APPENDIX A: Methodology Memorandum

DRAFT - SUBJECT TO CHANGE

Methodology for Evaluating Groundwater Zones of Benefit Santa Clara County, California

Prepared for:
Santa Clara Valley Water District

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EXECUTIVE SUMMARY

The Santa Clara Valley Water District (District) Act gives the District Board of Directors the authority to establish, amend, and revise groundwater charge zones and to levy and collect groundwater charges within a zone or zones that benefit from the recharge of underground water supplies or the distribution of imported water. The two primary existing charge zones, Zones W-2 and W-5, were established in 1963 and 1977, respectively. Zone W-2 generally covers the Santa Clara Plain in North County while Zone W-5 generally covers the Coyote Valley and Llagas Subbasin in South County

The purpose of the Groundwater Zone of Benefit Study (Study) is to complete a holistic review of the groundwater charge zones to ensure they reflect areas where current and future groundwater users receive similar benefit from current and planned District activities. Although the District is not aware of any specific problems with the existing Zone of Benefit designations, the District has received requests for exemption and recognizes that it is important for the District to periodically undertake an updated analysis of various factors upon which the zones are based and revise the boundaries if necessary. The Study will evaluate the ways in which the various District activities benefit groundwater users. These benefits are derived not only from the use of alternative water supplies for direct recharge, but also include the direct and indirect benefits of the District's holistic groundwater management, including in-lieu recharge, demand management, development of alternative water supplies and storage, conservation, and protection of water quality, amongst others.

An area within the District's legal jurisdiction will be included in a groundwater zone of benefit if any of the following criteria are met:

- Water supply is provided by a District activity
- Groundwater supply reliability is improved due to District activities
- Land subsidence is prevented or limited due to District activities
- Saltwater intrusion is reversed or controlled due to District activities
- Groundwater quality is improved or maintained due to District activities
- Groundwater levels are improved due to District activities

Historical data and groundwater modeling will be used to assess the areas benefitting from District activities. If data and modeling are insufficient to assess whether an area benefits from District activities, the following assumptions will be made:

- Benefits from District activities extend to all areas that are hydrogeologically connected.

- Adjacent bedrock areas are not benefitting from District activities unless they are receiving District supply.

Evaluating groundwater zones of benefit is based on the hydrogeological characteristics that govern the movement of groundwater, District activities, and the benefits to groundwater users provided by the activities. The following methodology will be used to complete the study:

1. Map current and planned District activities that provide or will provide benefits to groundwater users in the District.
2. Map hydrogeologic features and groundwater occurrence and movement to define hydrogeologically connected areas.
3. Plot water balance over time in hydrogeologically connected areas to assess where the benefit of District activities can be demonstrated.
4. Use groundwater data and groundwater flow models to demonstrate the benefit of District activities.
5. Create recommended zones of benefit by grouping areas where users benefit from a similar set of District activities.

The evaluation of where groundwater users benefit from specific District activities will consider hydrogeologically connected areas and multiple lines of evidence. The lines of evidence can be grouped as follows:

1. Data demonstrating benefits derived from improved groundwater levels associated with District activities. In addition to groundwater level data, this includes the evaluation of land subsidence and saltwater intrusion data.
2. Groundwater model results demonstrating improved groundwater levels as a result of District activities have occurred or are projected to occur.
3. Data related to improved groundwater quality associated with District managed aquifer recharge.

All available information will be considered in identifying areas benefitting from specific District activities. Zones will be proposed for areas receiving benefits from similar sets of District activities.

INTRODUCTION

The Santa Clara Valley Water District (District) Act gives the District Board of Directors the authority to establish, amend, and revise groundwater charge zones and to levy and collect groundwater charges within a zone or zones that benefit from the recharge of underground water supplies or the distribution of imported water. The two primary existing charge zones, Zones W-2 and W-5, were established in 1963 and 1977, respectively. Zone W-2 generally covers the Santa Clara Plain in North County while Zone W-5 generally covers the Coyote Valley and Llagas Subbasin in South County (Figure 1). Figure 2 shows the three groundwater management areas of the District (Santa Clara Plain, Coyote Valley, and Llagas Subbasin) along with the California Department of Water Resources (DWR) subbasin definitions. Coyote Valley is part of southern zone W-5, but DWR includes Coyote Valley with the Santa Clara Subbasin in the north. While District water supply activities have changed considerably since the zones were established, the zones themselves have undergone only relatively minor, parcel-based revisions.

The purpose of the Groundwater Zone of Benefit Study (Study) is to complete a holistic review of the groundwater charge zones to ensure they reflect areas where current and future groundwater users receive similar benefit from current and planned District activities. The benefits to those who receive groundwater supplies are derived from the occurrence of groundwater and its movement through the sediments below ground surface. Therefore, the methodology will consist of hydrogeologic analyses consistent with existing understanding of the groundwater basins.

The Study will evaluate the ways in which the various District activities benefit groundwater users in different ways across the District. These benefits are derived not only from the use of alternative water supplies for direct recharge, but also include the direct and indirect benefits of the District's holistic groundwater management, including in-lieu recharge, demand management, development of alternative water supplies and storage, conservation, and protection of water quality, amongst others. Furthermore, due to the interconnected nature of the groundwater system, benefits are not limited to the immediate vicinity of particular District activities. Rather, benefits can extend from a project location throughout a surrounding basin or subbasin. Areas where groundwater users receive reasonably similar benefits or similar potential benefits from District activities, regardless of their surface proximity to District activities, will be grouped into zones. The purpose of this technical memorandum is to describe the approach and methodology for establishing the zones of benefit so that it can be reviewed and commented on by District partners and stakeholders.

As background for developing the methodology for this Study, HydroMetrics WRI conducted a cursory statewide review of other groundwater management agencies that have created multiple groundwater zones of benefit to determine the methodologies used to define the zones. A report summarizing the findings from that research is attached as Appendix A. The two significant findings are: 1) not many agencies who have the legal authorization to create groundwater zones of benefit have done so, meaning that the costs of groundwater management activities are spread throughout the agency's jurisdiction without making a distinction between benefits in different areas; 2) six agencies were identified that have developed a methodology for determining zone boundaries. Methods used by these six agencies to define zones of benefit vary between following DWR subbasin boundaries; identifying sub-areas based on hydrogeologic features; or creating a separate zone for areas benefitting from a singular beneficial activity such as delivered water. None of the agencies identified have undertaken the level of benefit analysis to justify the zone boundaries that will be performed in this Study.

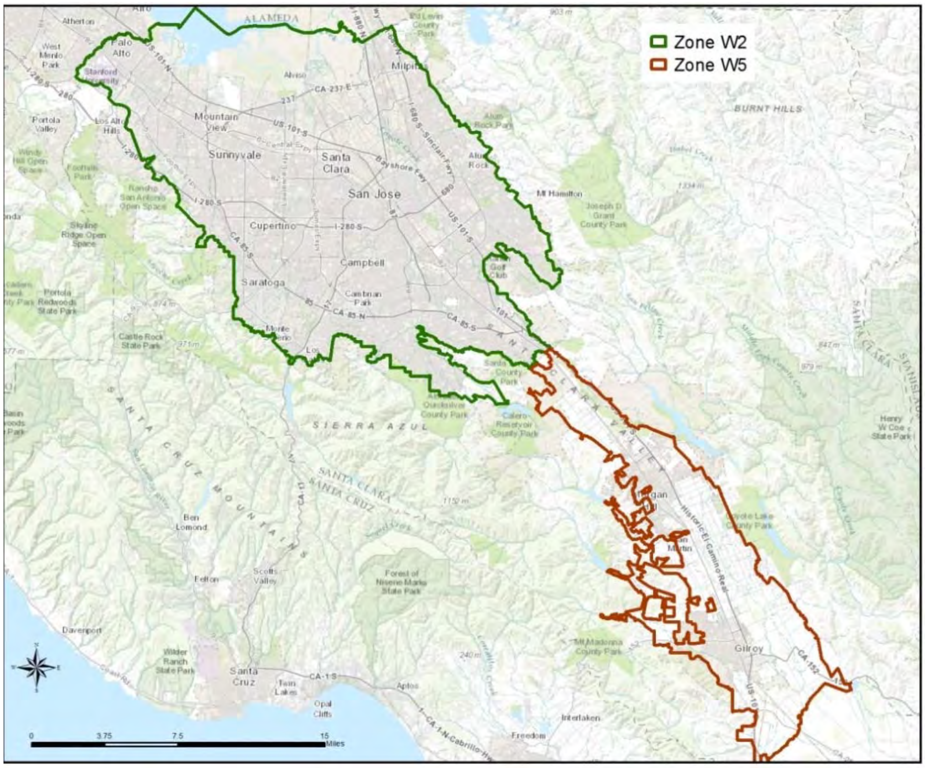

Figure 1: Existing Zones of Benefit

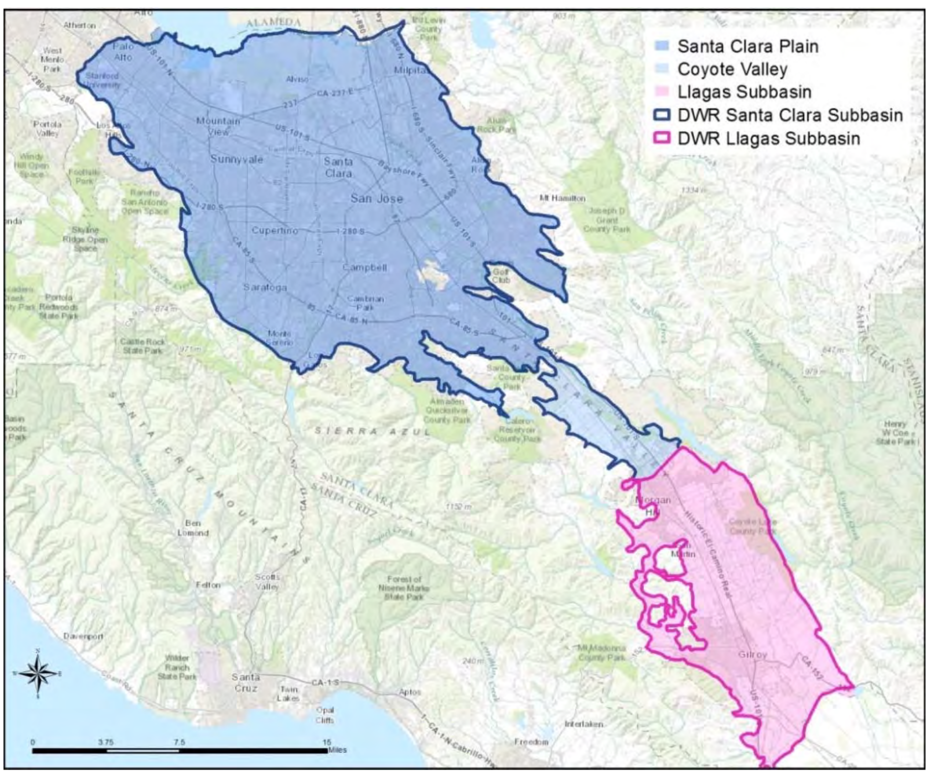

Figure 2: DWR Bulletin 118 Subbasins and District Groundwater Management Areas

CONCEPTS FOR EVALUATING GROUNDWATER ZONES OF BENEFIT

The proposed evaluation of groundwater zones of benefit is based on the hydrogeological characteristics that govern the movement of groundwater, District activities, and the benefits to groundwater users provided by the activities. First, we identify District activities that may provide benefits will be mapped. Second, we map hydrogeologically connected areas to the District activities. Third, we will map the areas where benefits to groundwater users from District activities are demonstrated. The recommended zones will be based on areas receiving benefit from similar District activities based on the analysis of hydrogeologically connected areas and observed and modeled groundwater data.

SUMMARY OF GROUNDWATER ZONE OF BENEFIT CRITERIA

An area within the District's legal jurisdiction will be included in a groundwater zone of benefit if any of the following criteria are met:

- Water supply is provided by a District activity
- Groundwater supply reliability is improved by District activities
- Land subsidence is prevented or limited due to District activities
- Saltwater intrusion is reversed or controlled due to District activities
- Groundwater quality is improved or maintained due to District activities
- Groundwater levels are improved due to District activities

Historical data and groundwater modeling will be used to assess the areas benefitting from District activities. If data and modeling are insufficient to assess whether an area benefits from District activities, the following assumptions will be made:

- Benefits from District activities extend to all areas that are hydrogeologically connected.
- Adjacent bedrock areas are not benefitting from District activities unless they are receiving District supply.

DISTRICT ACTIVITIES PROVIDING BENEFIT

District activities that provide a benefit to groundwater users include those covered under the District Act:

- Groundwater recharge,
- Importing water,
- Runoff capture,
- Water storage,
- Water treatment,

- Water distribution,
- Water recycling,
- Groundwater protection, and
- Water conservation.

The primary benefits to groundwater users are derived from District activities that support groundwater recharge. Managed aquifer recharge improves groundwater conditions by supplementing natural recharge of the underlying aquifers. Activities that support managed aquifer recharge are shown in
Figure 3. The District's direct delivery of water through various combinations of District activities, also shown in
Figure 3, improves groundwater conditions by reducing groundwater extractions; this is referred to as in-lieu recharge. Demand management through water conservation programs also constitutes in-lieu recharge.

Additional benefits are derived from the District's groundwater protection programs, which improve groundwater conditions by maintaining or improving groundwater quality. Protecting groundwater quality is inextricably linked to water supply reliability as are District efforts to conserve and augment groundwater supplies.

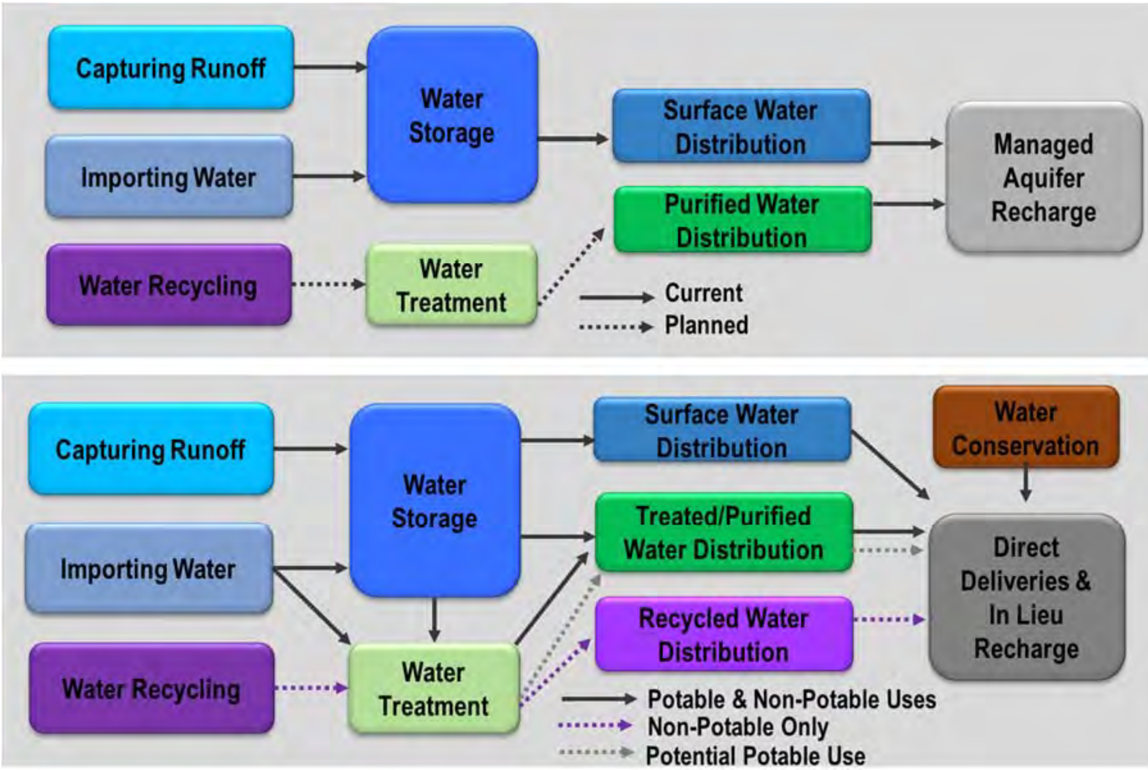

Figure 3: District Activities Supporting Groundwater Recharge For Benefit of Groundwater Users

BENEFITS OF DISTRICT GROUNDWATER MANAGEMENT ACTIVITIES

Groundwater is a shared resource that can be represented by a water budget, which includes estimates of groundwater inflows and outflows and conjunctive use of surface water supplies within a given area. Improved groundwater conditions resulting from District groundwater management activities can be summarized by an improved water budget, i.e. groundwater conditions would be worse in the absence of District activities. An improved water budget represents the overall benefit of District managed aquifer recharge and in-lieu recharge activities that sustain an area's groundwater supply. As an example, District activities in calendar year 2013 resulted in 96,000 acre-feet of managed aquifer recharge and 129,000 acre-feet of in-lieu recharge compared to 39,000 acre-feet of natural recharge (SCVWD, 2014). District activities that result in an improved water budget provide the following benefits to groundwater users:

Improved Groundwater Supply Reliability

On average, forty percent of the water used in Santa Clara County comes from wells pumping groundwater. Groundwater pumping (approximately 150,000 acre-feet in 2013) far exceeds natural recharge, and the District's managed and in-lieu recharge programs help replenish and sustain groundwater supplies. Figure 4 shows the rapidly growing population of Santa Clara County after World War II that was supported by a groundwater supply improved by District activities. This groundwater supply also supported high rates of business development and a viable agricultural economy. Community growth, quality of life and economic prosperity depend on a reliable and sustainable water supply that can be attributed to District groundwater management activities.

Reduced Risk of Land Subsidence

As shown in Figure 4, land in portions of the Santa Clara Valley subsided approximately 13 feet between 1915 and 1970 when groundwater pumping generally exceeded recharge. During that time, there was at least a 1-foot drop in the land surface over a 100-square mile area including portions of Palo Alto, Mountain View, Sunnyvale, Santa Clara, and San Jose. Since then, permanent subsidence has been halted due to an improved water budget resulting from District activities. Subsidence can result in adverse effects such as damaged infrastructure, increased flooding risk, increased sediment erosion or deposition, and, where relevant, impairment of leveled agricultural fields. Therefore, preventing subsidence is a benefit of the improved water budget resulting from District activities.

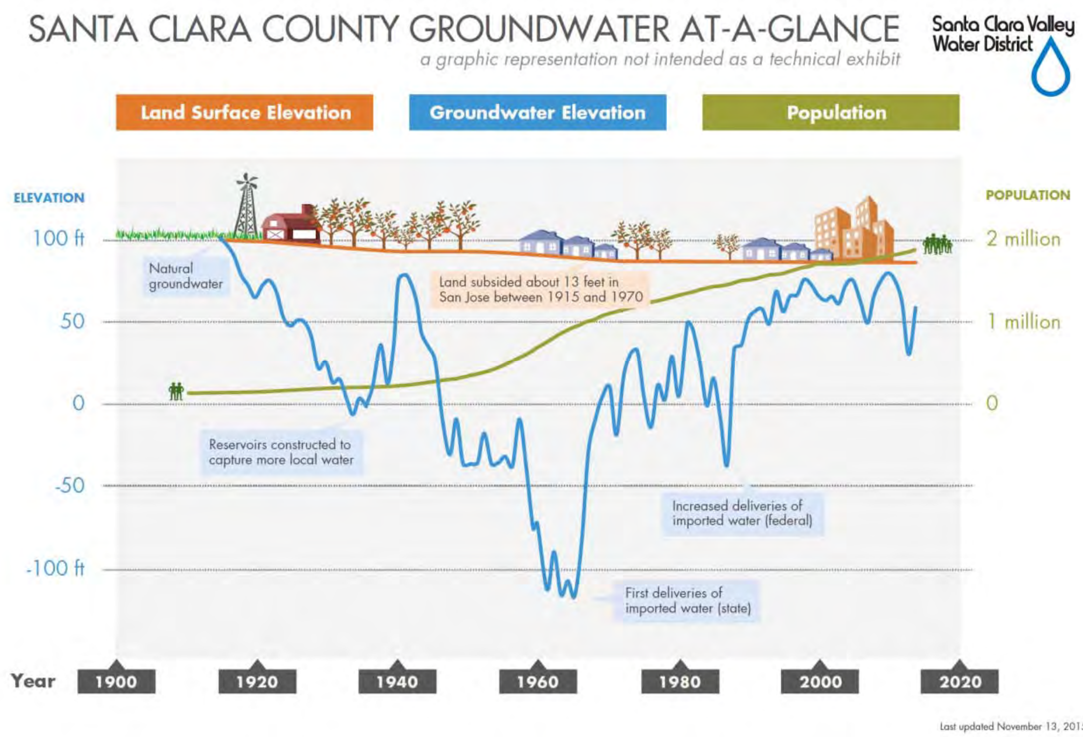

Figure 4: Graphic Representation of Groundwater Levels, Population and Land Subsidence (Courtesy SCVWD)

Saltwater Intrusion Prevention

Historically, denser saltwater moved inland from brackish channels connected to the San Francisco Bay when groundwater pumping exceeded natural recharge and subsidence resulted in greater tidal influence on the creeks connected to the bay. Figure 5 shows the inland migration of saltwater intrusion in the shallow aquifer zone from 1945 to 1980. Figure 5 additionally illustrates the reversal of saltwater intrusion in the shallow zone from 1980 to 2012. Saltwater intrusion adversely affects groundwater quality and can consequently have an adverse effect on groundwater use. Therefore, preventing saltwater intrusion is a benefit of the improved water budget from District activities.

