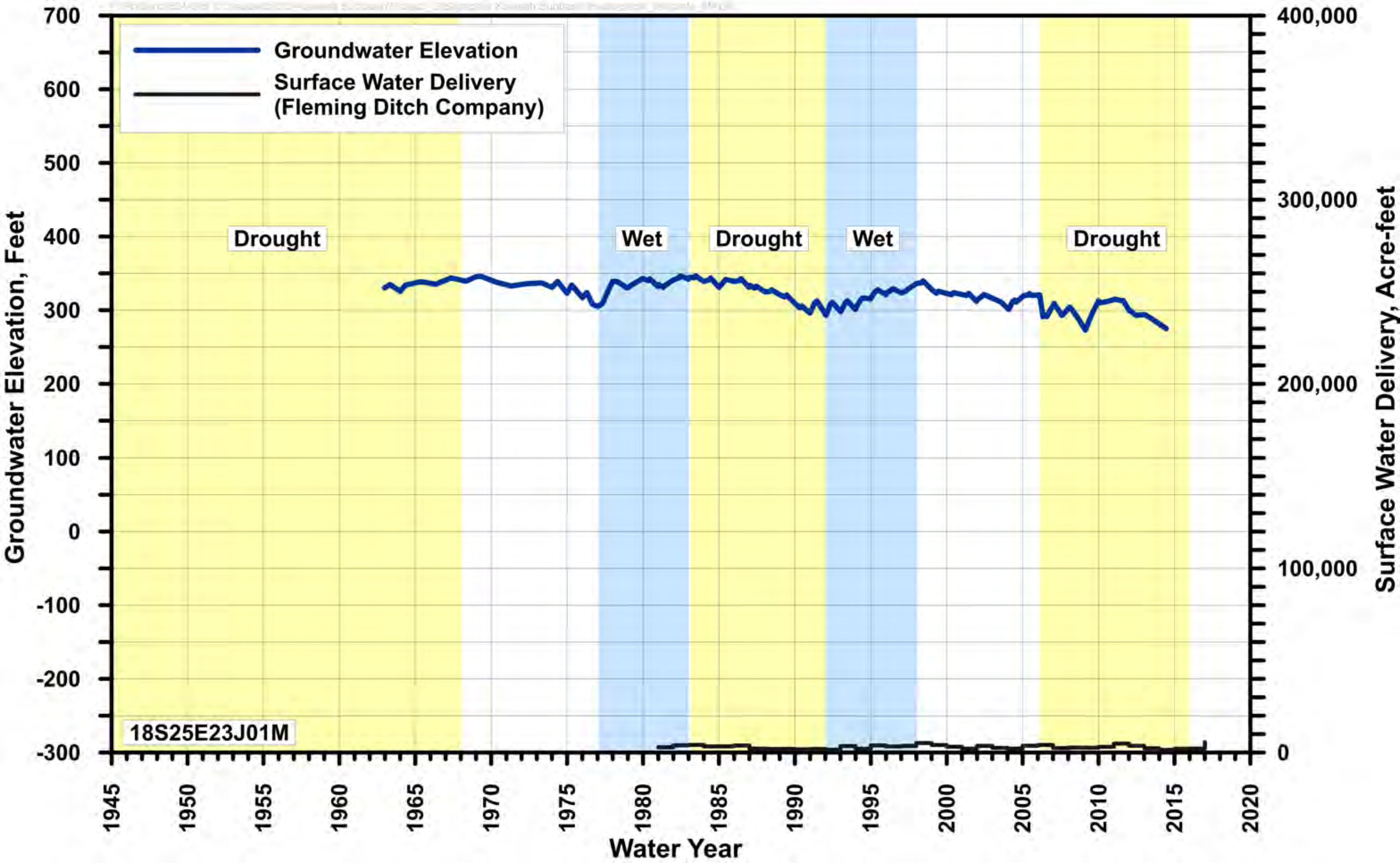

Groundwater Elevation
Surface Water Delivery
(Fleming Ditch Company)
Drought
Wet
Drought
Wet
Drought
18S25E23J01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
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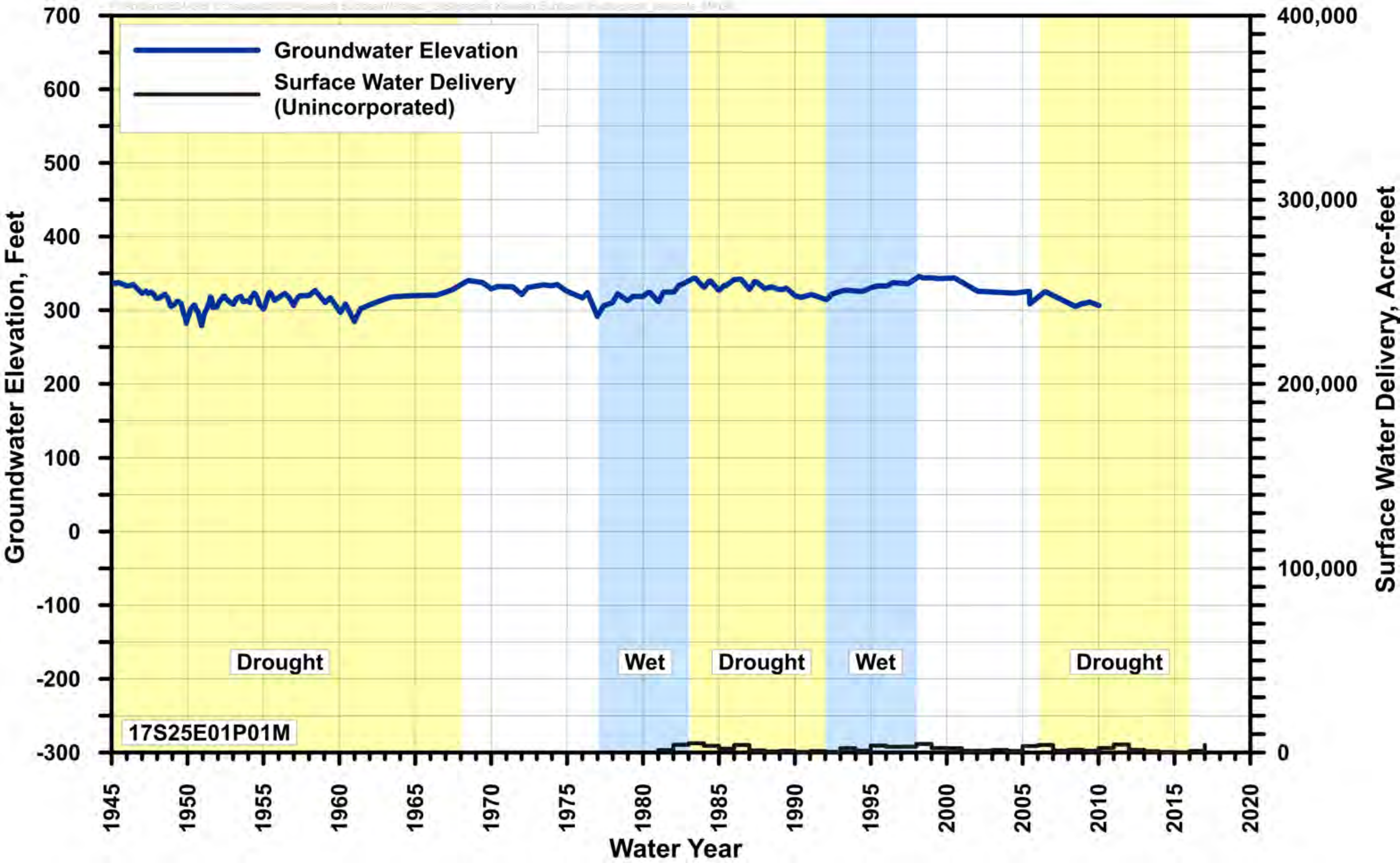

Groundwater Elevation
Surface Water Delivery (Unincorporated)
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
Drought
Wet
Drought
Wet
Drought
17S25E01P01M
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
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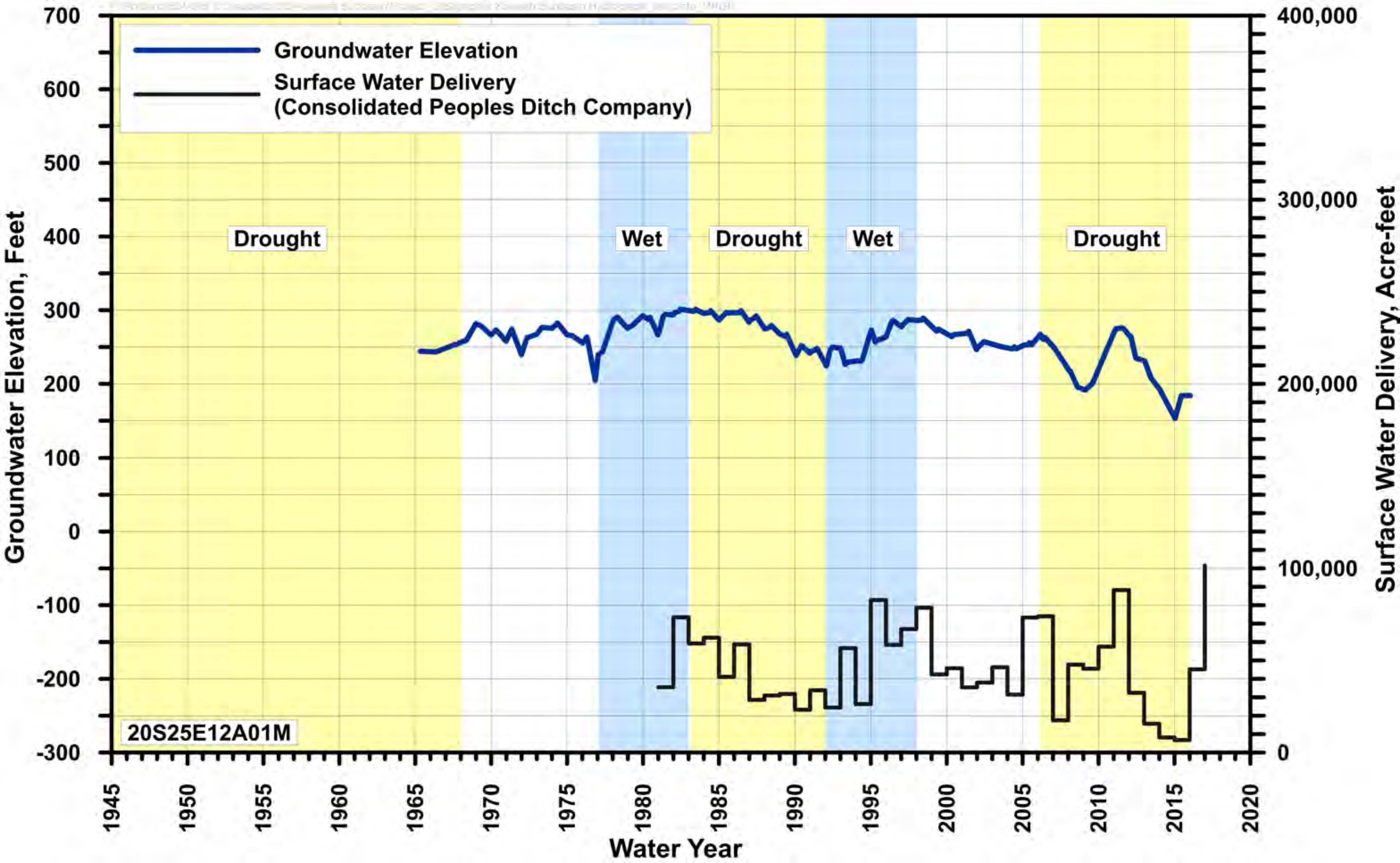

Groundwater Elevation
Surface Water Delivery
(Consolidated Peoples Ditch Company)
Drought
Wet
Drought
Wet
Drought
20S25E12A01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
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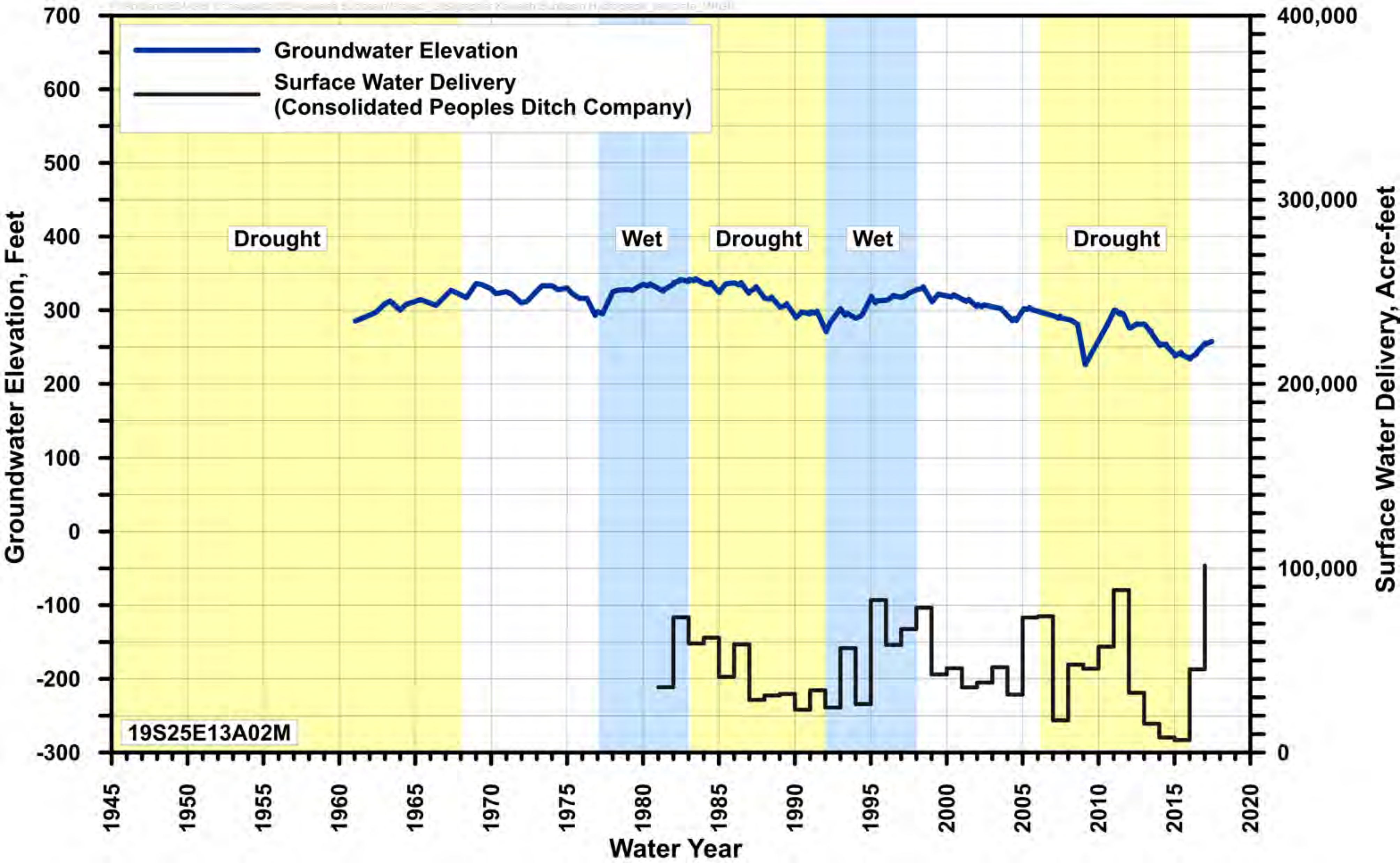

Groundwater Elevation
Surface Water Delivery
(Consolidated Peoples Ditch Company)
Drought
Wet
Drought
Wet
Drought
19S25E13A02M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
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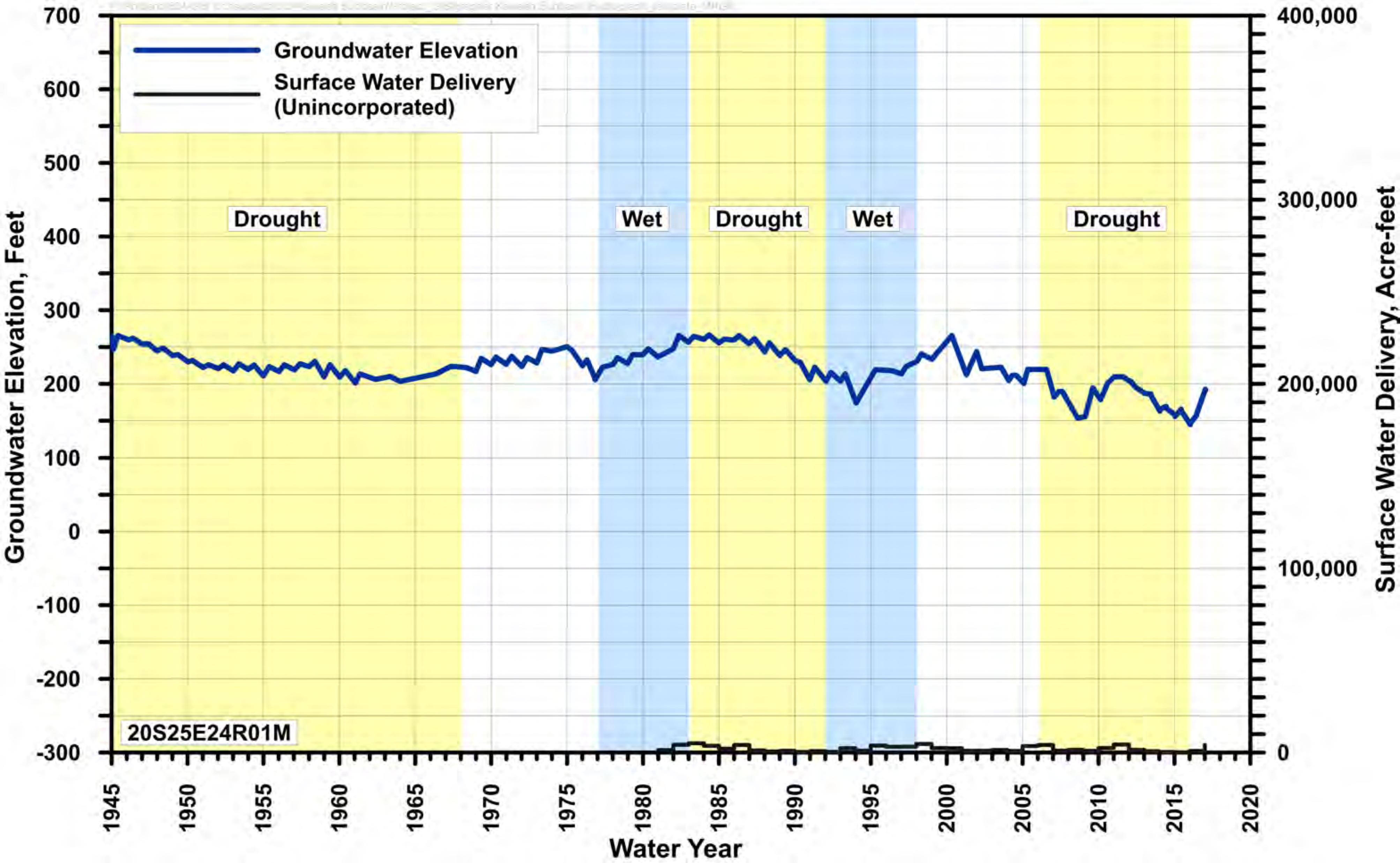
2015
2020



Groundwater Elevation
Surface Water Delivery (Unincorporated)
Drought
Wet
Drought
Wet
Drought
20S25E24R01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
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1950
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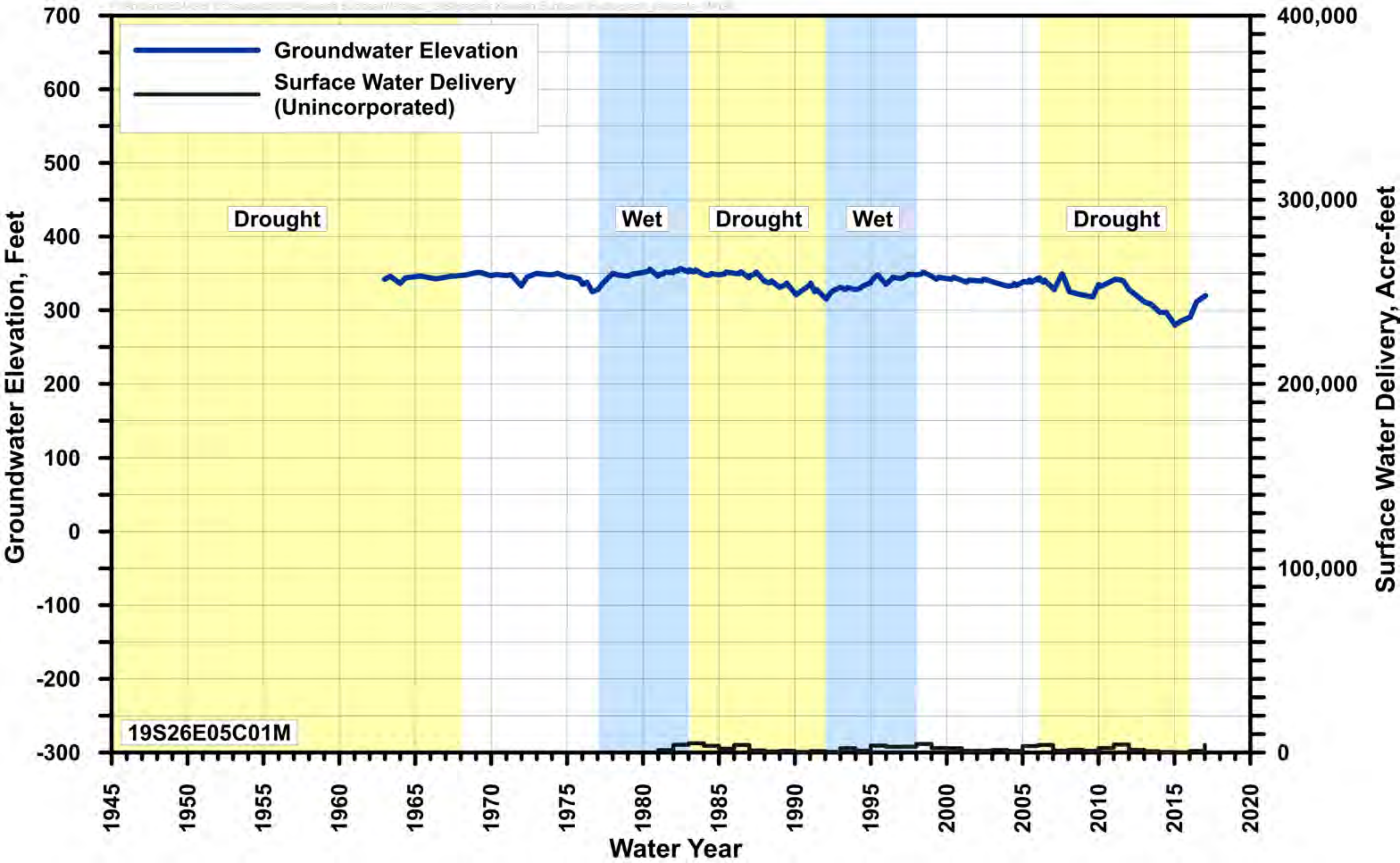
2015
2020



Groundwater Elevation
Surface Water Delivery (Unincorporated)
Drought
Wet
Drought
Wet
Drought
19S26E05C01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
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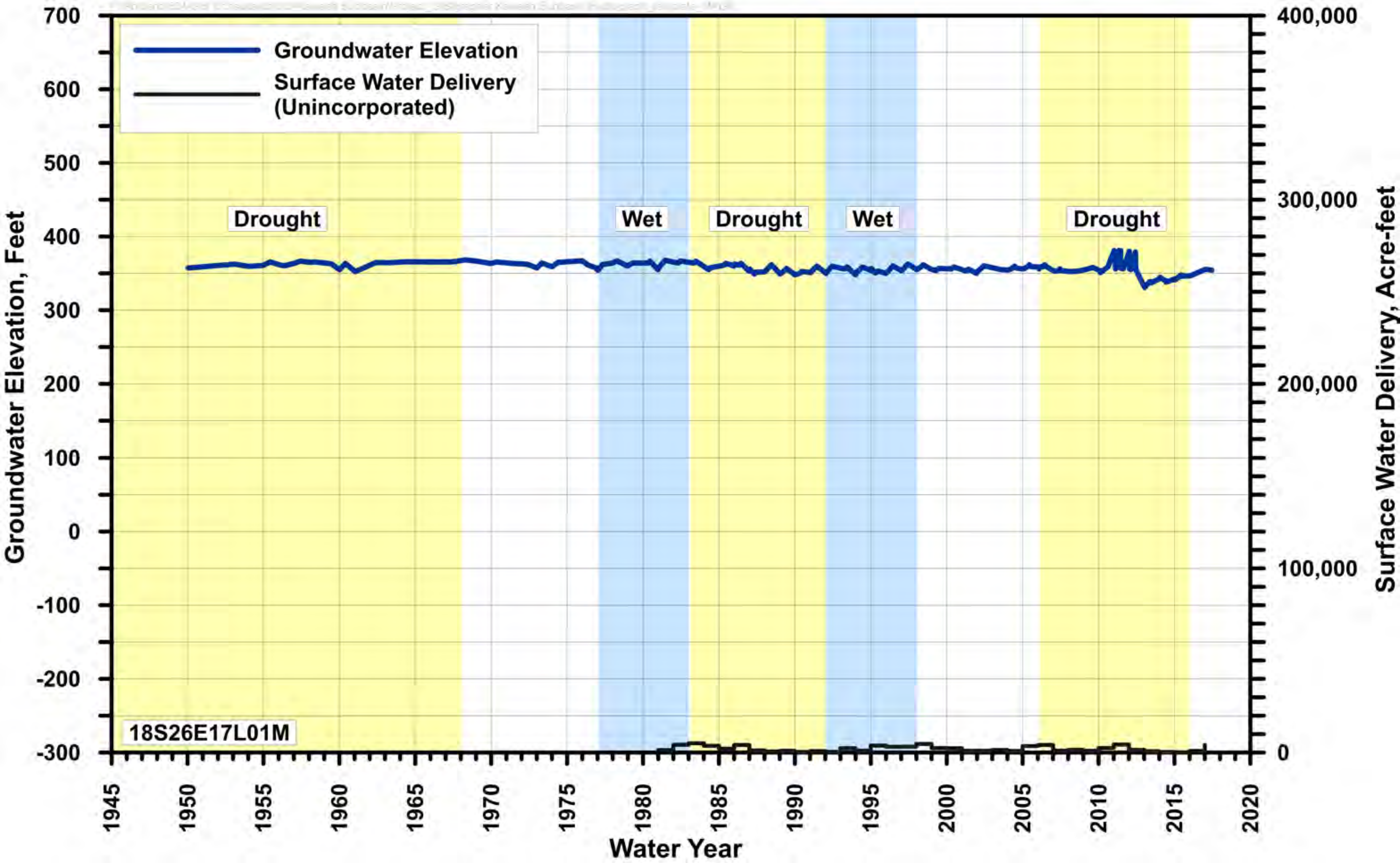
2015
2020



Groundwater Elevation
Surface Water Delivery (Unincorporated)
Drought
Wet
Drought
Wet
Drought
18S26E17L01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
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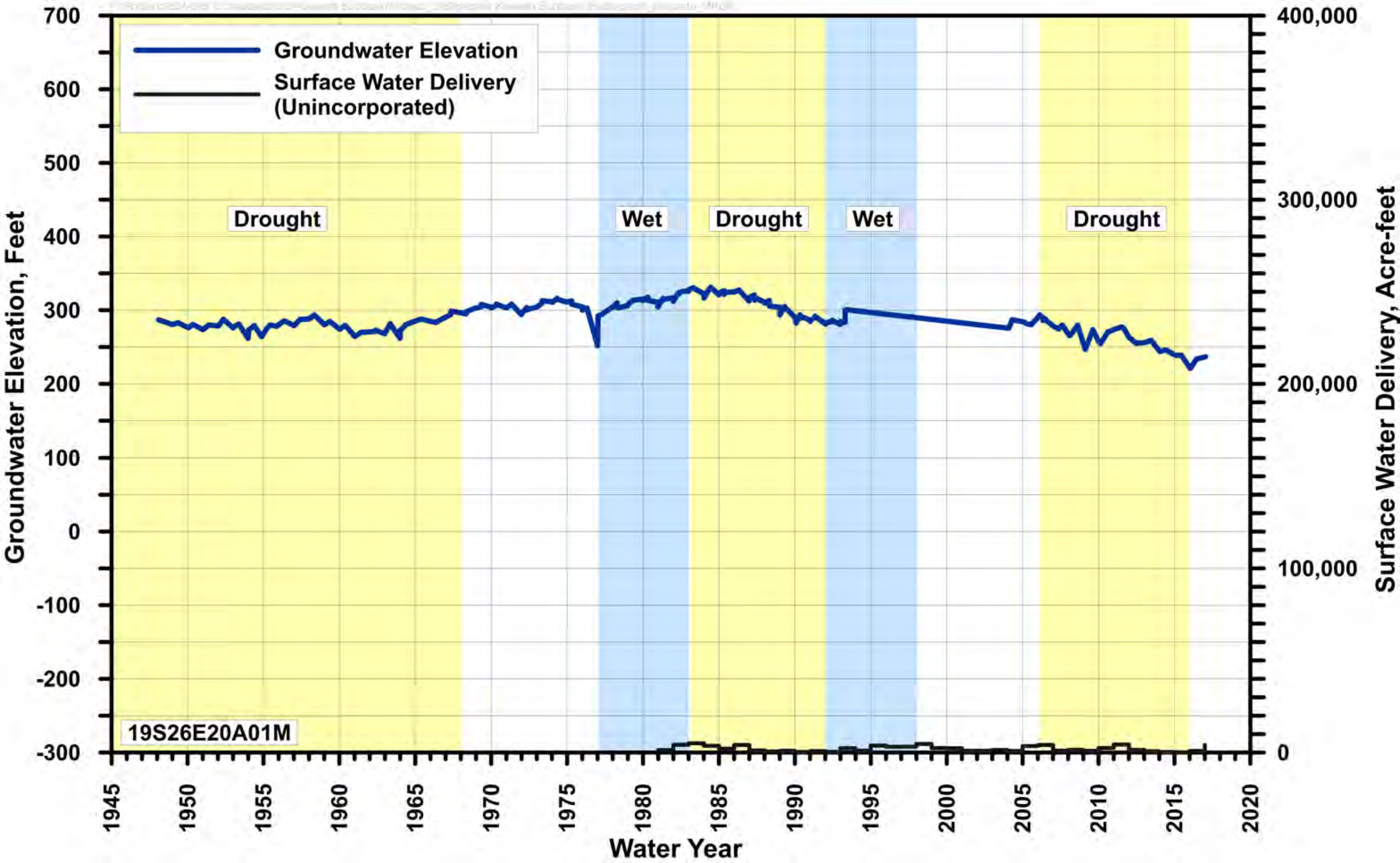
2015
2020