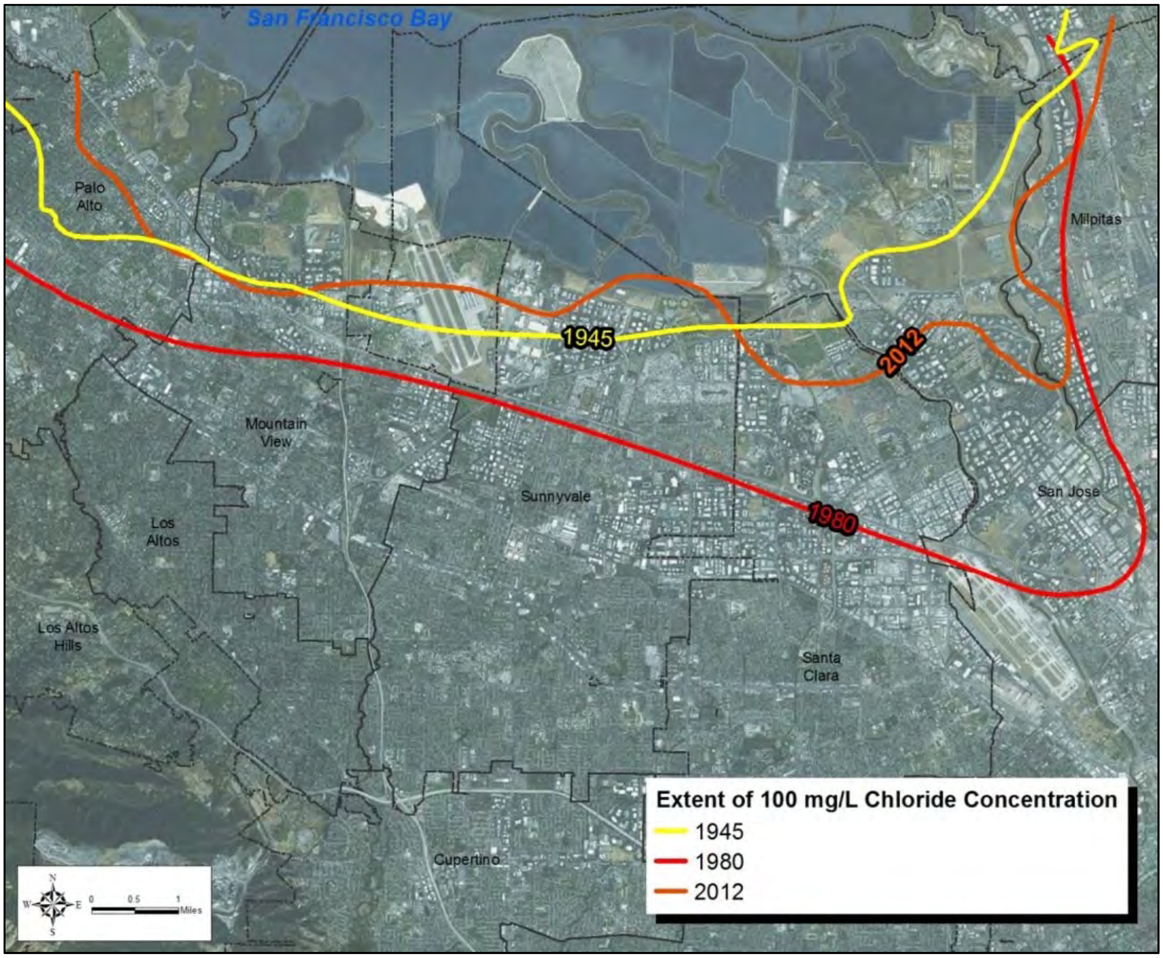

Figure 5. Extent of Shallow Zone Saltwater Intrusion

Improved Groundwater Quality

Recharge water can be higher quality than the ambient groundwater so an improved water budget from District activities can also improve groundwater quality. For example, nitrate concentrations are high in ambient groundwater in portions of the Llagas Subbasin, but imported water used for managed aquifer recharge has a dilution benefit by adding water with low nitrate concentrations to the water budget (MACTEC, 2009). Groundwater protection activities also conserve and improve groundwater quality. This prevents depletion of groundwater supply due to groundwater quality concerns and helps maintain an improved water budget.

MAPPING EXTENT OF BENEFITS BASED ON HYDROGEOLOGIC FEATURES

The initial evaluation of the areal extent of benefits from District activities will be based on defining hydrogeologically connected areas. District activities that improve the water budget are assumed to benefit all groundwater users within the hydrogeologically connected area subject to further evaluation with data and models described below. The areal extent of benefit beyond the District activity will be initially defined by mapping hydrogeologic features that control groundwater flow, such as the contact between water-bearing sediments and bedrock, the thickness of the water-bearing sediments, and the location of groundwater divides and faults. Mapping these features will form the boundaries of hydrogeologically connected areas that will be the first step for defining zones.

EVALUATING EXTENT OF BENEFITS WITH DATA AND MODELS

Field data, including groundwater levels, land subsidence, saltwater intrusion, and groundwater quality, will be evaluated to map the extent of benefits associated with District activities. Comparison of model simulations with and without District activities will also be used to map the extent of benefits. These maps will show areas where users receive benefits from a similar set of District activities. A defined zone of benefit will be created for each of these areas. There may be spatial data gaps, particularly along the subbasin margins, so areas demonstrated to be receiving benefit will be extended based on hydrogeologically connected areas as discussed above.

METHODOLOGY FOR EVALUATION OF GROUNDWATER ZONES OF BENEFIT

Groundwater zones of benefit will be defined initially based on areas of hydrogeologic connection and refined, if necessary, based on where benefits are demonstrated from a specific set of District activities. Groundwater flow extends benefits beyond the immediate location of activities to hydrogeologically connected areas. Benefits from current and planned District activities within initially defined hydrogeologic areas will be evaluated based on historical data and groundwater model results. The methodology to evaluate the zones of benefit will rely on a four-step process:

1. Map current and planned District activities that provide or will provide benefits to groundwater users in the District.
2. Map hydrogeologic features and groundwater occurrence and movement to define hydrogeologically connected areas.
3. Plot water balance over time in hydrogeologically connected areas to demonstrate overall benefit of District activities.

4. Use groundwater flow models and groundwater data to demonstrate the benefit of District activities.
5. Create recommended zones of benefit by grouping areas where users benefit from a similar set of District activities.

IDENTIFY AND MAP DISTRICT ACTIVITIES

As shown on
Figure 3, the two main categories of District activities that provide groundwater benefits are managed aquifer recharge and in-lieu recharge. The managed aquifer recharge facilities and end-point uses of deliveries that result in in-lieu recharge will be identified and mapped. The mapping of activities is illustrated on Figure 6 which contains a series of hypothetical maps for demonstrating the methodology.

Managed Aquifer Recharge Activities

Managed aquifer recharge occurs in District recharge ponds (off-stream recharge) and within streambeds (in-stream recharge). Geographic Information System (GIS) data of pond and stream features mapped by the District will be used to define these locations (Figure 6A). Benefits from managed aquifer recharge extend beyond the immediate area of recharge.

In order to evaluate the areal extent where groundwater users receive benefit from District managed aquifer recharge activities, recharge volumes will be plotted over time at each recharge system using data from the District. Recharge volumes over time represent changes in District activity that can be associated with groundwater benefits. When data or estimates for recharge volumes are not available for historical periods, periods when recharge volumes increased or decreased can be identified based on qualitative information such as commencement of recharge at any location.

In addition to identifying locations of current recharge from captured local runoff and imported surface water, potential locations of recharge from purified recycled water (Indirect Potable Reuse or IPR) will also be mapped. IPR is in the planning stage and is expected to be implemented by the District within the next 5 years.

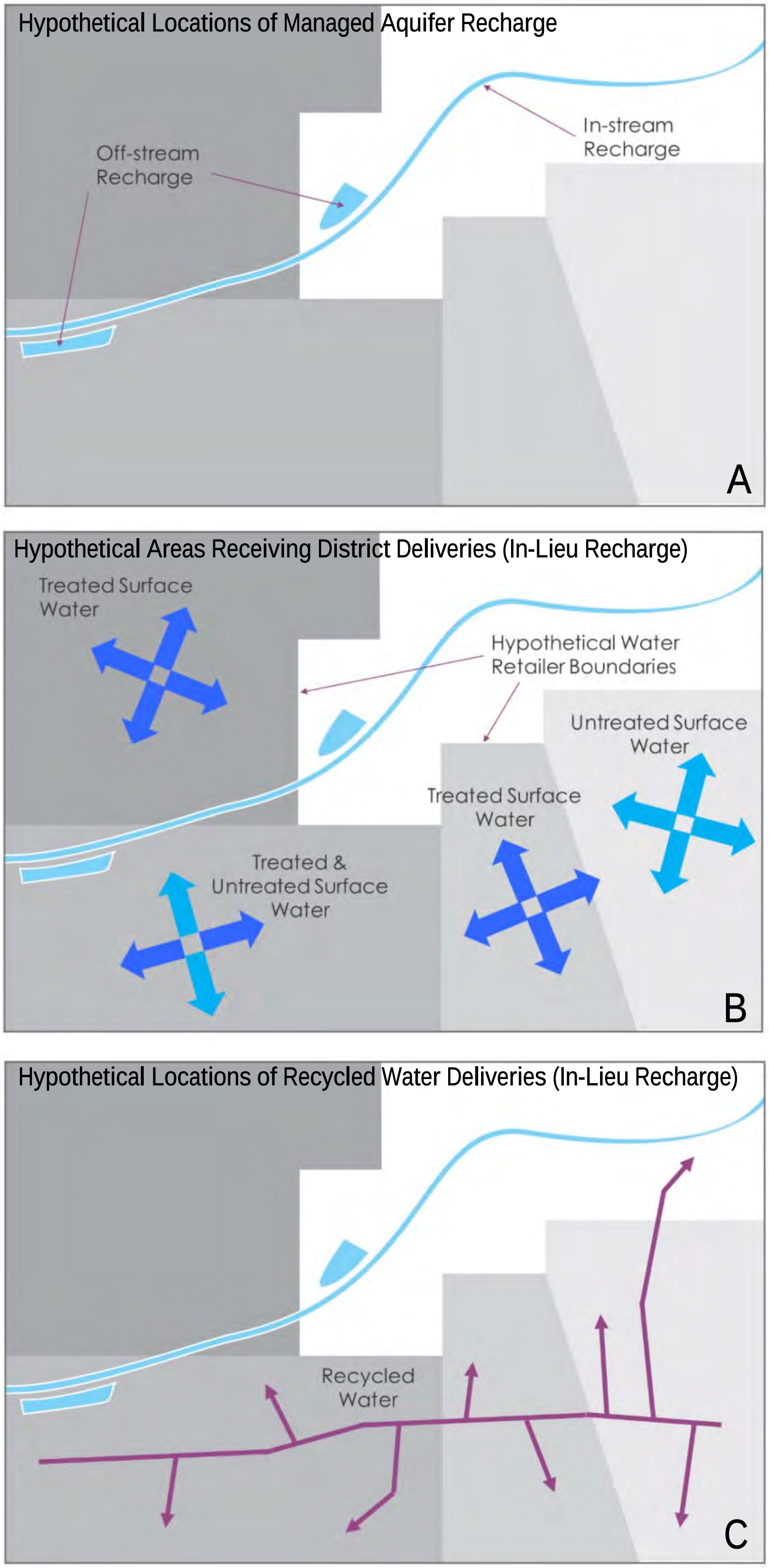

Figure 6: District Activities Mapping Methodology

In-Lieu Recharge Activities

Deliveries of treated water that provide in-lieu recharge benefits to groundwater users will be mapped to correspond to the service area boundaries of the retailers that receive District water supplies (Figure 6B). If a retailer delivers specific District supplies to distinct areas, those distinct areas will be mapped. Deliveries of surface water to non-retailer users will also be mapped. More detailed mapping than retailer service areas will be required to distinguish areas within a retailer boundary that receive different water sources. For example, an area receiving raw surface water from the District would be distinguished from an area receiving treated surface water from the District. GIS data provided by the District, retailers, and California Public Utilities Commission (PUC) will be used to provide these boundaries. Groundwater users in the areas receiving deliveries of District treated, raw, and recycled water are benefitting from in-lieu recharge provided by the District supplies. In addition, benefits from in-lieu recharge also extend beyond the delivery area.

In order to identify areas where groundwater users benefit from District delivery of raw and treated surface water, the volumes of District water supplies over time to each area will be charted using data from the District. These volumes over time represent changes in District supplies that can be associated with groundwater benefits. When data or estimates for recharge volumes are not available for deliveries, periods when deliveries increased or decreased can be identified based on qualitative information such as the availability of imported water to deliver.

Areas receiving recycled water will also be mapped based on GIS data provided by the District (Figure 6C). As with surface water benefits, recycled water benefits extend beyond the areas of direct delivery. To evaluate the extent of the area receiving in-lieu benefits, as discussed below, deliveries of recycled water to various areas will be charted over time using data from the District.

Based on the availability of data, these charts may be limited to indicating when deliveries increased or decreased based on qualitative information about the recycled water program. Historically, the areas receiving recycled water have been smaller than areas receiving raw or treated surface water and the volumes of water were smaller, which may make it difficult to distinguish between in-lieu benefits from recycled water and raw and treated surface water. Therefore, areas receiving recycled water located within areas receiving raw or treated surface water will be grouped within the larger area receiving in-lieu benefits from raw or treated surface water deliveries. Areas receiving recycled water that are outside of areas receiving raw or treated surface water may provide in-lieu benefits that do not overlap areas with in-lieu benefits from raw or treated surface water deliveries.

Water conservation provides benefits to groundwater users resulting from in-lieu recharge facilitated by the reduced demand. These are broad benefits throughout the groundwater basins. Areas that benefit from managed aquifer recharge and other in-lieu recharge activities are also assumed to benefit from water conservation activities. However, to assist in identifying zones of benefit, areas where conservation activities occur will be mapped based on information from the District.

Groundwater Protection Activities

Groundwater protection activities provide broad benefits to groundwater quality throughout the groundwater basins. Areas that benefit from managed aquifer recharge and in-lieu recharge activities are also assumed to benefit from the groundwater protection activities. Similar to the approach to be used for water conservation activities, groundwater protection activities will be summarized and mapped based on information from the District to assist with identifying zones of benefit.

DEFINE HYDROGEOLOGICALLY CONNECTED AREAS BASED ON HYDROGEOLOGIC FEATURES

As discussed previously, District activities provide groundwater benefits beyond the immediate location of an activity. Groundwater flow patterns control how benefits extend beyond the activity locations. Several hydrogeologic features affect groundwater flow and will be mapped to define areas hydrogeologically connected to District activities. The planned features to be mapped are the contact between water-bearing sediments and bedrock and the location of groundwater divides and faults. These features will provide the boundaries for the hydrogeologically connected areas.

Mapping Water-Bearing Sediments

Quaternary deposits are mostly alluvium that provide the highest permeability for groundwater flow and therefore the greatest potential for connecting areas with groundwater users to benefits from District activities. Quaternary deposits mapped at the surface that are not specifically labeled alluvium are included because they are relatively young deposits and are relatively permeable compared to the older bedrock that bounds the basin. Bedrock has much lower overall permeability for groundwater flow and groundwater flow typically occurs in fractures that have not been mapped. Therefore, the Quaternary deposit/bedrock contact (Figure 7A) will define the hydrogeologically connected areas used to define the extent of potential benefit.

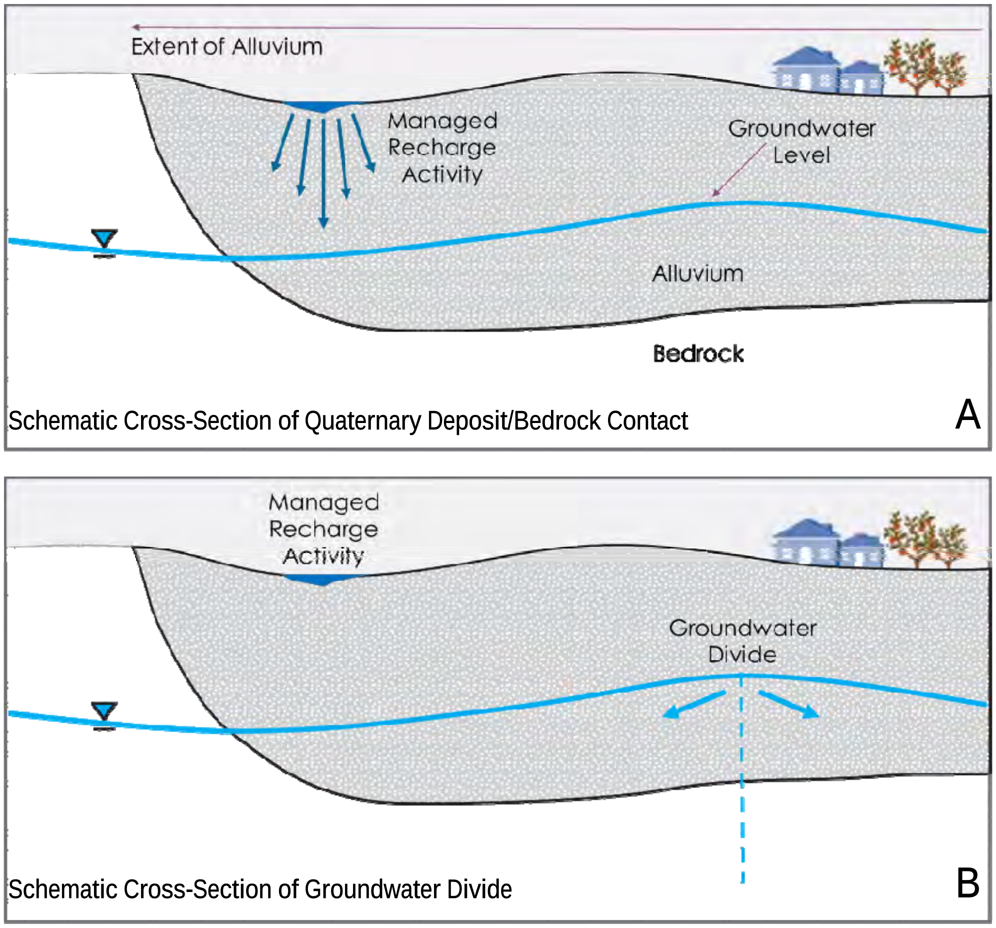

Figure 7: Schematic Cross-Sections

The Quaternary deposit/bedrock contact will be based on existing sources, such as mapping by the U.S. Geological Survey and California Geological Survey, including but not limited to *Maps of Quaternary Deposits and Liquefaction Susceptibility in the Central San Francisco Bay Region, California* (Witter et al., 2006) and *Preliminary Maps of Quaternary Deposits and Liquefaction Susceptibility, Nine County San Francisco Bay Region, California* (Knudsen et al., 2000). GIS formats of these maps are available for use in this study.

Available basin wide information on the thickness of the Quaternary deposits and stratigraphy of the deposits will also be mapped. Large changes in thickness or stratigraphy could be geologic features that affect how groundwater flows between areas. One source that will be considered is *Physical Subdivision and Water-Bearing Sediments of the Santa Clara Valley, California* (Wentworth et al., 2015). These maps only cover North County.

Groundwater Divides and Faults

A groundwater divide occurs where there is a regionally high groundwater level and groundwater flows in opposite directions on either side of the divide (Figure 7B). Groundwater benefits are unlikely to extend from a District activity on one side of the divide to the other side of the divide unless the activity provides a large enough change to groundwater levels or is close enough to the divide to actually alter the divide's location. Groundwater divides can change over time, so groundwater divides over different years will be mapped to the extent possible. Available District groundwater level contour maps will be evaluated to identify the groundwater level contours that represent a divide. One of the main groundwater divides of interest is expected to be in South County between the Coyote Valley and Llagas Subbasin. California Department of Water Resources defines the northern boundary of the Llagas Subbasin based on the groundwater divide near Cochrane Road in Morgan Hill (DWR, 2004).

Faults can be barriers to groundwater flow. However, faults are not expected to be significant barriers to flow that define the extent of benefits in the District. Nonetheless, faults will be mapped and groundwater flow in the vicinity of faults will be evaluated . The initial evaluation will compare mapped faults with the contour maps. Faults identified as barriers to groundwater flow will be considered when identifying areas with improved groundwater levels as discussed below. The U.S. Geological Survey and California Geological Survey (2010) have developed fault maps in GIS format, which will be used for this purpose.

PLOT WATER BUDGET OVER TIME IN HYDROGEOLOGICALLY CONNECTED AREAS

In order to summarize the benefit of District activities in hydrogeologically connected areas, the water budget in each area will be plotted over time. The plots will show the effect of District activities on the water budget for the hydrogeologically connected area. Estimated volumes for different categories of District activities shown in
Figure 3 that result in managed aquifer and in-lieu recharge will be included along with estimates of outflows such as pumping. There may not be data or published estimates for volumes of groundwater inflows and outflows for historical periods, but the plots will represent and document the conceptual water budget for these periods given available information. These plots will provide background for how District activities improve conditions for the shared groundwater resource defined by each hydrogeologically connected area.

EVALUATE AREAS WHERE GROUNDWATER USERS BENEFIT FROM SPECIFIC DISTRICT ACTIVITIES

The evaluation of where groundwater users benefit from specific District activities will consider multiple lines of evidence. The lines of evidence can be grouped as follows:

1. Data demonstrating benefits derived from improved groundwater levels associated with District activities. In addition to groundwater level data, this includes the evaluation of land subsidence and saltwater intrusion data.
2. Groundwater model results demonstrating improved groundwater levels as a result of current or future District activities.
3. Data demonstrating improved groundwater quality associated with District managed aquifer recharge.

All available information from these lines of evidence will be considered in identifying areas benefitting from specific District activities. Figure 8 summarizes the use of the three lines of evidence. If any of the lines of evidence demonstrate that groundwater users in an area benefit from a set of District activities, then the area will be mapped as benefitting from that set of District activities. Additional lines of evidence and alternate methods of evaluating information may be considered as new information become available and data are compiled. Any changes to methodology will be fully documented.

Evaluation of Data Related to Improved Groundwater Levels

This line of evidence is based on an evaluation of groundwater levels, land subsidence, and saltwater intrusion data. If data show groundwater levels, land subsidence, and saltwater intrusion in an area have improved or stabilized as a result of a District activity, then groundwater users in the area are benefitting from that activity. Historically, the District has implemented its activities to mitigate chronic overdraft that was causing undesirable effects such as declining groundwater levels, subsidence and saltwater intrusion. Therefore, the analyses will find a beneficial improvement whenever District activities result in any rise or stabilization of groundwater levels or prevention of the undesirable effects associated with declining groundwater levels. These groundwater level analyses are summarized in Figure 8 and described in greater detail below. The analysis as applied to groundwater level data is described immediately below. Discussion of specific differences in the analyses of land subsidence and saltwater intrusion data from the evaluation of groundwater level data follows.

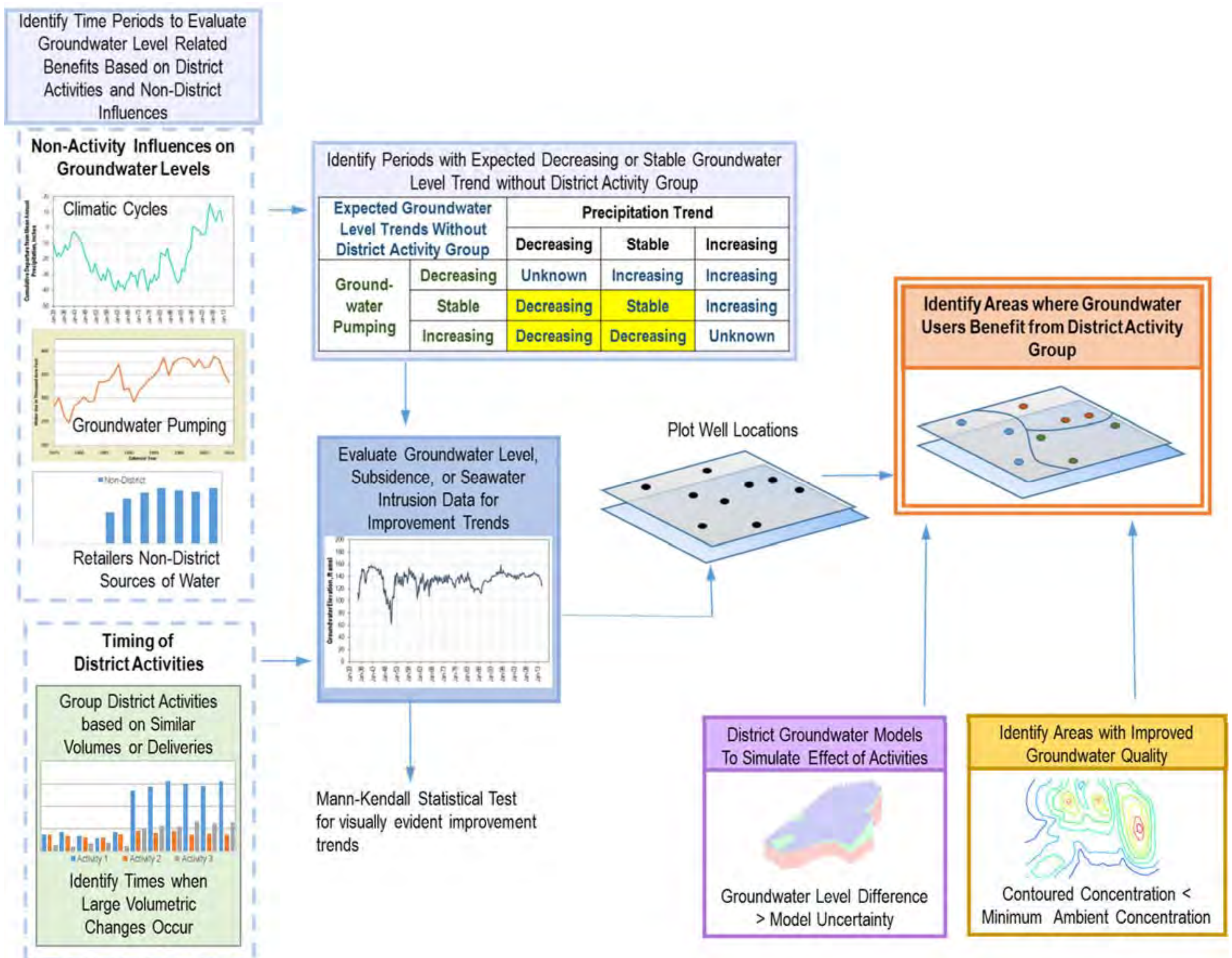

Figure 8. Flow Chart for Identifying Areas where Groundwater Users Benefit from Improved Groundwater Conditions

Analysis Applied to Groundwater Level Data

Groundwater level improvements associated with District activities will first be evaluated based on trends in groundwater level observation data at wells throughout the District. As described above, there are two main categories of District activities providing groundwater level improvement benefits: managed recharge and in-lieu recharge. In-lieu recharge encompasses a number of types of activities providing in-lieu recharge: treated water delivery, untreated surface water delivery, recycled water delivery, and conservation. The purpose of this analysis is to identify groundwater level improvements associated with specific groups of District activities. The steps for this analysis will be as follows:

1. Group District activities based on category, type, location and similar volumetric recharge or deliveries over time. This grouping will be based on the most reliable information available.
2. Identify time periods when volumetric recharge or deliveries increase for each group of activities from step #1. As in step #1, time periods will be identified based on the most reliable information available.
3. In order to evaluate the influence of each group of District activities on groundwater levels, evaluate influences on groundwater levels (as described below) that are unrelated to the group of District activities being evaluated (hereafter also referred to as "the District activity group") over each time period identified for the District activity group in step #2. These influences may be hydrologic conditions, non-District activities, or other District activities[1] not in the District activity group. Based on the evaluation of these influences, identify whether the expected groundwater level trend without the District activity group would be decreasing, stable, or increasing over each time period.
4. If the expected groundwater level trend without the District activity group , as defined in step #3, is decreasing or stable, evaluate whether the groundwater level trend in wells throughout the District show an improvement compared to the expected trend over the identified time period. Although periods will not be evaluated when there is an expected increasing groundwater level trend even

[1] Evaluating influences from other District activities has been added to the methodology since draft methodology was shared with stakeholders. This will facilitate evaluating benefits from District managed recharge in areas that receive District in-lieu recharge supplies. As a result, we are evaluating groundwater pumping for an area instead of non-District net demand as described in draft methodology.

without the District activity group , any demonstrated benefit from District activities for the area would still occur during those periods.

When volumetric recharge or deliveries increase over time from a District activity group (steps #1 and #2), groundwater levels should improve or stabilize in the areas with groundwater users receiving a benefit from the District activity. Time periods of increasing volumes will typically be associated with a new source of water coming online. The groundwater level trend at wells will be evaluated over each time period with increased volumes to assess whether an area's groundwater users are receiving a benefit from the District activity.

The evaluation of hydrographs will also consider other influences on groundwater levels over the time periods identified in steps #1 and #2 that are unrelated to the District activity group, such as changing climatic cycles, water demand, and water suppliers' sources of water. The effect of these other influences on the water balance will be evaluated to identify the expected groundwater level trend without the District activity (step #3).

Changing climatic cycles will be represented by charting the departure of mean annual precipitation from the mean precipitation measured at the nearest gauge with valid data. Historic long-term precipitation data from the ALERT hydrologic data collection system within or close to the groundwater basins will be used. The data from the most-representative station or stations for an area will be used for evaluating the climatic cycle. Figure 9 shows an example mean annual precipitation departure curve with periods of different precipitation trends. If groundwater levels responded only to climatic change, the expected groundwater level trend would be decreasing between 1942 and 1955 based on the decreasing precipitation trend. The expected groundwater level trend would be increasing between 1992 and 2005 based on the increasing precipitation trend. Although any benefit from a District activity would still be occurring, we will not be able to distinguish a groundwater benefit from District activities based on increasing groundwater levels during a period of increasing precipitation.

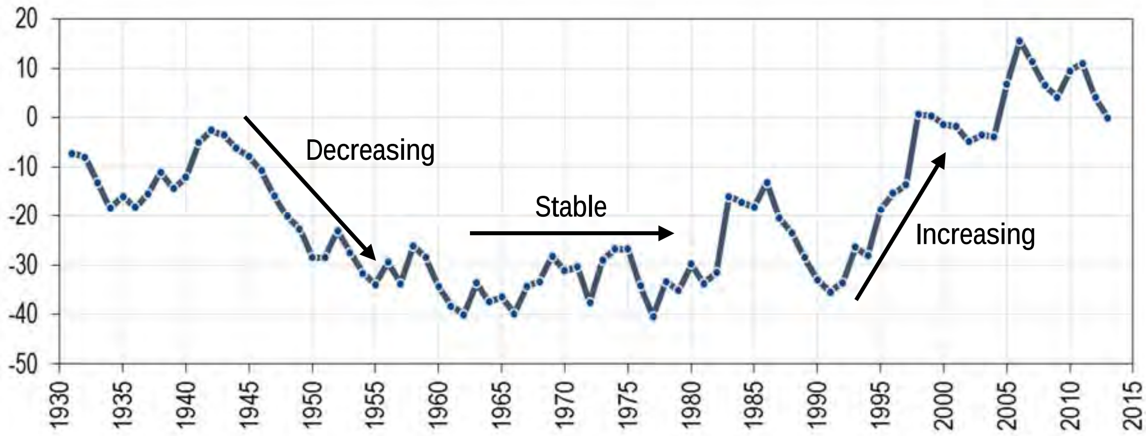

Figure 9: Example of Cumulative Departure from Mean Annual Precipitation

There are instances where water suppliers provide water sources other than groundwater, which for this study is referred to as in-lieu water supply. Groundwater pumping represents the expected influence of each water supplier's in-lieu water supplies on groundwater levels. In-lieu water supplies reduce groundwater pumping, and groundwater pumping has an inverse relationship to expected groundwater trends. Groundwater pumping will be evaluated for each water supplier's service area receiving a specific set of in-lieu water supplies. We expect a trend of decreasing groundwater levels when groundwater pumping increases within a water supplier's service area. We expect a trend of increasing groundwater levels when groundwater pumping decreases within a water supplier's service area.[2] This evaluation identifies periods when benefits from either a managed recharge or in-lieu District activity group cannot be identified due to non-District in-lieu water supplies. This evaluation also identifies periods when benefits from a managed recharge District activity group cannot be distinguished from District in-lieu recharge activities. In either of these cases, those periods will not be evaluated.

During periods of decreasing groundwater pumping, water budget information will be evaluated to assess whether the District's conservation activities may have resulted in decreasing groundwater pumping. If so, increasing groundwater levels during such a period would further demonstrate benefit from District conservation activities, but would be unable to demonstrate benefit from the District's other recharge activities.

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[2] In order to account for non-District in-lieu recharge activities, groundwater pumping is equivalent to non-District net demand concept discussed in draft methodology shared with stakeholders.

Land use changes can also alter water demand. The study will include a high level description of land use changes that have impacted demand, and such changes will not be attributed to District activities.

Table 1 shows the nine potential combinations of precipitation trends and groundwater pumping trends and the expected groundwater level trends without the District activity group based on those combinations. In order to identify groundwater benefits from District activities other than conservation, groundwater level trends will be evaluated when the expected trend is stable or decreasing. The four expected scenarios that result in stable or decreasing groundwater level trends are shown in grey boxes on Table 1. These expected groundwater level trends can be compared to observed groundwater level trends to identify benefits from District activities.

Based on this analysis, a benefit from the District activity group will be demonstrated when:

- the expected groundwater level trend without the District activity group is decreasing and observed groundwater level trends are stable or increasing
- the expected groundwater level trend without the District activity group is stable and the observed groundwater level trend is increasing

If the expected groundwater level trend without the District activity group is unknown or increasing, there will not be enough information to determine the benefits from District activities. However, a benefit from the District activity group as demonstrated during other periods would still occur during these periods.

Table 1: Expected Groundwater Level Trend Based on Precipitation and Groundwater Pumping (Without the District Activity Group)

Expected Groundwater Level Trend Without the District Activity Group		**Precipitation Trend**		
		Decreasing	**Stable**	**Increasing**
Groundwater Pumping	**Decreasing**	Unknown	Increasing	Increasing
	Stable	Decreasing	Stable	Increasing
	Increasing	Decreasing	Decreasing	Unknown

Groundwater level hydrographs will be evaluated for a trend that demonstrates a groundwater level improvement compared to the expected trend and therefore a benefit to groundwater users in the area from the District activity (step #4). The groundwater level trend demonstrating improvement will need to be visually evident in the hydrograph over the period of increased volumes by the District activity as identified in step #2. A single period that shows groundwater level improvement from the District activity demonstrates benefit to groundwater users in the area because the benefits may be masked for periods where other influences evaluated in step #3 prevent identification of improvements from District activities. Figure 10 shows an example hydrograph with periods of increased volumes by District activities annotated based on new water sources being secured by the District. Note that the increasing trend in the late 1930s would likely not be used to demonstrate benefit based on groundwater level data because precipitation increased during that time (Figure 9) while the stable trend in the 1950s would be used to demonstrate benefit because precipitation was stable and demand increased.

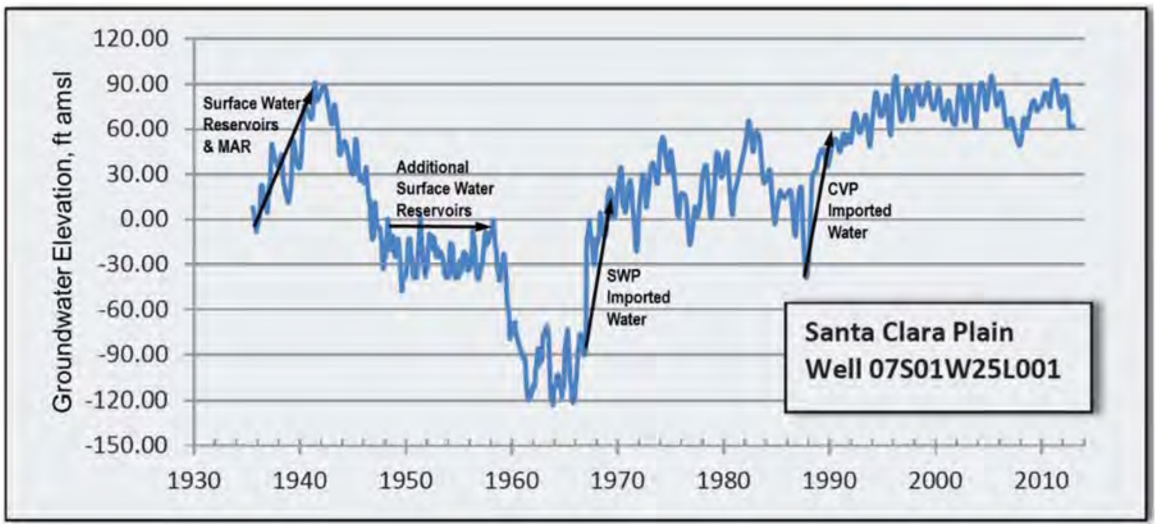

Figure 10: Groundwater Level Responses to District Activities

In order to quantify the statistical significance of the visually evident groundwater level trend demonstrating improvement, a Mann-Kendall test will be performed for data over the time period when a trend demonstrates improvement. The Mann-Kendall test is appropriate because it is non-parametric and does not rely on the distribution of the data set (Heisel and Hirsch, 2002). If data show regular seasonal variation, the seasonal Kendall test will be performed to calculate the probability that the visually evident trend is false.

If groundwater level data from a well demonstrates a benefit from a set of District activities for any time period, the map of benefits to groundwater users from that set of District activities will extend to the hydrogeologically connected area around the well.

Data used for the hydrograph analyses will be from the District's monitoring well network, and from water suppliers and stakeholders, as available. Data being considered for use will be evaluated to verify adequate measurement protocol and ensure there are sufficient regularly measured static groundwater levels to evaluate trends during times of increased volumes from District activity (step #2). Stakeholders should submit all information about the well such as a well log and construction information.

Available data for individual wells will be evaluated to ensure the wells are representative of aquifer conditions. Criteria that will be used to evaluate which individual wells will be used in the analysis include, but are not limited to:

- Well construction information, such as well depth, screened intervals, and lithology
- Period/frequency of water level measurements
- Completeness of water level records

Stakeholders are also encouraged to provide any other information, including data related to the calculation of groundwater pumping and non-District recharge activities, that they wish the study to consider. For example, information about non-District recharge activities would be evaluated using a similar procedure to District managed recharge activities. Hydrographs for wells near a non-District recharge activity would be compared to the non-District recharge quantities over time as well as District activity quantities over time to assess whether groundwater level improvements at those wells can be associated with District activities and are not solely a result of the non-District recharge activity.

Analysis of Land Subsidence Data

Improved groundwater levels are the mechanism by which land subsidence has been halted and prevented. However, land subsidence data will also be useful for evaluating benefit from District activities to groundwater users. Subsidence data will be evaluated from locations where land subsidence has occurred since 1915. Data to be evaluated includes key benchmark ground surface elevations and extensometer measurements. The expected trend without District activities given the historical subsidence at the location is continued lowering of the ground surface. If data show subsidence stops occurring after groundwater volumes increase from a set of District activities, a benefit to groundwater users in the area is demonstrated.

Analysis of Saltwater Intrusion Data

Similar to land subsidence, improved groundwater levels are the mechanism by which saltwater intrusion has been halted or reversed. Likewise, saltwater intrusion data will also be useful for evaluating benefit from District activities to groundwater users. Saltwater intrusion data represented by chloride concentrations will be evaluated from wells along the San Francisco Bay where concentrations increased above 100 mg/L after 1945. The trend in chloride concentrations over and after periods of increased water volumes from District activities will be evaluated using similar methodology to trends in groundwater levels. Trends at monitoring locations may not follow the same time periods because the effect of improved groundwater levels on saltwater intrusion may be delayed. The expected trend without District activities given the historical saltwater intrusion at the location is continued saltwater intrusion or increasing chloride concentrations. If chloride concentration data show a trend of stable or decreasing concentrations after groundwater volumes increase from a set of District activities, a benefit to groundwater users in the area is demonstrated.