Groundwater Elevation
Surface Water Delivery (Unincorporated)
Drought
Wet
Drought
Wet
Drought
19S26E20A01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
100,000
0
1945
1950
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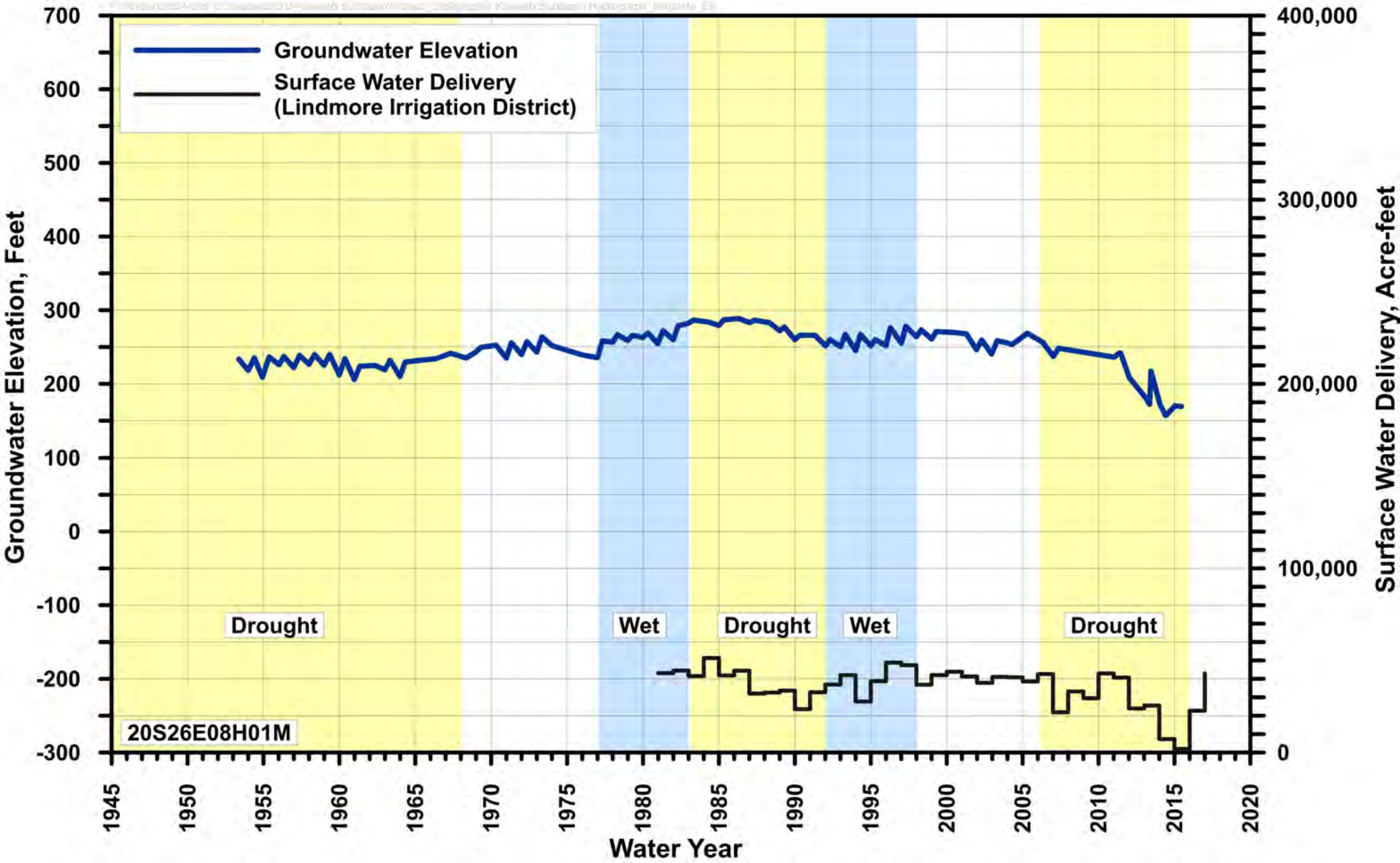
2010
2015
2020



Groundwater Elevation
Surface Water Delivery
(Lindmore Irrigation District)
Drought
Wet
Drought
Wet
Drought
20S26E08H01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
100,000
0
1945
1950
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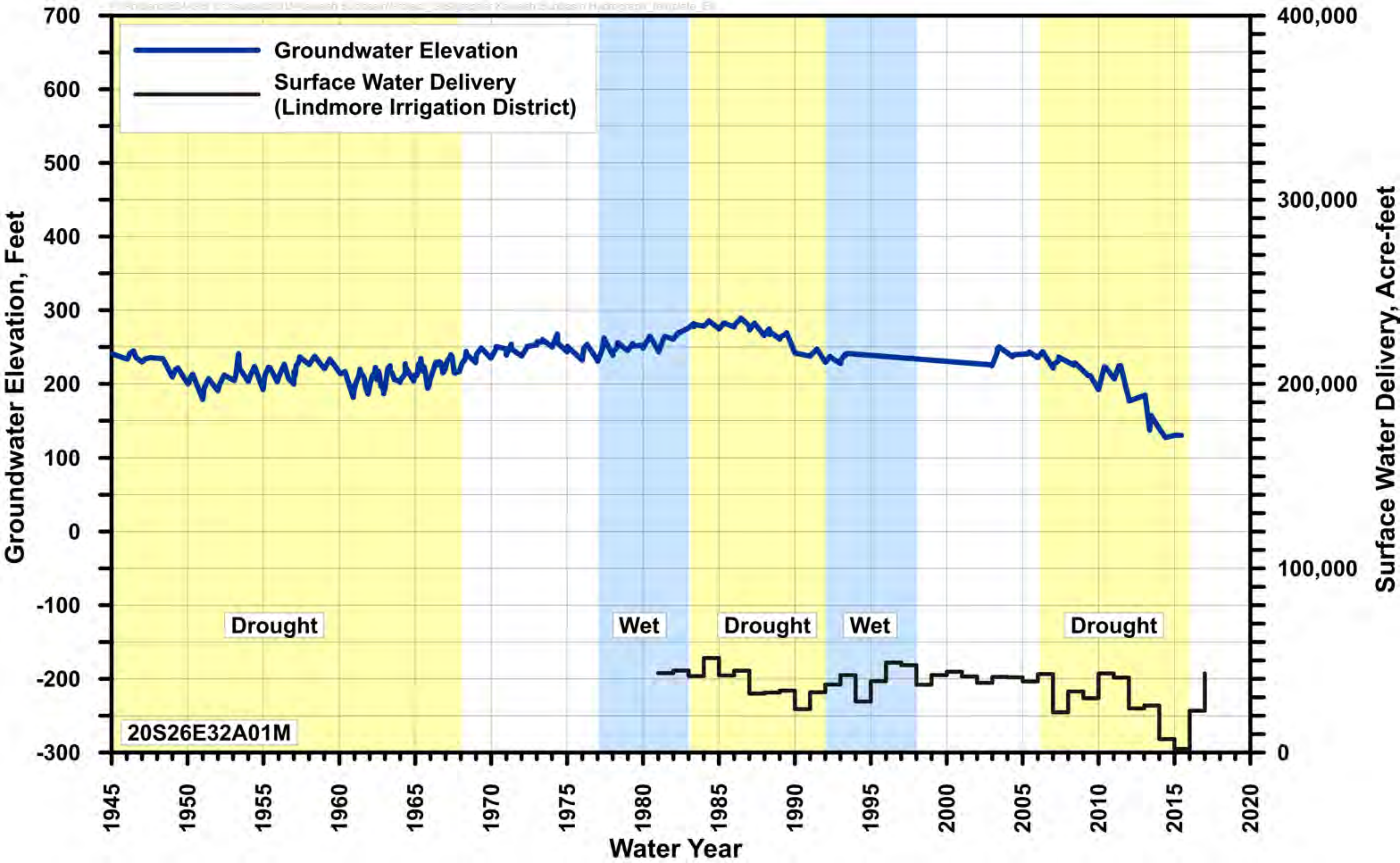
2010
2015
2020



Groundwater Elevation
Surface Water Delivery
(Lindmore Irrigation District)
Drought
Wet
Drought
Wet
Drought
20S26E32A01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
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100,000
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1945
1950
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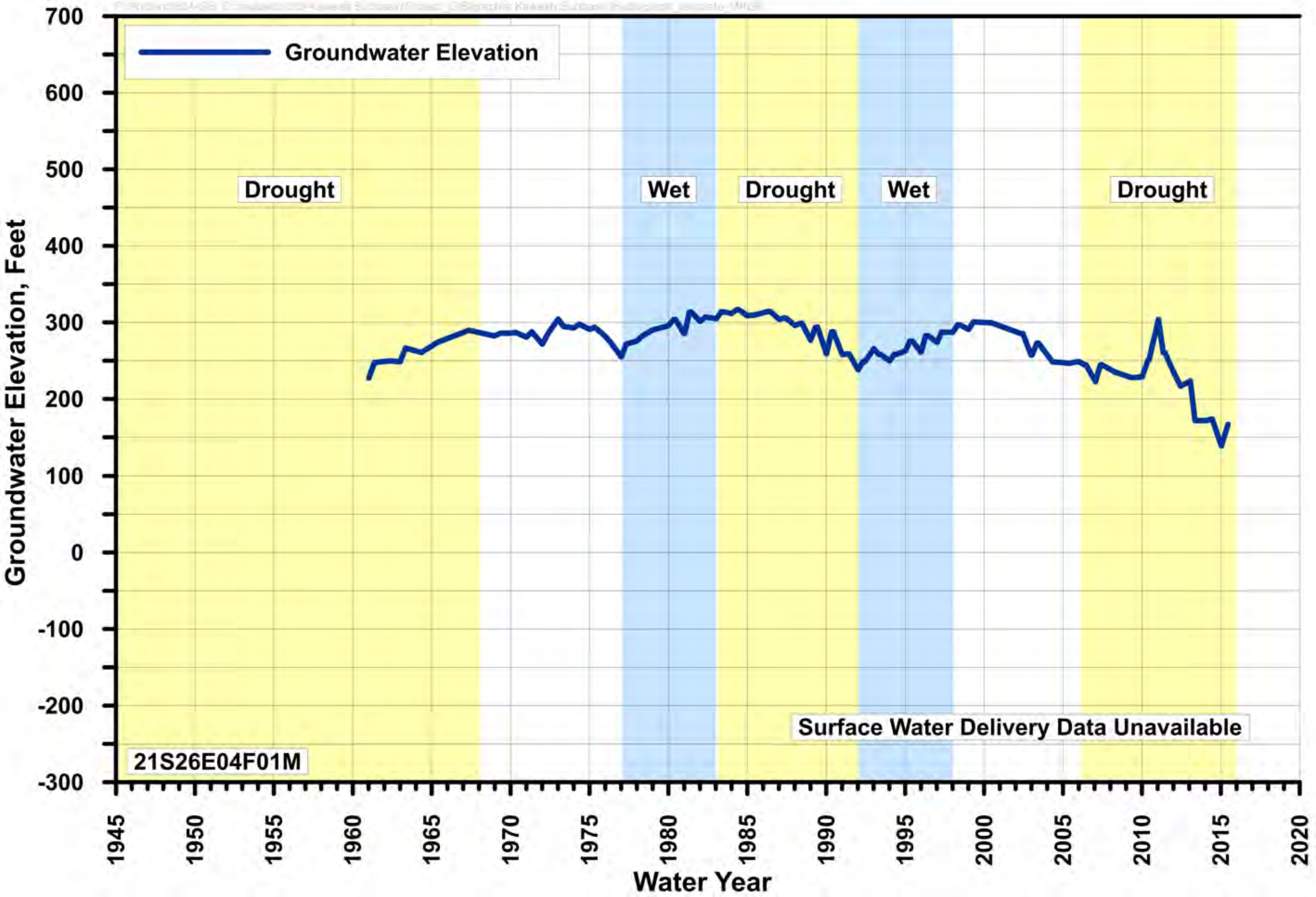
2020



Groundwater Elevation
Drought
Wet
Drought
Wet
Drought
Surface Water Delivery Data Unavailable
21S26E04F01M
Groundwater Elevation, Feet
700
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500
400
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200
100
0
-100
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-300
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1970
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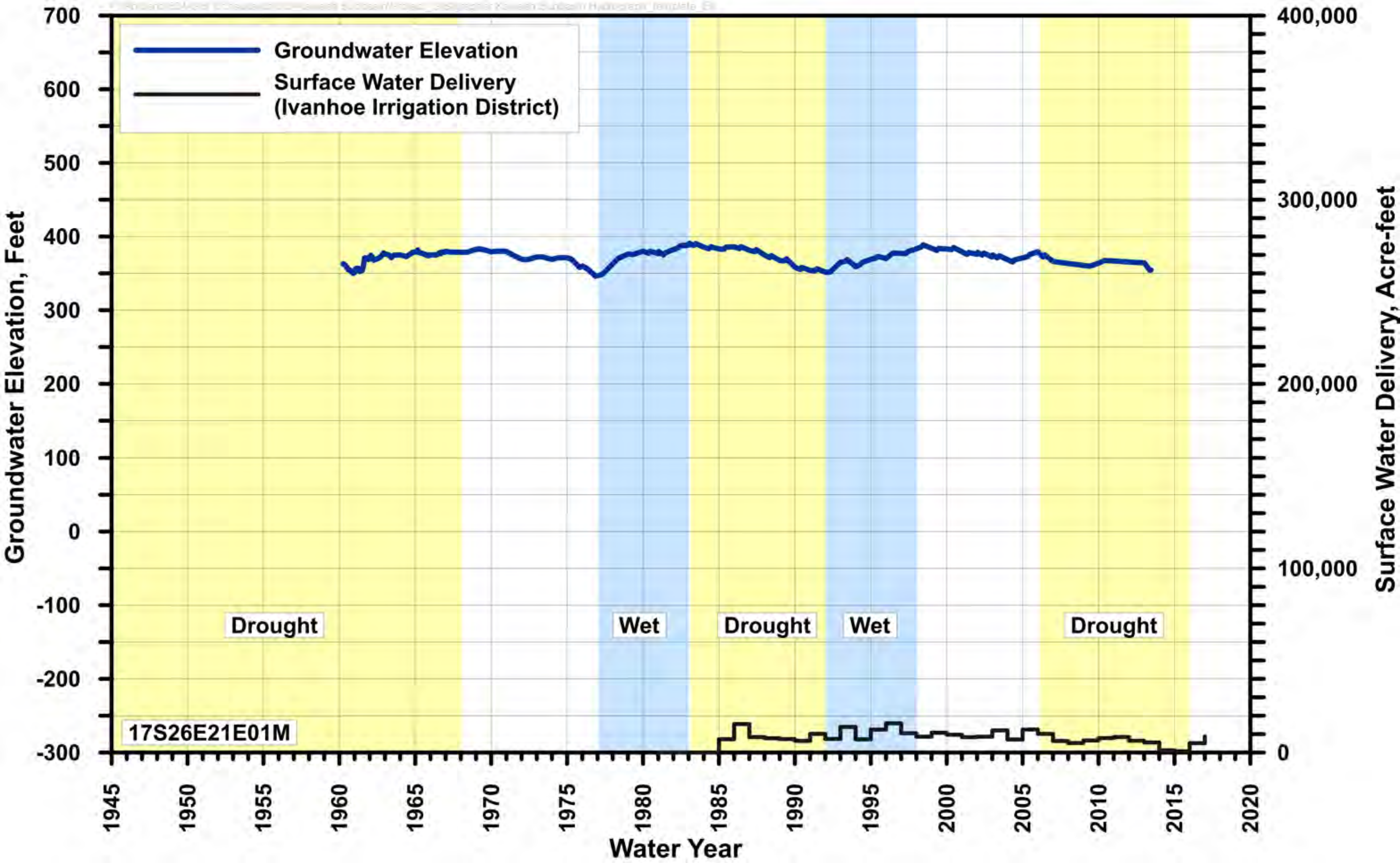
1980
1985
1990
1995
2000
2005
2010
2015
2020
Water Year


Groundwater Elevation
Surface Water Delivery
(Ivanhoe Irrigation District)
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
Drought
Wet
Drought
Wet
Drought
17S26E21E01M
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
100,000
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1945
1950
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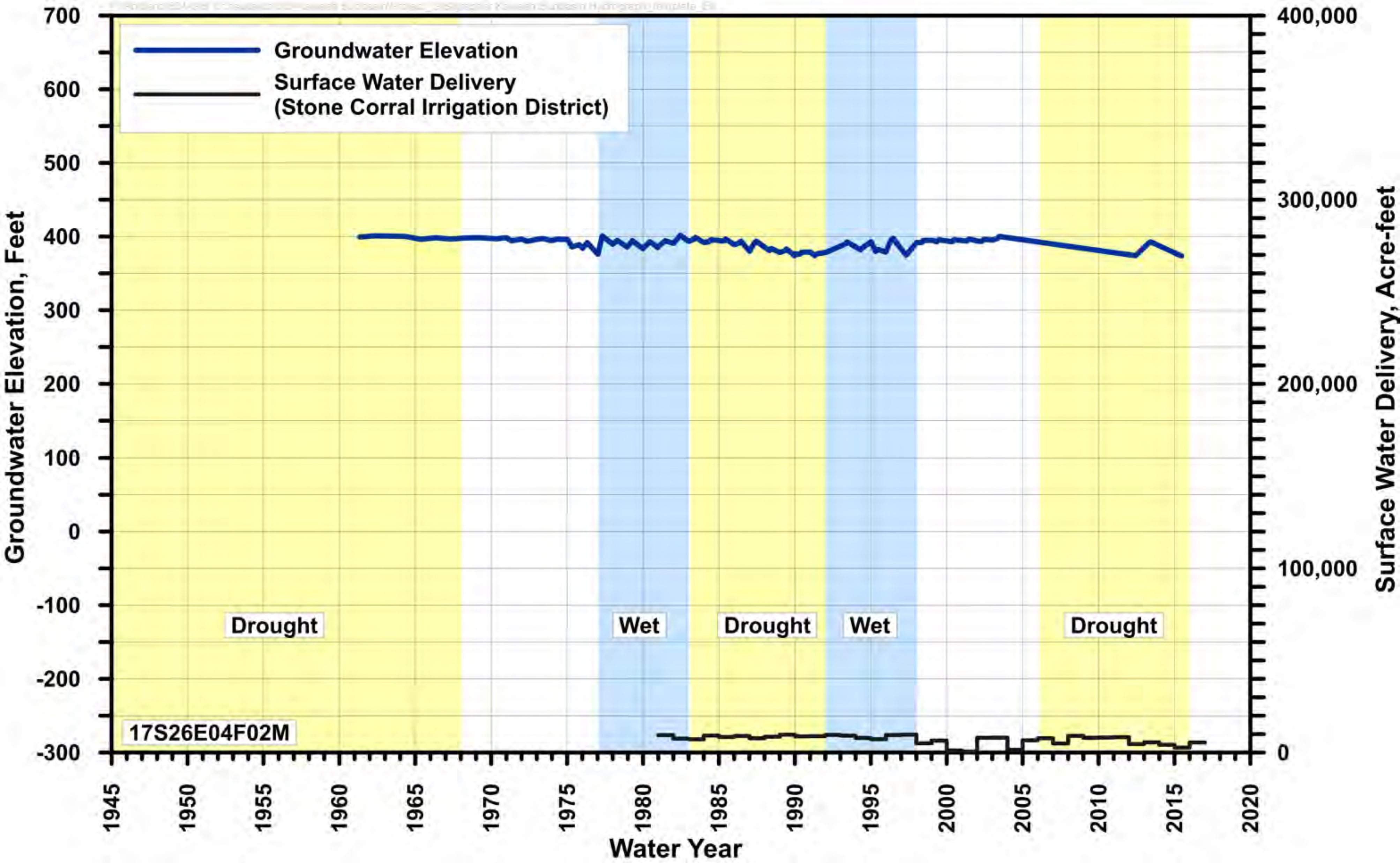
2010
2015
2020



Groundwater Elevation
Surface Water Delivery
(Stone Corral Irrigation District)
Drought
Wet
Drought
Wet
Drought
17S26E04F02M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
100,000
0
1945
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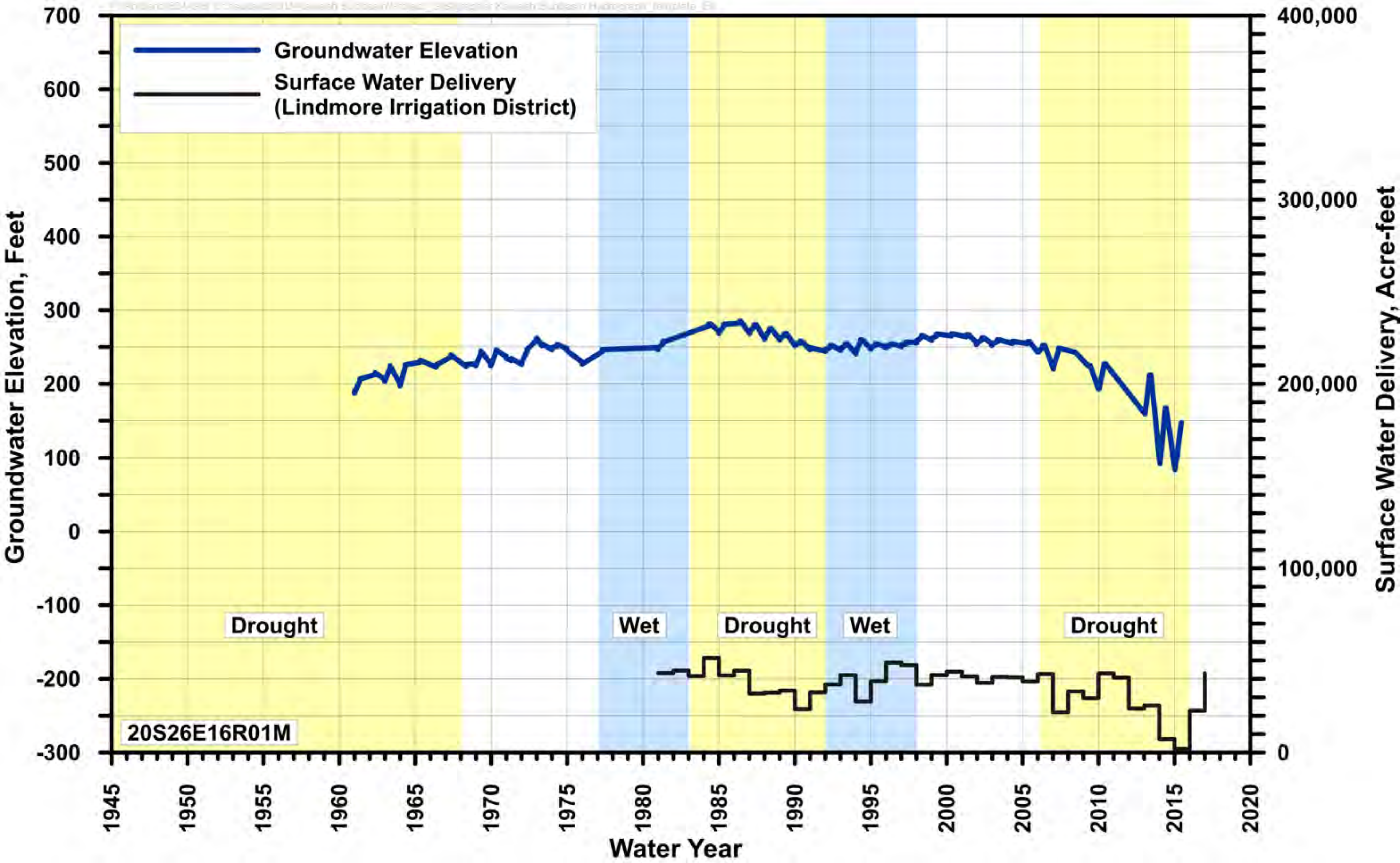
2005
2010
2015
2020



Groundwater Elevation
Surface Water Delivery
(Lindmore Irrigation District)
Drought
Wet
Drought
Wet
Drought
20S26E16R01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
100,000
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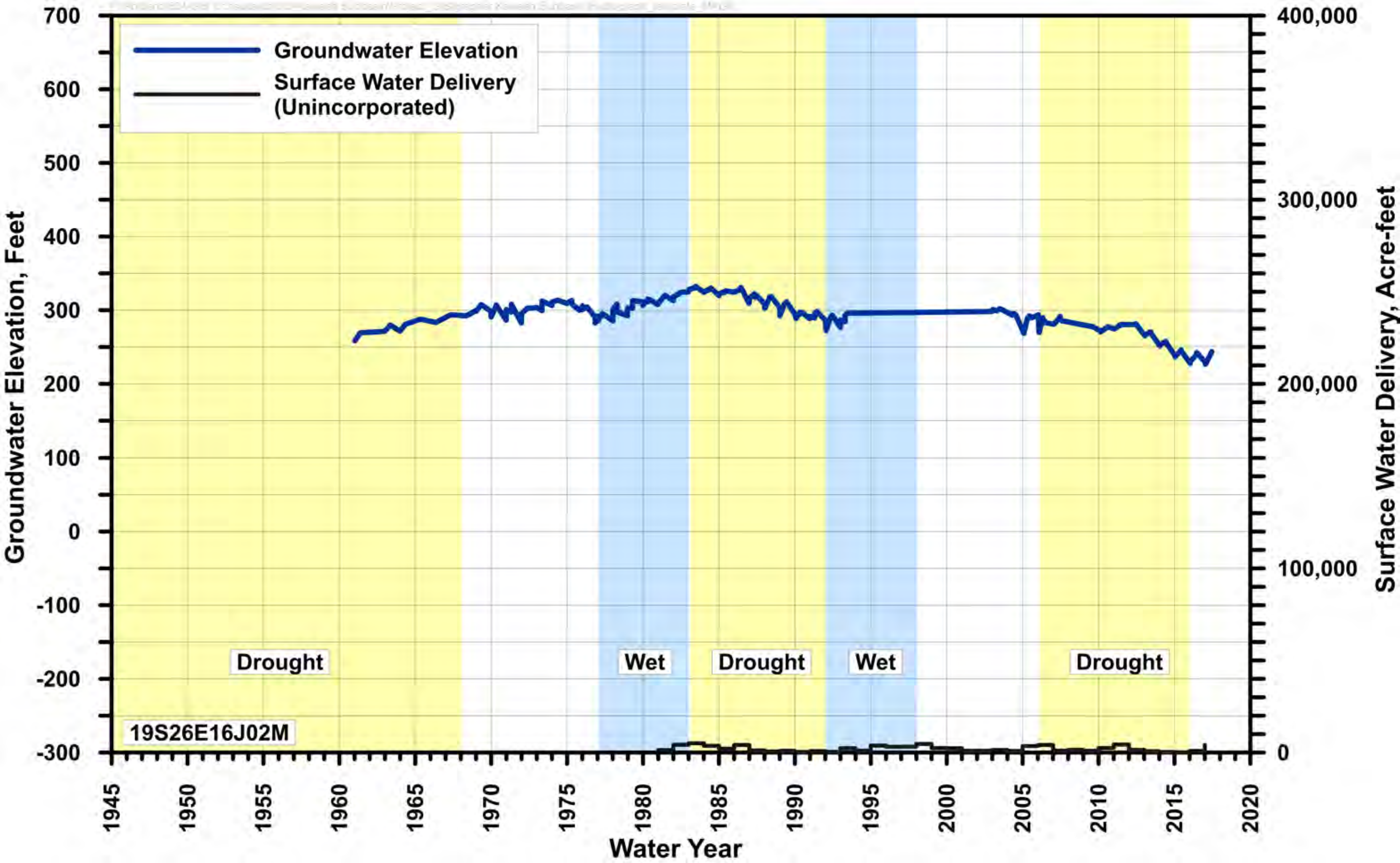
2010
2015
2020



Groundwater Elevation
Surface Water Delivery (Unincorporated)
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
Drought
Wet
Drought
Wet
Drought
19S26E16J02M
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
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1945
1950
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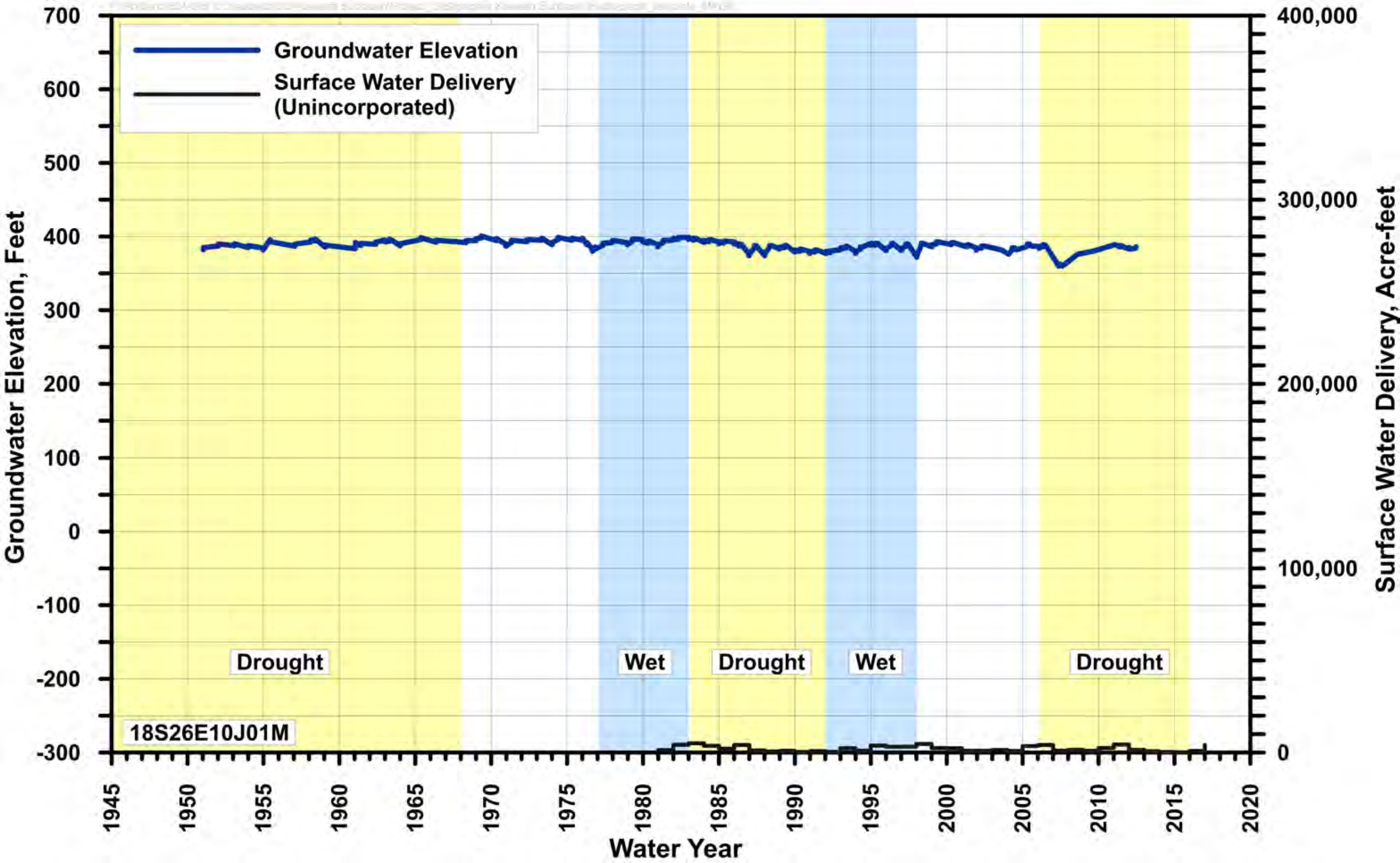
2020