Groundwater Model Simulations

Results from groundwater model simulations will be a second and equivalent line of evidence evaluated for the effect of District activities in different areas. The simulated data will be generated using calibrated District groundwater flow models for the Santa Clara Plain, Coyote Valley, and Llagas Subbasin.

Evaluating whether groundwater levels improve from District activities will be performed by comparing simulations of conditions with and without District activities. Therefore, the modeling will evaluate the same sets of District activities evaluated in the groundwater level analysis.

District activities for managed aquifer recharge are simulated in various ways in the models and reduced recharge volumes will simulated accordingly. Reduced volumes of deliveries for in-lieu recharge will be simulated as increased pumping in the models. Complete removal of managed aquifer recharge and/or delivered water for any set of District activities may alter the water balance so drastically that the basin completely dries out in the model so alternatives such as partial reductions in recharge volumes may be used for the model to provide meaningful results that can be used to evaluate the effect of District activities.

Groundwater levels simulated with District activities removed or reduced will be subtracted from groundwater levels simulated with actual historical conditions. The average difference in groundwater levels will be calculated over the modeled time period of the set of District activities. The map of the average differences will show where groundwater levels improve and benefits occur. All models have some uncertainty, and we will ensure that the benefits we identify in the model are the result of District activities, and not model uncertainty.

If results from model simulations using the Santa Clara model evaluating indirect potable reuse are available, results showing benefit from the planned recharge of purified water will be used in the evaluation.

Identifying Areas with Improved Groundwater Quality

The first step in identifying areas with improved groundwater quality as a result of District activities is identifying key constituents that differentiate ambient groundwater from recharge water. Possible constituents include total dissolved solids and nitrates. For each of these constituents, the expected range of concentrations will be estimated for ambient groundwater and recharge water. Contours of current groundwater quality will be developed around recharge streams and ponds for identified constituents using data from monitoring wells sampled by the District. Contours of concentrations below the low end of concentrations expected for ambient groundwater will define the area with improved groundwater quality and therefore benefits from the managed aquifer recharge. Isotopic analysis that differentiate ambient groundwater from recharge water will also be considered. These data were collected by the GAMA program (Ray, 2009) and as part of the Olin remediation project (MACTEC, 2009).

Proposing Zones of Benefit

Zones of benefit will be proposed based on the analyses described above that provides maps illustrating where groundwater users are benefiting from District activities. Zones will be proposed for areas receiving benefits from similar sets of District activities.

Summary

District activities provide benefits to groundwater users through managed aquifer recharge, in-lieu recharge, and groundwater protection. A methodology has been outlined that defines the areas hydrogeologically connected to District activities. Then, available data and groundwater model simulations will be evaluated to identify the benefits from all District activities in the area. Zones of benefit will be defined based on areas receiving benefits from similar sets of District activities.

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APPENDIX A: EVALUATION OF METHODOLOGIES USED TO ESTABLISH GROUNDWATER ZONES OF BENEFIT IN CALIFORNIA

Historically, California water agencies have been limited in their ability to establish groundwater zones of benefit as a means for funding projects and programs. Statutes creating agencies to manage groundwater (such as the Santa Clara Valley Water District Act) as well as other special act districts providing water related services (e.g. Coachella Valley Water District, Monterey County Water Resources Agency, and San Benito County Water District) have various provisions related to creating charge zones. Water conservation districts formed under Water Code Division 21, and agencies providing groundwater management under AB3030 (Water Code Sections 10754 *et. seq.)* are legislatively authorized to form zones of benefit and assess charges to groundwater users to recover the cost of district activities that benefit the groundwater resource. At the request of Santa Clara Valley Water District, HydroMetrics WRI has researched current groundwater zones of benefit and the methodologies used to establish multiple zones within a single agency's jurisdiction.

The initial agencies to review for methodologies establishing groundwater zones of benefit were identified from a paper on funding sustainable groundwater management in California posted by the UC Davis Center for Watershed Sciences (Hanak et al., 2014). The UC Davis paper includes a chart prepared by the Public Policy Institute of California listing groundwater pumping charges in special act districts as of 2013/2014. Of the 15 agencies created by statute to manage groundwater, the authors found evidence that only five of those agencies charge pumping fees, including Santa Clara Valley Water District[3]. Of the remaining four, only Pajaro Valley Water Management Agency assesses charges depending on pumping location, thereby establishing different charge zones. The paper also notes that, according to the DWR Bulletin 118 2003 update, none of the AB 3030 agencies was known to have exercised its authority to enact groundwater pumping charges through the creation of groundwater replenishment districts. Five additional agencies with multiple charge zones were identified through personal knowledge and research. These are the special act districts of Coachella Valley Water District, Monterey County Water Resources Agency (Salinas Valley Basin), and San Benito County Water District, and the water conservation districts of Santa Ynez

[3] It is worth noting that the activities performed by these agencies to manage groundwater range considerably. In previous research, HydroMetrics WRI could not find any evidence that four of the listed agencies are functioning and three others do not appear to have active groundwater restoration programs.

River Water Conservation District and United Water Conservation District. The methodologies used by the six identified agencies to establish multiple zones of benefit are summarized below.

COACHELLA VALLEY WATER DISTRICT (CVWD)

The CVWD has three zones of benefit. Initially, there were two zones with boundaries corresponding to DWR subbasins. A USGS study indicated a clay aquitard within the Whitewater River subbasin, which resulted in CVWD sub-dividing that zone of benefit into two. No further analysis of the zone boundaries has been conducted, although CVWD is reconsidering restoring the Whitewater River subbasin as a single zone. The CVWD District Act limits zone charges to benefits from imported water used for direct groundwater recharge and in-lieu recharge from use of recycled water (Reyburn, 2015).

PAJARO VALLEY WATER MANAGEMENT AGENCY (PVWMA)

The PVWMA Agency Act provides for creating zones of benefit for areas within PVWMA's jurisdiction that will benefit from planning, studies, or any management program undertaken by PVWMA in a manner different from other areas within the agency's jurisdiction. Zones of benefit are established by a resolution of the board that describes the boundaries of the zones and may only be adopted following a noticed public hearing.

Two zones were established in 2010 based on delivered water (Carollo, 2010). Parcels along the coast with access to water delivered through PVWMA's coastal distribution system are in the Delivered Water Zone. All other parcels within PVWMA's boundaries are in the Outside Delivered Water Zone. In arriving at the current zone determination, several options were considered including geographic segmentation using 1/2 mile contours, hydrogeologic segmentation based on seawater intrusion, and zone of service segmentation based on availability of delivered water. The adopted variation in zone definition was intended to recognize that the water users closer to the coast benefit more (receive greater service) from PVWMA's system than inland water users.

MONTEREY COUNTY WATER RESOURCES AGENCY (SALINAS VALLEY BASIN) (MCWRA)

The Salinas Valley Basin zone of benefit has been defined based on geological conditions and hydrologic factors, which define and limit the benefits derived from MCWRA's reservoir operations. Historic work showed there to be five distinct sub-areas within the Salinas Valley Basin. Those sub-areas were first identified in DWR Bulletin 52, which established the division in accordance with sources of replenishment of groundwater for the respective areas served as indicated by direction of groundwater flow after the close of the 1944 irrigation season. Bulletin 52 emphasizes that these areas are not in any way to be confused with subbasins. This analysis resulted in the five original zones.

Historic work showed that each of the sub-areas within the Salinas Valley is hydraulically connected, but due to their varying geology and geography, they receive varying levels of benefits from the operation of the two existing reservoirs. Many of those same bodies of work have shown that the benefits that could be derived from proposed Salinas Valley Water Project facilities would also vary by geographic location within the Salinas Valley.

In 2001, a Technical Committee reviewed the sub-area delineations established in DWR Bulletin 52, and determined that there is information supporting those delineations and there is no known contradictory information. However, a review of the geology of the Salinas Valley indicates water-bearing alluvium extends south of the Upper Valley area, as delineated in DWR Bulletin 52, to beyond the Monterey/San Luis Obispo County line. This alluvium also extends west from the Salinas River area to the area surrounding San Antonio Reservoir. The original five sub-areas were, therefore, expanded to seven.

Prior to 2003, special benefit zones covering the Salinas Valley were known as: Zone 2 and 2A, which funded standby and availability charges associated with the operation and maintenance of existing facilities; and Zone 2B, which included approximately 12,800 acres of irrigated agricultural lands within the Castroville Seawater Intrusion Project (CSIP) distribution system. In 2003, Zone 2C was created and includes the lands that receive benefits from the Salinas Valley Water Project. Zone 2C overlays the previous Salinas Valley zones and was defined based on geological conditions and hydrologic factors, which define and limit the benefits derived from the reservoirs and the proposed changes to the operations, storage, and release of water from the reservoirs. Zone 2C is separated into the seven major hydrologic sub-areas described above.

The basis for inclusion within the Zone 2C zone of benefit consists of the following eight criteria reviewed and approved by the Technical Committee in 2001:

(a) There must be a hydro-geologic or flood protection basis for establishing benefit;

(b) The zone of hydrologic benefits is defined as land overlying water bearing alluvium that has hydraulic continuity with the Salinas River;

(c) The zone of benefit excludes narrow, likely shallow, channels off the main basin where pumping cannot induce an up-gradient recharge;

(d) Existing annexations that are non-hydraulically connected have been included since they are receiving benefits through physically installed pumping and piping equipment;

(e) The southern boundary of the zone of benefit is defined by the Monterey/San Luis Obispo County line;

(f) Lands immediately adjacent to San Antonio reservoir receive hydrologic benefits due to recharge of the underlying aquifer and receive recreational benefits afforded by their proximity to San Antonio reservoir;

(g) The boundary in the Fort Ord area is defined by the existing boundary of zone 2A. ;

(h) Any contiguous parcel that overlies a portion of the alluvial material that is in hydrologic continuity with the Salinas River has been included in a zone of benefit since the overlying portion of the parcel provides access to all hydrologic benefits (RMC, 2003).

Section 3.2.1 of the Salinas Valley Water Project Engineer's Report (RMC, 2003) describes the benefits and weighting factors assigned to each benefit in developing the Zone 2C charges. The benefits are identified as: (1) control of seawater intrusion; (2) flood control; (3) increased groundwater recharge; (4) groundwater quality; (5) timing and location of the recharge; (6) drought protection; (7) preservation of aquifer storage; and (8) recreation.

SAN BENITO COUNTY WATER DISTRICT (SBCWD)

SBCWD was formed by a special legislative Act in 1953. The original jurisdiction was valley-wide instead of county-wide. An early amendment to the Act, redefined the boundaries to be county-wide; however, taxing powers were limited to areas within zones of benefit. Five zones were created between 1953 and 1967 to fund specific projects. Only Zone 3 of those original five zones remains active. Zone 3 was formed in 1957 to finance construction and operation of the Hernandez and Paicines reservoirs and related groundwater recharge and management activities. The original Zone 1 practically overlapped with Zone 3 exactly and was dissolved. The other original zones were dissolved for the following reasons: the Zone 2 function was assumed by the Tri-County Water Authority; the Zone 4 function was turned over to the City of Hollister; and Zone 5 was temporary to finance engineering and hydrological studies to prepare development of facilities to distribute San Felipe water and was succeeded by the permanent operating Zone 6 (Creegan & D'Angelo-McCandless, 1977, pages I-2 – I-3).

The current Zone 1 encompasses the entire county and provides the funding base for specific SBCWD administrative expenses. The methodology used to define the Zone 3 boundaries could not be located. A master plan report prepared in 1977 by Creegan & D'Angelo-McCandless, Consulting Engineers, documents the formation of Zone 6, which establishes the assessment area for financing the capital and operating expenses of the San Felipe project (CVP). Zone 3 and Zone 6 overlap in areas that receive benefits from projects funded by the both zones.

The Zone 6 boundaries were determined primarily by land classifications within the area to receive CVP water. The foundation document for establishing the project benefit area was the U.S. Bureau of Reclamation's March, 1973, "Land Classification Appendix" for the Hollister Subarea, San Felipe Division, Central Valley Project. The Zone 6 area encompasses acreage referred to in the Land Classification Appendix as the Hollister Basin and San Juan Valley. Zone 6 boundary modifications were made in the above referenced master plan to eliminate non-irrigable lands in adjacent hills, for political considerations, and to observe parcel boundaries to simplify taxation.

SANTA YNEZ RIVER WATER CONSERVATION DISTRICT (SYRWCD)

SYRWCD was formed in 1939 for the primary purpose of protecting water rights on the lower Santa Ynez River following construction of two upstream reservoirs. Additional projects or exportation of water were also being studied, and the Cachuma Project was administratively authorized in the same year. For these reasons, the people of the Santa Ynez and Lompoc Valleys joined together to form a water conservation district. The purpose of SYRWCD is to protect, and if necessary, augment the water supplies of the SYRWCD. (Stetson Engineers, 2015). SYRWCD's role is essentially that of an oversight authority and it operates on a budget of approximately $500,000/year. Groundwater charges are incurred by the owners of water production facilities and are charged at uniform rates (for each category of water) within SYRWCD or each Zone thereof, based on the amount of groundwater produced (Wales, 2015).

There were three zones prior to 1995: the Santa Ynez River alluvial channel; the Lompoc Plain; and all others. In the course of preparing an AB3030 plan, SYRWCD convened a committee of five geologists who determined boundaries for three additional zones based on hydrogeological distinctions and groundwater recharge from the Santa Ynez River. While SYRWCD continues to be segregated into six zones, there are only two groundwater rate schedules: Zone A (Santa Ynez River alluvial channel), which accounts for 27% of the total groundwater pumping, and Zone B (Lompoc Plain, Lompoc Upland and Lompoc Terrace sub-basins), which accounts for 50% of the total groundwater pumping, are charged at a higher rate; Zones C, D, E, and F are charged a lower rate (Wales, 2015). Zone C encompasses all portions of the SYRWCD not included in the other zones, and Zones D, E, and F cover the SYRWCD's portion of three distinct upland basins.

UNITED WATER CONSERVATION DISTRICT

United Water Conservation District (UCWD) has established two zones. Zone A includes all lands lying within the boundaries of UWCD. Zone B was formed to pay for operation and maintenance of, and any improvements to, the Freeman Diversion project facilities. Zone B is a sub-area of Zone A that encompasses the portions within the UWCD boundaries of all DWR defined basins or subbasins down gradient of the diversion project. Since 2012, two of these basins have been re-labeled (Montalvo is now referred to as Oxnard Forebay; and North Las Posas is now referred to as West Los Posas), but the zone boundaries have not been re-evaluated (Morgan, 2015).

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APPENDIX B: Comments and Responses to Comments on Methodology

Meeting Summary
Technical Review Committee
October 20, 2015

Participants

Technical Review Committee:
Carl Hauge, California Department of Water Resources (Retired)
Randy Hanson, US Geological Survey
Rebecca Nelson, Stanford Woods Institute (as of January 1, 2016 University of Melbourne Law School)

Project Team:
George Cook, Santa Clara Valley Water District
Bassam Kassab, Santa Clara Valley Water District
Cameron Tana, HydroMetrics WRI
Laura Brown, HydroMetrics WRI
Charles Gardiner, Catalyst Group

Questions and Comments

Topic Introduced by Carl Hauge

- **Does the water budget include a bedrock flow contribution? More wells pumping from bedrock would reduce mountain front recharge.**
  Response: The water budget includes a bedrock flow contribution so wells pumping from bedrock potentially do affect the water budget. However, the distribution and extent of fractures connecting the Quaternary deposits into bedrock is generally unknown. Unless there is specific information showing the extent of hydrogeologic connection into bedrock, bedrock areas will not be considered hydrogeologically connected with the Quaternary deposits.
- **Will the confining layer under the aquitard be included in hydrogeologically connected areas?**
  Response: Yes.
- **Include a map of the recharge areas in the methodology technical memorandum.**
  Response: The reason such a map was excluded is that we did not want to include results of implementation steps in the methodology memo. The map will be included in the technical study report.
- **Does "groundwater balance" mean a water budget? Use "water budget" to emphasize integrated resource management.**
  Response: Terminology in the memo is changed from "groundwater balance" to "water budget."
- **Randy Hanson also commented that conjunctive use should be made part of the metric.**
  Response: The water budget includes conjunctive use of surface water supplies and will be explicitly stated in discussion of water budget in the memo. For example, District activities in calendar year 2013 resulted in 96,500 acre-feet of managed aquifer recharge and 205,300 acre-feet of in-lieu recharge compared to 39,500 acre-feet of

natural recharge (SCVWD, 2014). Most of the District activities that provide benefit to groundwater users are conjunctive use activities.

- **Overall, this is a good exercise because you will develop more detail about managing groundwater, which is very much needed across the state.**
  Response: Comment noted.
- **The specificity of the zones shouldn't exceed the specificity of the data.**
  Response: The zones will, of necessity, exceed the specificity of the data as the zones will need to define the specific parcels that will pay groundwater charges. The zones will be based on the best approximation of the areas benefitting from similar District activities as supported by the available data. The study will also develop a procedure to apply for exemptions from the zones, which will increase the specificity of the data by allowing groundwater users to provide data for specific locations that could result in redefining zone boundaries in response to more location-specific data.
- **Have you considered the possibility that you will come up with the same zones?**
  Response: Without good information to change the zones, they will remain the same. The District is looking for an honest, unbiased evaluation of the zones of benefit without a preconceived outcome.

<u>Topic Introduced by Randy Hanson</u>

- **The fault lines may have a significant effect on groundwater flow, such as the Silver Creek Fault and underlying Vasona Creek.**
  Response: We will revise the memo to better recognize this possibility and make sure to evaluate groundwater flow in the vicinity of faults.
- **Are you looking at the benefits of other activities (besides District programs)?**
  Response: We are evaluating beneficial non-District activities to make sure benefits that may result from those non-District activities are not attributed to District activities in recommending modifications to zones. However, separate zones for areas where benefits from non-District activities occur will not be recommended.
- **Are you considering passive benefits? For example, the San Jose Water Company wells are constructed such that they provide a deep conduit to increase recharge of deep aquifer layers and provide water that can be re-pumped in to prevent subsidence.**
  Response: We will consider passive benefits that are identified in a similar manner to non-District activities discussed above, but there needs to be evidence that the passive benefits have improved or are improving the water budget.
- **Are there also areas where additional activities could have negative effects that could be defined as zones of hazard, e.g., pumping in the shallow central area could remobilize contaminants?**
  Response: Evaluation of negative effects from non-District activities is beyond the scope of this study.
- **Could District groundwater programs have adverse effects, such as increasing the artesian effects from "overfilling" the basin? The USGS model shows that the basin could be refilled to a point that could result in recharged water being lost back to the streams.**
  Response: The District manages its activities to minimize the risk of adverse effects. This possibility will not affect the definition of zones of benefit, which will be based on benefits resulting from District activities.
- **Oxygen and deuterium isotopes have been used to track the extent of recharge. Could that approach be used here?**

Response: Yes, as stated in the methodology memo, isotopic analyses that differentiate ambient groundwater from recharge water will also be considered. We have identified these data collected by the GAMA program (Ray, 2009) and as part of the Olin remediation project (MACTEC, 2009).

- **The overall groundwater quality of the basin is very good, much better than many other basins in California. What is the quality concern, and what water quality benefits are you looking for?**
  Response: This evaluation will occur in areas where there is an identified quality concern. For example, nitrate concentrations are high in ambient groundwater in portions of the Llagas subbasin. Imported water used for managed aquifer recharge has a dilution benefit by adding water with low nitrate concentrations to the groundwater balance (MACTEC, 2009). Perchlorate could be another relevant quality concern.
- **How will the Santa Clara Valley comply with SGMA and will activities be credited?**
  Response: SCVWD is named as the exclusive groundwater management agency for Santa Clara County, and will be updating the groundwater management plan in accordance with SGMA requirements. The plan will cover the Santa Clara and Llagas groundwater subbasins. The updated groundwater management plan will reflect the District activities that provide benefits used to define the zones of benefit.

<u>Topic Introduced by Rebecca Nelson</u>

- **Have the recharge areas changed over time?**
  Response: Recharge facilities have changed over time in that they have come online at different times and the water delivery to them varies with availability and recharge needs. The differences in timing of recharge for different areas will be evaluated in the analysis to identify benefits from recharge activities with different histories.
- **Have you thought about changes in water use over time, from agriculture to urban, and changes to the levels of conservation? Describe the background levels of land use change that could explain the differences that are not the result of District programs.**
  Response: The memo discusses evaluation of net demand to assess whether improving groundwater conditions can be attributed to District activities. We will revise the memo to clarify that land use change could cause changes in net demand and the study will include a high level description of land use changes that have caused changes in net demand.
- **The Great Oaks lawsuit may change the definitions you are using.**
  Response: District staff will ensure the study complies with all legal requirements including any requirements resulting from a final decision rendered in the Great Oaks case.
- **It makes sense that if there is a benefit, users pay for it.**
- **Include conservation as a beneficial activity.**
  Response: District conservation activities are included as providing benefit, but will likely not be a major factor in defining zones because those activities and benefits are widespread throughout the District.
- **Will the zones cover the entire basin?**
  Response: The zones may not cover the entire basin. Only areas identified as benefitting from District activities will be included as zones. For example, bedrock areas that don't receive water deliveries from SCWVD likely will not be part of the zones unless there are data showing a hydrogeologic connection into bedrock from Quaternary deposits.