Groundwater Elevation
Surface Water Delivery (Unincorporated)
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
Drought
Wet
Drought
Wet
Drought
18S26E10J01M
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
100,000
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1945
1950
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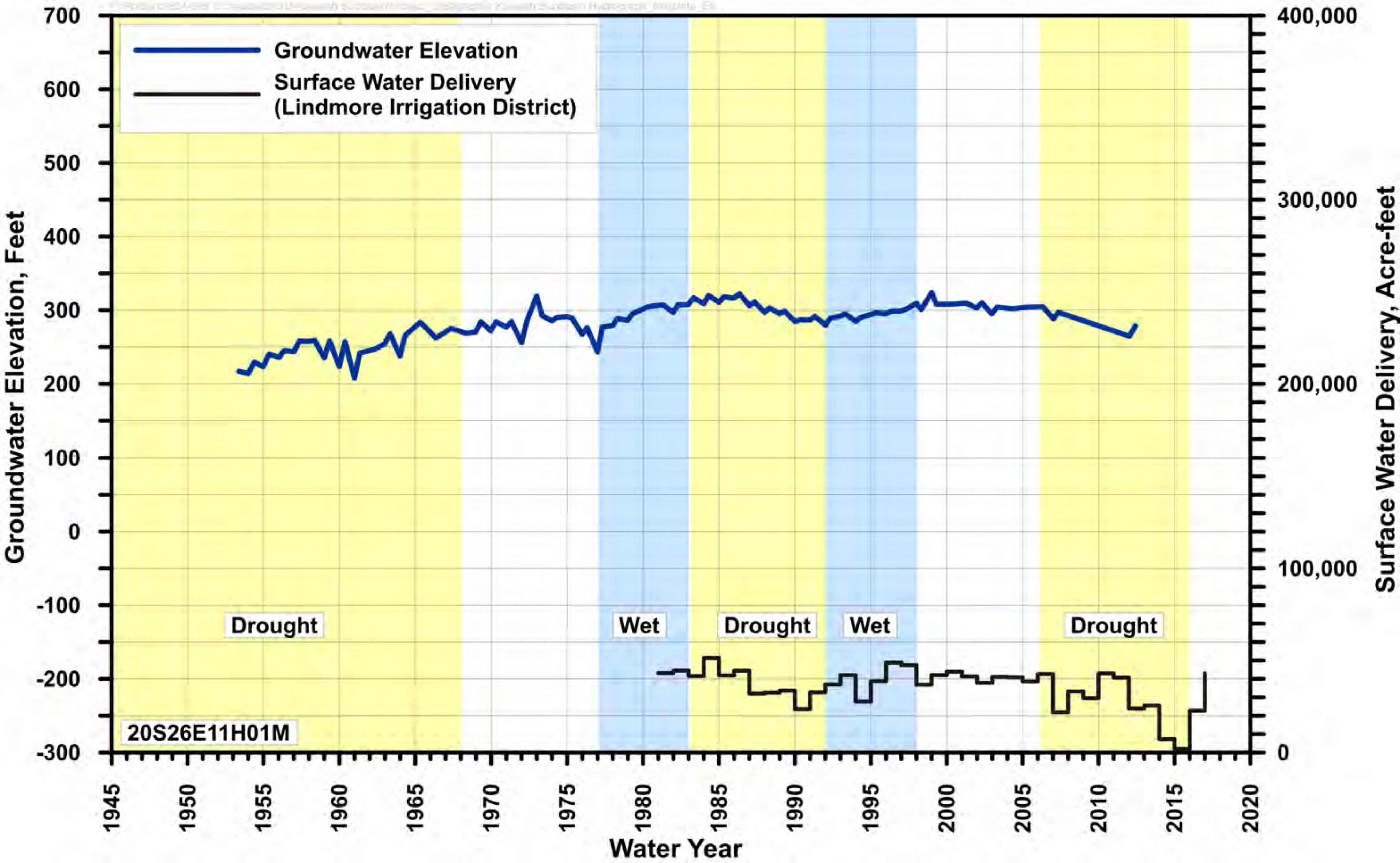
2010
2015
2020



Groundwater Elevation
Surface Water Delivery
(Lindmore Irrigation District)
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
Drought
Wet
Drought
Wet
Drought
20S26E11H01M
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
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1950
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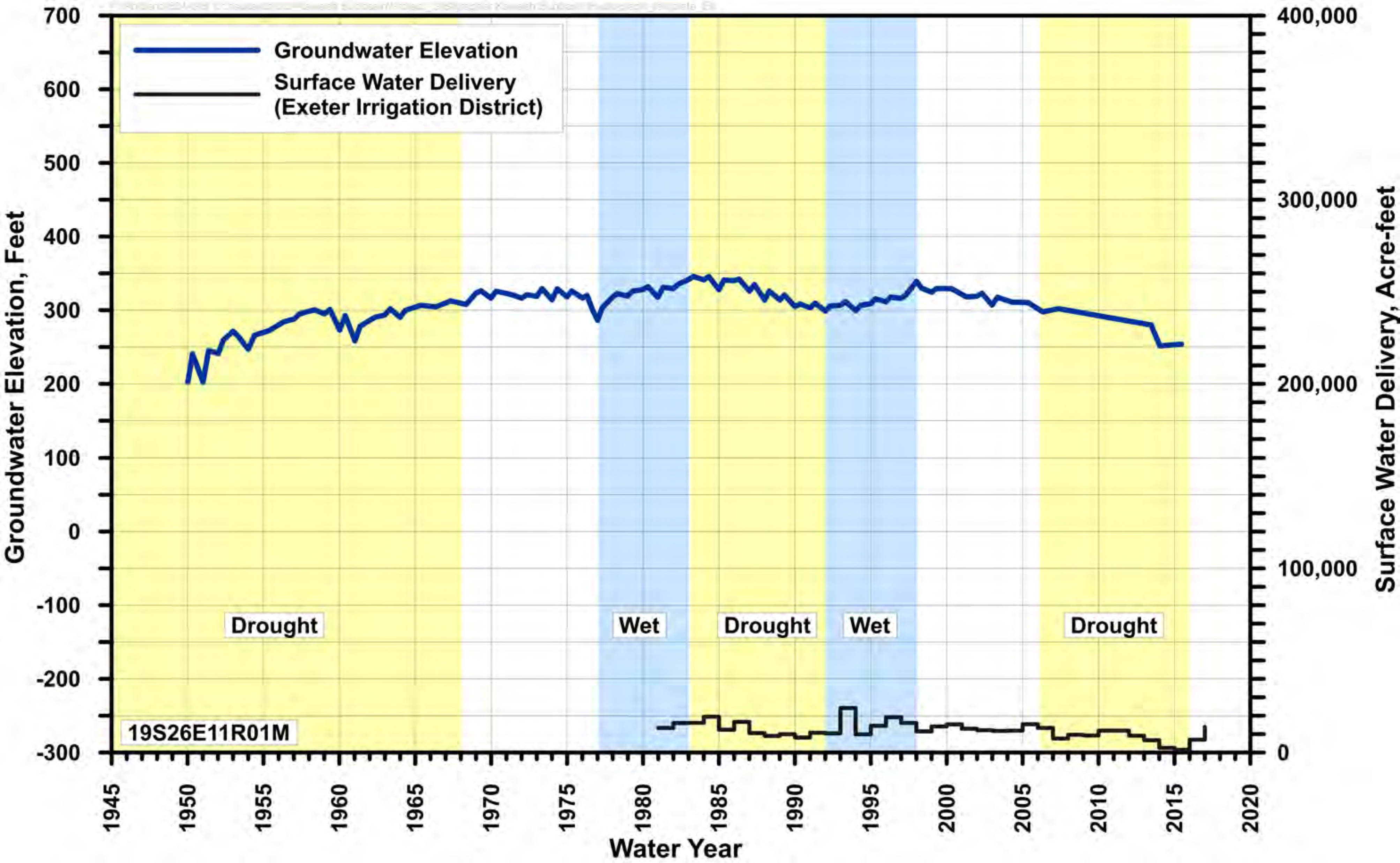
2010
2015
2020



Groundwater Elevation
Surface Water Delivery
(Exeter Irrigation District)
Drought
Wet
Drought
Wet
Drought
19S26E11R01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
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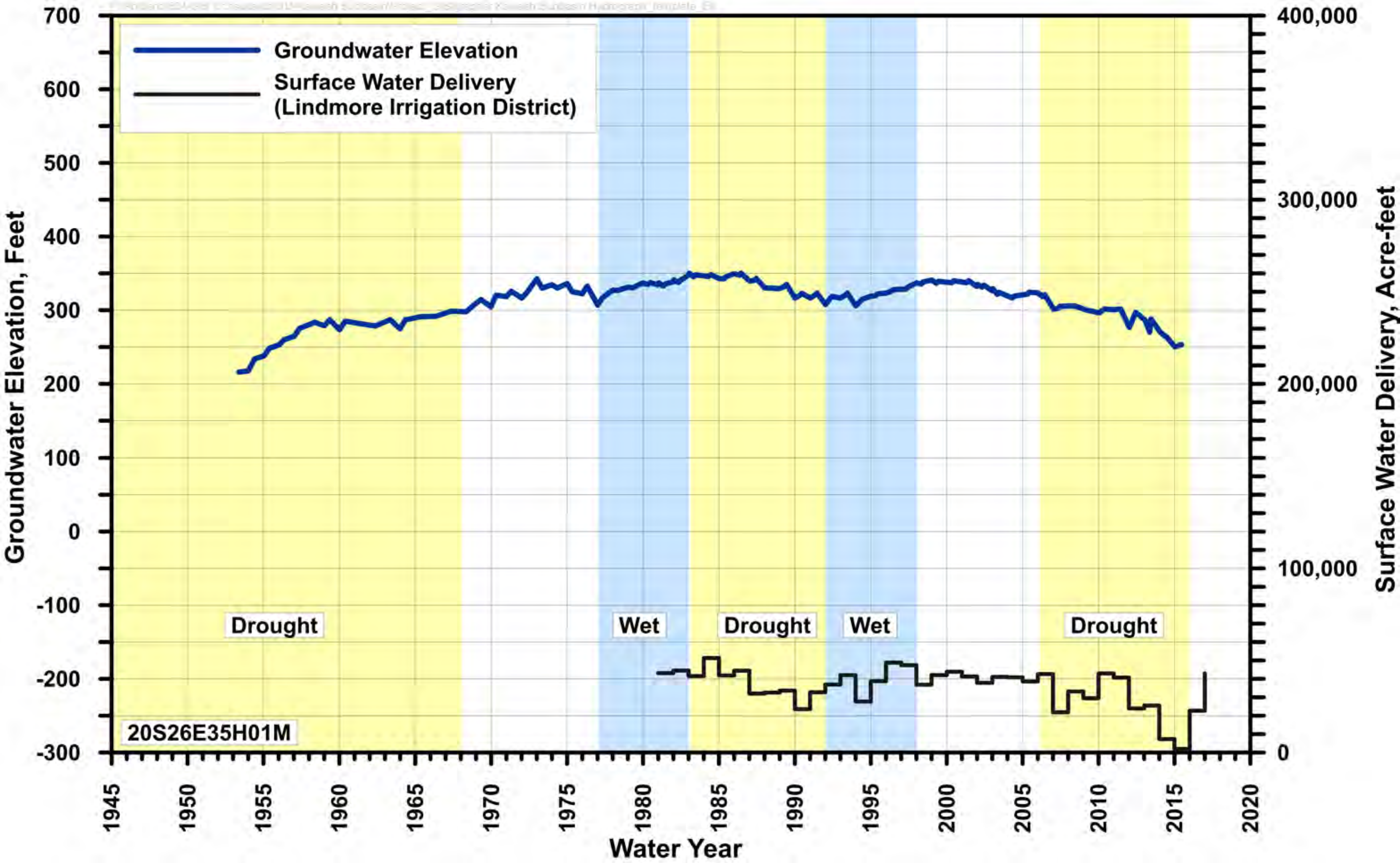

Groundwater Elevation
Surface Water Delivery
(Lindmore Irrigation District)
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
Drought
Wet
Drought
Wet
Drought
20S26E35H01M
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
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2010
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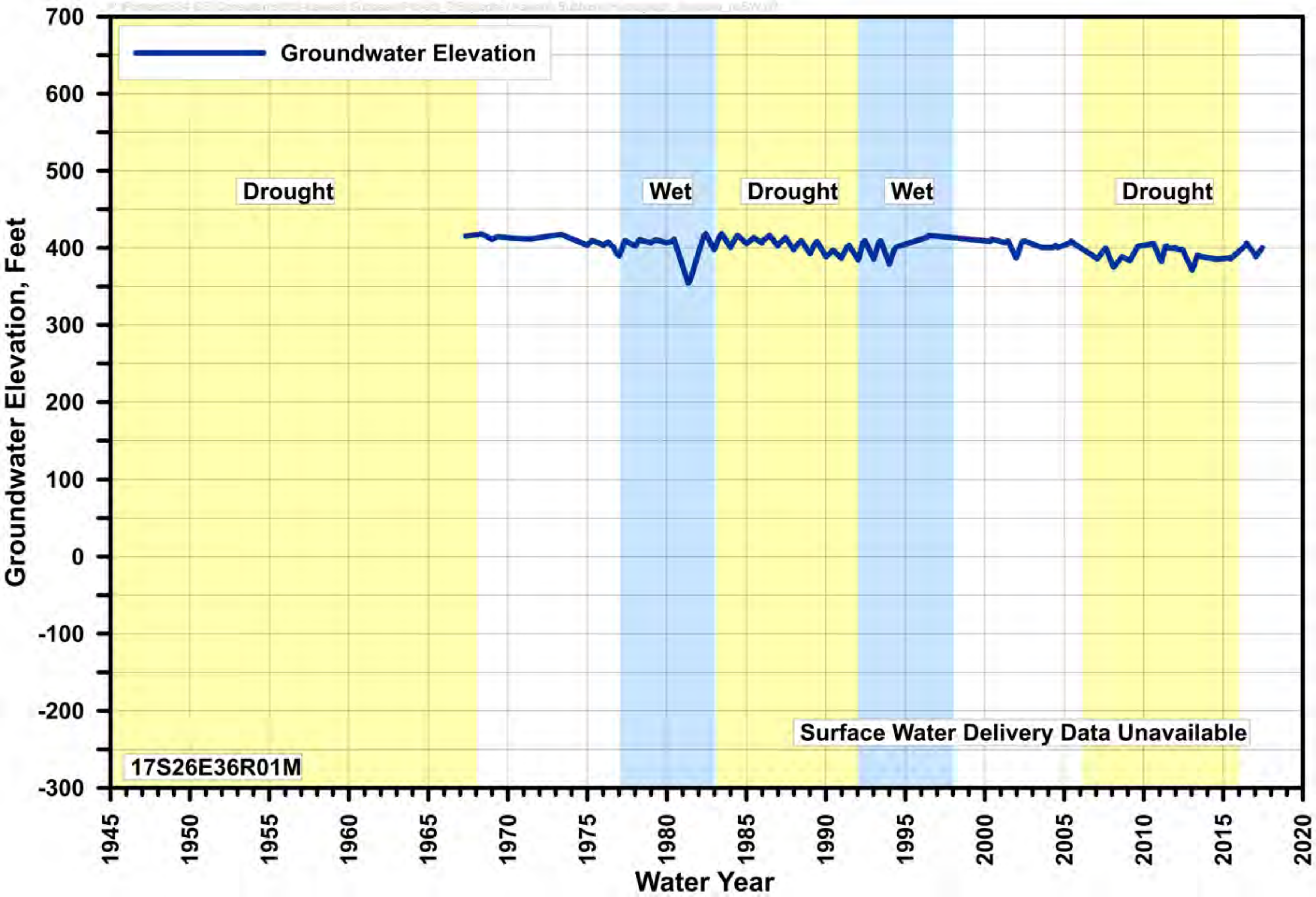
2020



Groundwater Elevation
Drought
Wet
Drought
Wet
Drought
Surface Water Delivery Data Unavailable
17S26E36R01M
Groundwater Elevation, Feet
700
600
500
400
300
200
100
0
-100
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1945
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1960
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1970
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1985
1990
1995
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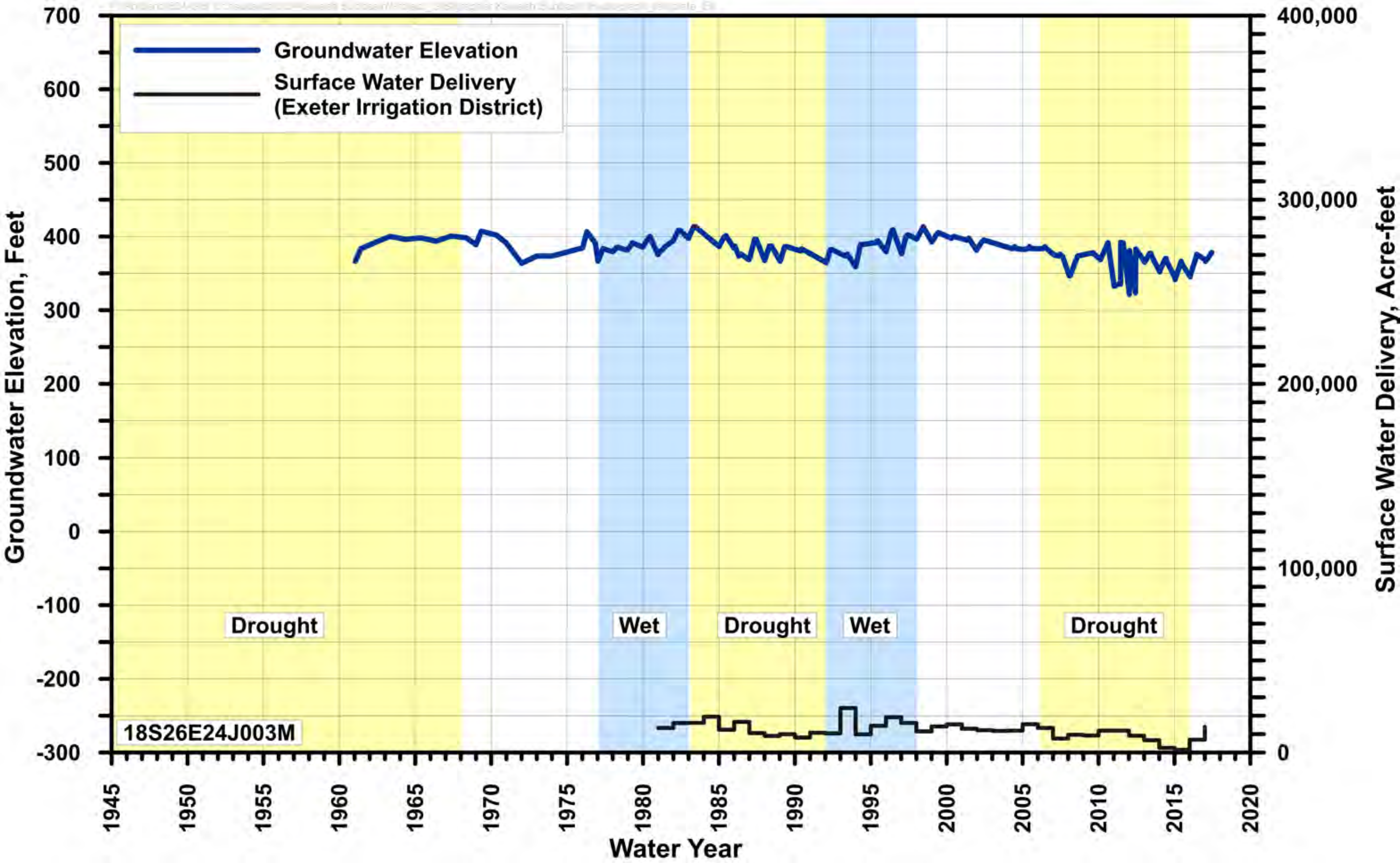
2010
2015
2020
Water Year



Groundwater Elevation
Surface Water Delivery
(Exeter Irrigation District)
Drought
Wet
Drought
Wet
Drought
18S26E24J003M
Groundwater Elevation, Feet
700
600
500
400
300
200
100
0
-100
-200
-300
Surface Water Delivery, Acre-feet
400,000
300,000
200,000
100,000
0
Water Year
1945
1950
1955
1960
1965
1970
1975
1980
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1990
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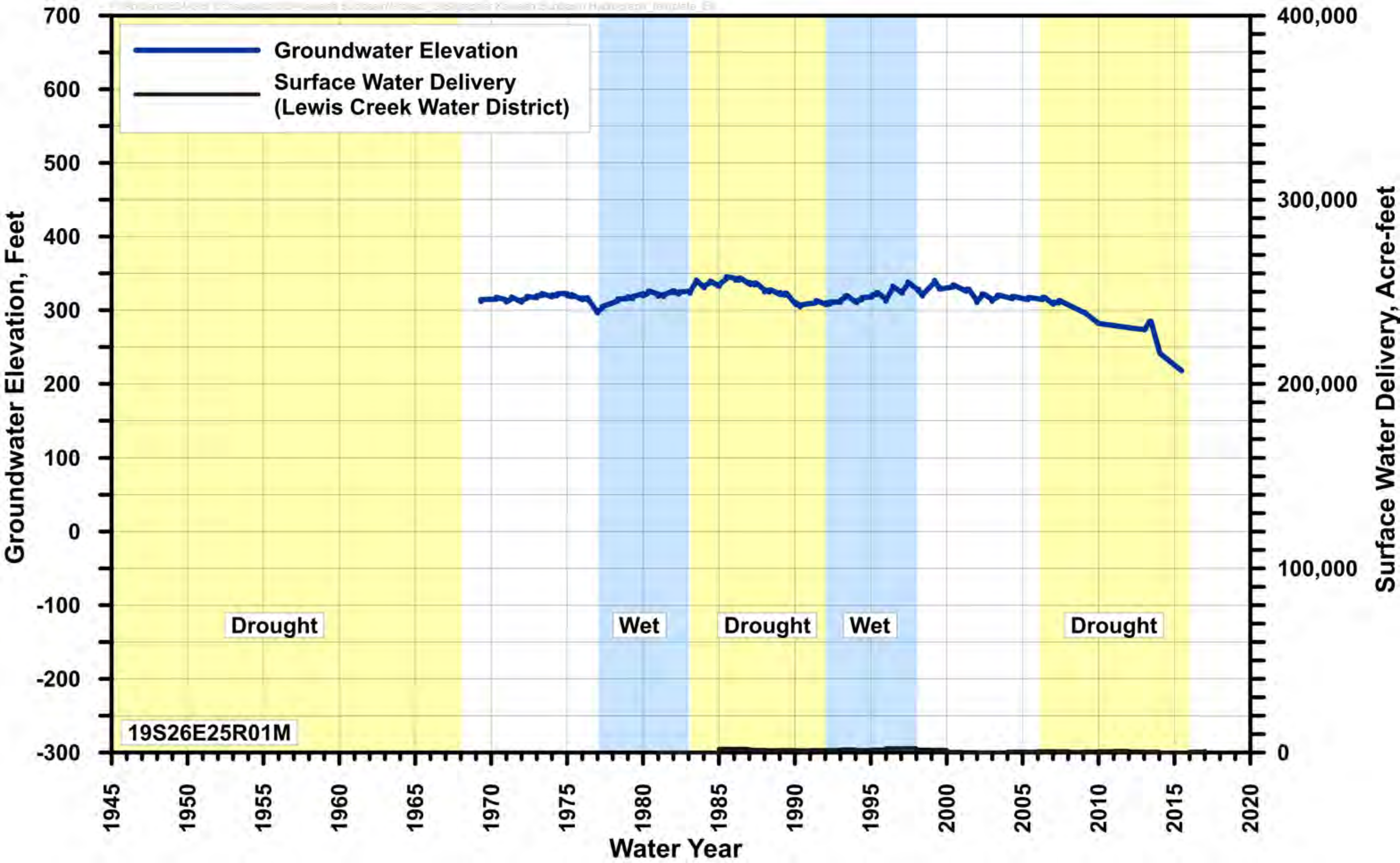
2010
2015
2020



Groundwater Elevation
Surface Water Delivery
(Lewis Creek Water District)
Drought
Wet
Drought
Wet
Drought
19S26E25R01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
100,000
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1945
1950
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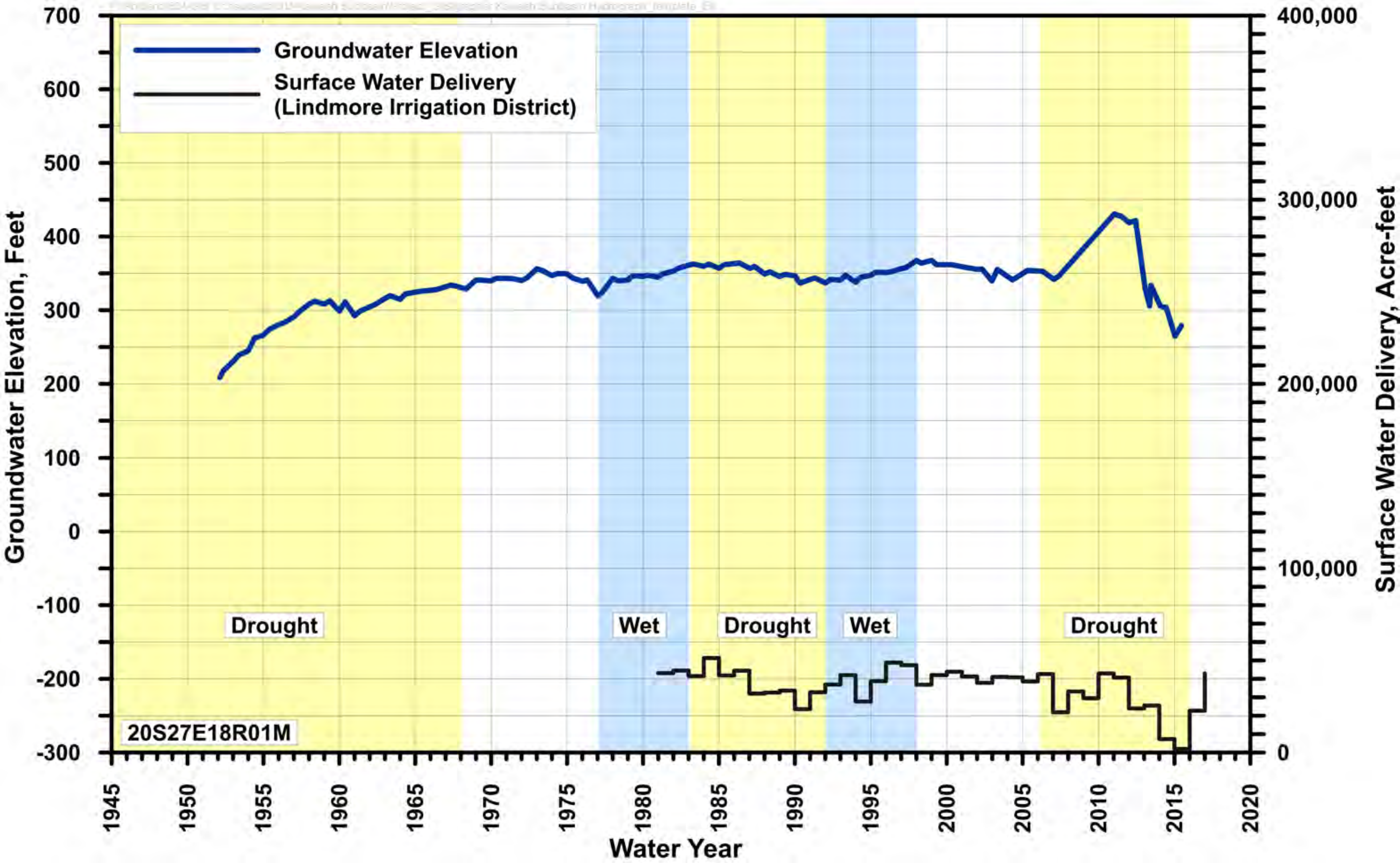
2020



Groundwater Elevation
Surface Water Delivery
(Lindmore Irrigation District)
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
100,000
0
Drought
Wet
Drought
Wet
Drought
20S27E18R01M
1945
1950
1955
1960
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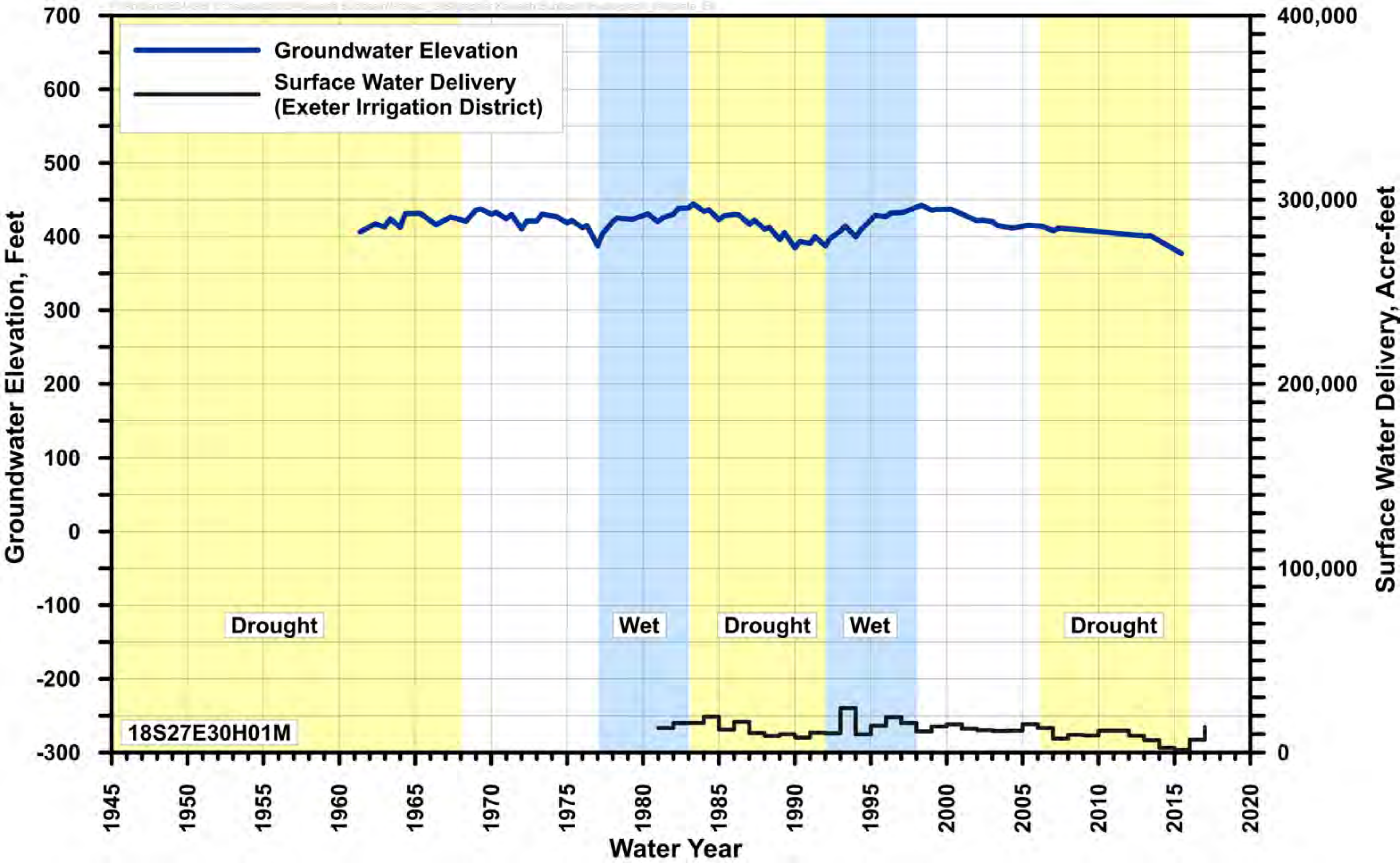
1995
2000
2005
2010
2015
2020
Water Year