- **Will planned activities substantially change the area of benefit?**
  Response: We will evaluate benefits from planned activities with available information, but the study will also develop a procedure for revising zones in the future to reflect benefit changes and a recommended timeframe for regularly reviewing and updating the zones.
- **Both Carl Hauge and Rebecca Nelson commented that it is good to be developing a methodology that can be repeated in the future.**
- **What would happen if there is disagreement between the model and physical data?**
  Response: If either of the lines of evidence demonstrate that groundwater users in an area benefit from a set of District activities, then the area will be mapped as benefitting from that set of District activities. For example, there may be factors that result in the data not clearly demonstrating a benefit, or the model may not show improvement greater than the error of calibration. Therefore, if the data show benefits that can be attributed to District activities, or if the model shows improvement greater than model uncertainty, then a benefit will have been demonstrated.
- **Randy Hanson commented that model accuracy depends on what you are using for calibration. You need to use higher order observations, stream flows, etc., not just groundwater levels, to calibrate the model. Note that the USGS also looked at rejected infiltration.**
  Response: We will be using the groundwater models as calibrated by the District to groundwater levels. This is appropriate because the methodology uses the model to look at head differences under different scenarios. Calibrating the model to other observations is not part of the study's scope.
- **It is good to quantify uncertainties in the model. Also discuss how the uncertainties will influence how you draw boundaries.**
  Response: Model results need to show groundwater level improvement greater than model uncertainty to demonstrate benefit. Where model results define boundaries, recommended modifications to zones of benefits will only be based on areas where modeled groundwater level improvement is greater than model uncertainty.
- **Carl Hauge commented that relying on the model vs. demonstrated increase in head could be controversial. Landowners will trust measurements over model results.**
  Response: Ideally, both the data and the model will show similar results. However, as discussed above, measured data may not be available in all areas or data may not demonstrate benefit due to other factors. In such cases, using the model will isolate effects of District activities and, therefore, it is appropriate to use model results.
- **How do you connect groundwater levels to water supply reliability?**
  Response: In general, higher groundwater levels indicate higher water supply reliability due to lower risk of wells drying out, lower risk of well damage from aeration of screens, higher yields, and lower pumping costs.
- **Carl Hauge noted that developing a scale of reliability would be a difficult exercise.**
  Response: Yes, a reliability scale would be difficult, which is one of the reasons why relative differences in benefits from a similar set of District activities will not be used to define zones.

- **TRC members expressed appreciation for the presentation and discussion.**
- **The TRC agreed to provide any additional questions or comments by November 6, 2015.**

Comments Provided by Rebecca Nelson via email November 10, 2015

- **Current versus planned activities: The document refers to zones reflecting areas receiving benefits from current and planned District activities. The District should consider whether it is equitable/legal to include within a zone an area that will only receive benefits in the future (and if so, how far into the future is justifiable), or whether the boundaries of zones should change in the future in response to the commencement of significant future District activities. The document also occasionally refers to "potential" activities. This sounds a little too uncertain or hypothetical to justify zone boundaries, whereas "planned" activities seems more justifiable.**
  Response: Planned District activities will be considered as a different set of activities than current activities. An area that will only receive benefits in the future from planned activities will be recommended as a separate zone from areas that receive benefits from current activities. Likewise, areas that receive benefits from current activities may be recommended to be divided into multiple zones if only parts of those areas will receive benefits from planned activities.

  A process for conducting future reviews of zones of benefit that will be developed as part of the study. A review of zone boundaries based on benefits from new or expanded District activities will be included in that process. We will also revise the methodology memo to only include planned activities and not potential activities.
- **Quality as a benefit: In relation to quality as a benefit, it would be helpful to explain the statement on page 15 that connects in lieu recharge with groundwater protection activities: "Areas that benefit from … in-lieu recharge activities are also assumed to benefit from the groundwater protection activities." I wasn't clear on the mechanism for in-lieu recharge to influence groundwater quality.**
  Response: This does not refer to a physical mechanism for in-lieu recharge to influence groundwater quality. Groundwater protection activities provide broad benefits to groundwater quality throughout the groundwater basins. Areas where there are in-lieu recharge benefits to groundwater supply are assumed to also benefit from groundwater protection activities because those activities protect (i.e. preserve) the groundwater supply that is more reliable due to in-lieu recharge.
- **The overall approach is clearly well thought out, and the District should be congratulated on its effort and approach, which appears to be uniquely rigorous in the state.**

Meeting Summary
Joint Meeting of the Water Retailer Water Supply and Groundwater Committees
October 22, 2015

Joint Meeting of the Water Retailer Water Supply and Groundwater Committees

Zone of Benefit Study

- **Have notices gone out for the October 28 small group briefing meeting?**
  Response: Notices went out October 17, 2015.
- **Who is commenting on the Methodology Technical Memorandum?**
  Response: We received verbal comments from the two attendees at the October 28 meeting: a mutual water company representative and interested citizen. We also received written comments from Stanford University.
- **Is the District taking frequent measurements of subsidence?**
  Response: To monitor subsidence in the Santa Clara Subbasin, the District:
  - monitors two 1,000-foot deep extensometers that measure vertical ground motion
  - conducts annual benchmark leveling surveys along three cross valley level circuits
  - measures water levels at ten subsidence index wells to ensure they remain above established thresholds.
- **What are the main things you hope to get out of the Zone of Benefit Study?**
- Response: The District's goals for the Study are: 1) Develop a well comprehensive process for evaluating the Zone of Benefit boundaries based on the latest information and technology, 2) ensure that the boundaries are accurate and reflect hydrological conditions in a way that groups pumpers based on the benefits they receive from current District programs, and 3) develop processes for exemption requests and future changes.
- **Will this study help with groundwater modeling?**
  Response: The study will use groundwater modeling. It is possible that evaluation of model runs will inform future groundwater modeling improvements.
- **Does the Technical Memorandum outline what is different now about this approach?**
  Response: The technical memorandum outlines what is different from previous work, but does not outline differences with what was presented in our first presentation to the retailers.
- **This will presumably help the District comply with Proposition 218.**
- Response: Proposition 218 restricts local governments' ability to impose assessments and property-related fees and requires elections to approve many revenue raising methods. The District does not believe that its groundwater charges are subject to Proposition 218; however, it has also ensured that its groundwater charges are adopted in a manner consistent with Proposition 218 as a matter of policy. The study is consistent with this policy in that it will help ensure that the District's charges are appropriately aligned with the costs of providing service and the benefits payors receive
- **Will there be new information about the hydrogeology?**
  Response: We will use available information about hydrogeology, including a new study published by the U.S. Geological Survey in the last two years.

Participants

George Cook, Aaron Baker, Water Retailers
Cameron Tana, HydroMetrics WRI

Charles Gardiner, Catalyst Group

Meeting Summary
Stakeholder Small Group Meeting
October 28, 2015

George Cook provided an overview of the purpose of the Groundwater Zone of Benefit Study and Cameron Tana reviewed the study methodology.

Comments and Questions

1. **Have you sampled salt in the groundwater to determine where the saltwater intrusion is?**
   Response: Yes, Figure 5 of the draft technical memo on the study methodology is based on ongoing salinity monitoring in groundwater wells.
2. **Where does the replenishment come from to reduce the intrusion?**
   Response: SCVWD captures surface water runoff and imports water from the State Water Project and Central Valley Project. These sources provide water for managed and in-lieu recharge that maintain groundwater levels and help to prevent subsidence and saltwater intrusion.
3. **The resiliency of the basin since 1980 is impressive.**
   Response: comment noted.
4. **The 1975 to 1979 period was a severe drought, which could have contributed to the saltwater intrusion.**
   Response: Yes, climatic conditions can affect groundwater conditions such as saltwater intrusion. However, much of the advancement of the saltwater intrusion from 1945 to 1980 as shown in Figure 5 was related to declining and depressed groundwater levels related to increases in groundwater pumping.
5. **Higher average rainfall after 1980 also provided a benefit to the groundwater basin and helped reduce saltwater intrusion.**
   Response: Yes, climatic conditions can improve groundwater conditions such as saltwater intrusion. The study methodology evaluates climatic conditions to identify groundwater benefits that can be attributed to District activities and are not the result of climatic conditions.
6. **The groundwater basin is connected only to a certain point. There are wells in South County that are only a half-mile apart and show very different groundwater levels.**
   Response: Water levels in individual wells can vary greatly, even if the wells are located in close proximity. This difference can be caused by either hydrogeologic difference, or by differences in well construction or adjacent pumping. The study methodology includes evaluation of groundwater level trends to evaluate whether benefits extend throughout mapped alluvium.
7. **Are you using actual well log data to determine the extent of the alluvium and the hydrogeology of the basin?**
   Response: Due to the size of the basin and limited availability of well logs along the edge of the basin, we are not evaluating well log data to determine extent of the alluvium and hydrogeology. However, we are using published reports, such as those by the U.S. Geological Survey and California Geological Survey. Those reports used actual well log data.
8. **The study should look at well data throughout the zones, not just information down the center of the basin.**
   Response: The published reports that will be used to map hydrogeology used well data throughout the basin. The study of groundwater levels and other data will include available data from throughout the basin.

9. **At the New Avenue Mutual Water Company, we have some well data that dates back to 1978. More recently, we have collected well data more regularly and more extensively. We can make this data available.**
   Response: The draft technical memorandum discusses the use of stakeholder data. Data being considered for use will be evaluated to verify adequate measurement protocol and ensure there are sufficient regularly measured static groundwater levels to evaluate trends during times of increased volumes from District activity. Stakeholders that wish to share their well data to support this evaluation should submit all information about the well such as a well log and construction information.
10. **The groundwater levels in the New Avenue Mutual Water Company wells are where we would expect them to be given the drought and weather conditions.**
    Response: The study methodology evaluates climatic conditions to ensure groundwater benefits can be attributed to District activities and not climatic conditions.
11. **Since the San Felipe project went online, groundwater levels went from 145 feet to 130 feet.**
    Response: The evaluation of whether a benefit is occurring requires looking at other factors than just the change in water levels. Increasing demand (pumping), wet years, and drought will cause water levels to decline or increase independently of any benefit from District activities. The study will evaluate the water level trends by comparing the observed and expected trends with trends (i.e in a drought period, a decline in water levels would be expected; if the observed trend is increasing or stable, a benefit from District activities would be indicated). The study methodology will assign benefits to an area only if there are periods of stable or increasing groundwater level trends that can be attributed to District activities.
12. **We don't see a benefit from recharge activities at Church Avenue and along Highway 101.**
    Response: The study intends to document where groundwater benefits are demonstrated. The stakeholder review process will provide an opportunity to review the findings prior to the District adopting the zone boundaries.
13. **How do you measure groundwater pumped by farmers?**
14. Response: Groundwater pumping is measured by either metering or through the use of standardized water use factors. Meters are required for wells that meet the following volumetric thresholds:

Zone	Volumetric Threshold for Metering (AF/Yr)	
	Municipal	Agriculture
W-2	1	4
W-5	2	20

Factors used to estimate groundwater pumped by smaller users include the number of residents, lawn area, and crop type.

15. **There is a discrepancy between actual water use and what the formula determines for unmetered groundwater pumping.**
    Response: It is not practical to meter all wells due to the cost for installing, maintaining, and operating (including reading) meters. The water use for smaller accounts is an estimate based on self reported information and standard water use factors. The factors are based on published studies and industry standards and are regularly reviewed and updated as necessary. Although the volume pumped from smaller wells is an estimate, over 90% of the groundwater pumped is from metered wells.

16. **The residential use in South County is not very large. Farmers are cycling three crops a year and using a lot of water.**
Response: The relative use of water by different stakeholders will not be a consideration for how zones are mapped. The zones will be mapped based on the extent of benefit from District activities. Groundwater charges are assessed based on use and volume.
17. **How do you forecast precipitation trends?**
Response: We are looking at past precipitation trends in the historical data, not forecasting future precipitation.
18. **Have you considered farming operations and the amount of water that evaporates, get taken up by plants, and recharged back into the ground? At least 50% is percolating back into the ground.**
Response: We are considering changes in net demand to evaluate whether changes in groundwater conditions can be attributed to District activities. Net demand by farming will mostly be related to crop evapotranspiration demands and not changes in return flow. The groundwater models that will be used as part of the evaluation account for return flow.
19. **What is the time it takes for water to percolate from recharge ponds to the 300-foot aquifer? Are you considering that time when you are looking for the effects of groundwater programs?**
Response: We will consider the delay in effect from the implementation or changes in the recharge activity in the data evaluation.
20. **Show a chart of the amount of water put into the basin and the precipitation patterns. Show the volumes of natural recharge and the amount of District recharge.**
Response: This information will be included in the study.
21. **The groundwater quality in the south County is very good. If anything, recharge activities add contamination to the basin.**
Response: Recharge activities can actually improve water quality by diluting certain contaminants such as nitrate or perchlorate. The District monitors the quality of the water at our recharge facilities. Recharge water quality is generally good, with most water quality indicators similar to or better than receiving water throughout the year. Groundwater quality benefits from managed recharge activities will be assessed.
22. **Where did perchlorate in the groundwater basin come from?**
Response: Perchlorate has been attributed to contamination from Olin Corporation's former road flare manufacturing facility in Morgan Hill. (SCVWD)
23. **For the most part, people take water for granted. The New Avenue Mutual Water Company has 108 shareholders; only about 10 shareholders attend the annual meeting.**
Response: comment noted.
24. **How detailed is the methodology for prescribing the analysis and results?**
Response: The methodology is detailed for describing the analysis, but does include flexibility. Any changes to the methodology will be fully documented in the study report. The methodology does not prescribe results.
25. **Is there a time we can present data that our area doesn't benefit from recharge programs? Our area has static water levels and steady consumption over the last 30 years. We have cut water use by 25%, but we haven't seen any change in the water levels. Some surface springs have dried up, but the 300-foot aquifer doesn't show much change.**
Response: Please provide the data by the end of February if you would like it to be considered for this study.
26. **New users need to pay for new water.**
Response: comment noted.

27. **Be objective in the analysis. Deal with the data to reach conclusions. Don't be subjective.**
    Response: The study methodology is based upon published studies and data. Hydrometrics will be objective in their data analysis.
28. **South County lost control of the water district when Gavilan merged with SCVWD.**
    Response: Comment noted.
29. **What do you mean by visually evident changes when reviewing the data?**
    Response: We mean that when any reasonable person reviews the graph of the data, they should be able to see the trends that we are describing. We will not use statistics to state that there is a trend that is difficult to see. Statistics will only be used to quantify the visually evident trend.

Participants

Loverine Taylor, Portola Valley
Alan Heinzen, New Avenue Mutual Water Company
Vanessa de la Piedra, SCVWD
George Cook, SCVWD
Bassam Kassab, SCVWD
Cameron Tana, HydroMetrics WRI
Charles Gardiner, The Catalyst Group

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Santa Clara Valley Water District

April 18, 2016

Mr. Tom Zigterman
Director - Water Resources & Civil Infrastructure
Stanford University
327 Bonair Siding
Stanford, CA 94305-7272

Subject: Response to Stanford Comments on the Santa Clara Valley Water District Zone of Benefit Study

Dear Mr. Zigterman:

The Santa Clara Valley Water District (District) received Stanford's letter dated November 5, 2015 providing comments on the Draft Technical Memorandum, Methodology for Evaluating Groundwater Zones of Benefit. The District's responses to your specific comments are attached. These, along with other comments received and responses, will be posted on the study website and included in the Preliminary Zone of Benefit Study Report.

In summary, the District believes the current study methodology addresses your comments concerning hydrogeologic and hydraulic variability and accounting for non-District activities. The comment regarding a groundwater charge credit is noted, but is beyond the scope of this study, which is focused on the extent of the zones of benefit, rather than rates or credits applied within those zones.

Thank you for providing your comments on the study. If you have any questions, please call me at (408) 630-2964.

Sincerely,

George E Cook Jr

George Cook, P.G.
Associate Engineering Geologist
Groundwater Monitoring and Analysis Unit

cc: J. Fiedler, G. Hall, V. De La Piedra
Cameron Tana, Hydrometrics Water Resources

Attachments: Stanford Comment Letter Dated November 5, 2016
District Response to Stanford Comments

Stanford University SUSTAINABILITY AND ENERGY MANAGEMENT

Mr. George Cook
Santa Clara Valley Water District
5750 Almaden Expressway
San Jose, CA 95118

November 5, 2015

Subject: Santa Clara Valley Water District Zones of Benefit Study
Stanford's initial comments on the ***Draft Technical Memorandum, Methodology for Evaluating Groundwater Zones of Benefit*** (Hydrometrics WRI, September 2015)

Dear Mr. Cook:

Stanford University appreciates the opportunity to provide comments on the *Draft Technical Memorandum, Methodology for Evaluating Groundwater Zones of Benefit,* Hydrometrics WRI, September 2015 (hereinafter referred to as the Draft Tech Memo). As you are aware, the technical, legal and equitable basis for the Santa Clara Valley Water District's (District) groundwater pumping charge has long been an issue for the University. The University is encouraged by the District's study and is supportive of the District's efforts to take a hard look at the current benefit zones supporting the District's groundwater charge. Stanford provides the following comments to inform the Draft Tech Memo and the District's Zones of Benefit study process going forward.

1. The Zones of Benefit study should account for hydrogeologic and hydraulic variability throughout the Zones and sub-areas within the Zones.

   Stanford requests that the Zones of Benefits analysis investigate and recognize the unique characteristics of the San Francisquito Cone from which Stanford and other local pumpers derive groundwater supply. The axis of this physiographic feature closely coincides with the modern-day San Francisquito Creek channel and is a source of groundwater on either side of the Santa Clara-San Mateo County line. The County line is the current Bulletin 118 boundary separating the Santa Clara and San Mateo Subbasins (Department of Water Resources Bulletin 118 - Update 2003). Hydrogeologic continuity across this boundary has been observed and reported in DWR investigations, and the alluvial fan of San Francisquito Creek was historically termed the San Francisquito Groundwater Area (Bulletin 118-1, 1967). Within this area, wells of distinctively favorable yield and quality have been developed and used for municipal and agricultural purposes since the early 1900s. These distinctive characteristics were not recognized in the District's 1963 W2 Zone classification and we now urge the District to acknowledge the importance of these physiographic and hydrogeologic features that have long been recognized locally through their effects on groundwater development and protection.

   The Zones of Benefit study also should recognize that seawater intrusion and subsidence impairments vary throughout the Zones, and have been determined to be minor and relatively insignificant in the

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San Francisquito Cone area. While concerns regarding degradation of freshwater aquifers in the Palo Alto area were raised decades ago, ultimately water quality degradation was determined to be due to improperly sealed wells and vertical migration from shallow brackish aquifers downward through well structures, not seawater intrusion. The presence of Bay muds and the configuration of the primary supply aquifers in relation to the Bay were not conducive to intrusion as in the southern part of the Valley. Subsequently, the local problem of vertical migration through wells was effectively mitigated through well sealing practices. Similarly, as should be apparent from previous studies available to the District, a lack of measureable subsidence on and around the Stanford campus, even during periods of groundwater decline in the 1950s and 1960s, is consistent with the coarse nature of aquifer materials in the San Francisquito Cone area where most of the local groundwater supplies are developed. From these studies, the San Francisquito Cone area is far less vulnerable to localized subsidence due to pumping than other areas of the basin. The Zones of Benefit study must take into account this local variability.

2. The Zones of Benefit study should identify and account for local or regional groundwater management benefit in the same manner as District activities that benefit the zones or subareas of zones

In addition to the hydrogeologic and hydraulic factors discussed above, the Zones of Benefit study should assess historic and current benefits of District and local activities on the basis of actual effects to groundwater availability and quality. Stanford refers the District to its own historical technical studies concerning the significant effects of overdraft in the region and the myriad solutions and projects that were brought to bear – by the District and local interests – to address declining water levels, seawater intrusion, and subsidence. We note, for example, that while the District once considered a cross valley conveyance to deliver surface water to cities and areas in the north and northwest areas of the basin, water imported by the District ultimately was delivered to other areas of the basin to mitigate overdraft in the southern areas. The Zones of Benefit study must recognize that conditions of groundwater decline and overdraft in the northwest portions of the basin were addressed locally, at great expense, by connecting to the San Francisco water system at roughly the same time that the District's surface water imports commenced in the southern part of the basin. These distinct local activities, which continue today, addressed groundwater conditions in the northwest portions of the basin, and should be recognized in the Zones of Benefit study and in future District decisions concerning groundwater fees.