Groundwater Elevation
Surface Water Delivery
(Exeter Irrigation District)
Drought
Wet
Drought
Wet
Drought
18S27E30H01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
100,000
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1945
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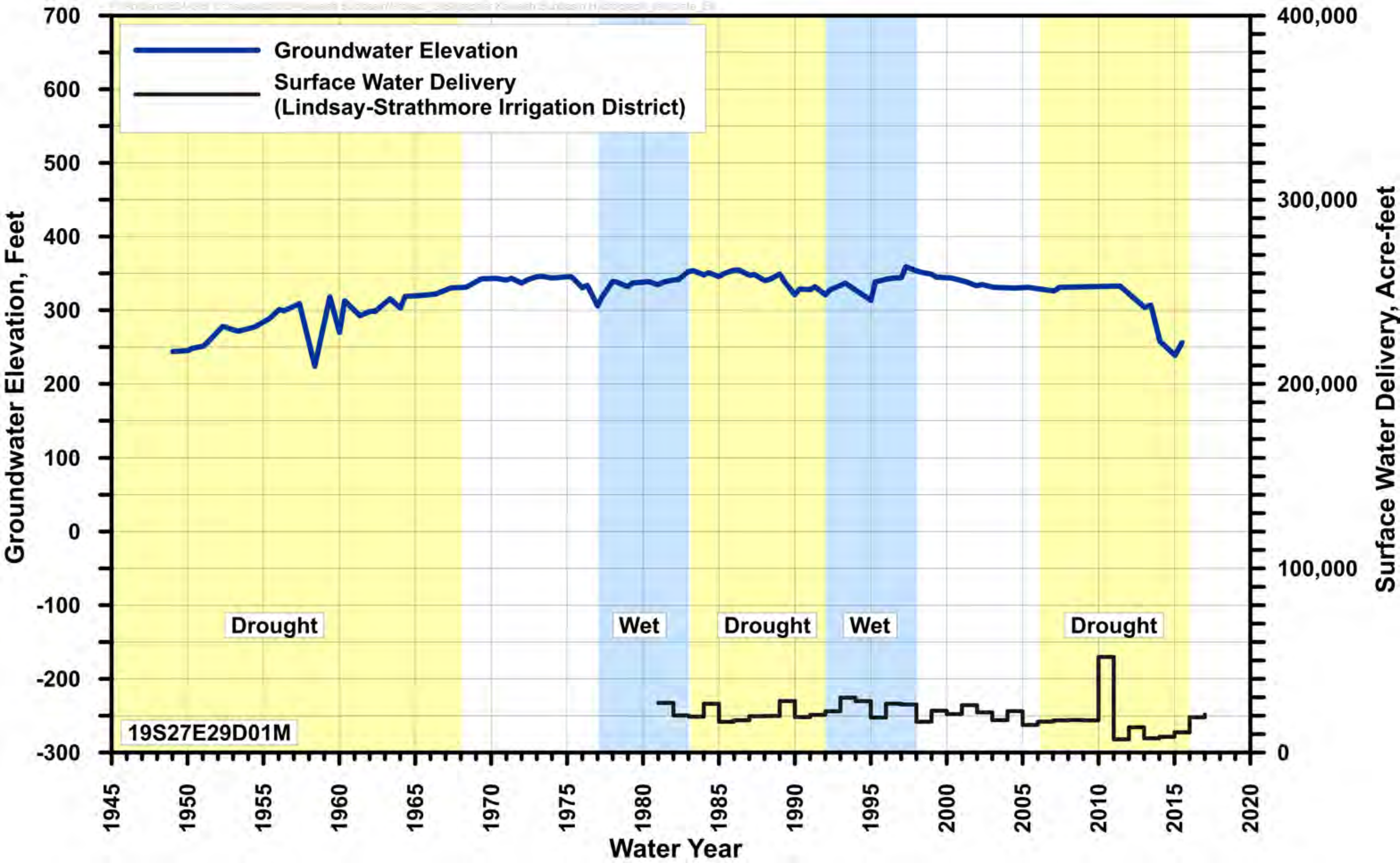
2005
2010
2015
2020



Groundwater Elevation
Surface Water Delivery
(Lindsay-Strathmore Irrigation District)
Drought
Wet
Drought
Wet
Drought
19S27E29D01M
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
700
600
500
400
300
200
100
0
-100
-200
-300
400,000
300,000
200,000
100,000
0
1945
1950
1955
1960
1965
1970
1975
1980
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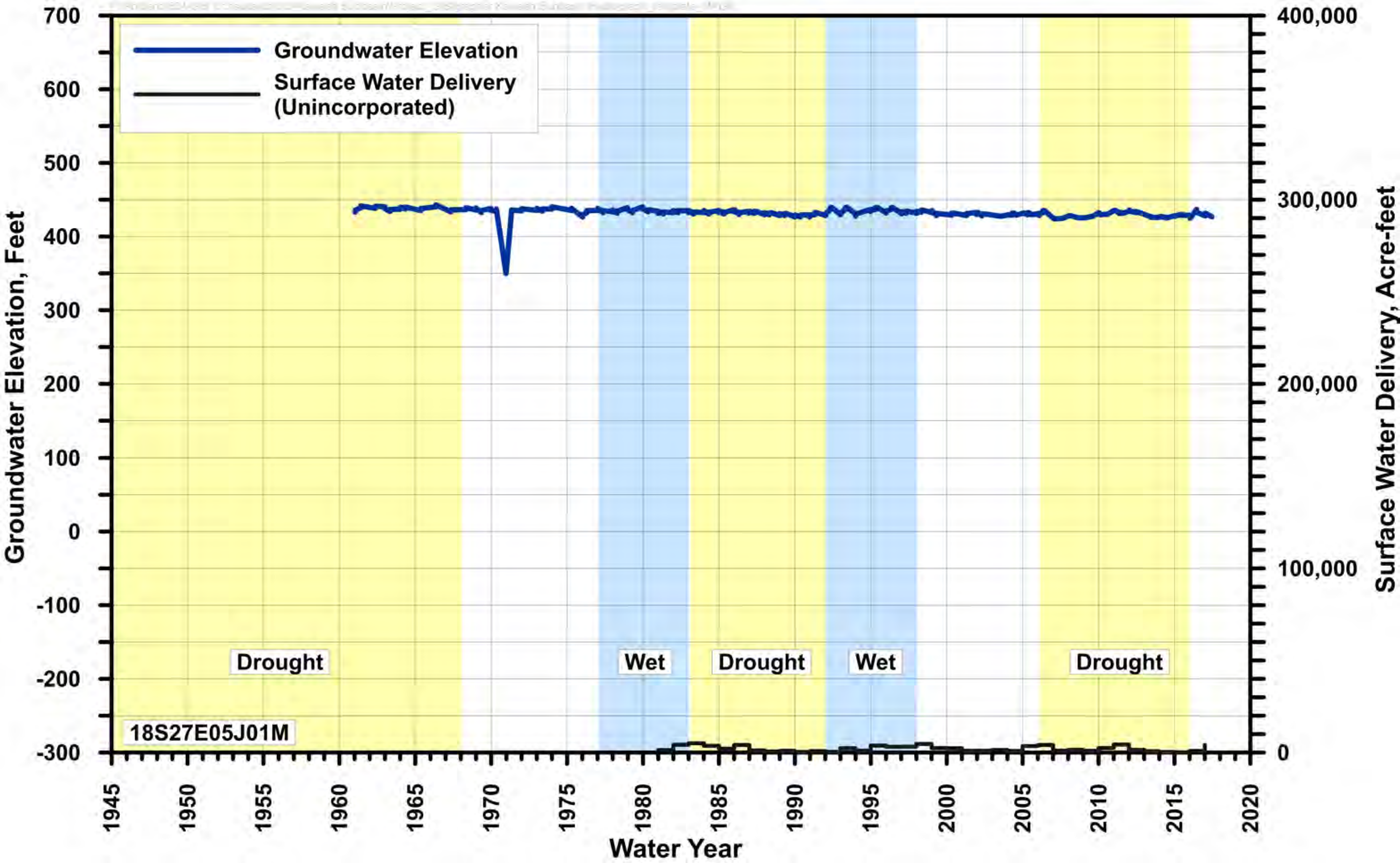

Groundwater Elevation
Surface Water Delivery (Unincorporated)
Drought
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Drought
Wet
Drought
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Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
Water Year
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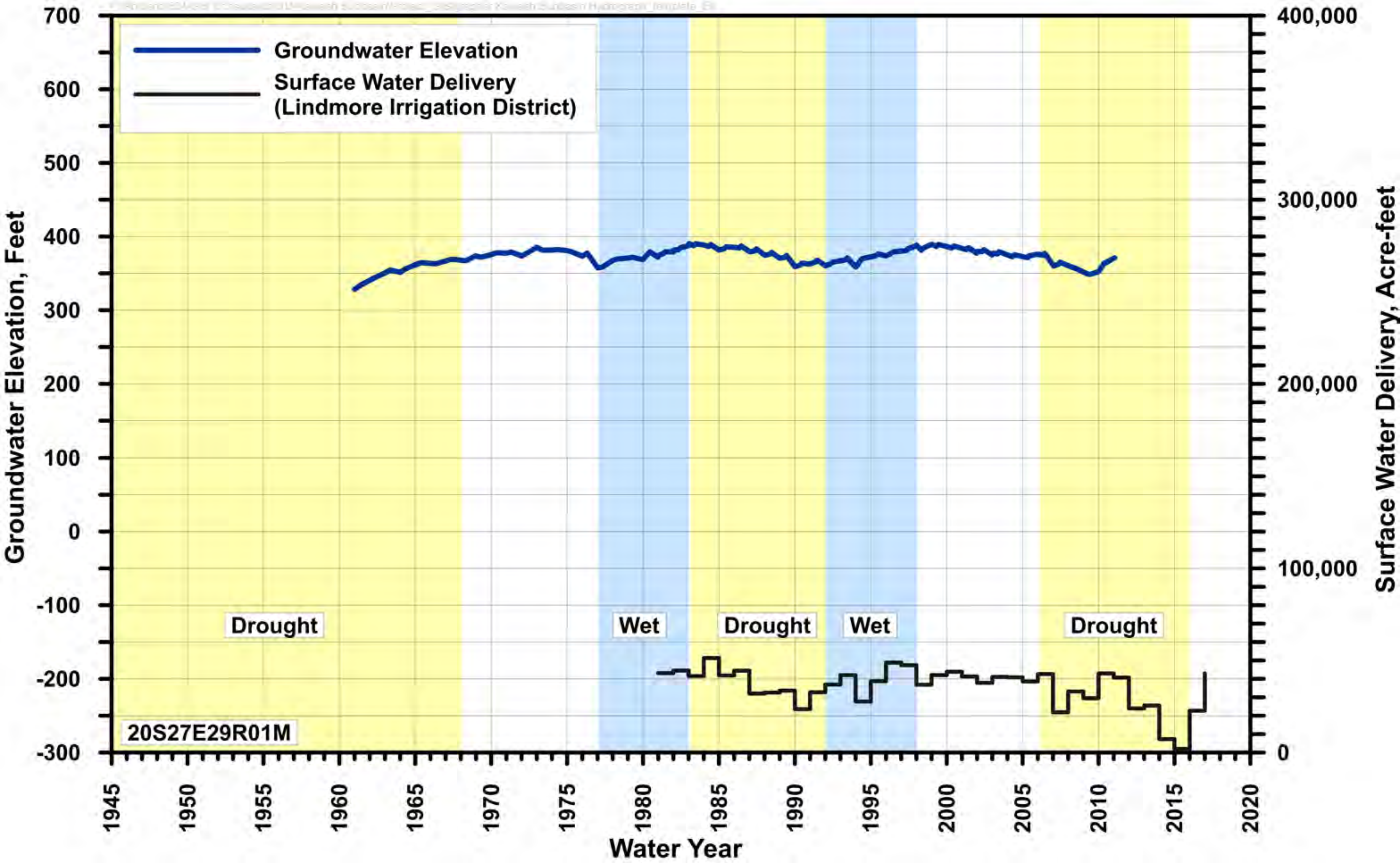

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Surface Water Delivery, Acre-feet
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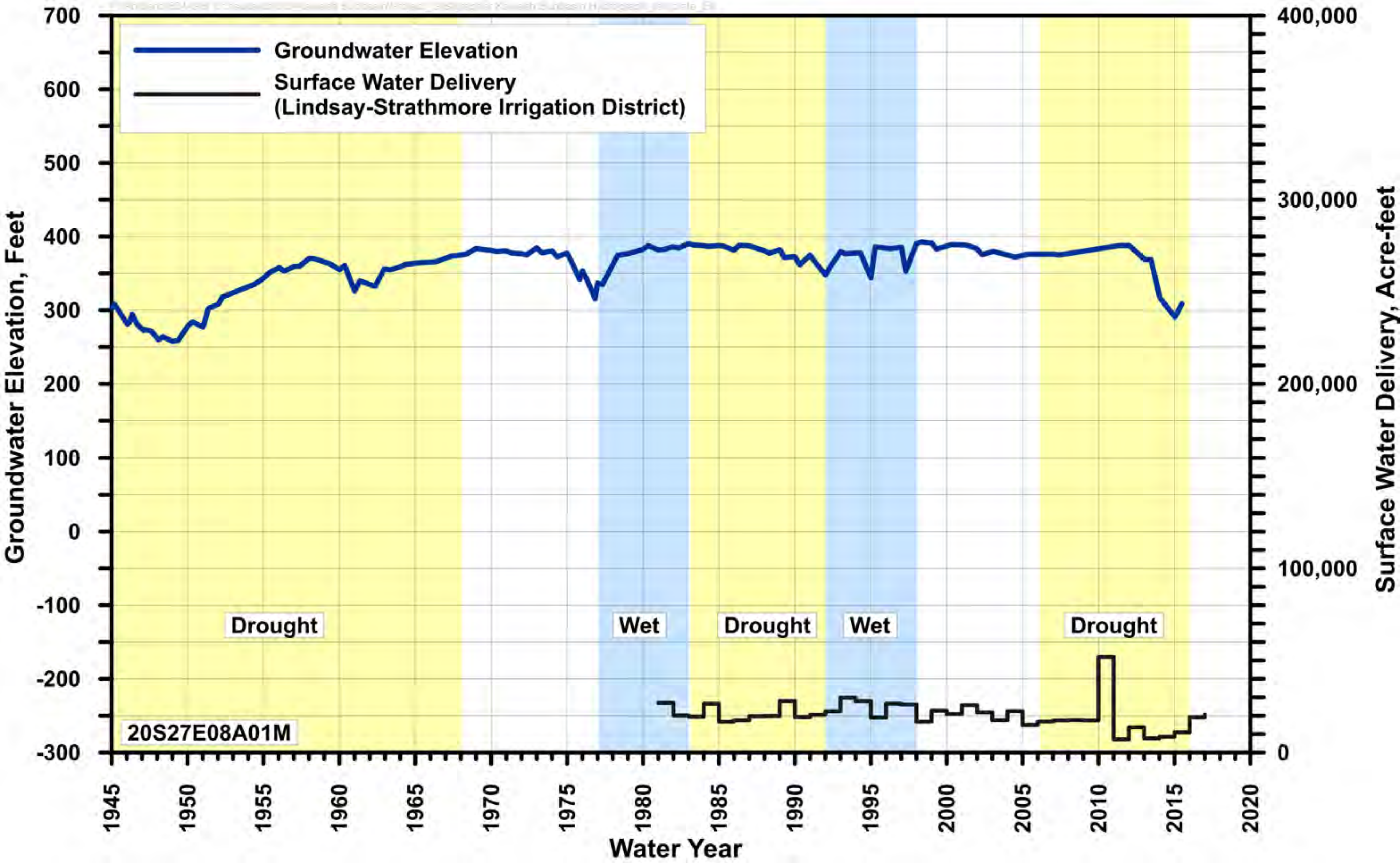

Groundwater Elevation
Surface Water Delivery
(Lindsay-Strathmore Irrigation District)
Groundwater Elevation, Feet
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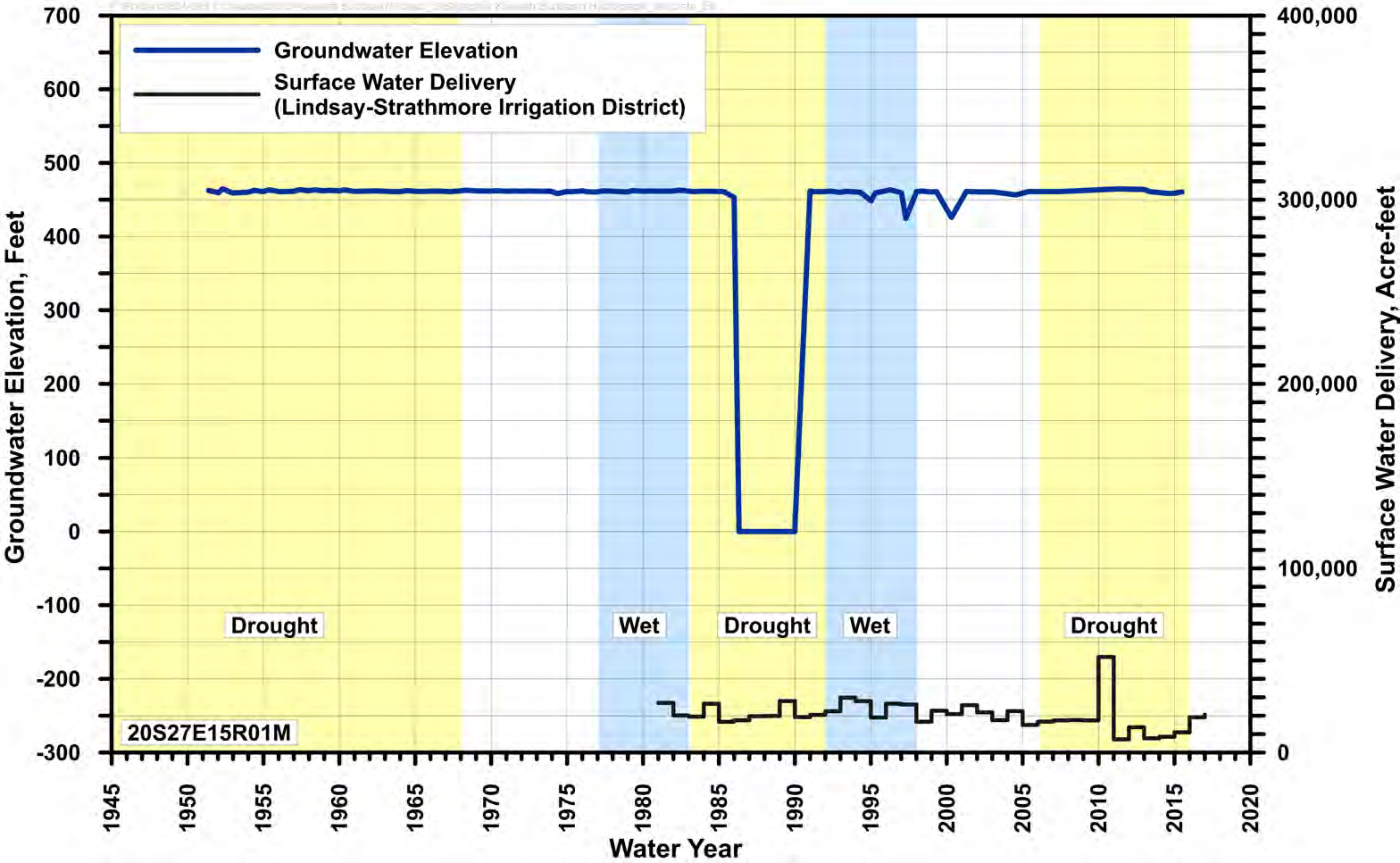

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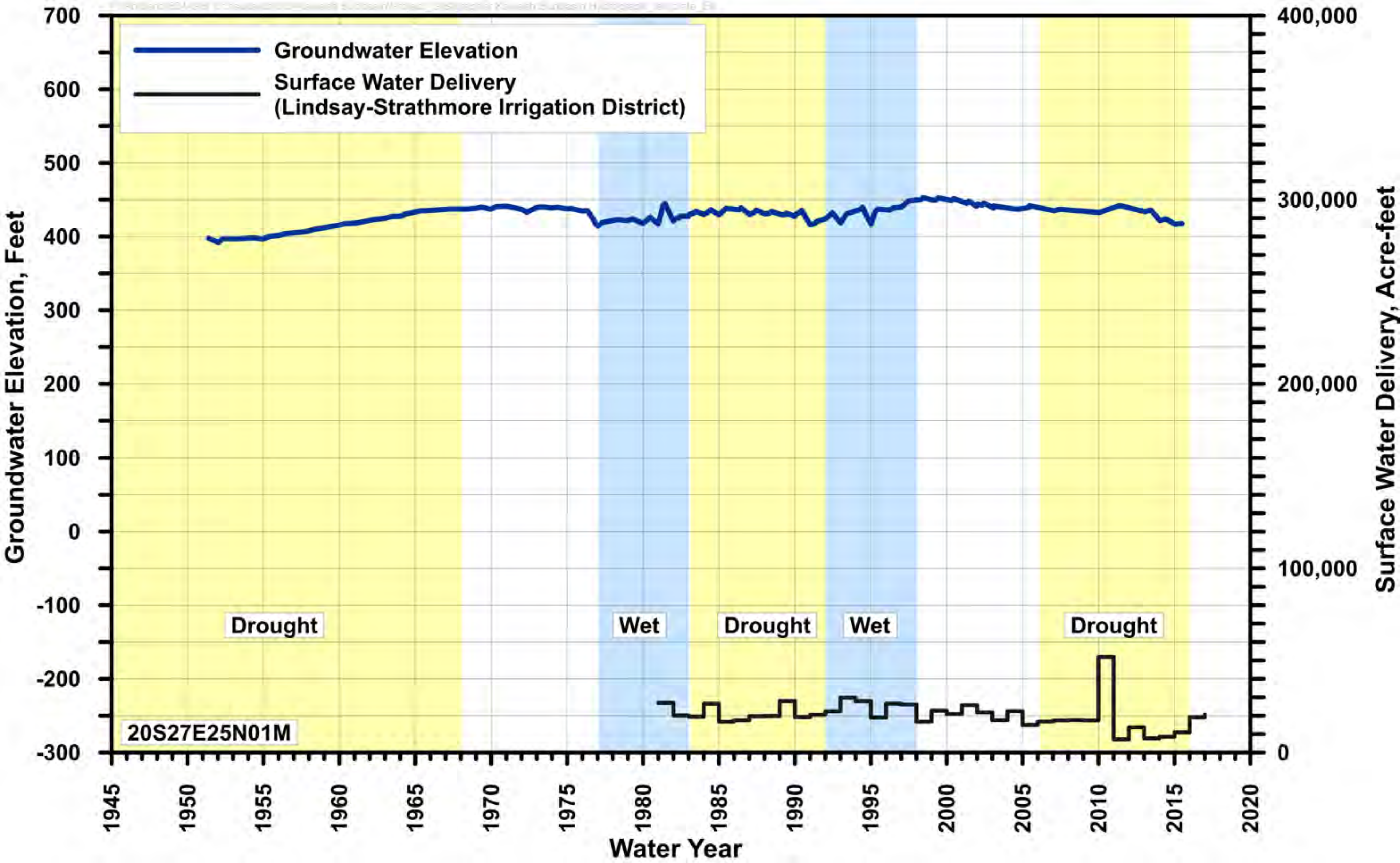

Groundwater Elevation
Surface Water Delivery
(Lindsay-Strathmore Irrigation District)
Groundwater Elevation, Feet
Surface Water Delivery, Acre-feet
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Appendix C

Specialists in Agricultural Water Management
Serving Stewards of Western Water since 1993

Technical Memorandum

To: GEI Consultants

From: Davids Engineering

Date: November 30, 2018

Subject: **Kaweah Subbasin Development of Evapotranspiration and Applied Water Estimates Using Remote Sensing**

1 Summary

The purpose of this effort is to develop time series estimates of agricultural water demands for the Kaweah Subbasin from 1999 through 2017. This effort updates a similar analysis previously completed for the Kaweah Delta Water Conservation District (KDWCD) from 1999 through 2016 to include the areas currently not included in the KDWCD area but lying within the Kaweah Subbasin and to extend the estimates through 2017.

The consumptive use of water (i.e., evapotranspiration) is the primary destination of infiltrated precipitation and applied irrigation water within the Kaweah Subbasin. Quantification of consumptive use was achieved by performing daily calculations of evapotranspiration (ET) for individual fields from October 1998 through December 2017. ET was separated into its evaporation (E) and transpiration (T) components. Transpiration was quantified using a remote sensing approach where Landsat satellite images acquired from USGS were used to calculate the Normalized Difference Vegetation Index (NDVI), which was subsequently translated to a basal crop coefficient and combined with referent ET to calculate transpiration over time.

A spatial coverage of field boundaries was developed for the Kaweah Subbasin, and individual field polygons were assigned cropping and irrigation method information over time based on available data. Field boundaries were delineated by combining polygon coverages in GIS format from the United States Department of Agriculture (USDA) and the California Department of Water Resources (DWR). The area encompassed by the field boundary GIS coverage includes the Kaweah Subbasin and the area immediately surrounding but outside of the subbasin.

Crop ET was calculated based on a combination of remote sensing data and simulation of irrigation events in a daily root zone water balance model. Due to the remote sensing approach crop ET estimates are relatively insensitive to crop type and irrigation method so detailed, accurate assignment of crop types and irrigation methods to each field is not critical to developing relatively reliable estimates of crop ET. Crop types and irrigation method were assigned to each field based on a combination of data from DWR and USDA. The amount of green vegetation present over time was estimated for each field polygon based on NDVI, which is calculated using a combination of red and near infrared reflectances as measured using multispectral satellite sensors onboard Landsat satellites. Following the preparation of NDVI imagery spanning the analysis period all images were quality controlled to remove pixels affected by clouds.

Mean daily NDVI values for each field were converted to basal crop coefficients based on cropping information from the 2007 Tulare County crop survey, combined with an analysis of actual evapotranspiration (ET_a) by crop conducted using the Surface Energy Balance Algorithm for Land (SEBAL®) for 2007 (Bastiaanssen et al., 2005; SNA, 2009). Daily precipitation was estimated based on assembly and review of data from the PRISM Climate Group at Oregon State University[1]. Daily reference evapotranspiration (ET_o) was estimated based on information from California Irrigation Management Information System (CIMIS) weather stations. Root zone parameters that influence the amount of available soil moisture storage were estimated based on crops and soils present in the Kaweah Subbasin.

A summary for the 1999 to 2017 analysis period of the annual ET of applied water (ET_{AW}), ET_c (synonymous with ET_a), applied water (AW), deep percolation of applied water (DP_{AW}) and deep percolation of precipitation (DP_{pr}) estimates based on the root zone water balance model is given in the Results section.

Application of remote sensing combined with daily root zone water balance modeling (RS-RZ model) provides an improved methodology for estimation of surface interactions with the groundwater system including net groundwater depletion through estimation of ET of applied water and other fluxes.

2 Introduction

The purpose of this effort is to develop time series estimates of agricultural water demands for the Kaweah Subbasin from 1999 through 2017. Demand was estimated quantitatively at the field scale using a daily root zone water balance model and aggregated to monthly time steps. It is anticipated that these estimates will be used to support development of an integrated hydrologic model for the Kaweah Subbasin and water budget development for one or more Groundwater Sustainability Plans (GSPs). Crop evapotranspiration (ET), the primary driver of agricultural water demand, was estimated based on a combination of remote sensing and simulation of irrigation events using the water balance model.

This effort updates a similar analysis previously completed for the Kaweah Delta Water Conservation District (KDWCD) from 1999 through 2016 to include the areas currently not included in the KDWCD area but lying within the Kaweah Subbasin. In addition to adding the additional areas within the Kaweah subbasin, this analysis extends the estimates through the end of the 2017 calendar year.

3 Methodology

3.1 Daily Root Zone Simulation Model

A conceptual diagram of the various surface layer fluxes of water into and out of the crop root zone is provided in Figure 3.1. The consumptive use of water (i.e., evapotranspiration or ET) is the primary destination of infiltrated precipitation and applied irrigation water within the Kaweah Subbasin. Quantification of consumptive use was achieved by performing daily calculations of ET for individual fields from October 1998 through December 2017. Evapotranspiration was separated into its evaporation (E) and transpiration (T) components. Additionally, each component was separated into the amount of E or T derived from precipitation or applied water.

[1] http://prism.oregonstate.edu/

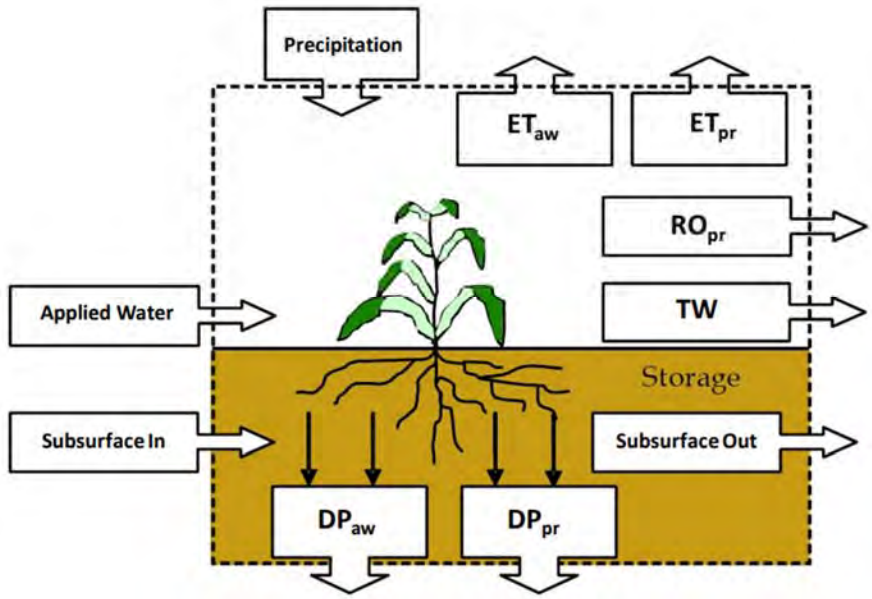

Figure 3.1. Conceptualization of Fluxes of Water Into and Out of the Crop Root Zone

Transpiration was quantified using a remote sensing approach whereby Landsat satellite images acquired from USGS were used to calculate the Normalized Difference Vegetation Index (NDVI), a measure of the amount of green vegetation present. NDVI values were calculated and interpolated for each field over time. NDVI values were then converted to transpiration coefficients that were used to calculate transpiration over time by multiplying daily NDVI by daily reference evapotranspiration (ET_o). Evaporation was quantified by performing a surface layer water balance for the soil based on the dual crop coefficient approach described in FAO Irrigation and Drainage Paper 56 (Allen et al. 1998). On a daily basis, evaporation was calculated based on the most recent wetting event (precipitation or irrigation) and the evaporative demand for the day (ET_o). This methodology is described in greater detail by Davids Engineering (Davids Engineering 2013).