Proper allocation of benefits is a particularly important concern to the University with respect to methodologies pertaining to analysis of groundwater levels. Absent evaluation of local activities and conditions at appropriate local scales, along with their relative effects on historical groundwater levels, the study will incorrectly characterize improved and stabilized groundwater levels solely to District activities. As discussed below under Comment 3, local activities by Stanford and others in the

San Francisquito Creek groundwater area have long been recognized to provide benefits that are not the result of District activities.

The University previously discussed with the District the University's own local groundwater management efforts, such as augmentation of natural recharge through Lake Lagunita located on campus which has a direct, significant and beneficial impact on the local groundwater supplies and conditions in the San Francisquito Creek cone area where Stanford's wells are located. The viability of recharge augmentation is supported in historical reports of the geology and replenishment sources of the San Francisquito Cone (DWR Bulletin 118-1, 1967). The District's current proposed study should identify, quantify and incorporate these local and regional activities where concurrent efforts of non-District entities have resulted in the protection and augmentation of local groundwater supplies for the past several decades. The University is not aware, for example, that local groundwater protection activities, such as augmented recharge in Lake Lagunita, were previously recognized or accounted for by the District. This adds to our concern that the proposed analyses of groundwater levels (e.g., Draft Tech Memo: Analysis Applied to Groundwater Level Data) will not be based on an appropriate level of detail or historical perspective. Such detail and perspective can only be achieved through a major outreach to water entities and users throughout the District, which is clearly not part of the methodologies described in the Draft Tech Memo.

3. The Zones of Benefit study proposes to employ groundwater modelling

As stated in the Draft Tech Memo (Groundwater Model Simulations), the use of groundwater flow models is proposed as a "second and equivalent line of evidence evaluated for the effect of District activities in different areas." The University is not aware that the District's past or current groundwater flow models are sufficiently refined and calibrated to meet the stated objectives in the Draft Tech Memo in the area of the Santa Clara-San Mateo Subbasin boundary where Stanford's groundwater resources occur. Therefore, it is difficult to see how the District's study will appropriately allocate benefits using such a tool. To the extent that a groundwater modeling is employed in the Zones of Benefit study, Stanford would like the opportunity to review and evaluate the District's model and to work with the District to incorporate appropriate information and data concerning the relative benefits of local, non-District groundwater management and augmentation activities. Stanford has monitored local groundwater conditions and observed local benefits and effects of its own groundwater management activities in the San Francisquito Creek cone area, commencing with the historical development of local groundwater resources and importation and augmentation of surface water to address groundwater decline. To the extent that groundwater data Stanford possesses might be useful and inform the District's current study, we would be happy to meet and discuss further.

4. The District should consider restoring the Groundwater Charge Credit for local investment in in-kind groundwater management activities.

   In recognition of the local groundwater management programs and projects that have been implemented by parties other than the District, the Zones of Benefit Study should consider restoring the groundwater charge credit that once existed in the District groundwater charge structure. The credit recognized the benefits and investment of various entities in certain areas of the basin, including the City of Palo Alto and Stanford University, to import surface water from San Francisco in lieu of or to reduce the use of groundwater. These activities are precisely what the Zones of Benefit study will attempt to quantify as it relates to District activities, and there is no reason the study should not also consider and incorporate local groundwater management efforts that result in the same Basin benefits. Similarly, the study should quantify and incorporate local groundwater augmentation activities, such as Stanford's groundwater replenishment activities at Lagunita on the Stanford Campus, and should include programs to credit and reimburse local entities for those groundwater benefits.

5. The Zones of Benefit study must consider weighting of the relative benefits of certain activities in various areas of the basin.

   The Draft Tech Memo discusses other groundwater charge programs and cost allocation/ benefit assessment methodologies employed by other agencies in California. One feature of some of the more successful of these methodologies is a "relative weighting" concept, whereby the benefits to certain areas of the basin are weighted relative to the benefits received in other areas for that particular benefit. For example, whereas direct and in-lieu recharge may provide a water quality benefit to a broad area within a zone, certain sub-areas of the zone may receive a much greater benefit than other areas. The Zones of Benefit study should be refined such that the relative benefits are accounted for in the development of new zones, or within the components of the groundwater charge assessed within a particular zone. Similarly, the study should account for the relative value of particular benefits (e.g., groundwater elevation benefits vs. subsidence benefits), and should be designed to allocate the actual District costs to provide certain benefits (e.g., the cost of providing water quality benefits vs. the cost of providing protection against subsidence).

The Draft Technical Memorandum should be revised to reflect these general scoping comments. In addition, while not a complete review, we do have some examples of specific comments on the text of the Draft T.M.:

   Page 1, second paragraph, second sentence: the sentence should be revised to read: "Although the District is not aware of any specific problems with the existing Zone of Benefit designations, *the*

District has received requests for a benefits analysis and recognizes that it is important for the District to periodically undertake…".

Page 1, fourth paragraph, third sentence: the sentence should be revised to read: "Unless adjacent bedrock areas *and areas that are hydraulically up-gradient from the District's recharged areas are receiving District water supply, it will be assumed that the areas are not within the zone of benefit…*".

Page 2, point 4: replace "demonstrate" with "assess".

Page 3, third paragraph, first sentence: revise to read "The Study will *identify and* evaluate the ways…".

Page 3, add another paragraph that reads: "*The Study will also consider non-District import of water supply by groundwater users (which decreases their use of groundwater), and recharge conditions and activities conducted by groundwater users.*".

We look forward to working with the District on this important Study. Please let us know if you would like to meet and discuss these comments, the Study process, or Stanford's understanding of the groundwater conditions in the San Francisquito Cone area.

Sincerely,

Tom W. Zigterman

Tom W. Zigterman, P.E., D.WRE

Director – Water Resources and Civil Infrastructure

Response to Comments
Received from Stanford University
November 5, 2015

Comments

1a. The Zones of Benefit study should account for hydrogeologic and hydraulic variability throughout the Zones and sub-areas within the Zones.

Response: Hydrogeologic features will be mapped to assess the extent of hydrogeologic connection to District activities. If information can be provided to show features that limit the hydrogeologic connection in the Quaternary deposits, those features will be considered. The sections of DWR Bulletin 118-1 referenced by the commenter and Bulletin 118 updates will be reviewed, along with other relevant hydrogeologic studies, to evaluate the connection of the San Francisquito Cone with Quaternary deposits of the Santa Clara Plain. However, the possibility that adjacent areas have different yield or hydraulic characteristics does not preclude a hydrogeologic connection; therefore the different yield or hydraulic characteristics do not necessarily prevent the occurrence of a groundwater benefit from District activities within an area. The data analyses are meant to test the assessment of hydrogeologic connection of an area with District activities and available data should account for any hydrogeologic and hydraulic variability that limits the extent of a benefit to an area.

1b. The Zones of Benefit study should recognize that seawater intrusion and subsidence impairments vary throughout the Zones, and have been determined to be minor and relatively insignificant in the San Francisquito Cone.

Response: Benefits from District activities may take the form of improved groundwater supply reliability via improved groundwater levels, improved groundwater quality, and/or the prevention of seawater intrusion and subsidence. Areas receiving reasonably similar aggregate benefits from similar sets of District activities will be grouped together in the recommended zones.

2a. The Zones of Benefit study should identify and account for local or regional groundwater management benefit in the same manner as District activities that benefit the zones or subarea of zones.

Response: The methodology addresses the commenter's point that "Absent evaluation of local activities and conditions at appropriate local scales, along with their relative effects on historical groundwater levels, the study will incorrectly characterize improved and stabilized groundwater levels solely to District activities." Non-District, non-groundwater supplies of water will be subtracted from water demand to calculate a water supplier's net demand for District water and groundwater over time for the supplier's service area. When net demand is decreasing due to local activities, an improving groundwater level trend will not demonstrate a benefit from District activities (see Table 1 in draft memo). The draft memo refers to "retailers" net demand in this discussion, but that will be revised to "water suppliers" to clearly include suppliers that do not receive surface water from the District.

2b. The University is not aware, for example that local protection activities, such as augmented recharge in Lake Lagunita, were previously recognized or accounted for by the District. This adds to our concern that the proposed analyses of groundwater levels will not be based on an appropriate level of detail or historical perspective. Such detail and perspective can only be achieved through a major outreach to water entities and

users throughout the District, which is clearly not part of the methodologies described in the Draft Tech Memo.

Response: Local recharge quantities will be considered in the calculation of non-District net demand discussed in the response to comment 2a. Please provide data showing these quantities over time. There is discussion in the technical memorandum about using groundwater level data provided by stakeholders, but the memo will be revised to clarify that other information from stakeholders, including data related to the calculation of net demand, will also be considered.

The Draft Tech Memo focuses on the technical methodology, but outreach is a major part of the project. The stakeholder outreach plan is intended to provide a transparent process that includes public access to the data used and provides the opportunity for interested parties to submit supplemental data that they believe would influence the benefit assessment. The study has been discussed in several Water Retailer Groundwater Subcommittee meetings, and updates will continue to be provided through that forum as the study progresses. A web site providing the tentative study schedule and comment opportunities as well as links to documents developed as part of the study has been created (http://www.valleywater.org/ZoneofBenefitStudy/). Stanford University has been added to the list of those to receive project updates and small group briefings.

3. The University is not aware that the District's past or current groundwater flow models are sufficiently refined and calibrated to meet the stated objectives in the Draft Tech Memo in the area of the Santa Clara-San Mateo Subbasin boundary where Stanford's groundwater resources occur.

Response: As stated in the Draft Tech Memo, we will ensure that the benefits we identify using the model or other analytical tools are the result of District activities, and not model uncertainty. We would request that you provide any Stanford data that might be useful for the groundwater level analysis. As described in the Draft Tech Memo, data being considered for use will be evaluated to verify adequate measurement protocol and ensure there are sufficient regularly measured static groundwater levels to evaluate trends during times of increased volumes from District activity. Stakeholders are encouraged to submit all information about their wells, such as a well log and construction information, to the District. We appreciate your offer to meet and discuss your data, and will contact you to schedule a meeting.

4. The District should consider restoring the Groundwater Charge Credit for local investment in-kind groundwater management activities.

Response: The zone of benefit study is limited to recommending new or modified zones based on benefits from District activities and does not encompass policies related to fees and charges. If the District Board of Directors approves changes to the zones of benefit, a separate rate study will be performed. Restoring a groundwater charge credit would be a separate policy consideration.

As stated in the response to comment 2a, local activities will be considered to ensure that benefit is not assigned to District activities when the benefit may result from non-District activities. Only when benefit from District activities can be demonstrated will that benefit be used to define zones of benefit even though there may be additional benefits that result from local investment.

5. The Zones of Benefit must consider weighting of the relative benefits of certain activities in various areas of the basin

Response: Separate zones will be defined for areas where groundwater users receive benefits from different sets of District activities. This concept has been used by other agencies in California as discussed in the Draft Tech Memo Appendix A and is also consistent with requirements of the District Act.

Our research and interpretation of groundwater benefit zones established by other California agencies does not present examples of a "relative weighting" concept as described by the commenter. The relative benefit is likely to continuously change with distance from District activities, so defining zones based on a specified level of benefit would be arbitrary. The methodology includes evaluation of different types of benefits in order to assess the extent of benefit to the water budget from specific District activities. However, the different types of benefit will not be used to assess or weigh relative benefit. The zones will be drawn based on District activity that is improving the water budget of the shared resource for the area and on the premise that all groundwater users in the associated area should pay an equal share for the activity.

Suggested Edits

P. 1, 2nd paragraph, 2nd sentence: Suggestion partially accepted and memo will be revised to read: "Although the District is not aware of any specific problems with the existing Zone of Benefit designations, the District has received requests for exemption and recognizes that it is important for the District to periodically undertake…"

P. 1, 4th paragraph, 3rd sentence: "Unless adjacent bedrock areas and areas that are hydraulically upgradient from the District's recharge areas are receiving District water supply, it will be assumed that the areas are not within the zone of benefit…"

Response: This suggested edit will not be incorporated. Groundwater level improvements from recharge areas can transmit upgradient of the recharge areas.

P. 3, 3rd paragraph, 4th bullet: "Use groundwater data and groundwater flow models to ~~demonstrate~~ assess the benefit of District activities."

Response: The bullet will be changed to "Use groundwater data and groundwater flow models to *assess where the benefit of District activities can be demonstrated.*"

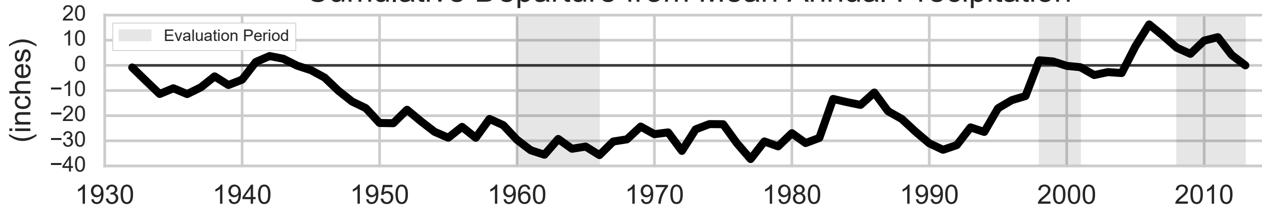
P. 3 add paragraph: "The Study will also consider non-District import of water supply by groundwater users (which decreases their use of groundwater), and recharge conditions and activities conducted by groundwater users."

Response: The study is considering non-District supplies to ensure observed groundwater improvements can be assigned to District activities as stated in the response to comment 2a. However, zones of benefit will be based on where benefits from District activities can be demonstrated only. Since this introduction describes the general basis for the zones, this detail will not be added.

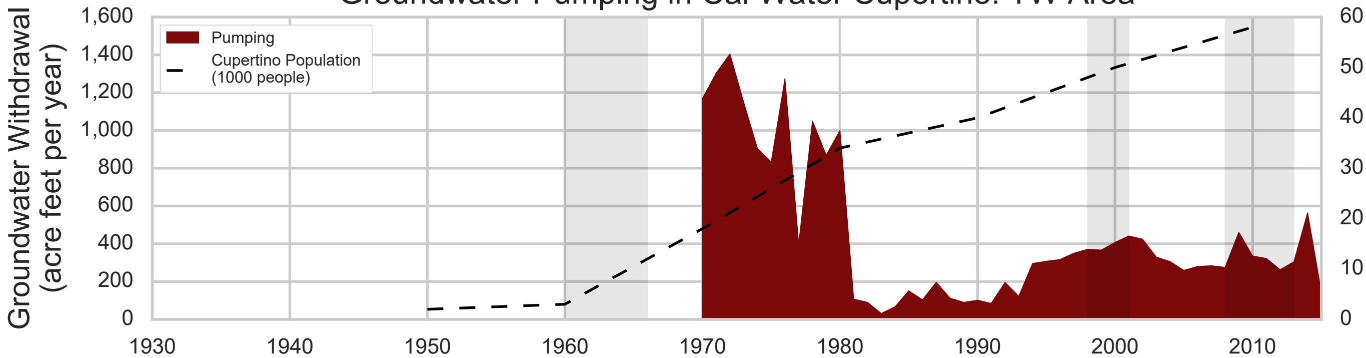
APPENDIX C: Groundwater Level Trends in Monitoring Wells to Evaluate Benefits from Managed Aquifer Recharge in Santa Clara Subbasin

Pumping Area: Cal Water Cupertino: TW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

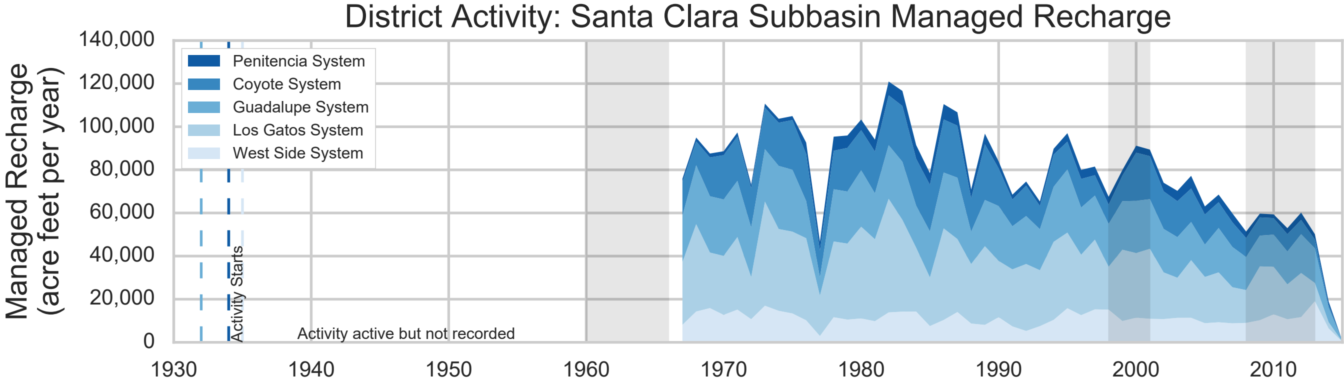
Cumulative Departure from Mean Annual Precipitation



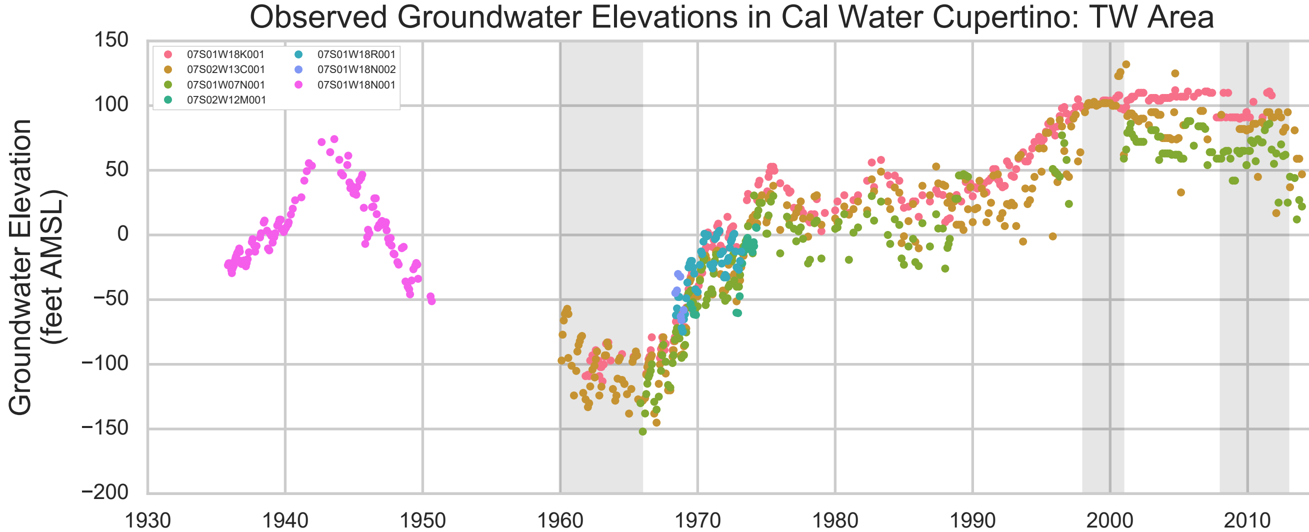
Groundwater Pumping in Cal Water Cupertino: TW Area



District Activity: Santa Clara Subbasin Managed Recharge



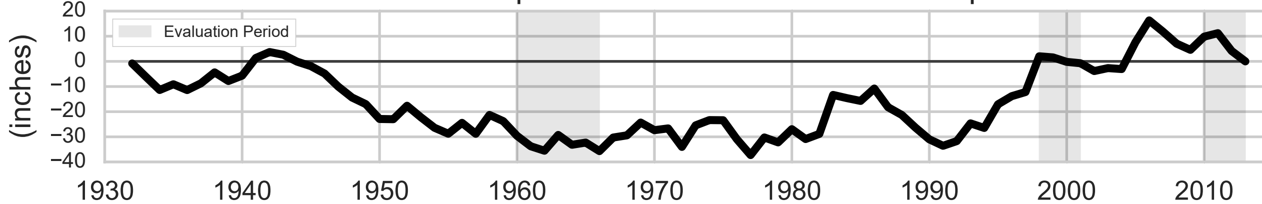
Observed Groundwater Elevations in Cal Water Cupertino: TW Area