3.2 Development of Field Boundaries

A spatial coverage of field boundaries was developed for the Kaweah Subbasin, and individual field polygons were assigned cropping and irrigation method information. For each field polygon, daily water balance calculations were performed for the 1999 to 2017 analysis period, and irrigation events were simulated to estimate the amount of water applied to meet crop irrigation demands. This section describes the development of the field polygon coverage and assignment of cropping and irrigation method attributes.

3.2.1 Development of Field Boundaries

Field boundaries were delineated by combining publicly available polygon coverages in GIS format from the United States Department of Agriculture (USDA) and the California Department of Water Resources (DWR). For the original KDWCD study area, common land unit (CLU) coverages developed by the USDA Farm Services Administration (FSA) on a county by county basis were combined to develop the base field coverage. Gaps exist in the CLU field coverages for fields not participating in USDA farm programs. These gaps were filled by overlaying the FSA CLU data with field polygons from DWR land use surveys for Kings and Tulare counties.

For the expanded study area encompassing the full Kaweah Subbasin, the original field boundaries were retained, and additional fields were added based on DWR's 2014 statewide spatial cropping dataset.

The area encompassed by the field boundary GIS coverage includes the Kaweah Subbasin and the area immediately surrounding, but outside of, the subbasin. Fields outside of the subbasin were included to provide a more robust dataset for model calibration and validation. Ultimately, results specific to the subbasin as a whole include only those fields with their centroid located within the Kaweah Subbasin.

3.3 Assignment of Cropping and Irrigation Method

As described previously, crop evapotranspiration (ET) was calculated based on a combination of remote sensing data and simulation of irrigation events in a daily root zone water balance model. A result of the remote sensing approach is that crop transpiration was estimated with little influence from the assigned crop type for each field. Additionally, crop transpiration is the dominant component of ET, meaning that ET estimates are likewise largely independent of the assigned crop type.

Crop evapotranspiration is driven to some extent by the characteristics of the irrigation method and its management, including the area wetted during each irrigation event and the frequency of irrigation. Surface irrigation methods typically wet more of the soil surface than micro-irrigation methods; however, surface irrigated fields are typically irrigated less frequently than their micro-irrigated counterparts. As a result, evaporation rates can be similar among surface and micro-irrigated fields and estimates of evaporation are likewise somewhat independent of the assigned irrigation method. Parameters related to irrigation method were assigned based the predominant irrigation method for each crop, as described by recent historical DWR land and water use surveys.

A key result of the relative insensitivity of the crop ET estimates to crop type or irrigation method (due to the remote sensing approach), is that detailed, accurate assignment of crop types and irrigation methods to each field is not critical to developing reliable estimates of crop ET at the field scale and, more importantly, at coarser scales due to the cancellation of errors in individual field estimates as they are aggregated.

Crop types were assigned to each field based on a combination of data from DWR and USDA. DWR data consisted of land use data from 2003 and 2014 for Kings County and from 1999, 2007, and 2014 for Tulare County. USDA data consisted of Cropland Data Layer coverages for 2008 to 2013 and 2015 to 2016. The source of land use data for each year is summarized in Table 3.1.

Table 3.1. Land Use Sources by County and Year.

County	Year(s)	Source
Kings	1999-2007	DWR (2003)
	2008-2013	CDL
	2014	DWR (2014)
	2015-2017	CDL*
Tulare	1999-2002	DWR (1999)
	2003-2007	DWR (2007)
	2008-2013	CDL
	2014	DWR (2014)
	2015-2017	CDL*

* CDL data for 2016 was used for 2017

3.4 NDVI Analysis

The amount of green vegetation present over time was estimated for each field polygon based on the Normalized Difference Vegetation Index (NDVI), which is calculated using a combination of red and near infrared reflectances, as measured using multispectral satellite sensors onboard Landsat satellites. NDVI can vary from -1 to 1 and is typically varies from approximately 0.15 to 0.2 for bare soil to 0.8 for green vegetation with full cover. Negative NDVI values typically represent water surfaces.

3.4.1 Image Selection

Landsat images are preferred due to their relatively high spatial resolution (30-meter pixels, approx. 0.2 acres in size). A total of 682 raw satellite images were selected and converted to NDVI spanning the period from September 1998 to January 2018. Of the images selected, 230 were from the Landsat 5 satellite, 350 were from the Landsat 7 satellite (first available in 2001), and 102 were from the Landsat 8 satellite (first available in 2013). These images were used to process and download surface reflectance (SR) NDVI from the USGS Earth Resources Observation and Science (EROS) Center Science Processing Architecture (ESPA)[2].

An example time series of NDVI imagery for 2010 for the Kaweah Delta Water Conservation District (KDWCD) is shown in Figure 3.1 in Davids Engineering (2013). In the figure, areas with little or no green vegetation present are shown in brown, and areas with green vegetation are shown in green.

There was sufficient cloud-free Landsat imagery available that no cloud gap filling as in Davids Engineering (2013) was necessary. The number of days between image dates ranged from 5 to 56, with an average of 10 days. Generally, there was at least one image selected for each month.

3.4.2 Extraction of NDVI Values by Field and Development of Time Series NDVI Results

Following the preparation of NDVI imagery spanning the analysis period, all images were masked using the Quality Assessment Band (BQA) provided by ESPA to remove pixels affected by clouds. Then, mean NDVI was extracted from the imagery for each field for each image date. These NDVI values were then interpolated across the full analysis period from October 1, 1998 to December 31, 2017 to provide a daily time series of mean NDVI values for each field.

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[2] USGS ESPA website: https://espa.cr.usgs.gov/

Top of Atmosphere (TOA) NDVI was calculated for several image dates and compared to SR NDVI on the same image dates to establish the following relationship (R^2=0.99):

$$(\text{TOA NDVI}) = 0.9224*(\text{SR NDVI}) - 0.0171 \quad [3.1]$$

This regression was applied to all image dates to convert from SR to TOA NDVI to provide consistency with the relationship between NDVI and the transpiration coefficient developed by Davids Engineering (2013) Error! Bookmark not defined..

Landsat 8 bandwidth was adjusted to be consistent with bandwidths from Landsat satellites 5 and 7 using the following empirical relationship:

$$(\text{L7 mean NDVI}) = 0.984*(\text{L8 mean NDVI}) - 0.0421 \quad [3.2]$$

An example of time varying NDVI for individual fields over time is found in Section 3 of Davids Engineering (2013). Interpolated NDVI values for selected fields are provided for the period 1999 through 2010 on an annual basis, from January 1 to December 31 of each year. These figures illustrate the ability of the remote sensing approach to account for both changes in cropping over time and the presence of double- and triple-cropping.

3.4.3 Development of Relationships to Estimate Basal Crop Coefficient from NDVI

Basal crop coefficients (K_{cb}) describe the ratio of crop transpiration to reference evapotranspiration (ET_o) as estimated from a ground-based agronomic weather station. By combining K_{cb}, estimated from NDVI, with an evaporation coefficient (K_e), it is possible to calculate a combined crop coefficient ($K_c = K_{cb} + K_e$) over time[3]. By multiplying K_c by ET_o, crop evapotranspiration (ET_c) can be calculated. For this analysis, ET_o, K_{cb}, K_e, and ET_c (synonymous to actual ET, ET_a) were estimated for each field on a daily time step from October 1, 1998 to December 31, 2017.

Mean daily NDVI values for each field were converted to basal crop coefficients based on cropping information from the 2007 Tulare County crop survey conducted by DWR, combined with an analysis of actual evapotranspiration (ET_a) by crop conducted using the Surface Energy Balance Algorithm for Land (SEBAL®) for 2007 (Bastiaanssen et al., 2005; SNA, 2009). Specifically, a relationship between actual basal crop coefficients estimated using SEBAL and field-scale mean NDVI values developed by Davids Engineering (2013) was applied to calculate daily basal crop coefficients for each field over time[4].

3.5 Precipitation

Daily precipitation was estimated based on assembly and review of data from the PRISM Climate Group at Oregon State University[5]. Specifically, each field was assigned estimated precipitation from the 4km PRISM grid cell within which its centroid fell. The update generally results in modest increases in estimated precipitation within the study area, with greater increases moving from west to east due to orographic effects.

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[3] The estimation of Ke is based on a daily 2-stage evaporation model presented in FAO Irrigation and Drainage Paper No. 56 (Allen et al. 1998).

[4] This relationship is developed based on comparison of the combined crop coefficient to NDVI for individual fields, but represents only the transpiration component of ET. Thus, the relationship developed predicts the basal crop coefficient, Kcb.

[5] http://prism.oregonstate.edu/

Annual precipitation totals, averaged over the study area for water years 1999 to 2017, are shown in Figure 3.1. Water year precipitation over the study period varied from 4.1 inches in 2014 to 16.1 inches in 2011, with an annual average of 9.1 inches.

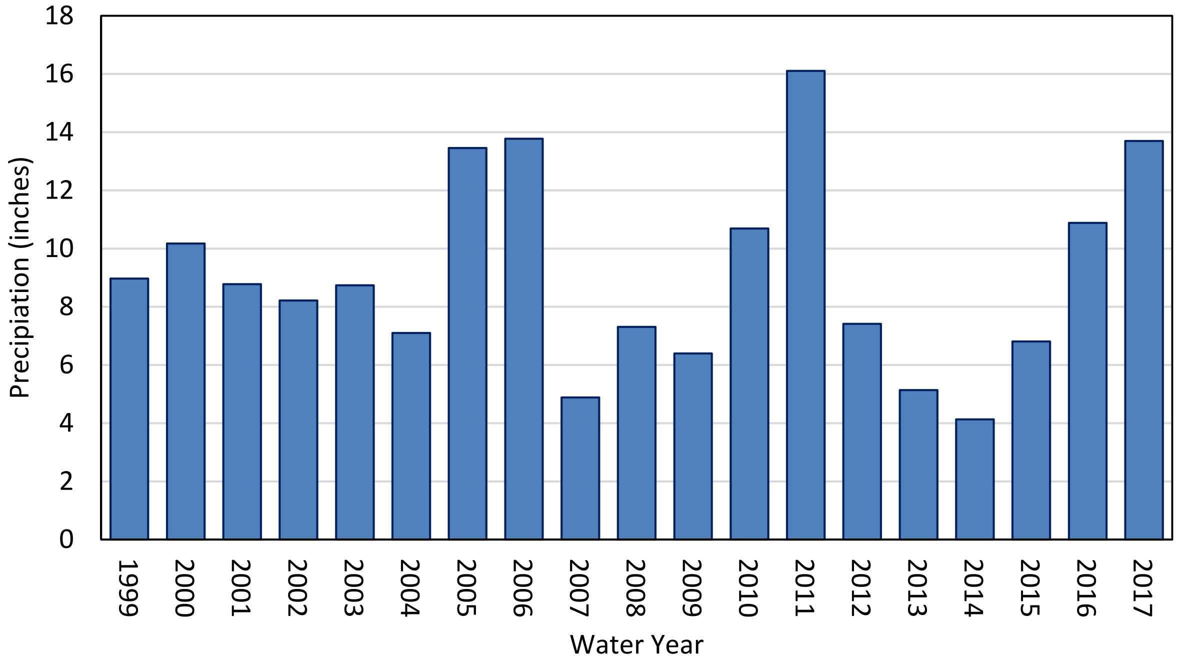


Figure 3.2. Annual Precipitation Totals

3.6 Estimation of Daily Reference Evapotranspiration

Daily reference evapotranspiration (ET_o) was estimated based on information from California Irrigation Management Information System (CIMIS) weather stations. ET_o provides a means of estimating actual crop evapotranspiration over time for each field. Based on review of nearby weather stations with data available during the period of analysis, the Porterville station (169) was selected based on it being relatively close to the Kaweah Subbasin, at a similar elevation to the Kaweah Subbasin, having relatively good fetch, and having available data for the majority of the analysis period.

Individual parameters from the available data including incoming solar radiation, air temperature, relative humidity, and wind speed were quality-controlled according to the procedures of Allen et al. (2005). The quality-controlled data were then used to calculate daily ET_o for the available period of record.

CIMIS data for Porterville were not available prior to August 2000. As a result, it was necessary to estimate ET_o for the period from October 1, 1998 to August 1, 2000. ET_o for Porterville was estimated by developing a linear regression to estimate Porterville ET_o using quality-controlled data from the Stratford CIMIS station for the period of overlapping data availability.

3.7 Estimation of Root Zone Water Balance Parameters

Root zone parameters that influence the amount of available soil moisture storage were estimated based on crops and soils present in the Kaweah Subbasin. Crop parameters of interest include root depth, NRCS curve number[6], and management allowable depletion (MAD). Root depth was estimated by crop group based on published values and a representative mix of individual crops within each crop group for the Kaweah Subbasin. Curve numbers were estimated based on values published in the NRCS National Engineering Handbook, which provides estimates based on crop type and condition. MAD values by crop were estimated based on values published in FAO Irrigation and Drainage Paper No. 56 (Allen et al., 1998).

Soil hydraulic parameters of interest include field capacity (% by vol.), wilting point (% by vol.), saturated hydraulic conductivity (ft/day), total porosity (% by vol.), and the pore size distribution index (λ, dimensionless). These parameters were estimated by first determining the depth-weighted average soil texture (sand, silt, clay, etc.) based on available NRCS soil surveys. Then, the hydraulic parameters were estimated using hydraulic pedotransfer functions developed by Saxton and Rawls (2006). Next, hydraulic parameters were adjusted within reasonable physical ranges for each soil texture so that the modeled time required for water to drain by gravity from saturation to field capacity agreed with typically accepted agronomic values. Unsaturated hydraulic conductivity (e.g. deep percolation) within the root zone was modeled based on the equation developed by Campbell (1974) for unsaturated flow.

4 Results

4.1 Crop Evapotranspiration

Estimated annual crop evapotranspiration volumes for fields with their centroid within the Kaweah Subbasin are shown in Figure 4.1. Estimated volumes of ET derived from applied water (ETaw) and precipitation (ETpr) are shown in thousands of acre-feet (taf). Annual ETaw ranged from 721 taf to 916 taf, with an average of 817 taf. Annual ETpr ranged from 87 taf to 260 taf, with an average of 174 taf. Total crop ET ranged from 899 taf to 1,056 taf, with an average of 991 taf.

[6] The curve number runoff estimation method developed the Natural Resources Conservation Service (NRCS) was used to estimate runoff from precipitation in the model. For additional information, see NRCS NEH Chapter 2 (NRCS, 1993).

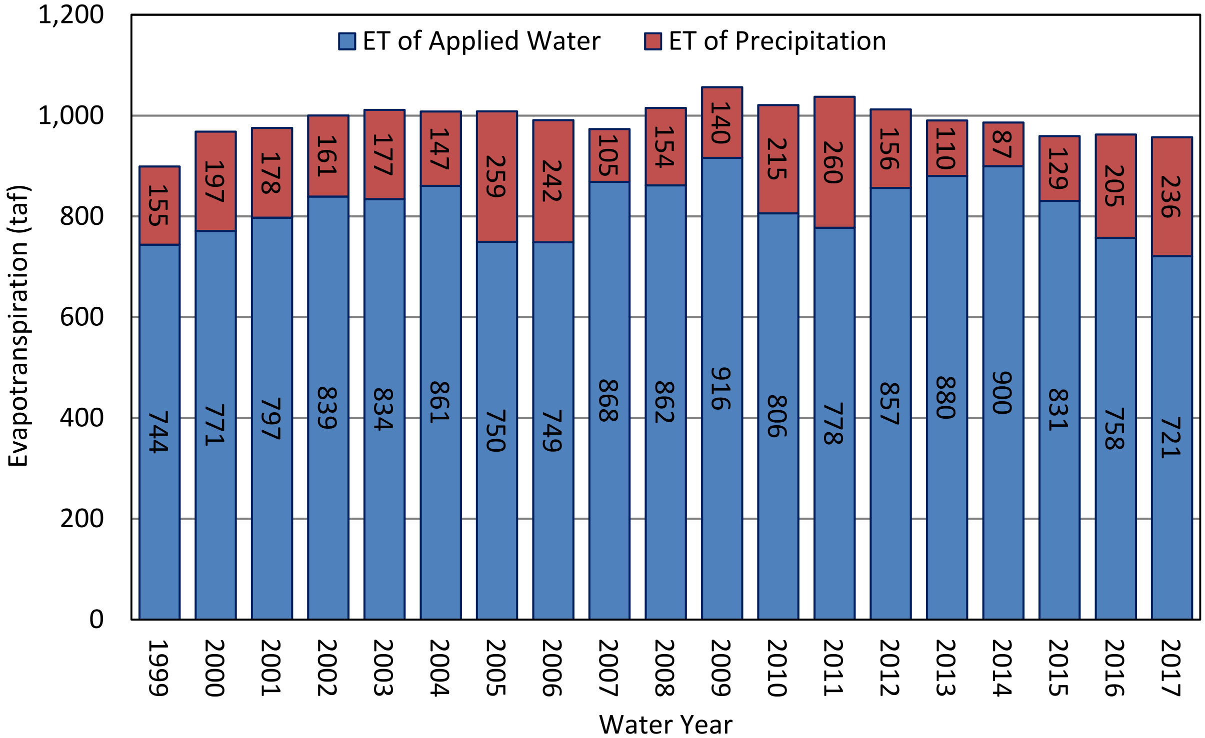


Figure 4.1. Kaweah Subasin Crop ET by Water Year

4.2 Irrigation Demands

Annual estimated irrigation demands for fields with their centroid within the Kaweah Subbasin are shown in Figure 4.2 in thousands of acre feet. Annual demands ranged from 948 taf to 1,149 taf, with an average of 1,042 taf.

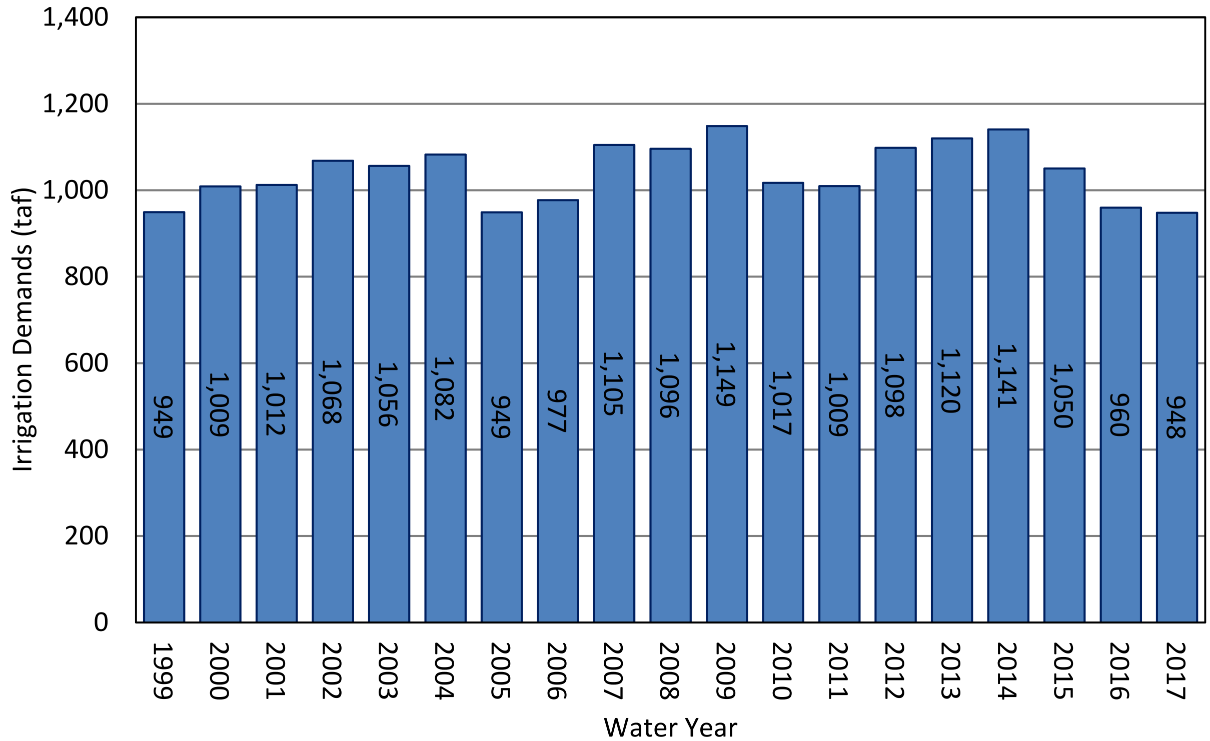


Figure 4.2. Kaweah Subasin Irrigation Demands by Water Year

4.3 Deep Percolation

Estimated annual deep percolation volumes for fields with their centroid within the Kaweah Subbasin are shown in Figure 4.3. Estimated volumes of deep percolation derived from applied water (DPaw) and precipitation (DPpr) are shown in thousands of acre-feet. Annual DPaw ranged from 208 taf to 242 taf, with an average of 227 taf. Annual DPpr ranged from 24 taf to 130 taf, with an average of 60 taf. Total deep percolation ranged from 255 taf to 372 taf, with an average of 287 taf.

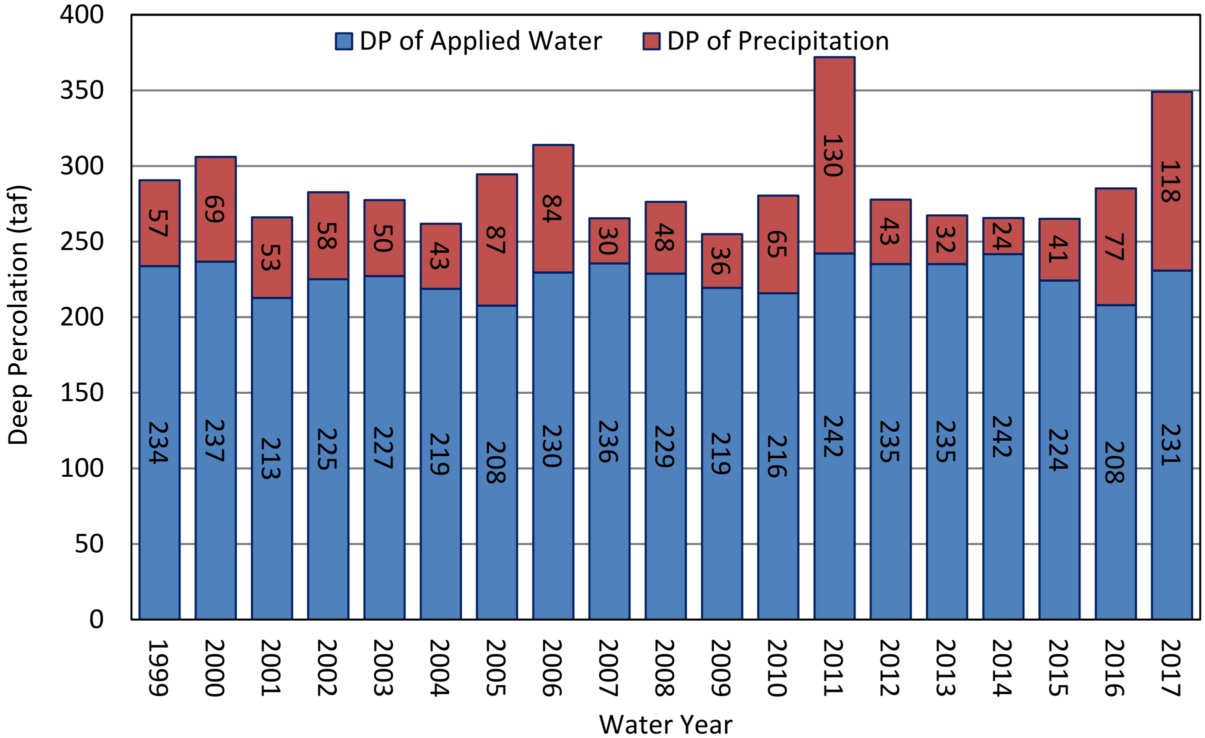


Figure 4.3. Kaweah Subasin Deep Percolation by Water Year

4.4 Annual Evapotranspiration by Crop for 2014

Estimated annual average evapotranspiration by crop is shown in Figure 4.4, along with the estimated acreage for each crop. Figure 4.4 shows the estimated average total ET by crop in inches in 2014. Average ET ranges from 7 inches for miscellaneous grain and hay to 49 inches for walnuts. The primary crops are corn, citrus, alfalfa and walnuts, representing 82, 60,40, and 31 thousand acres, respectively.

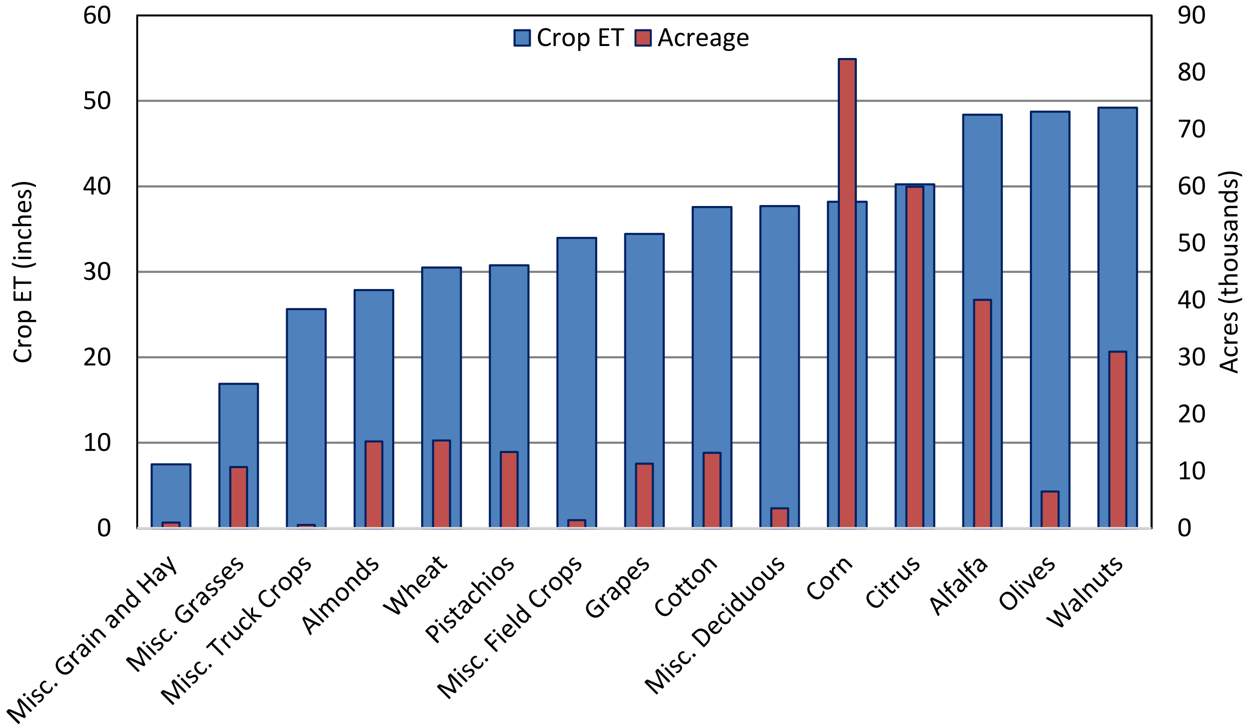


Figure 4.4. Kaweah Subasin 2014 Average ET by Crop and Crop Acreage

Additional monthly plots of ET_{oF}, ET_a and AW by crop for 2014 can be found in the appendix.

5 References

Allen, R.G, L.S. Pereira, D. Raes, and M. Smith. 1998. Crop Evapotranspiration - Guidelines for Computing Crop Water Requirements. FAO Irrigation and Drainage Paper 56. FAO. Rome, Italy.

Davids Engineering. 2013. Time Series Evapotranspiration and Applied Water Estimates from Remote Sensing. Kaweah Delta Water Conservation District. http://www.kdwcd.com/wp-content/uploads/2018/07/KDWCD-NDVI-ET-Analysis-FINAL-REPORT-March-2013.pdf

NRCS. 1993. Chapter 2 - Watershed Project Evaluation Procedures. National Engineering Handbook Part 630, Hydrology.

Saxton, K.E. and W.J. Rawls. 2006. Soil Water Characteristic Estimates by Texture and Organic Matter for Hydrologic Solutions. Soil Sci. Soc. Am. J. 70:1569–1578.

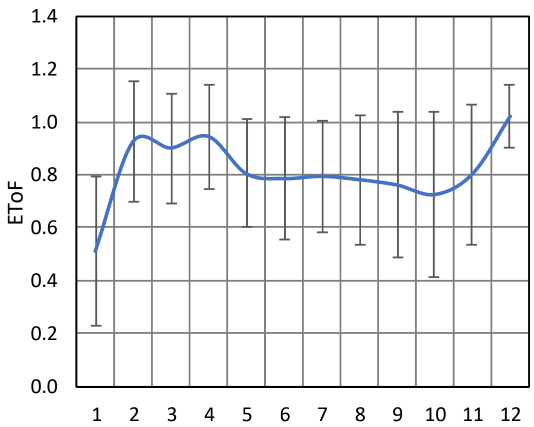
6 Appendix

This appendix includes the following figures:

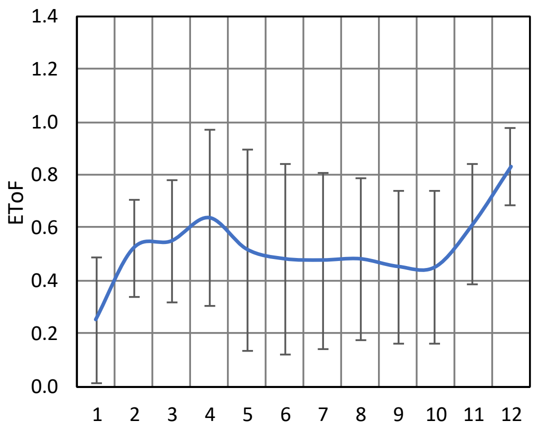
- Average monthly crop water use coefficients or “fraction of reference ET” (EToF) by crop, along with error bars depicting the standard deviation among fields.
- Average monthly crop ET by crop, along with error bars depicting the standard deviation among fields.
- Average monthly applied water by crop, along with error bars depicting the standard deviation among fields.

EToF 2014

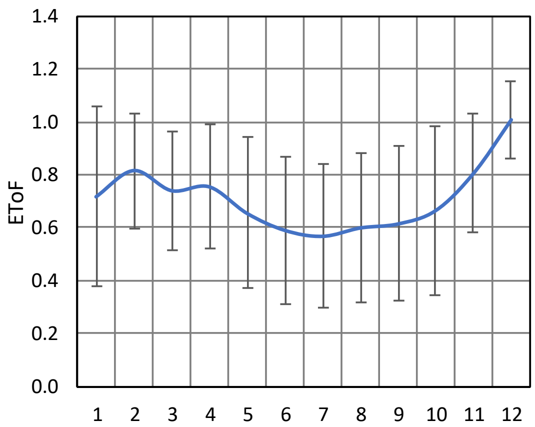
Alfalfa



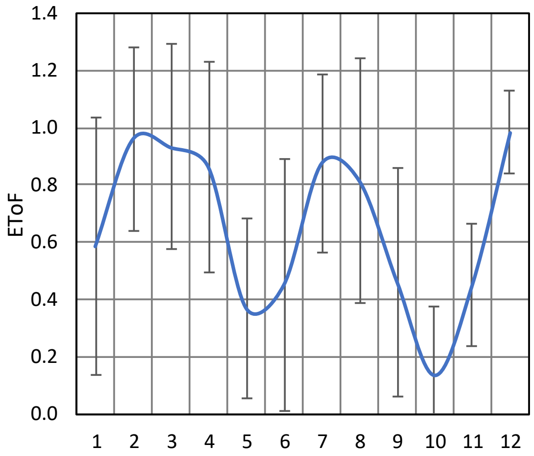
Almonds



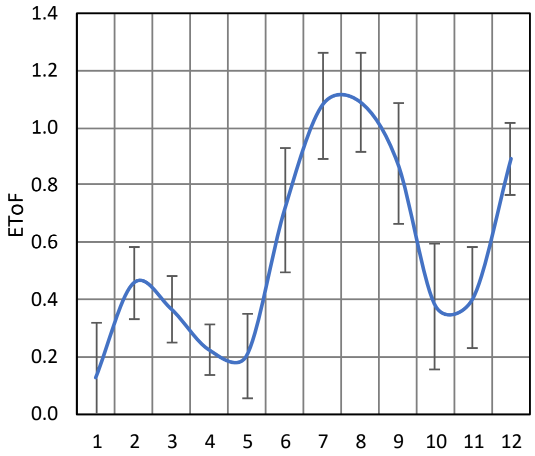
Citrus



Corn



Cotton



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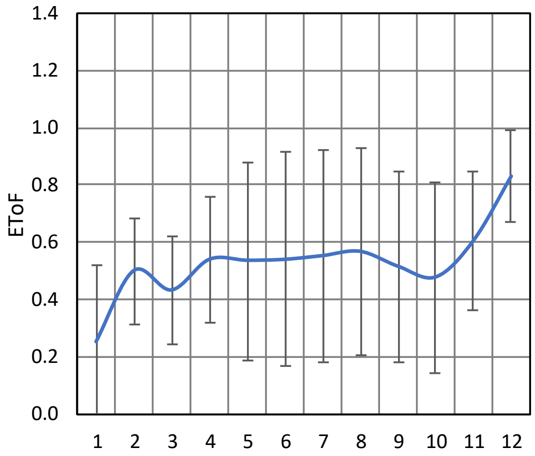

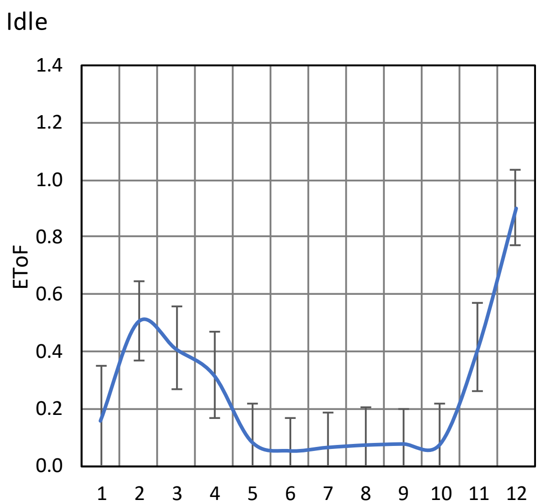
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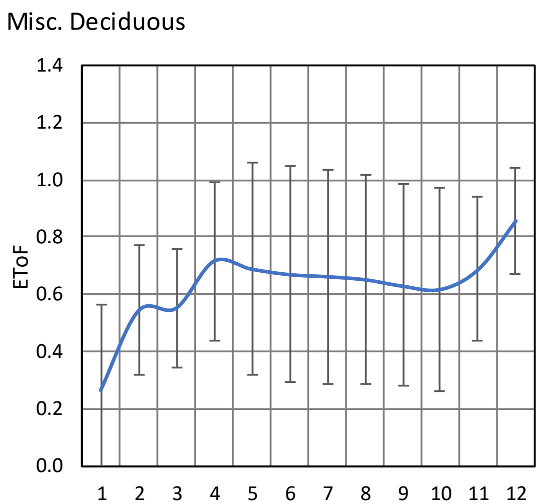
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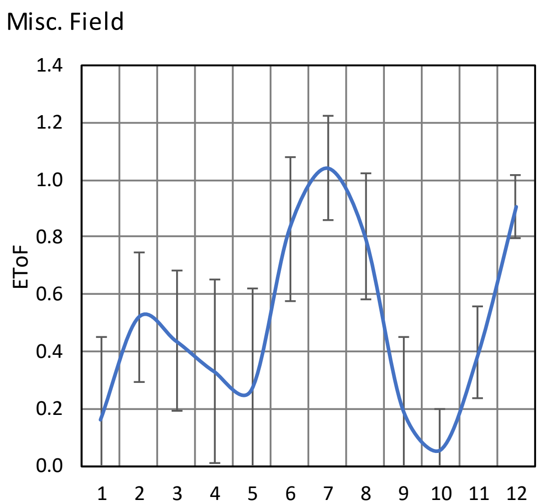
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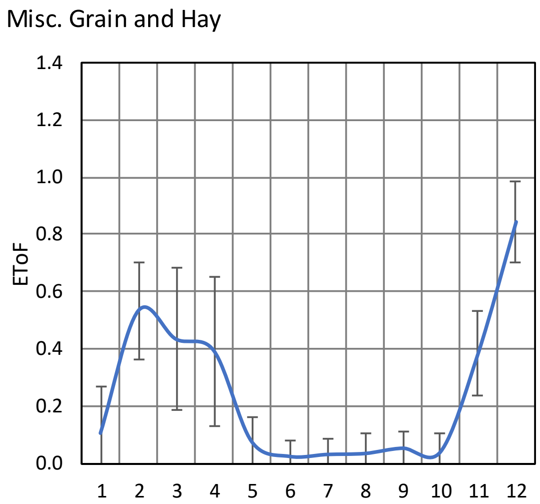
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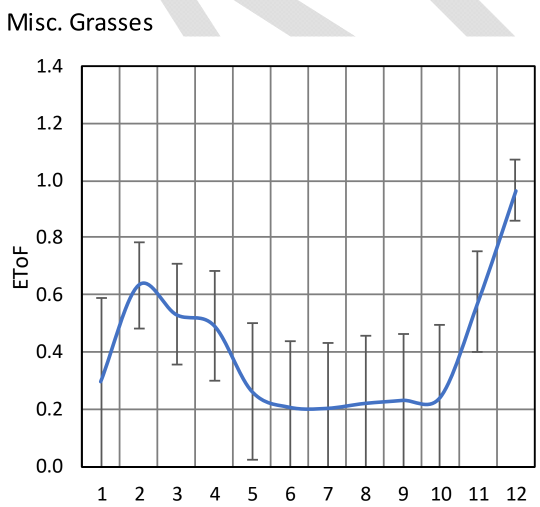
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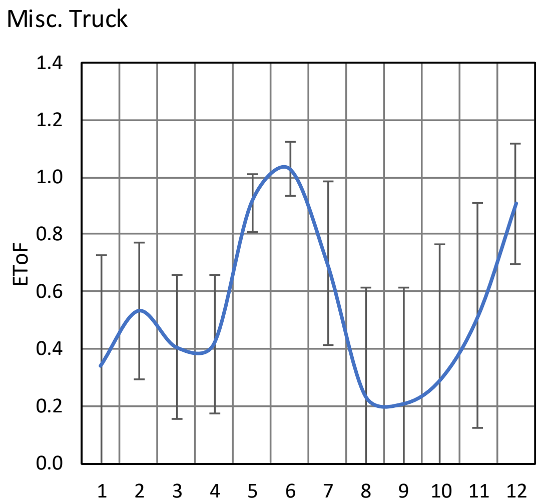
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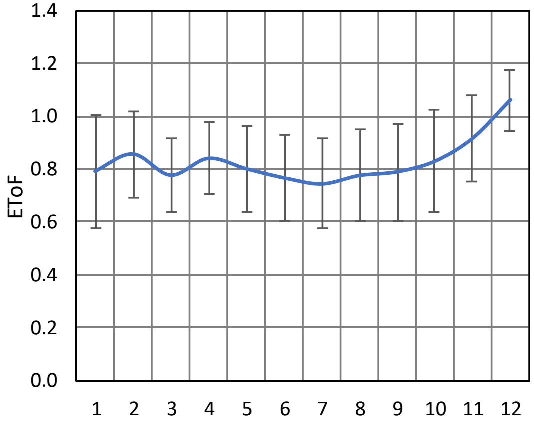

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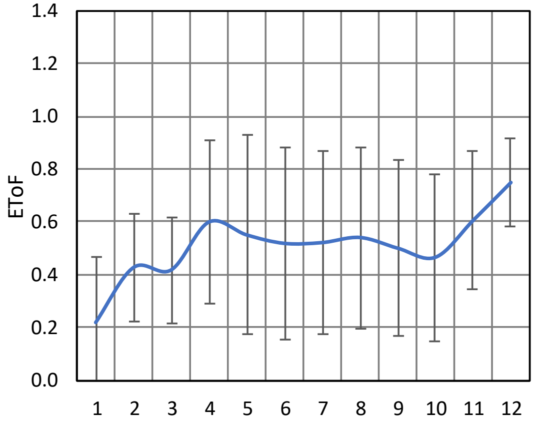

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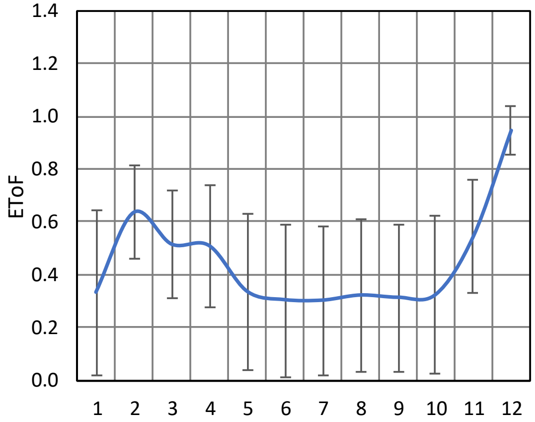

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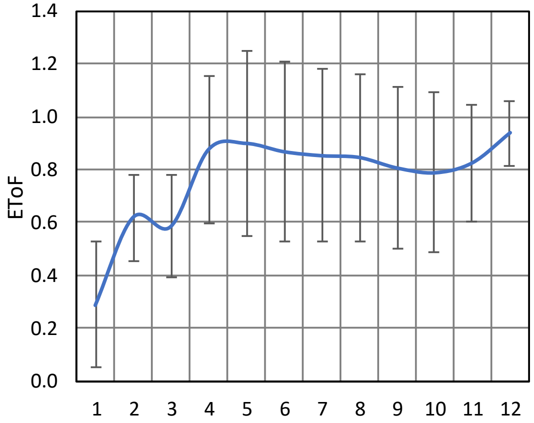

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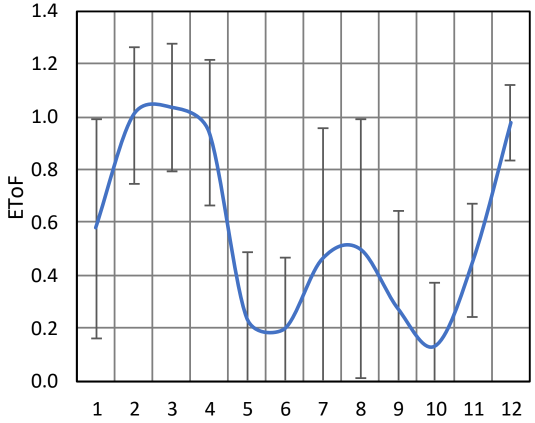

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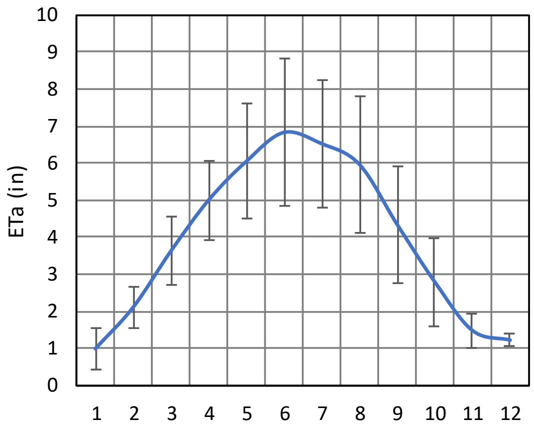

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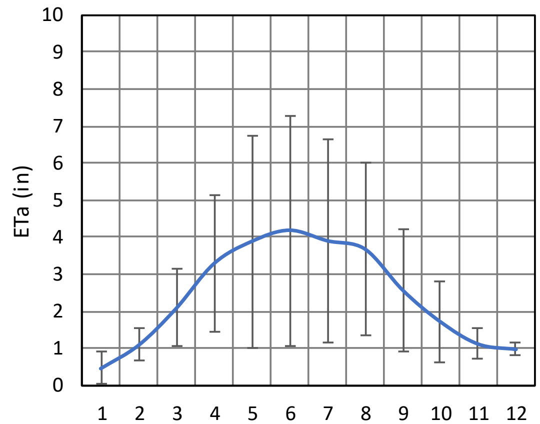

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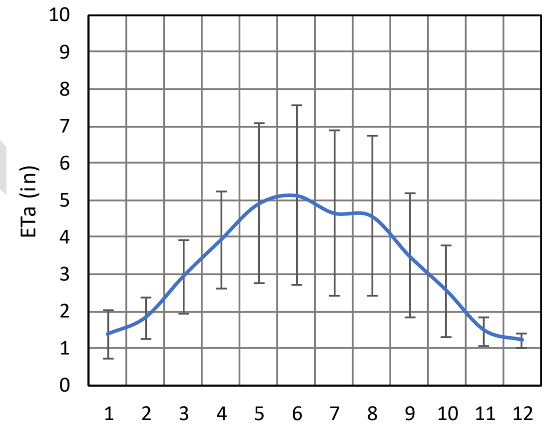

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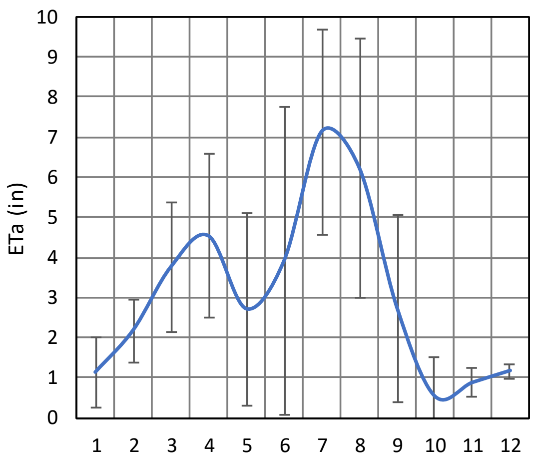

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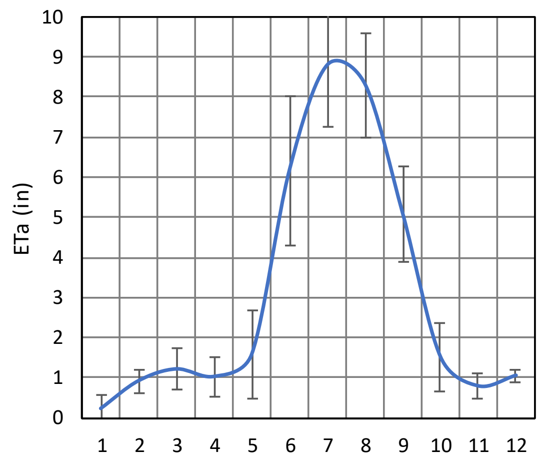

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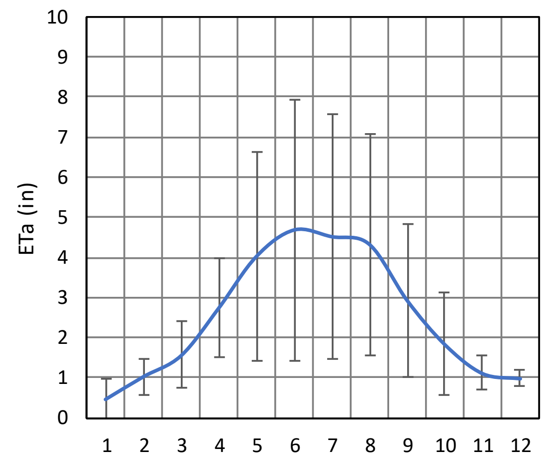

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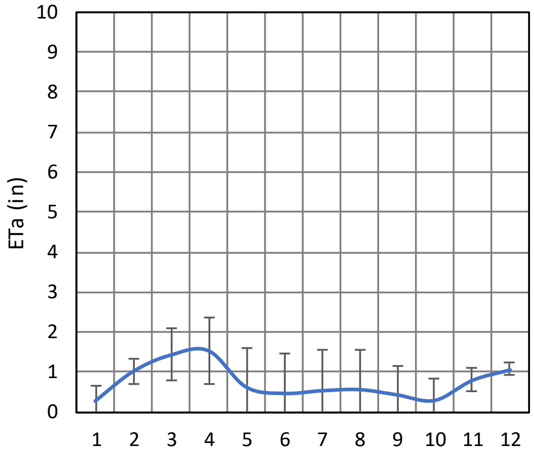

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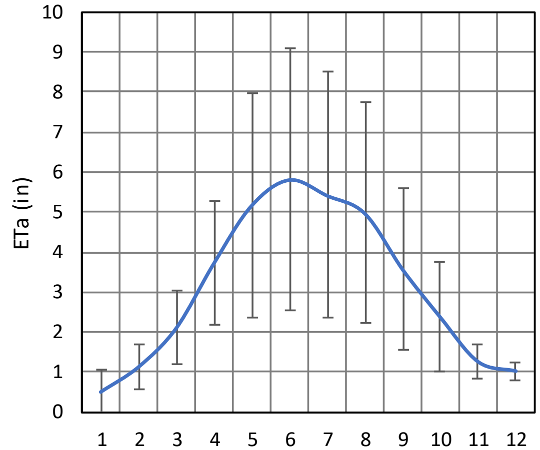

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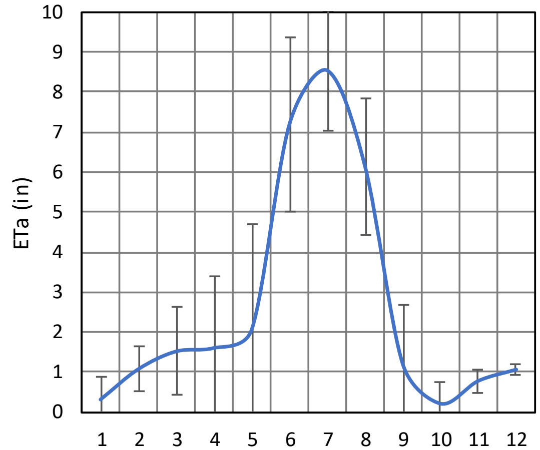

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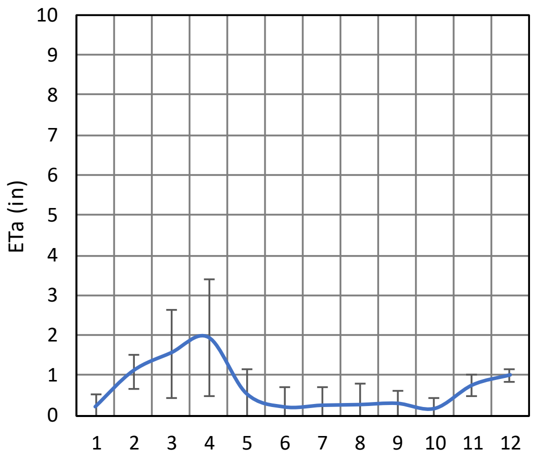

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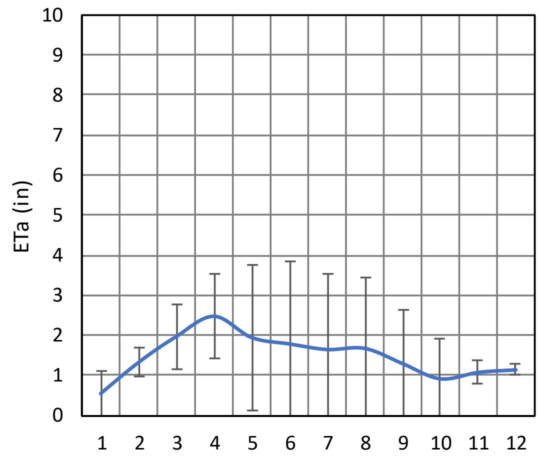

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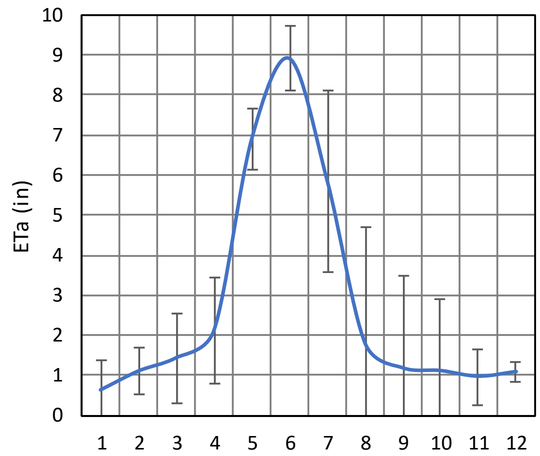

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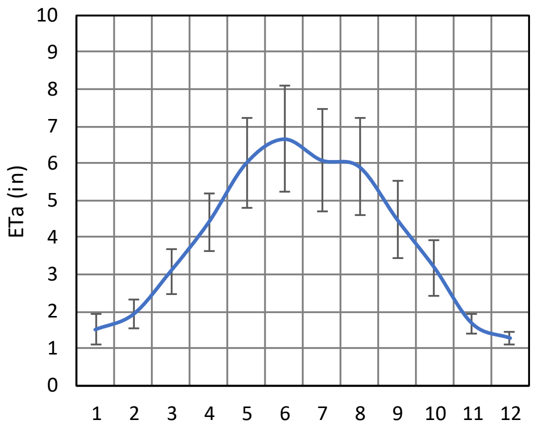

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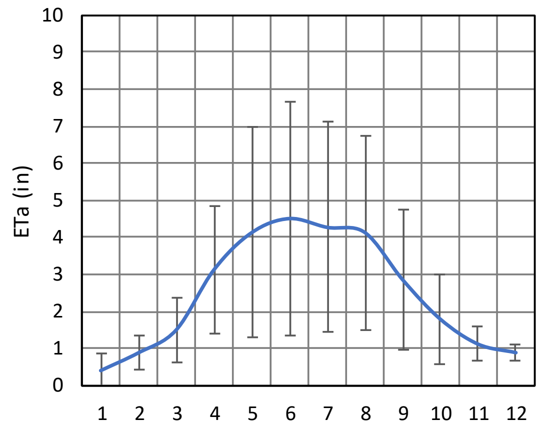

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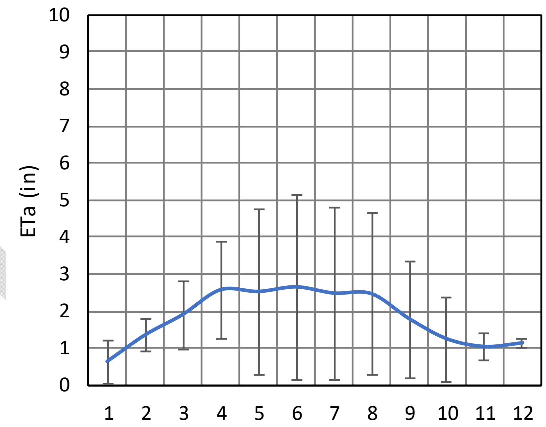

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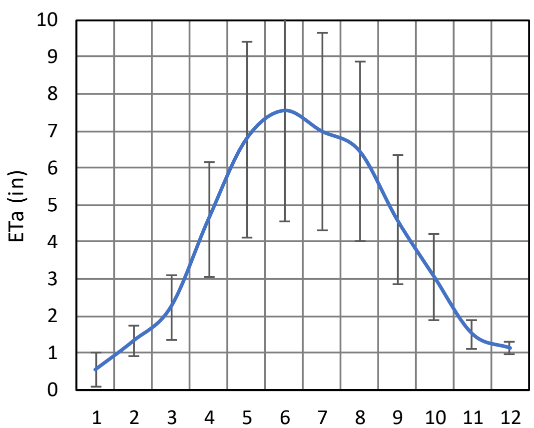

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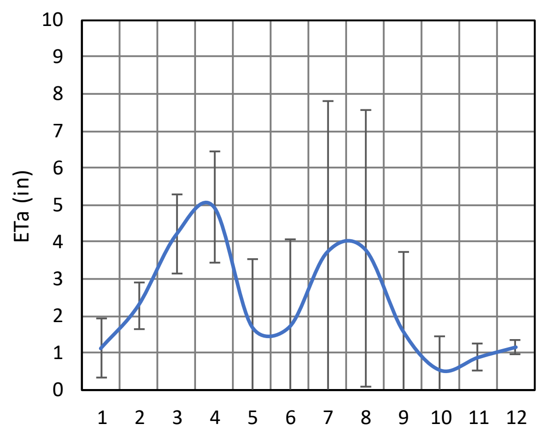

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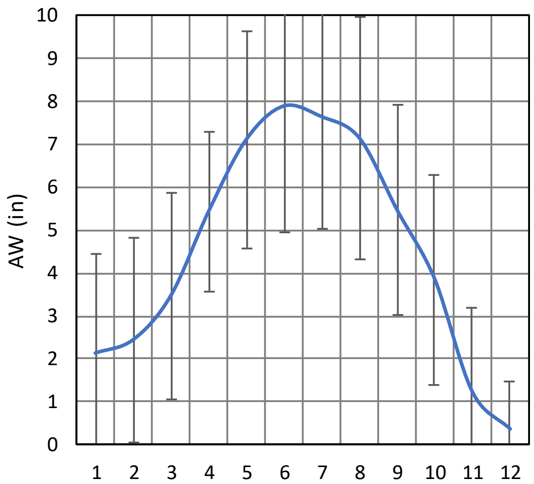

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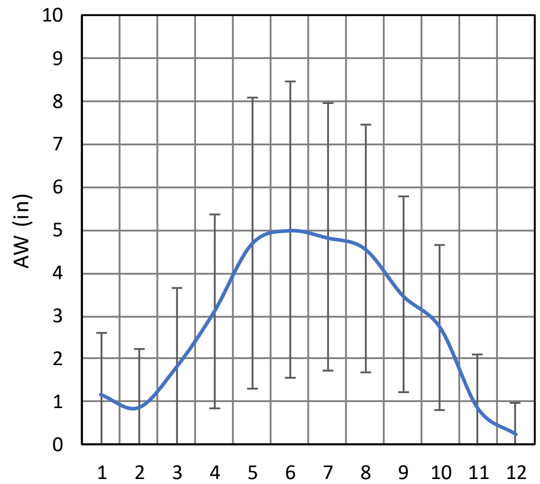

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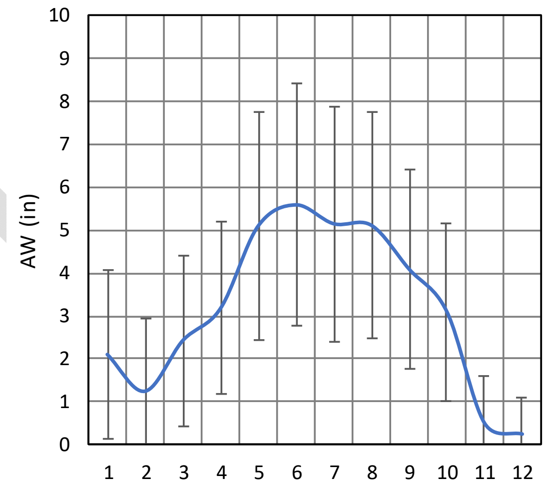

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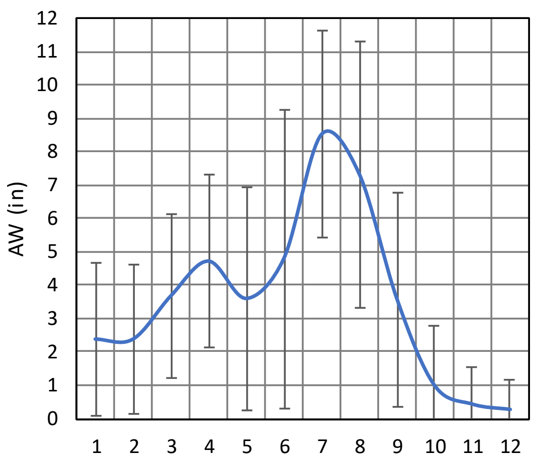

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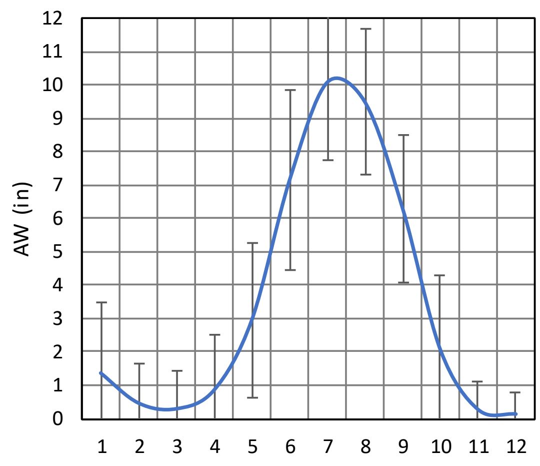