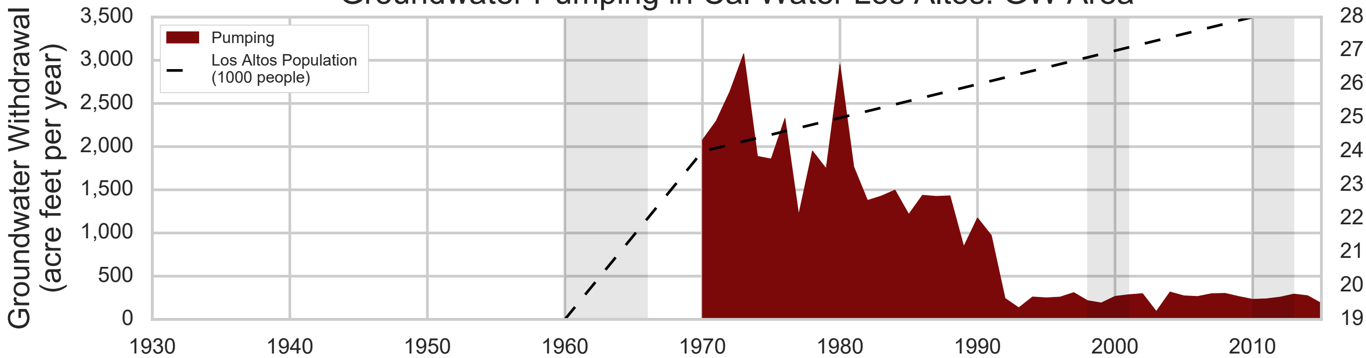
Pumping Area: Cal Water Los Altos: GW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

DRAFT - SUBJECT TO CHANGE

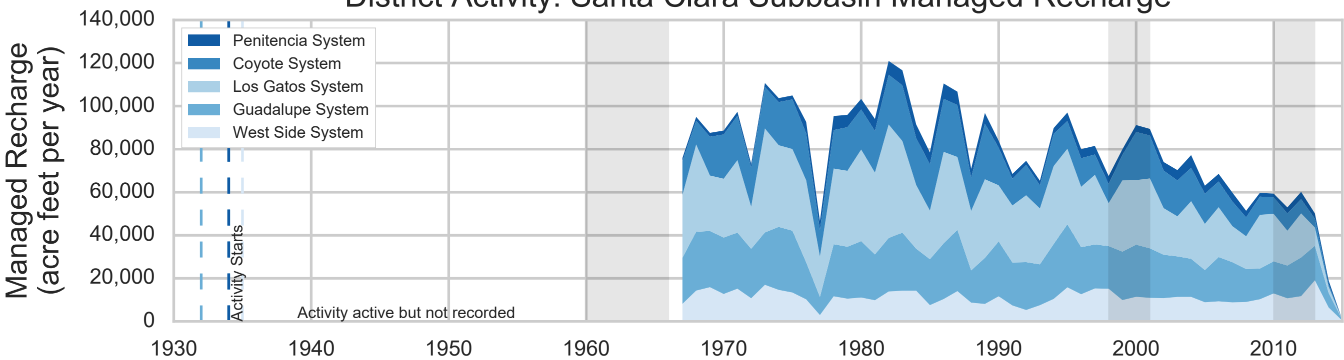
Cumulative Departure from Mean Annual Precipitation



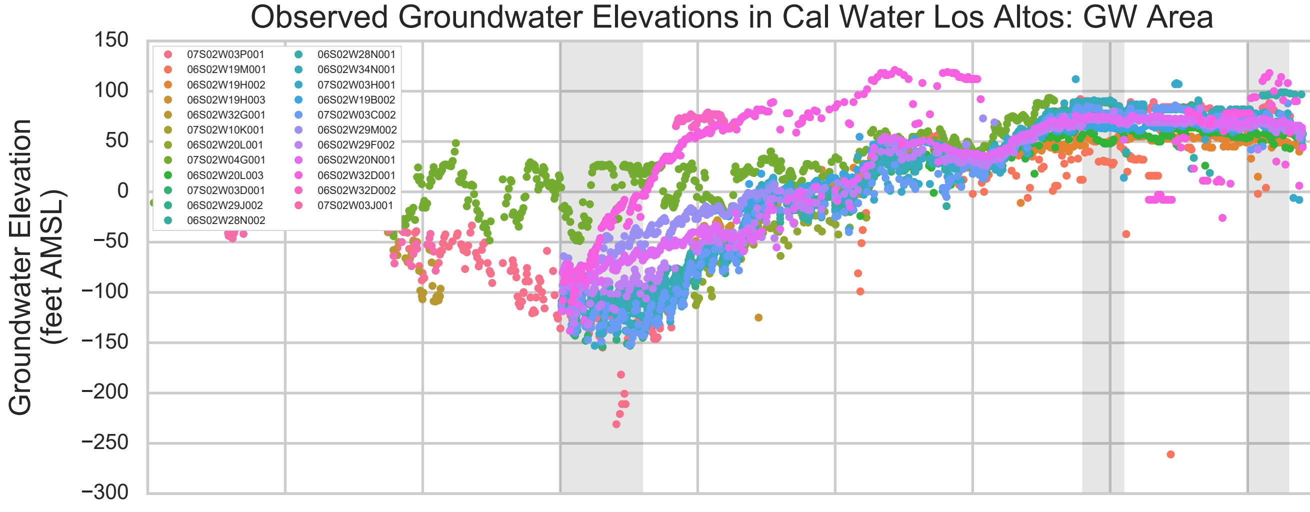
Groundwater Pumping in Cal Water Los Altos: GW Area



District Activity: Santa Clara Subbasin Managed Recharge



Observed Groundwater Elevations in Cal Water Los Altos: GW Area



Pumping Area: Cal Water Mountain View: GW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

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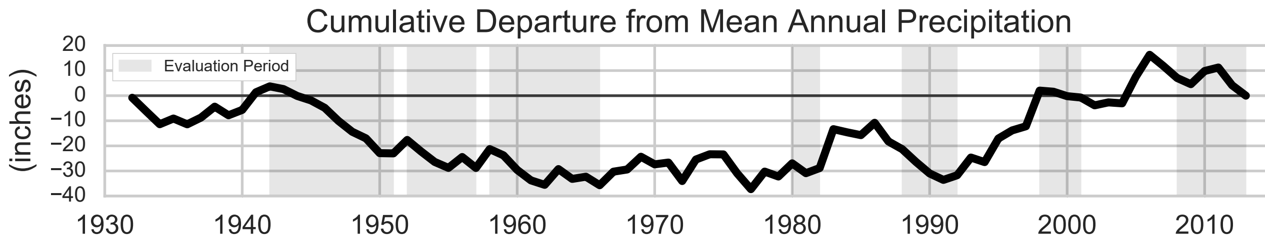
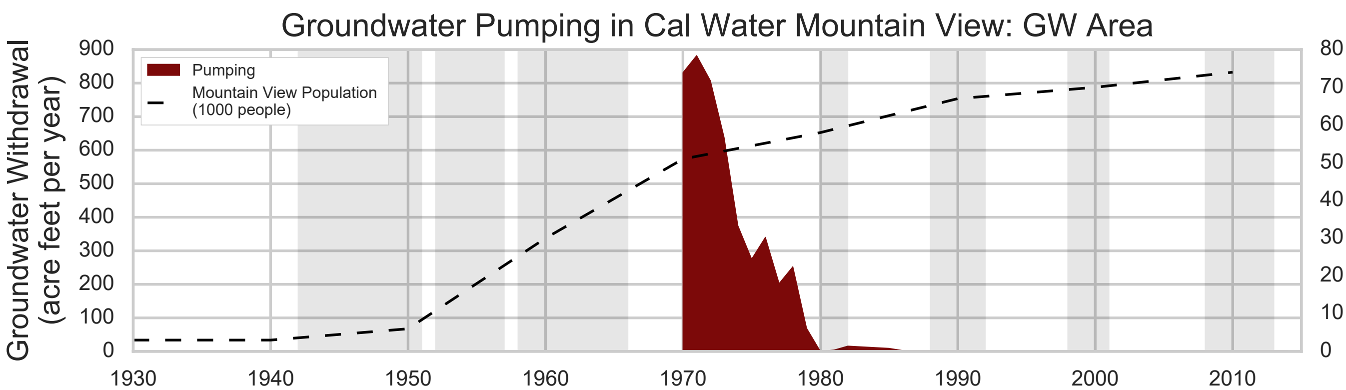
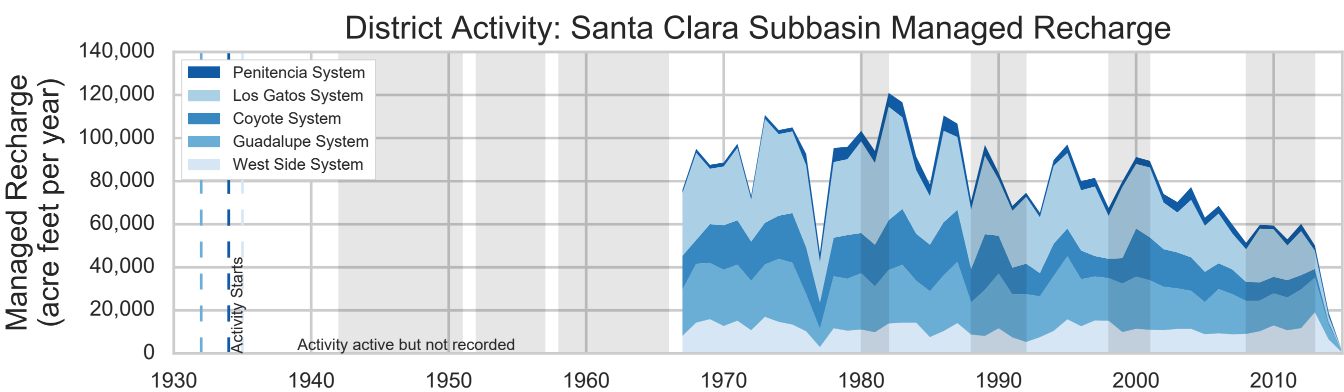
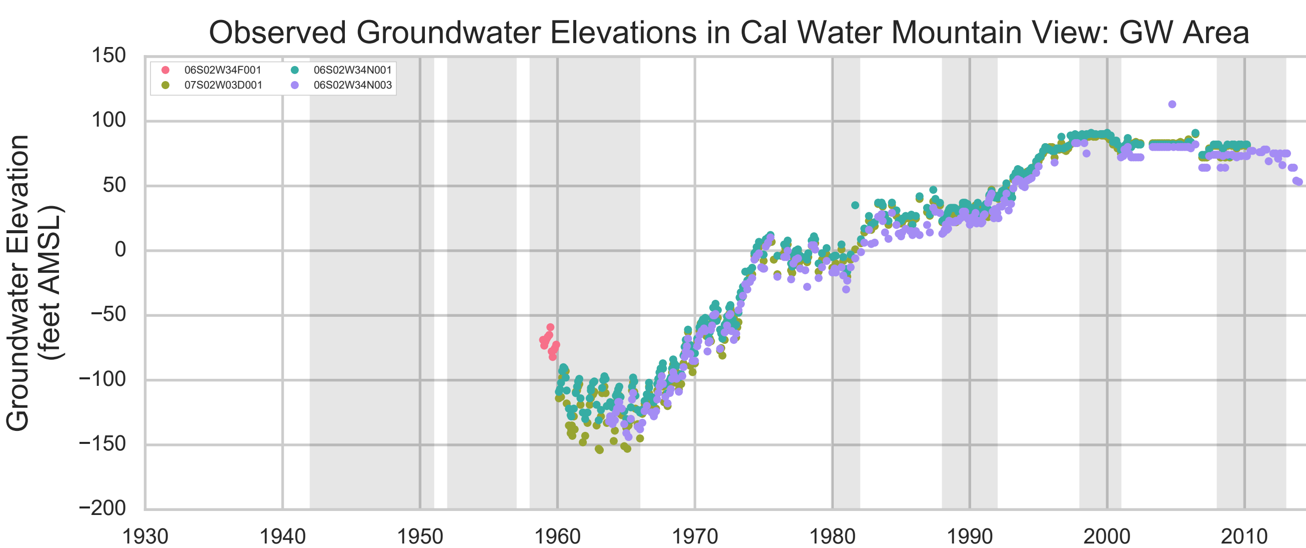
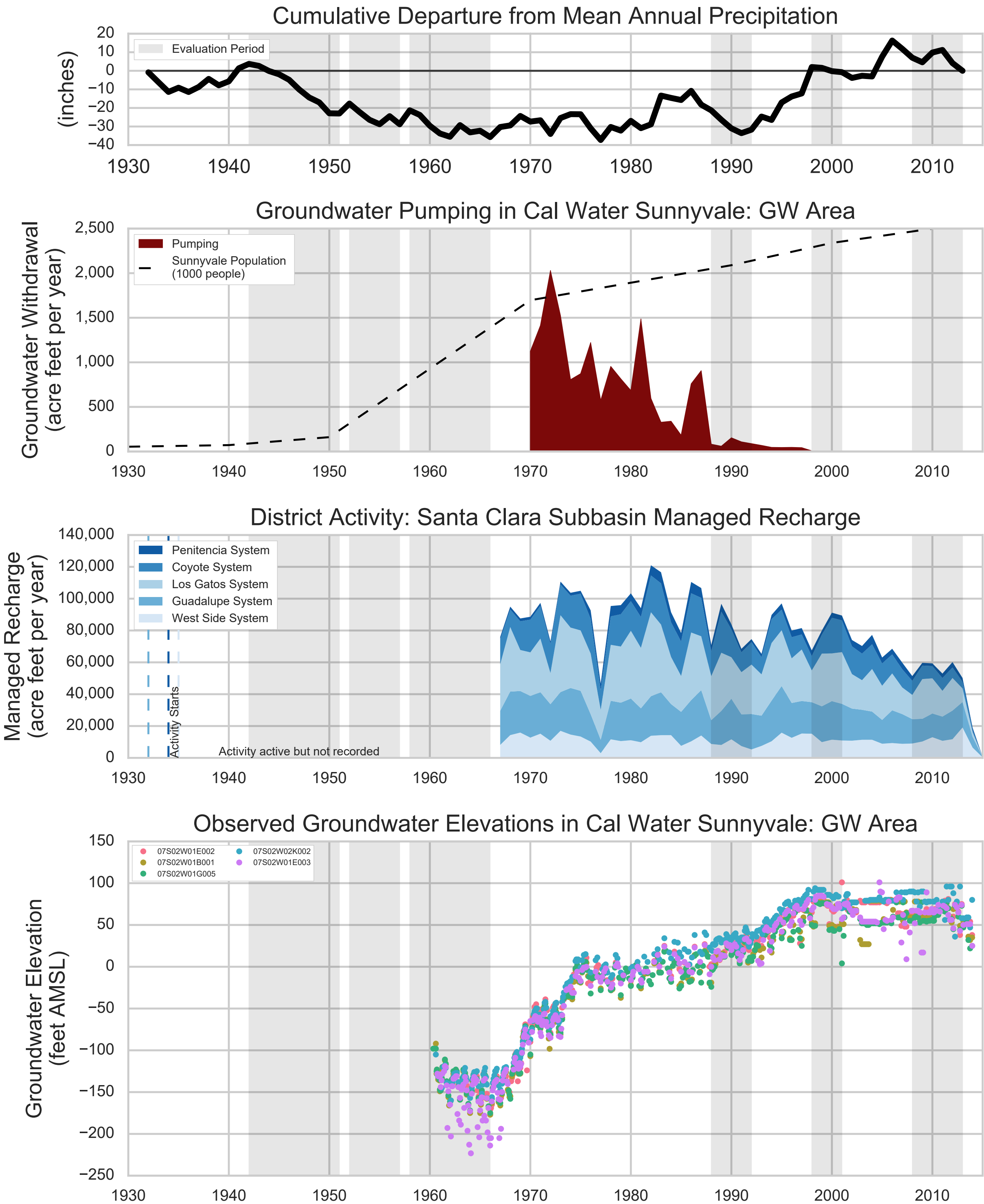








Pumping Area: Cal Water Sunnyvale: GW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells



Pumping Area: Great Oaks: GW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

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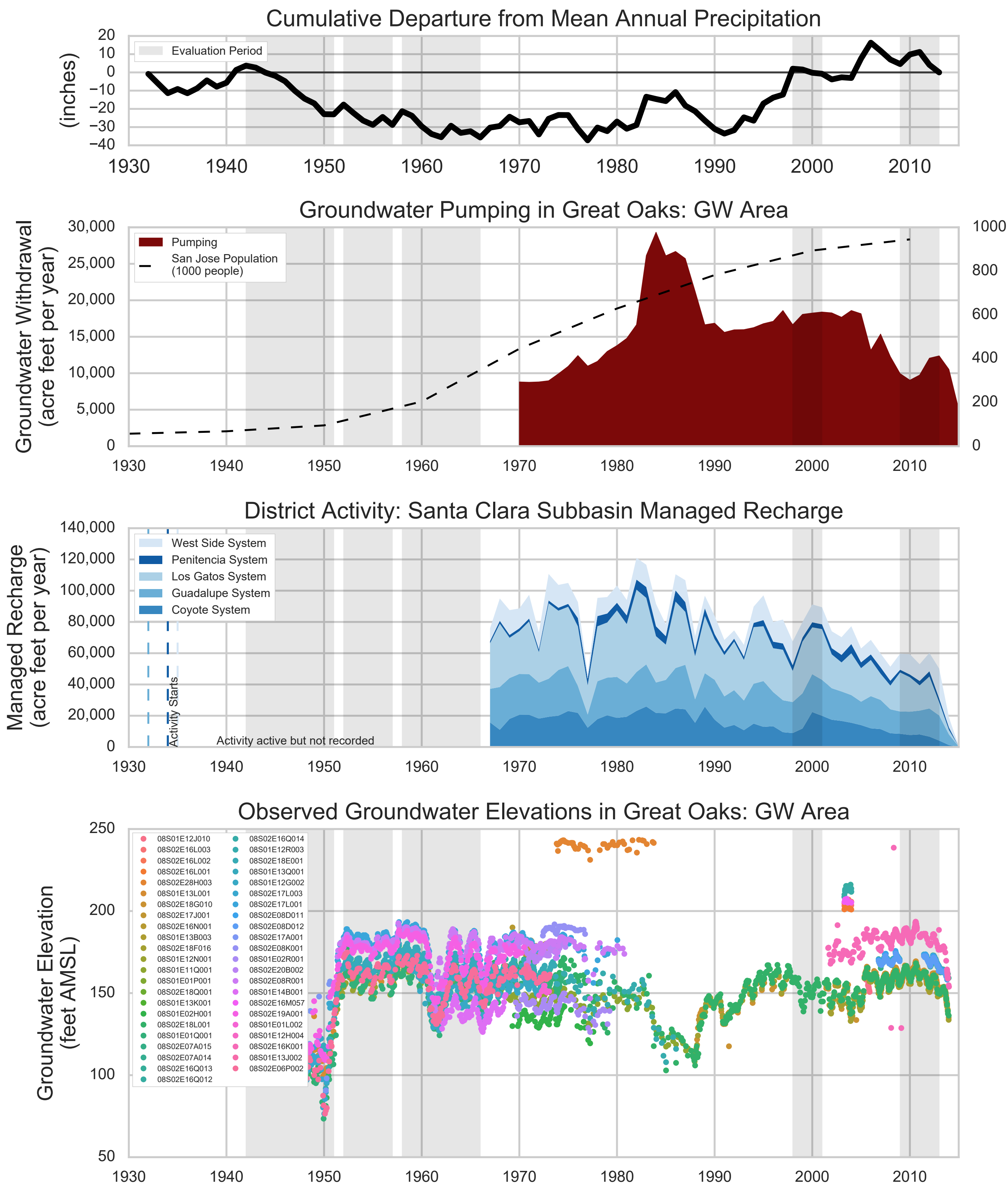

Pumping Area: Milpitas: RWS
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

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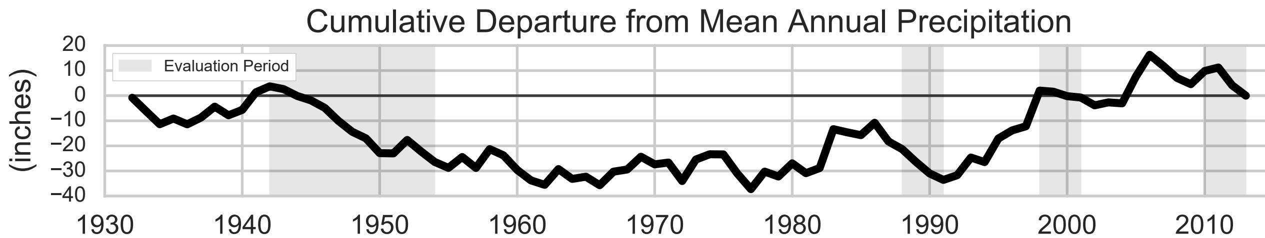