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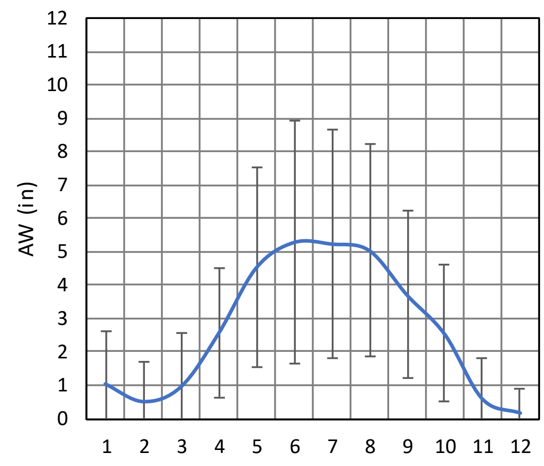

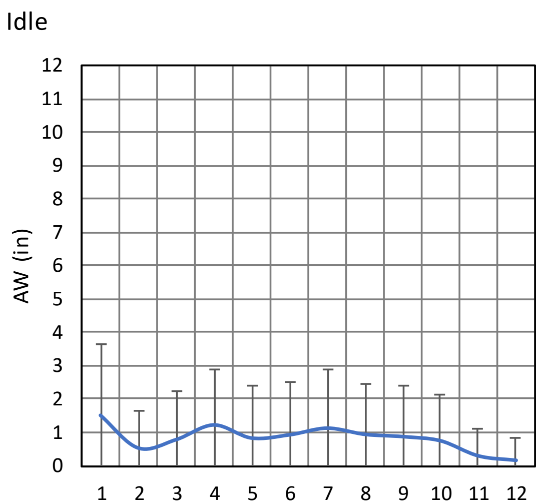
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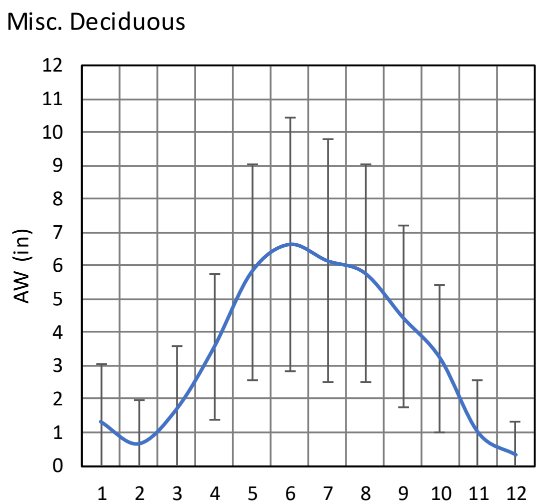
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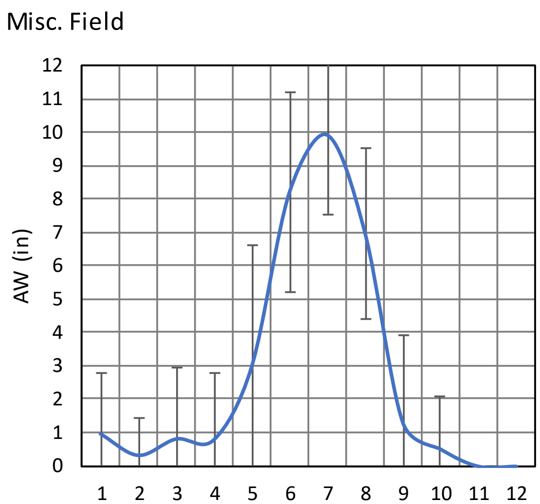
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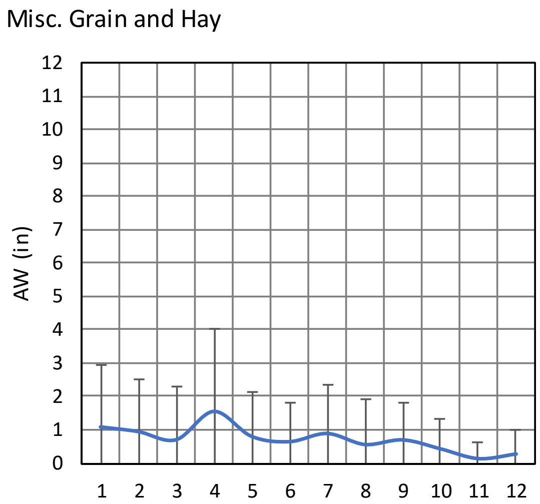
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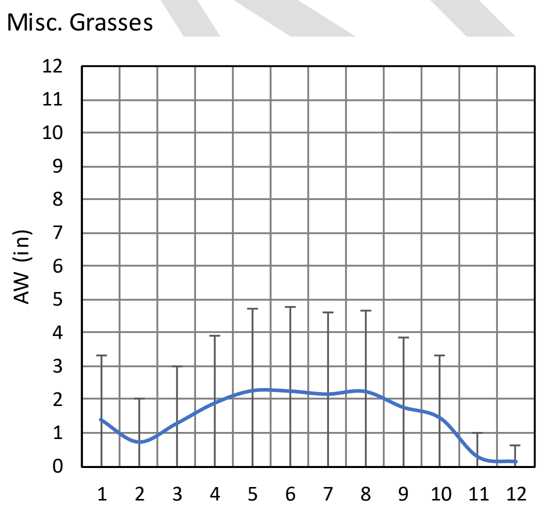
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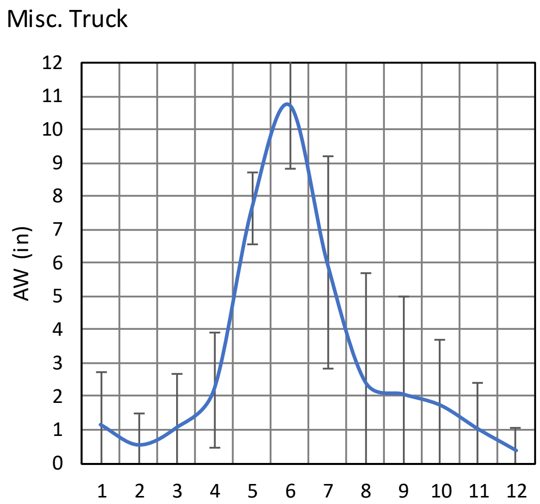
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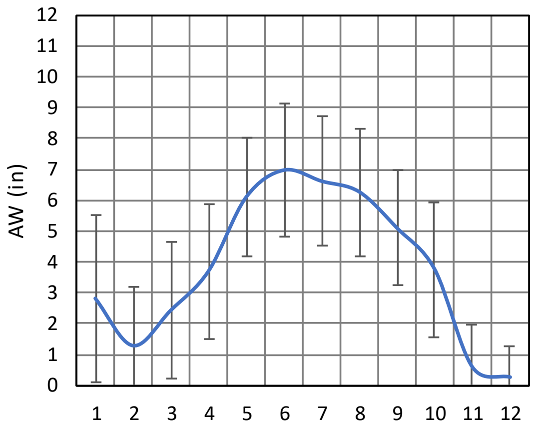

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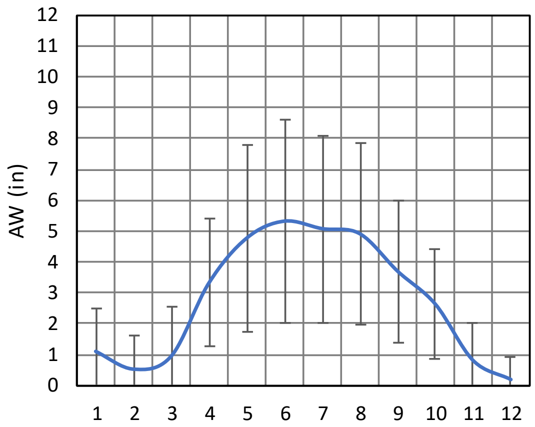

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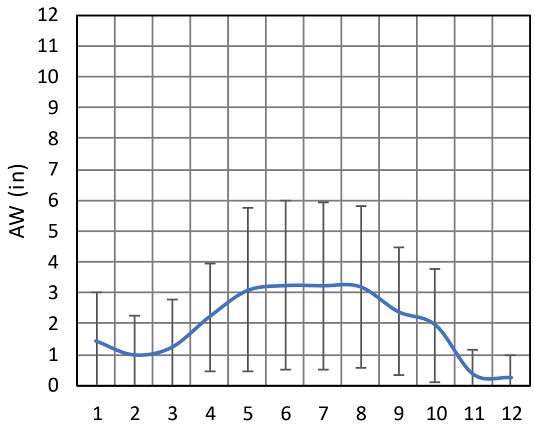

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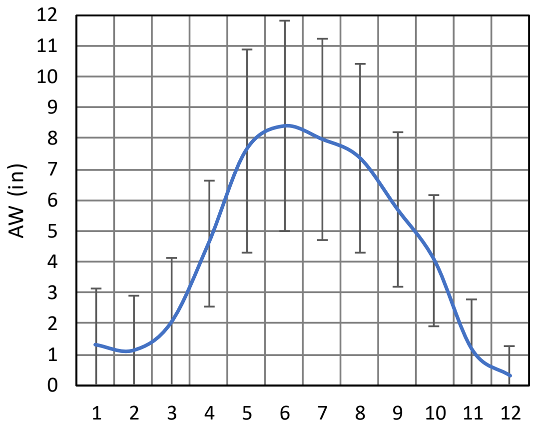

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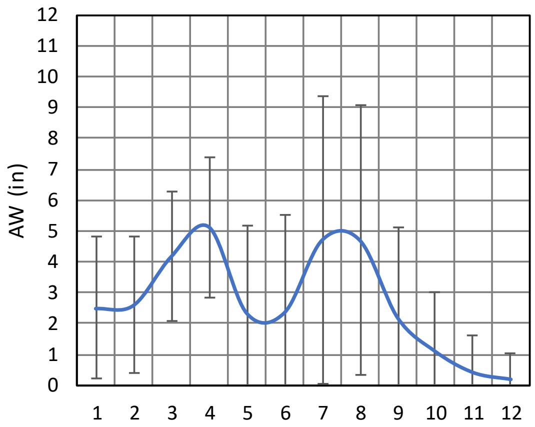

Appendix D

Friant
WATER AUTHORITY

Technical Memorandum

Estimate of Future Friant Division Supplies for use in Groundwater Sustainability Plans, California

CONTENTS

FIGURES

TABLES

ACRONYMS

CFS	cubic feet per second
CVP	Central Valley Project
CWC	California Water Commission
DEW	Drier/Extreme Warming
DWR	California Department of Water Resources
GSA	Groundwater Sustainability Agency
Friant	Friant Water Authority
Friant Contractors	Friant Division long-term contract holders
PEIS/R	Program Environmental Impact Statement/Report
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RWA	Recovered Water Account
SGMA	Sustainable Groundwater Management Act
SJRRP	San Joaquin River Restoration Program
SJRRS	San Joaquin River Restoration Settlement
SWP	State Water Project
TAF	thousand acre-feet
TM	Technical Memorandum
WMW	Wetter, Moderate Warming
WSIP	Water Supply Investment Program

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BACKGROUND

The Friant Water Authority (Friant) was approached by several Groundwater Sustainability Agencies (GSAs) for information about future water supply availability from the Central Valley Project (CVP) Friant Division. Those GSAs include the following, who were subsequently engaged during the development of analysis to meet their request:

- Mid-Kaweah GSA, represented by Paul Hendrix
- White Wolf Sub-basin GSA, represented by Jeevan Muhar
- Kern Groundwater Authority, represented by Terry Erlewine

This Technical Memorandum (TM) was prepared for use by those GSAs and others, in accordance with the expectations set by the Friant Board of Directors in their 2016 Strategic Plan to provide "accurate and up-to-date data needed to manage water supplies through modeling and data collection."

This TM presents five scenarios that were intended to represent a range of potential water supply conditions for the Friant Division through the end of the century, all of which were assembled from existing studies that were recently conducted using the CalSim-II computer model. These scenarios were assembled from pre-existing model runs and analysis and have been compiled and reviewed by Friant for use or consideration in plans developed by GSAs that receive Friant Contract surface water deliveries. The selected scenarios are summarized below and organized by their identification name in the accompanying "Summary_FutureFriantSupplies_Final" spreadsheet file.

1. **Model Run 2015.c (''2015.c'')** was designed to represent current conditions, where implementation of the San Joaquin River Restoration Settlement (SJRRS) is limited by downstream capacity limitations and the climate and hydrology are assumed to be most similar to historical hydrologic conditions.

2. **''2030.c''** was designed to represent near future climate conditions centered around 2030 and uses California Department of Water Resources (DWR's) central tendency climate projection. This scenario assumes implementation of the SJRRS, as described in the Reclamation's Funding Constrained Framework for Implementing the SJRRS (SJRRP, 2018).

3. **''2070.c''** was designed to represent far-future climate conditions centered around 2070 and uses DWR's central tendency climate projection. This scenario assumes implementation of the SJRRS, as described in the Reclamation's Funding Constrained Framework for Implementing the SJRRS (SJRRP, 2018).

4. **''DEW.c''** was included in this TM for completeness, as it represents an extreme climate condition (being: Drier/Extreme Warming, "DEW") that was produced by DWR for planning studies. The DEW scenario was developed by DWR as a means of bracketing the range of potential future climate conditions by 2070, which are highly uncertain. This scenario was modeled with implementation of the SJRRS, as described in the Reclamation's Funding Constrained Framework for Implementing the SJRRS (SJRRP, 2018).

5. **''WMW.c''** was included in this TM for completeness, as it represents an extreme climate condition (being: Wetter/Moderate Warming, "WMW") that was produced by DWR for planning studies. The WMW scenario was developed by DWR as a means of bracketing the range of potential future climate conditions by 2070, which are highly uncertain. This scenario was modeled with implementation of the SJRRS, as described in the Reclamation's Funding Constrained Framework for Implementing the SJRRS (SJRRP, 2018).

For questions, clarifications, or suggestions that will improve this TM or its application with the implementation of the Sustainable Groundwater Management Act (SGMA) for planning purposes, please contact Jeff Payne, Director of Water Policy at jpayne@friantwater.org

STUDY SETTING

The Friant Division includes storage for waters of the San Joaquin River at Friant Dam (Millerton Lake), as well as conveyance and delivery facilities through the Friant-Kern and Madera canals that deliver water to 32 Friant Division long-term contract holders (Friant Contractors) and other water users. Figure 1 shows the location of the Friant Contractors in the San Joaquin Valley. Friant Contractors all have access to waters of the San Joaquin River through their contracts with Reclamation. However, most Friant Contractors have other supplies that include groundwater and surface water supplies that are local to their geography.

Combined, the facilities of the Friant Division span over 180 miles, crossing seven rivers, and conveying water between 16 GSAs as shown in Figure 2. All the basins connected by the Friant Division and its facilities are considered by DWR to be “critically overdrafted” and therefore are each a “high priority” for the implementation of SGMA. Table 1 lists the Friant Contractors with lands overlapping a GSA and 2014 Friant Contractor irrigated lands. A Friant Contractor may appear in more than one GSA. The 2014 irrigated acreage was obtained from remote sensing from DWR (DWR, 2017). Friant Division M&I contractors were assumed to have no agricultural demand. Kaweah-Delta Water Conservation District agricultural demands were not estimated in this analysis. Any agricultural demand within City of Fresno is represented as part of the Fresno Irrigation District.

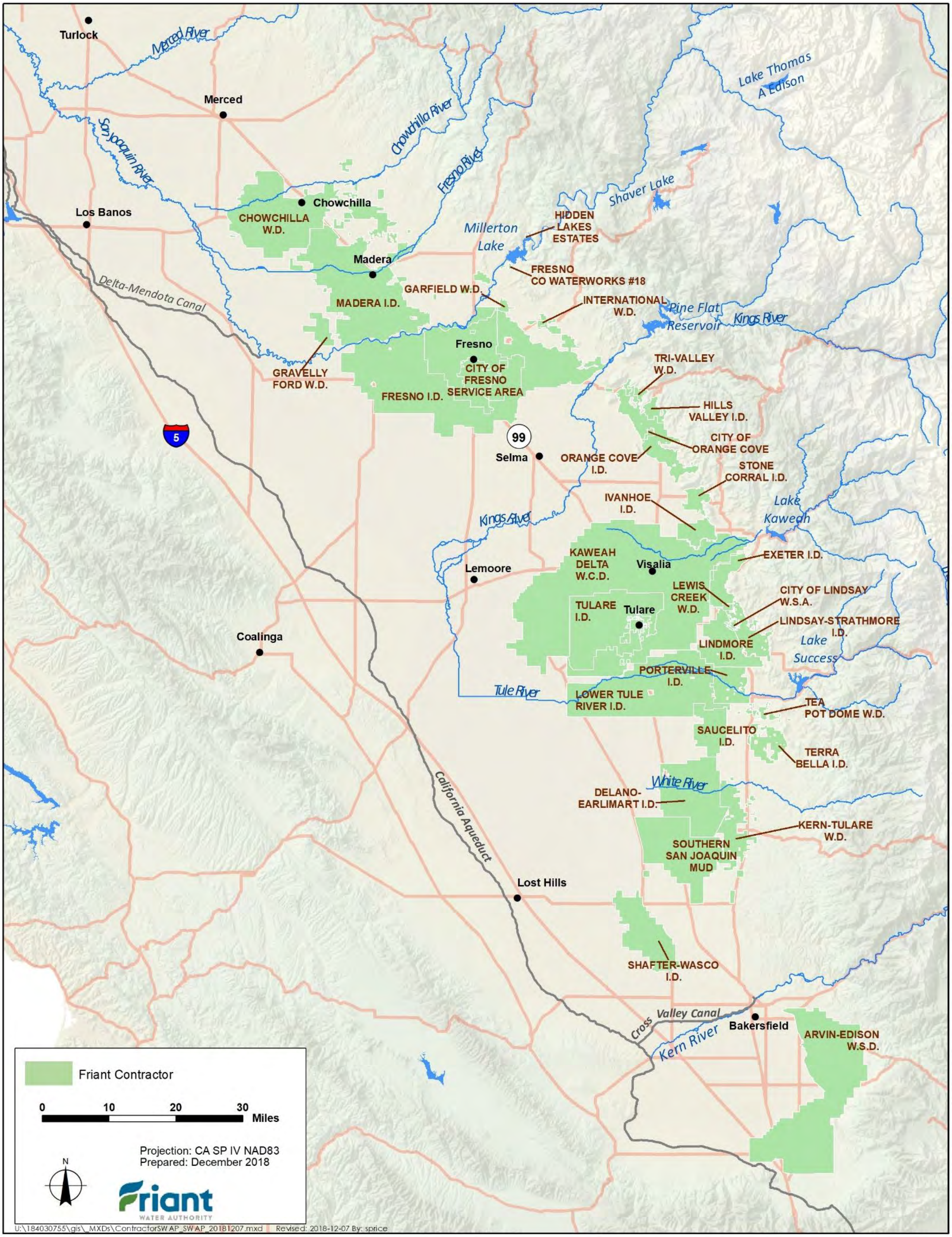

Figure 1: Location of Friant Contractors in the San Joaquin Valley

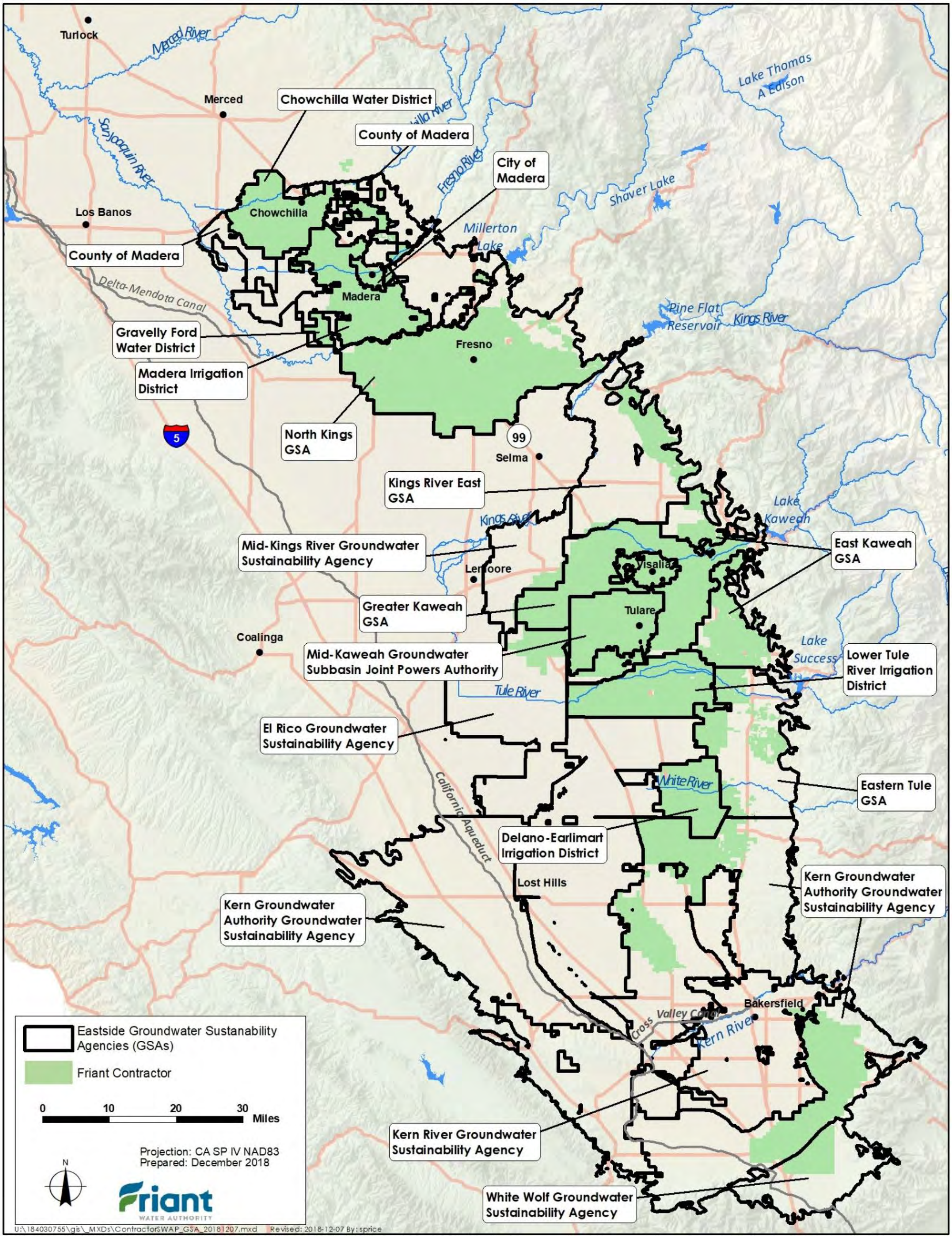

Figure 2: Location of Friant Contractors relative to GSAs

Table 1. Friant Contractors and Estimated Irrigated Acreage relative to GSAs (DWR, 2017)

GROUNDWATER SUSTAINABILITY AGENCY	FRIANT CONTRACTOR[1]	FRIANT CONTRACTOR IRRIGATED LAND[2] (ACRES)
Chowchilla Water District	Chowchilla Water District	67,170
City of Madera	Madera Irrigation District	910
County of Madera	Chowchilla Water District	30
	Madera Irrigation District	90
Gravelly Ford Water District	Gravelly Ford Water District	7,490
Madera Irrigation District	Madera Irrigation District	100,360
North Kings GSA	Fresno Irrigation District[3]	128,330
	Garfield Water District	1,160
	International Water District	540
Kings River East GSA	Hills Valley Irrigation District	2,830
	Orange Cove Irrigation District	24,360
	Tri-Valley Water District	1,040
Mid-Kings River GSA	Kaweah Delta Water Conservation District[2]	NE
East Kaweah GSA	Exeter Irrigation District	10,580
	Ivanhoe Irrigation District	9,630
	Lewis Creek Water District	1,010
	Lindmore Irrigation District	22,760
	Lindsay - Strathmore Irrigation District	10,880
	Lower Tule River Irrigation District	80
	Stone Corral Irrigation District	5,980
Greater Kaweah GSA	Exeter Irrigation District	500
	Ivanhoe Irrigation District	30
	Kaweah Delta Water Conservation District[4]	NE
	Tulare Irrigation District	60
Mid-Kaweah Groundwater Subbasin Joint Powers Authority	Tulare Irrigation District	58,160
El Rico GSA	Kaweah Delta Water Conservation District[4]	NE
Lower Tule River Irrigation District	Lower Tule River Irrigation District	80,480
	Porterville Irrigation District	70
Eastern Tule GSA	Kern - Tulare Water District	8,480
	Porterville Irrigation District	12,470
	Saucelito Irrigation District	18,060
	Tea Pot Dome Water District	3,090
	Terra Bella Irrigation District	9,110
Delano - Earlimart Irrigation District	Delano - Earlimart Irrigation District	49,960
Kern Groundwater Authority GSA	Arvin - Edison Water Storage District	84,280
	Kern-Tulare Water District	14,500
	Shafter - Wasco Irrigation District	30,190
	Southern San Joaquin Municipal Utility District	45,190
Kern River GSA	Arvin - Edison Water Storage District	190
White Wolf GSA	Arvin - Edison Water Storage District	20,830

Key:
GSA = Groundwater Sustainability Agency
NE = Not estimated
Notes:
[1]Only Friant Contractors with agricultural demands shown per GSA, Friant M&I contractors were assumed to have no agricultural demand.
[2] Irrigated lands rounded to nearest 10 acres
[3]Any agricultural lands within City of Fresno is represented as part of the Fresno Irrigation District
[4]Kaweah-Delta Water Conservation District agricultural lands were not estimated

PREVIOUS STUDIES AND REPORTS

The potential range of future Friant Division water supplies from the San Joaquin River have been studied for several recent efforts. This TM relies on computer models, assumptions, and analysis that were initially developed for and reported by the following:

- San Joaquin River Restoration Settlement, and Program (SJRRS and SJRRP)
  - Settlement Agreement (2006)
  - Program Environmental Impact Statement/Report (PEIS/R; Reclamation, 2009)
- Temperance Flat Reservoir studies, including:
  - Federal Feasibility Study (Reclamation, ongoing)
  - Application to California Proposition 1, Water Storage Investment Program (Temperance Flat Reservoir Authority, 2017)

FACTORS AFFECTING FRIANT SUPPLIES THROUGH YEAR 2100

Beyond the natural variability of annual precipitation in the headwaters of the San Joaquin River, several drivers are expected to greatly influence the water supplies of the Friant Division over the coming century. These include:

1. **Changes in the climate and hydrology**: These changes include a warming trend that is expected to reduce winter snow accumulation and hasten spring melt and runoff. Five climate conditions are considered in this report.
2. **Implementation of the SJRRS Restoration Goal:** The SJRRS Restoration Goal is currently limited in its implementation but is expected to be fully implemented by 2030, with the completion of river conveyance enhancements below Friant Dam. When completed, the impact of the SJRRS on Friant Contractor supplies will reach the extent anticipated in the SJRRS.
3. **Implementation of the SJRRS Water Management Goal**: The SJRRS Water Management Goal provides for several mechanisms to reduce or avoid water supply impacts on Friant Contractors. The water supply benefits of two SJRRS provisions are quantified in this analysis, being those described in Paragraphs 16(a) (i.e., recapture and recirculation) and 16(b) (i.e., water sold at $10 per acre foot during wet conditions).
   - Paragraph 16(a) is restricted at this time, being limited to the recapture of flows that can be released from Friant Dam. As implementation of the Restoration Goal progresses, so will recapture and recirculation.
   - Paragraph 16(b) is currently underutilized. At the time of the Settlement, a fixed $10 per acre foot price for wet year supplies was expected to stimulate investments in groundwater infiltration facilities. With subsequent water supply challenges imposed by SGMA on the Eastern San Joaquin Valley, the regional appetite for groundwater infiltration has grown dramatically. At this time, Friant Contractors anticipate considerable interest and ability to divert and infiltrate flows that may have spilled from Friant Dam under historical conditions. The upper end of implementation of 16(b) is expected to occur before 2030.

The technical representations of these conditions were taken from previous studies and reports, in the manner described below.

INVENTORY OF MODEL SIMULATIONS PERFORMED

This report presents simulated operations that account for five climate conditions and the eventual full implementation of SJRRS Restoration and Water Management goals. Table 2 identifies 15 individual modeling runs compiled for this TM, along with the major assumptions for each.

The reader should note that each of the five climate conditions contain three model runs, denoted with a suffix of “a”, “b”, and “c”. To calculate the Restoration Goal for each of these climate conditions, model runs “a” and “b” were conducted to create comparisons that are necessary for explaining effect of SJRRS implementation. Calculation of the Water Management Goal requires a comparison of model runs “a” to model runs “b” and “c” to represent the expected recapture and recirculation for each level of SJRRS implementation. Model runs denoted with “c” are provided for comparative analyses that calculate recapture and recirculation, as well as additional groundwater recharge deliveries during wet conditions.

All simulations were performed using CalSim-II, the State of California’s premiere water supply planning and analysis tool. The primary use of the CalSim model is for estimating water supply exports from the Sacramento-San Joaquin Delta for delivery to CVP and State Water Project (SWP) water users. CalSim-II simulates statewide water supply operations using a continuous 82-year hydrology, traditionally based on the period of historic records beginning October 1921 and running through September 2003.

Table 2. Fifteen model runs simulated for this Report

MODEL RUN	CLIMATE CONDITION	SJRRS SETTLEMENT RESTORATION GOAL	SJRRS SETTLEMENT WATER MANAGEMENT GOAL	BENCHMARK CALSIM-II MODEL USED
2015.a	2015 Conditions (historical modified for recent changes)	Pre-SJRRS	Pre-SJRRS	DWR Delivery Capability Report, 2015 climate
2015.b		Limited SJRRS	Limited Access	
2015.c			Full Access	
2030.a	Near-Future (DWR 2030 Central Tendency)	Pre-SJRRS	Pre-SJRRS	Water Commission, 2030 climate
2030.b		Full SJRRS	Limited Access	
2030.c			Full Access	
2070.a	Late-Future (DWR 2070 Central Tendency)	Pre-SJRRS	Pre-SJRRS	Water Commission, 2070 climate
2070.b		Full SJRRS	Limited Access	
2070.c			Full Access	
DEW.a	Late-Future, 2070 Drier/Extreme Warming	Pre-SJRRS	Pre-SJRRS	Water Commission, 2070 DEW climate
DEW.b		Full SJRRS	Limited Access	
DEW.c			Full Access	
WMW.a	Late-Future, 2070 Wetter/Moderate Warming	Pre-SJRRS	Pre-SJRRS	Water Commission, 2070 WMW climate
WMW.b		Full SJRRS	Limited Access	
WMW.c			Full Access	

Key:
DEW = Drier/Extreme Warming
DWR = California Department of Water Resources
SJRRS = San Joaquin River Restoration Settlement
WMW = Wetter/Moderate Warming

CLIMATE CHANGES EVALUATED

The California Water Commission Water Supply Investment Program (CWC WSIP) developed baseline CalSim-II simulations using several levels of potential climate change to modify input hydrology of the entire system, including the San Joaquin River. These scenarios were developed using the 20 combinations of climate change models and representative concentration pathways recommended by DWR Climate Change Technical Advisory Group as being most appropriate for California water resource planning and analysis. Further details on the specific climate change included in each of the simulations is included in the CWC WSIP Technical Reference (CWC, 2016). The resulting climate change conditions used in this analysis include:

1. **2015 Conditions:** This represents a historical hydrology modified to match climate and sea level conditions for a thirty-year period centered at 1995 (reference climate period 1981 – 2010).
2. **Near-Future 2030 Central Tendency:** This represents a 2030 future hydrology with projected climate and sea level conditions for a thirty-year period centered at 2030 (reference climate period 2016 – 2045).
3. **Late-Future 2070 Central Tendency:** This hydrology represents a 2070 future condition with projected climate and sea level conditions for a thirty-year period centered at 2070 (reference climate period 2056 – 2085).
4. **Late-Future 2070 Drier/Extreme Warming Conditions (DEW):** This hydrology represents a 2070 DEW future condition with projected climate and sea level conditions for a thirty-year period centered at 2070 (reference climate period 2056 – 2085).
5. **Late-Future 2070 Wetter/Moderate Warming Conditions (WMW):** This hydrology represents a 2070 WMW future condition with projected climate and sea level conditions for a thirty-year period centered at 2070 (reference climate period 2056 – 2085).

The seasonal timing of inflow to Millerton Lake is projected to change in response to climate change. Historical inflow to Millerton Lake generally peak during the month of June due to the delayed runoff from a large snow pack. The climate change scenarios for 2030 and 2070 are based on warmer conditions that will produce precipitation events with more rainfall and less snowpack than historically occurred, resulting in peak runoff earlier in the year. Peak runoff into Millerton Lake is projected to occur in May for the 2030 scenario, and in April for the 2070 scenario. Figure 3 shows the general trend of Millerton Lake inflow change due to climate change.

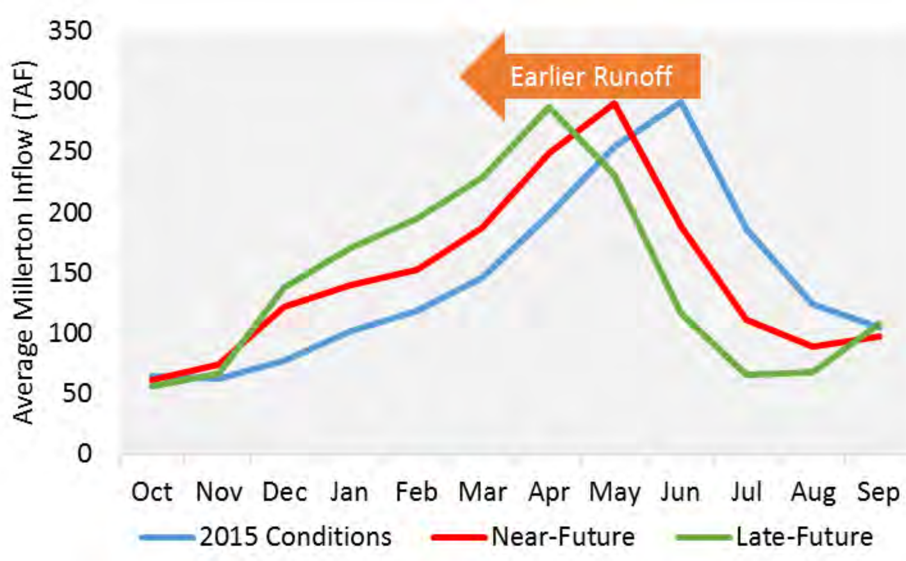

Figure 3. Millerton Lake Inflow Change Due to Climate Change

When analyzing CalSim-II outputs, the results are often summarized by water year type, which classifies groups of years with similar hydrologic characteristics. A water year starts October 1 of the preceding calendar year and ends September 30 of the current year. For example, water year 1922 starts October 1, 1921 and ends September 30, 1922. In this analysis the SJRRS water year type classification was used to summarize the estimated changes in Friant Division supplies. The SJRRS water year types are classified as follows: Wet, Normal-Wet, Normal-Dry, Dry, Critical High and Critical Low. For the CWC WSIP the SJRRP water year type classification remained unchanged between the five climate change conditions. In this TM, the SJRRS water year types were redefined based on Unimpaired Millerton Inflow (consistent with the SJRRS) from the CalSim II SV input files. This was done to update the SJRRS hydrographs to better reflect the anticipated climate change conditions. Table 3 summarizes the SJRRS water year types by climate condition. For reporting purposes, the designation of Critical water year type includes both Critical High and Critical Low SJRRS water year types.

Table 3. SJRRS Water Year Types per Climate Condition by Number of Years and Percentage of Total Years

SJRRS WATER YEAR TYPE	2015 CONDITIONS	NEAR-FUTURE, 2030	LATE-FUTURE, 2070	LATE-FUTURE, 2070 DEW	LATE-FUTURE, 2070 WMW
Wet	16 (20%)	18 (22%)	19 (23%)	21 (26%)	35 (43%)
Normal-Wet	25 (30%)	21 (26%)	20 (24%)	12 (15%)	21 (26%)
Normal-Dry	24 (29%)	25 (30%)	20 (24%)	11 (13%)	15 (18%)
Dry	12 (15%)	11 (13%)	16 (20%)	20 (24%)	9 (11%)
Critical[1]	5 (6%)	7 (9%)	7 (9%)	18 (22%)	2 (2%)
Long-Term[2]	82	82	82	82	82

Key:
DEW = Drier/Extreme Warming
DWR = California Department of Water Resources
SJRRS = San Joaquin River Restoration Settlement
WMW = Wetter/Moderate Warming
Note:
[1]For reporting purposes, the designation of Critical water year type includes both Critical High and Critical Low SJRRP water year types
[2]Long-Term average reflects the 82-year CalSim II simulation period (October 1921 thru September 2003)

SJRRS IMPLEMENTATION

Implementation of the SJRRS includes actions to meet both the Restoration and Water Management Goals. Both goals have a direct effect on Friant Division water supplies, and both are expected to change in implementation over time.

Presently, both goals are implemented in a limited manner because of capacity restrictions in the San Joaquin River below Friant Dam (which constrict releases for the Restoration Goal) and the need for further buildout of groundwater infiltration facilities to take full advantage wet year supplies, when available (for the Water Management Goals). However, Reclamation has plans for implementation that will allow for virtually all SJRRS releases to be made by 2025 (SJRRP, 2018). Further, water users throughout the Friant Division are pursuing a broad array of facilities that will enhance the ability to implement Paragraph 16(b) water supplies, when available.

To represent the current and anticipated future implementation of the SJRRS, the following variations were constructed.

Restoration Goal Implementation

Three levels of Restoration Goal implementation are considered, as follows:

1. **Pre-SJRRS:** This simulation sets the required minimum release from Millerton to the San Joaquin River to the values in the without project baseline conditions (SJRRP, 2009).
2. **Limited SJRRS:** This condition approximates current conditions, which are expected to remain limited until 2025. Simulations of this condition are based on the current channel capacity of 1,300 cubic feet per second (CFS) in Reach 2.
3. **Full SJRRS:** This condition represents the SJRRS hydrograph with capacities identified in the SJRRS Funding Constrained Framework. Under this plan, channel capacity will not exceed the identified 2025 channel capacity of 2,500 CFS in Reach 2. This hydrograph was used in the 2030, 2070, 2070 DEW, and 2070 WMW level of climate change simulations. Flow releases (Flow Schedules) for this condition were approximated with a spreadsheet developed by the SJRRP for the Framework Document (SJRRP, 2018). Table 3 shows the Full SJRRS Implementation hydrograph compared to the Funding Constrained Framework SJRRS hydrograph for the four climate change scenarios. The differences between the four climate change scenarios is due to the different number of years per SJRRS water year type, as shown in Table 3. Table 4 is not the impact of Friant Deliveries, but

represents the SJRRS releases under the Funding Constrained Framework under different climate change conditions.

Table 4 Long-Term Average SJRRS Releases under Full SJRRS Implementation and the Funding Constrained Framework Four Climate Conditions

SJRRS WATER YEAR TYPE	FULL SJRRP IMPLEMENTATION (TAF/YEAR)	FUNDING CONSTRAINED FRAMEWORK			
		NEAR-FUTURE, 2030 (TAF/YEAR)	LATE-FUTURE, 2070 (TAF/YEAR)	LATE-FUTURE, 2070 DEW (TAF/YEAR)	LATE-FUTURE, 2070 WMW (TAF/YEAR)
Wet	674	633	633	628	633
Normal-Wet	474	434	433	428	432
Normal-Dry	365	365	364	363	357
Dry	302	297	296	296	300
Critical High	188	188	188	188	188
Critical Low	117	117	117	117	117
Long-Term[1]	438	417	414	376	483[2]

Key:
DEW = Drier/Extreme Warming
DWR = California Department of Water Resources
SJRRS = San Joaquin River Restoration Settlement
TAF/year = thousand acre-feet per year
WMW = Wetter/Moderate Warming
Note:
[1]Long-Term average reflects the 82-year CalSim II simulation period (October 1921 thru September 2003)
[2] The Long-Term Average SJRRS release for 2070 WMW is higher than the Full SJRRP Implementation because, as Table 3 shows, the number of Wet water years increased from 16 years (20 percent) in the 2015 Condition to 35 years (43 percent) in the 2070 WMW Condition.

The quantification of SJRRS implementation impact is performed by comparing the with and without SJRRS water supplies diverted from Friant Dam.

In the course of compiling these model runs, it was discovered that previous studies had not correctly implemented SJRRS flows under climate change. SJRRS outflow requirements at Friant Dam are determined by the total annual hydrology, which can change enough under climate conditions to alter a given year's release requirements. All scenarios and results in this report have been adjusted to correctly set SJRRS flow requirements, including under climate change.

Water Management Goal Implementation

Three levels of Water Management Goal implementation are considered, as follows:

1. **Pre-SJRRS**: This represents the without SJRRS condition.
2. **Limited Access:** This represents 16(a) supplies available to Friant Contractors as part of the SJRRS that provides for recapture and recirculation of flows released from Friant Dam for the purposes of meeting the Restoration Goal.
3. **Full Access:** This represents supplies anticipated with future ability to divert 16(a) and 16(b) supplies to Friant Contractors. 16(b) stipulates a Recovered Water Account (RWA) that represents water not required to meet SJRRS or other requirements be made available to Friant Contractors who experience a reduction in water deliveries from the implementation of the SJRRS. 16(b) water is made available to those Friant Contractors at $10 per acre-foot during wet condition.

The SJRRS and implementing documents identify several locations for recapture, however modeling conducted for the SJRRP PEIS/R only provided for estimated recapture as the incremental improvement in total Delta Exports that result from the SJRRS. The quantification of water supplies recaptured in the Delta in conformance with 16(a) is performed by comparing simulated Delta exports with and without the implementation of the SJRRS. The net improvement in export is identified as recapturable supply.

The CalSim-II model simulates 16(b) as an additional demand after Class 1 and Class 2 delivery allocations are met and before 215 ("Other") deliveries are made. The CalSim-II simulated 16(b) delivery via the Friant Kern and Madera canals is based on anticipated development of groundwater infiltration facilities throughout the Friant Division in response to SJRRS implementation. These facilities are not identified and are represented as surrogate water demands in the CalSim-II model. As a result, use of 16(b) water supply availability must be viewed as total opportunity that has not been attributed among individual water users at this time.

The quantification of water supplies diverted from Friant Dam for 16(b) is performed by comparing the with and without SJRRS simulations that allow for added diversions. This required the additional simulation for each scenario, to provide for comparison. The "#.b" scenarios are included in results for reference.

GUIDANCE ON USE OF RESULTS

This TM provides descriptions of potential future water supplies for the Friant Division for five climate change conditions under different levels of SJRRS implementation.

The key outputs of this report are provided in tables by monthly and total volumes by contract year (which begins March 1 of the current calendar year and ends February 28 of the following year), except when noted, and summarized by SJRRS water year type classification and long-term average for each of the following:

- Millerton Lake Inflow
- Total Friant Division deliveries of:
  - Class 1
  - Class 2/Other
  - Paragraph 16(b) water (aka $10 water, or RWA water)
- Friant Dam Spill
- Potential Friant Division Delta Recapture (by year, only), for:
  - Class 1 Delta Recapture
  - Class 2 Delta Recapture
  - Total Delta Recapture

These data are provided in a spreadsheet, entitled: "Summary_FutureFriantSupplies_Final.xlsm"

Table 5 provides a portion of a tabulated output available in the spreadsheet. Tabulated information includes the average monthly and total volumes by SJRRS water year type classification and long-term average. For reporting purposes, the designation of Critical water year type includes both Critical-High and Critical-Low SJRRS water year types. Tabulated information also includes the monthly and total volumes per contract year (Mar-Feb). In the spreadsheet, the tables include the monthly and total volumes per contract year for the entire 82-year CalSim-II simulated period (October 1921 to September 2003).

Table 5. Example Output Table for Class 1 Deliveries

		Class 1 Delivery												
		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
		TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF
Wet		16.1	28.1	51.6	123.4	189.9	181.5	106.3	48.5	12.2	6.4	6.3	29.8	800.0
Normal-Wet		26.2	46.3	75.0	149.8	189.3	165.2	84.0	28.9	4.7	4.5	4.5	21.6	800.0
Normal-Dry		32.9	56.7	92.1	158.6	184.4	152.5	67.9	20.9	3.6	3.6	3.4	19.7	796.3
Dry		29.7	48.8	81.7	143.9	167.1	130.5	55.8	20.9	4.7	2.3	2.3	17.3	705.1
Critical		16.7	19.9	36.4	86.6	111.5	65.2	31.0	19.9	6.6	0.0	0.0	9.9	403.8
Long Term		26.1	44.6	74.1	142.4	179.9	153.4	76.2	28.7	6.0	4.0	3.9	21.3	760.4
2015 SJRRP WY Type	Month Year	Mar TAF	Apr TAF	May TAF	Jun TAF	Jul TAF	Aug TAF	Sep TAF	Oct TAF	Nov TAF	Dec TAF	Jan TAF	Feb TAF	Total TAF
Normal-Wet	1921								0.0	0.0	0.0	0.0	0.0	0.0
Normal-Wet	1922	22.3	37.4	59.8	138.2	189.1	174.0	97.8	36.4	5.5	5.3	5.3	28.9	800.0
Normal-Wet	1923	25.6	42.7	64.4	146.7	187.1	170.7	95.2	33.8	4.9	4.6	4.6	19.7	800.0
Critical	1924	17.9	21.4	39.2	93.2	120.0	72.2	31.6	21.4	7.1	0.0	0.0	10.7	434.7
Normal-Dry	1925	32.8	56.4	89.7	158.4	188.2	152.0	70.7	21.0	3.9	3.9	3.3	19.7	800.0
Normal-Dry	1926	33.2	57.1	98.8	160.4	183.9	151.2	65.6	19.9	3.3	3.3	3.3	19.9	800.0
Normal-Wet	1927	25.7	47.4	80.6	151.2	191.4	163.5	79.8	26.8	4.8	4.6	4.6	19.8	800.0
Normal-Dry	1928	31.6	57.8	92.0	162.4	186.2	153.1	66.4	20.2	3.4	3.4	3.4	20.2	800.0
Dry	1929	26.8	48.2	80.3	132.2	148.5	124.8	53.0	16.1	2.7	2.7	2.7	16.1	654.0
Dry	1930	27.1	48.8	81.1	133.6	150.1	126.2	53.6	16.3	2.7	2.7	2.7	16.3	661.1
Critical	1931	12.9	15.5	28.3	67.4	86.9	52.3	22.9	15.5	5.2	0.0	0.0	7.7	314.5
Normal-Wet	1932	25.6	42.7	64.4	146.7	187.1	170.7	95.2	33.8	4.9	4.6	4.6	19.7	800.0
Normal-Dry	1933	32.8	56.4	89.7	158.4	188.2	152.0	70.7	21.0	3.9	3.9	3.3	19.7	800.0
Dry	1934	24.0	28.7	52.2	124.2	159.9	96.2	42.2	28.5	9.5	0.0	0.0	14.2	579.6
Normal-Wet	1935	28.2	47.3	80.4	150.7	190.7	162.9	79.5	26.7	4.7	4.6	4.6	19.7	800.0
Normal-Wet	1936	28.2	47.2	80.3	150.7	190.7	162.9	79.5	26.7	5.0	4.6	4.6	19.7	800.0
Normal-Wet	1937	28.7	48.0	81.6	159.5	191.1	160.7	74.5	24.0	4.0	4.0	4.0	20.0	800.0
Wet	1938	17.2	28.4	52.1	115.8	193.9	182.0	104.2	49.9	13.0	6.6	6.6	30.4	800.0

CLASS 1 AND CLASS 2 SUPPLY PROJECTIONS

While CalSim-II does produce estimated deliveries of Class 1 water supplies with some confidence, the simulated "Class 2" and "Other" model outputs have always been problematic. This is because CalSim-II approximations of wet year operations were calibrated to mimic total releases – not actual deliveries of Class 2 or (separately) Other supplies. As a result, the modeling outputs provided with this TM do not distinguish between Class 2 and Other modeling categories. These two data outputs have been grouped to describe Class 2 behavior in aggregate. Through previous modeling conducted for SJRRS implementation, Friant Division managers have found the aggregation of Class 2 and Other model outputs performs closer to actual experience with Class 2 deliveries.

CalSim-II does not determine delivery by Friant Contractor, it simulates the annual allocations and then distributes them over the year on a monthly pattern. CalSim- II does approximate the division of flows between the Madera and Friant-Kern canals, but the actual final deliveries simulated in CalSim-II are not to specific Friant contractors or physical locations. Standard practice in interpreting deliveries to Friant Contractors has been to split Class 1 and Class 2/Other deliveries among individual contractors by contract quantity. For example, a district with an 80 thousand acre-feet (TAF) Friant Division Class 1 contract (i.e., 10 percent of total Class 1) and 70 TAF of Class 2 (i.e., five percent of total Class 2), would have access to 10 percent of the Class 1 supplies and five percent of the Class 2/Other supplies in a given year. Table 6 lists the Friant Contractors corresponding Class 1 and Class 2 contract amounts by volume and percentage. These have been incorporated into the spreadsheet to facilitate use.

NOTE: The reader may note that Section 215 water supplies are not discussed. While the factors that produce "215 water" are presumed to exist in the future, the frequency and magnitude of their availability is expected to be greatly diminished by implementation of the SJRRS, which has made available water supplies to Friant Contractors through Paragraph 16(b) of the Settlement. The assumed low availability of 215 water comports with recent experience, even with partial SJRRS implementation. As a result, this analysis makes no attempt to quantify future 215 water supply availability, which may be presumed to be nearly zero for planning purposes. "16(b)" or "RWA" or "$10" water (all the same) is discussed in a later section.

Table 6. Friant Contractor Summary

FRIANT CONTRACTOR	CLASS 1 ACRE-FEET	CLASS 2 ACRE-FEET	CLASS 1 PERCENTAGE	CLASS 2/OTHER PERCENTAGE
Arvin-Edison Water Storage District	40,000	311,675	5.0%	22.2%
Chowchilla Water District	55,000	160,000	6.9%	11.4%
City of Fresno	60,000	0	7.5%	0.0%
City of Lindsay	2,500	0	0.3%	0.0%
City of Orange Cove	1,400	0	0.2%	0.0%
Delano-Earlimart Irrigation District	108,800	74,500	13.6%	5.3%
Exeter Irrigation District	11,100	19,000	1.4%	1.4%
Fresno County Water Works District No. 18	150	0	0.0%	0.0%
Fresno Irrigation District	0	75,000	0.0%	5.4%
Garfield Water District	3,500	0	0.4%	0.0%
Gravelly Ford Water District	0	14,000	0.0%	1.0%
Hills Valley Irrigation District	1,250	0	0.2%	0.0%
International Water District	1,200	0	0.2%	0.0%
Ivanhoe Irrigation District	6,500	500	0.8%	0.0%
Kaweah Delta Water Conservation District	1,200	7,400	0.2%	0.5%
Kern-Tulare Water District	0	5,000	0.0%	0.4%
Lewis Creek Water District	1,200	0	0.2%	0.0%
Lindmore Irrigation District	33,000	22,000	4.1%	1.6%
Lindsay-Strathmore Irrigation District	27,500	0	3.4%	0.0%
Lower Tule River Irrigation District	61,200	238,000	7.7%	17.0%
Madera County	200	0	0.0%	0.0%
Madera Irrigation District	85,000	186,000	10.6%	13.3%
Orange Cove Irrigation District	39,200	0	4.9%	0.0%
Porterville Irrigation District	15,000	30,000	1.9%	2.1%
Saucelito Irrigation District	21,500	32,800	2.7%	2.3%
Shafter-Wasco Irrigation District	50,000	39,600	6.3%	2.8%
Southern San Joaquin Municipal Utility District	97,000	45,000	12.1%	3.2%
Stone Corral Irrigation District	10,000	0	1.3%	0.0%
Tea Pot Dome Water District	7,200	0	0.9%	0.0%
Terra Bella Irrigation District	29,000	0	3.6%	0.0%
Tri-Valley Water District	400	0	0.1%	0.0%
Tulare Irrigation District	30,000	141,000	3.8%	10.1%
Total	800,000	1,401,475	100%	100%

SJRRS WATER SUPPLY PROJECTIONS

The SJRRS Water Management Goal creates two new categories of supplies for Friant Contractors that are described in paragraphs 16(a) and (b) of the Settlement.

Delta recapture (Paragraph 16(a) is quantified in this analysis by taking the difference in Delta Exports between the with and without SJRRS implementation and crediting the net volume of improvement to the SJRRS recapture program. This does not account for the ability to recapture water supplies on the lower San Joaquin River. Delta recapture is reported as an annual quantity to overcome limitations in the simulation of monthly operations, which are not appropriate for use as monthly recapture volumes at this time. This supply represents an upper bound for potential recapture in the Delta. Discussions between Reclamation, DWR, and

Friant are ongoing to establish the availability of this water supply through Delta pumping. At the time of this report, no processes are in place to recapture in the Delta.

In recent practice, recaptured supplies have been split between Class 1 and 2 contractors, using recapture to back-fill for water contract allocations. For this analysis, Delta recapture has been split between Class 1 and Class 2 contractors, based on recent practices by Reclamation. At the request of Friant Contractors, recapture is provided first to Class 1 water users up to the point that the combination of Friant Division deliveries and recapture equal a 100 percent Class 1 allocation. Any volumes in excess are allocated to Class 2 contractors, proportional to their Class 2 contract volumes. The spreadsheet includes summary tables of total Delta recapture, and a breakout of Class 1 and Class 2 recapture by Friant Contractor proportional to their contract amounts as shown in Table 5. Users of this data are encouraged to apply contract quantities (Table 6) to attribute allocations among Friant Contractors.

The second SJRRS water category, Paragraph 16(b) supplies, are quantified in the CalSim II model by assuming a demand for this potential supply and meeting this demand, limited by availability of flood water and channel capacity for delivery. Any remaining flood water is then assumed available for 215/other delivery in the simulation. Specific patterns for the use of this supply do not yet exist and, thus, CalSim-II makes no assertion about anything except for the expectation and potential for these supplies to be delivered.

For consistency with previous efforts to interpret the CalSim II model and its output, 16(b) supplies have been divided among Friant Contractors in proportion to their share of impact from the SJRRS that accumulates to their water supplies. The impact from the SJRRS is estimated by comparison of the total C1 and C2/Other delivery in the Pre-SJRRS and "limited" CalSim II simulations. The allocation to the individual contractors was done based on percentage of impact from the Proposed Implementation Agreement of the Friant Settlement (SJRRP, 2009) and from the percentage impact computed from the new CalSim II simulation performed for this analysis. For example, a Friant Contractor with five percent of reduction in total Class 1 and Class 2/Other is and would have access to five percent of the 16(b) supplies. Table 7 and 8 shows impact of SJRRS under the five climate change conditions and computed impacts from the Mediator's Report for the Friant Contractors.

Table 7. Summary of Friant Contractor Impacts per Climate Change and Mediator's Report (Volume)

FRIANT CONTRACTOR	LONG-TERM AVERAGE CLASS 1 AND CLASS 2/OTHER IMPACTS					
	MEDIATOR'S REPORT	2015 CONDITION	NEAR-FUTURE, 2030	LATE-FUTURE, 2070	LATE-FUTURE, 2070 DEW	LATE-FUTURE, 2070 WMW
	TAF	TAF	TAF	TAF	TAF	TAF
Arvin-Edison Water Storage District	30.342	28.13	28.88	26.54	18.69	28.41
Chowchilla Water District	17.661	15.76	16.58	15.75	12.59	16.04
City of Fresno	3.629	2.30	3.06	3.71	5.22	2.52
City of Lindsay	0.151	0.10	0.13	0.15	0.22	0.11
City of Orange Cove	0.085	0.05	0.07	0.09	0.12	0.06
Delano-Earlimart Irrigation District	13.255	10.53	11.96	12.47	13.10	10.97
Exeter Irrigation District	2.398	2.05	2.20	2.15	1.89	2.10
Fresno County Water Works District No. 18	0.009	0.01	0.01	0.01	0.01	0.01
Fresno Irrigation District	6.719	6.40	6.46	5.79	3.66	6.43
Garfield Water District	0.212	0.13	0.18	0.22	0.30	0.15
Gravelly Ford Water District	1.254	1.19	1.21	1.08	0.68	1.20
Hills Valley Irrigation District[1]	0.000	0.00	0.00	0.00	0.00	0.00
International Water District	0.073	0.05	0.06	0.07	0.10	0.05
Ivanhoe Irrigation District	1.173	0.29	0.37	0.44	0.59	0.32
Kaweah Delta Water Conservation District[1]	0.000	0.000	0.000	0.000	0.000	0.000
Kern-Tulare Water District[1]	0.000	0.000	0.000	0.000	0.000	0.000
Lewis Creek Water District	0.088	0.05	0.06	0.07	0.10	0.05
Lindmore Irrigation District	3.967	3.14	3.58	3.74	3.94	3.28
Lindsay-Strathmore Irrigation District	1.663	1.06	1.40	1.70	2.39	1.16
Lower Tule River Irrigation District	25.024	22.66	23.62	22.16	16.94	22.99
Madera County	0.012	0.01	0.01	0.01	0.02	0.01
Madera Irrigation District	21.805	19.13	20.35	19.61	16.47	19.53
Orange Cove Irrigation District	2.371	1.50	2.00	2.42	3.41	1.65
Porterville Irrigation District	3.655	3.14	3.35	3.24	2.77	3.20
Saucelito Irrigation District	4.221	3.62	3.92	3.86	3.47	3.72
Shafter-Wasco Irrigation District	6.572	5.30	5.96	6.15	6.28	5.50
Southern San Joaquin Municipal Utility District	10.346	7.56	8.82	9.46	10.63	7.94
Stone Corral Irrigation District	0.605	0.38	0.51	0.62	0.87	0.42
Tea Pot Dome Water District	0.454	0.28	0.37	0.44	0.63	0.30
Terra Bella Irrigation District	1.754	1.11	1.48	1.79	2.52	1.22
Tri-Valley Water District[1]	0.000	0.000	0.000	0.000	0.000	0.000
Tulare Irrigation District	14.447	13.18	13.67	12.74	9.49	13.36
Total	**173.945**	**149.13**	**160.26**	**156.49**	**137.14**	**152.67**

Key:
DEW = Drier/Extreme Warming
TAF = thousand acre-feet
WMW = Wetter/Moderate Warming
Note:
[1] Friant Contractor calculated impact as zero because they do not receive a proportion of 16(b) supplies.

Table 8. Summary of Friant Contractor Impacts per Climate Change and Mediator's Report (Percentage)

FRIANT CONTRACTOR	LONG-TERM AVERAGE CLASS 1 AND CLASS 2/OTHER IMPACTS					
	MEDIATOR'S REPORT	2015 CONDITION	NEAR-FUTURE, 2030	LATE-FUTURE, 2070	LATE-FUTURE, 2070 DEW	LATE-FUTURE, 2070 WMW
	%	%	%	%	%	%
Arvin-Edison Water Storage District	17.444%	18.864%	18.020%	16.958%	13.630%	18.611%
Chowchilla Water District	10.153%	10.571%	10.347%	10.066%	9.183%	10.504%
City of Fresno	2.086%	1.544%	1.909%	2.368%	3.806%	1.653%
City of Lindsay	0.087%	0.064%	0.080%	0.099%	0.159%	0.069%
City of Orange Cove	0.049%	0.036%	0.045%	0.055%	0.089%	0.039%
Delano-Earlimart Irrigation District	7.620%	7.063%	7.464%	7.970%	9.553%	7.183%
Exeter Irrigation District	1.378%	1.373%	1.374%	1.376%	1.380%	1.373%
Fresno County Water Works District No. 18	0.005%	0.004%	0.005%	0.006%	0.010%	0.004%
Fresno Irrigation District	3.863%	4.292%	4.030%	3.701%	2.669%	4.213%
Garfield Water District	0.122%	0.090%	0.111%	0.138%	0.222%	0.096%
Gravelly Ford Water District	0.721%	0.801%	0.752%	0.691%	0.498%	0.786%
Hills Valley Irrigation District[1]	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
International Water District	0.042%	0.031%	0.038%	0.047%	0.076%	0.033%
Ivanhoe Irrigation District	0.675%	0.196%	0.234%	0.281%	0.430%	0.207%
Kaweah Delta Water Conservation District[1]	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Kern-Tulare Water District[1]	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Lewis Creek Water District	0.050%	0.031%	0.038%	0.047%	0.076%	0.033%
Lindmore Irrigation District	2.281%	2.108%	2.232%	2.388%	2.876%	2.145%
Lindsay-Strathmore Irrigation District	0.956%	0.708%	0.875%	1.085%	1.744%	0.758%
Lower Tule River Irrigation District	14.386%	15.194%	14.736%	14.159%	12.352%	15.057%
Madera County	0.007%	0.005%	0.006%	0.008%	0.013%	0.006%
Madera Irrigation District	12.536%	12.831%	12.699%	12.532%	12.011%	12.791%
Orange Cove Irrigation District	1.363%	1.009%	1.247%	1.547%	2.486%	1.080%
Porterville Irrigation District	2.101%	2.103%	2.089%	2.072%	2.019%	2.099%
Saucelito Irrigation District	2.427%	2.430%	2.446%	2.467%	2.531%	2.435%
Shafter-Wasco Irrigation District	3.778%	3.553%	3.719%	3.927%	4.581%	3.602%
Southern San Joaquin Municipal Utility District	5.948%	5.071%	5.504%	6.048%	7.754%	5.201%
Stone Corral Irrigation District	0.348%	0.257%	0.318%	0.395%	0.634%	0.276%
Tea Pot Dome Water District	0.261%	0.185%	0.229%	0.284%	0.457%	0.198%
Terra Bella Irrigation District	1.008%	0.746%	0.923%	1.144%	1.839%	0.799%
Tri-Valley Water District[1]	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Tulare Irrigation District	8.305%	8.840%	8.531%	8.141%	6.921%	8.748%
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.000%**

Key:
DEW = Drier/Extreme Warming
WMW = Wetter/Moderate Warming
Note:
[1] Friant Contractor does not receive a proportion of 16(b) supplies.

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