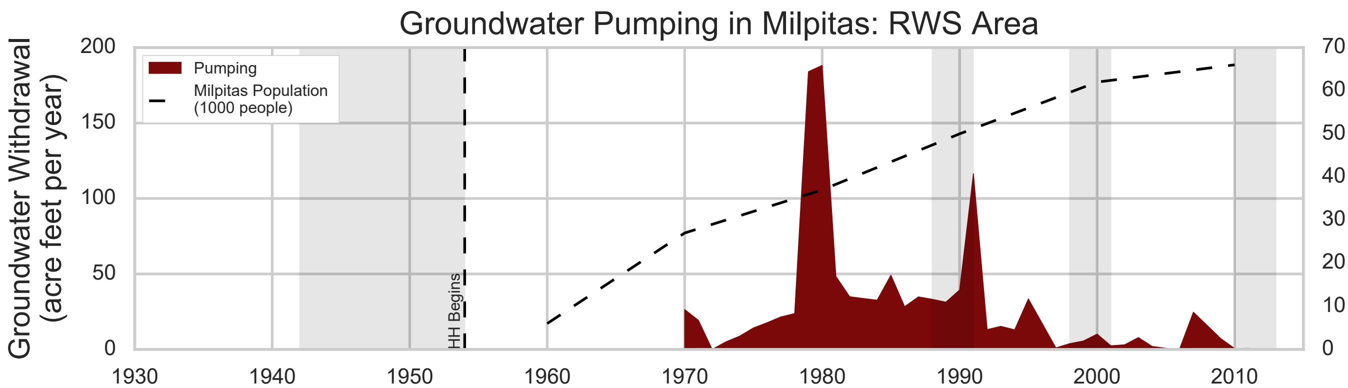

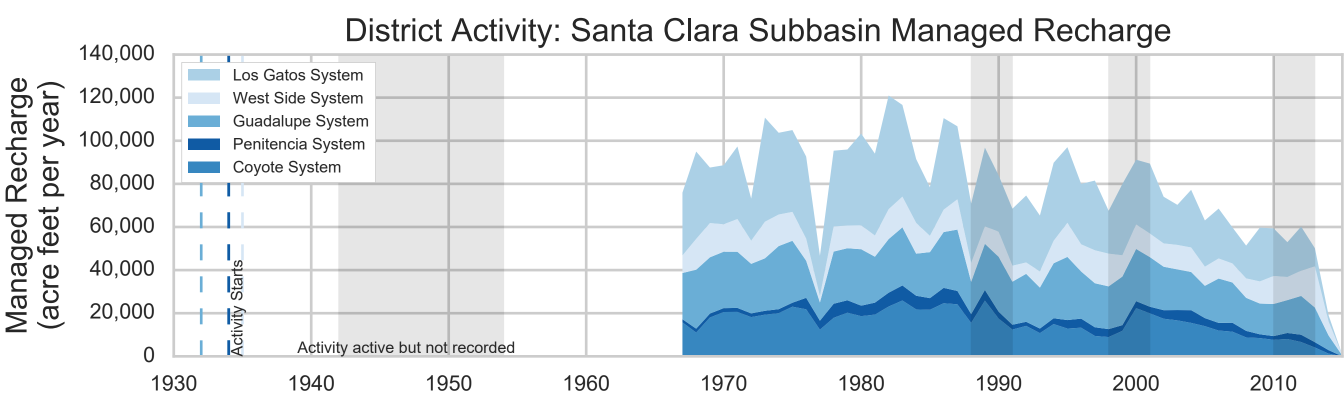

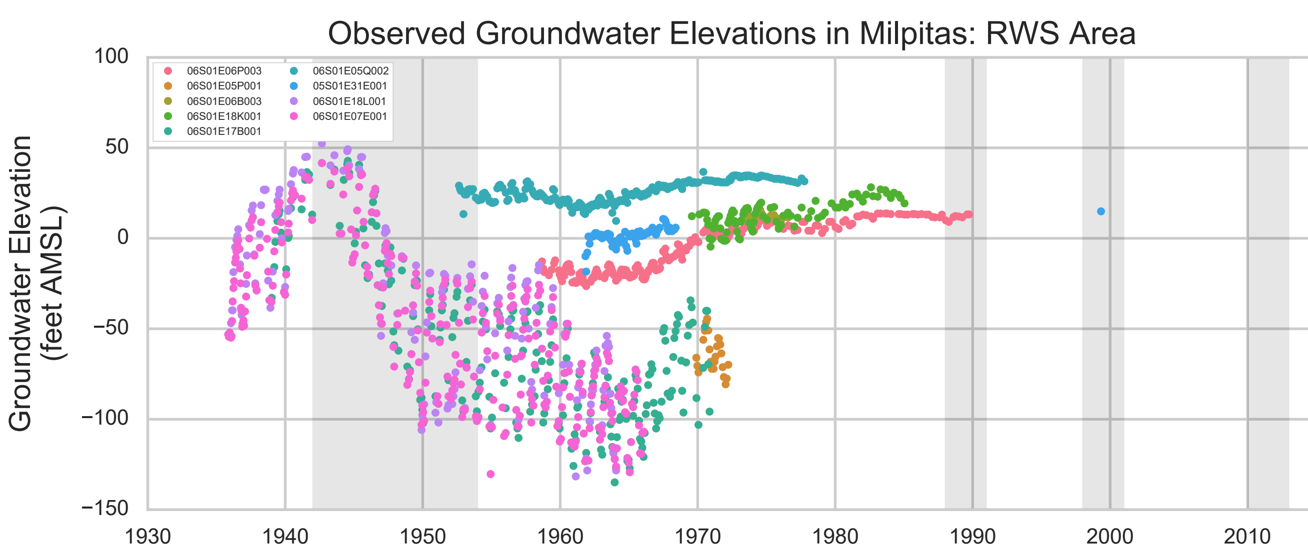

Pumping Area: Milpitas: TW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

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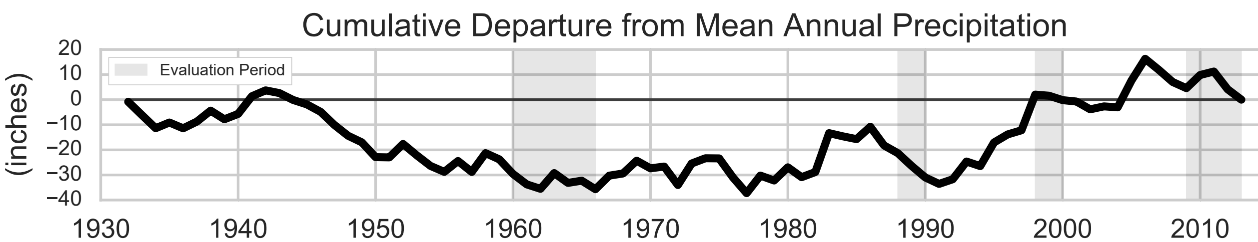

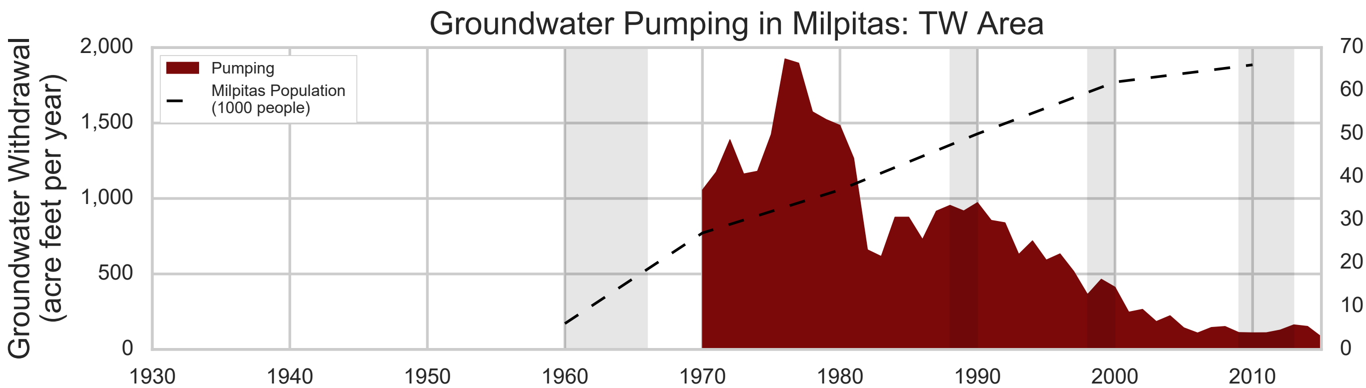

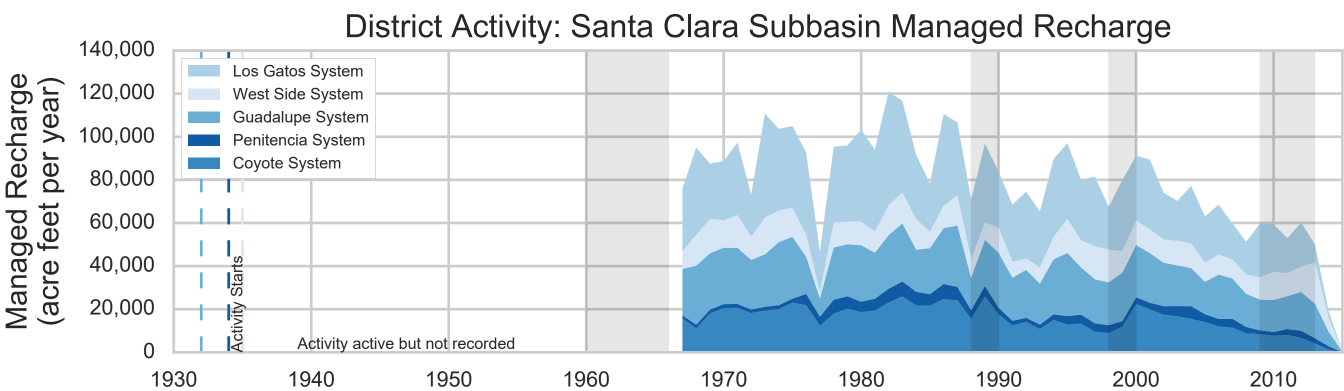

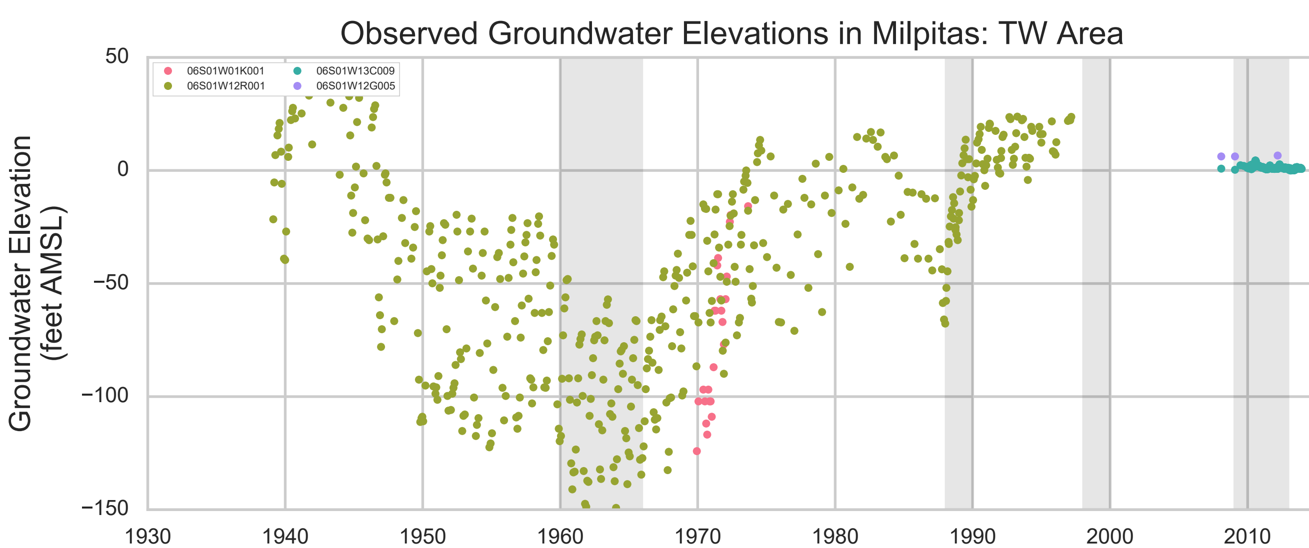

Pumping Area: Morgan Hill: GW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

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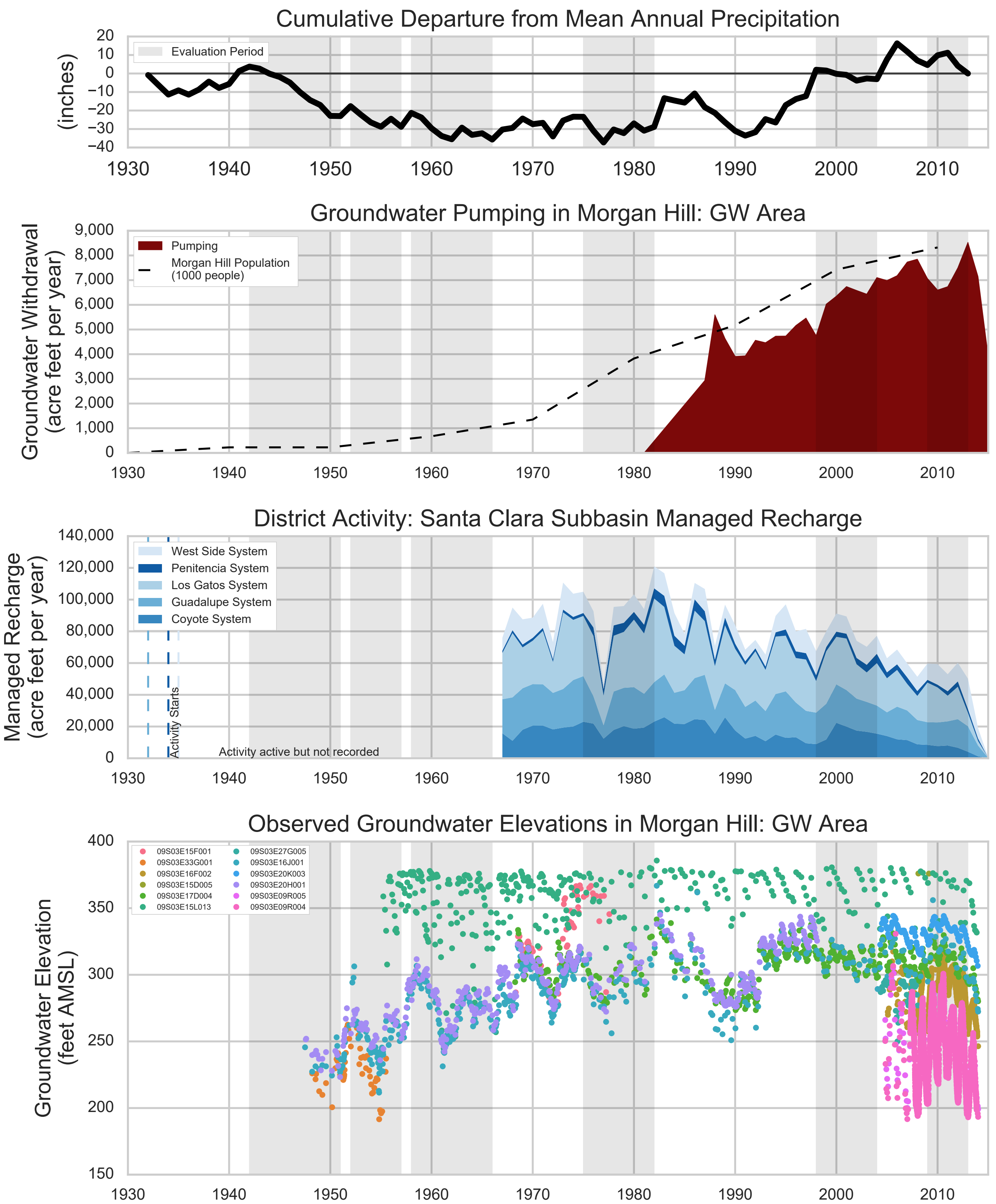

Pumping Area: Mountain View: RWS
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

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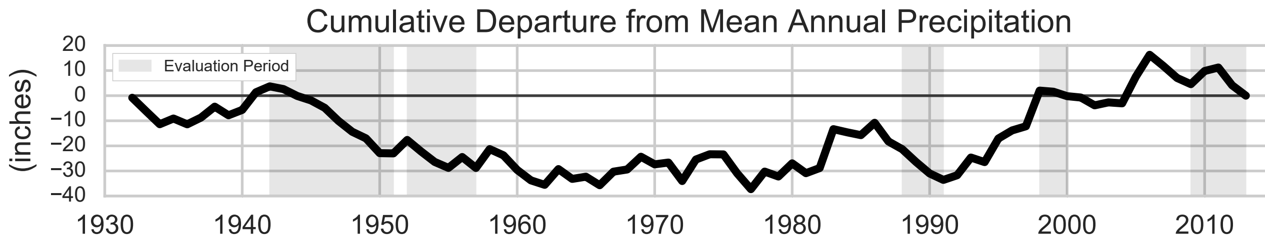

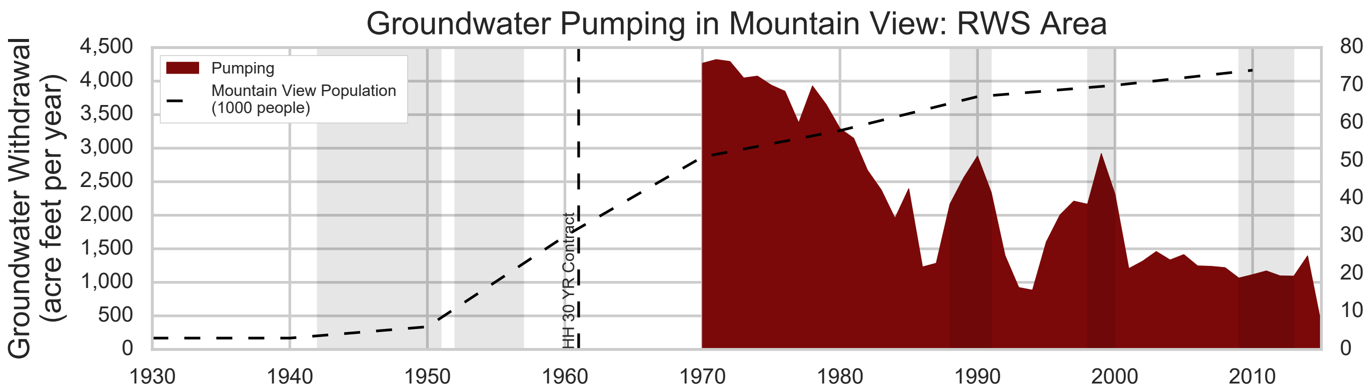

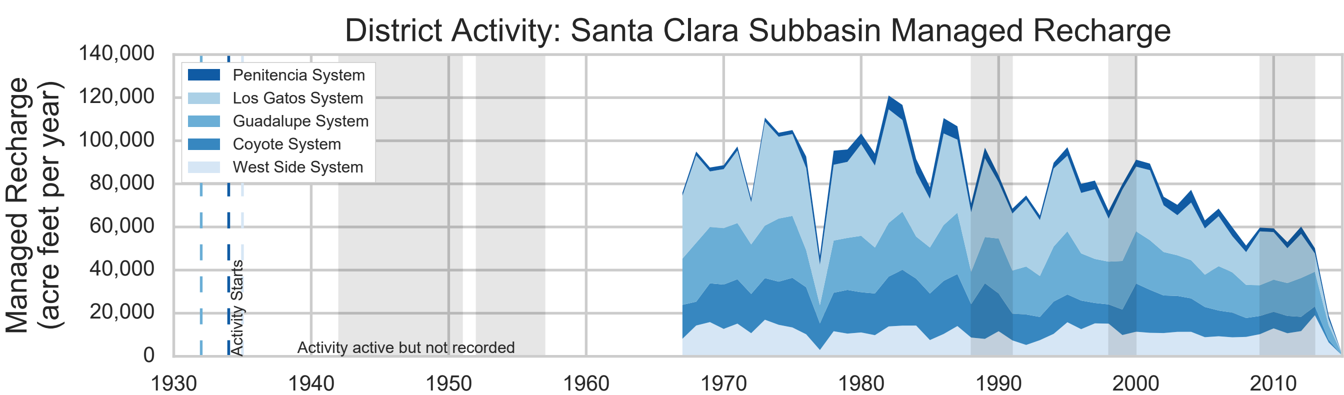

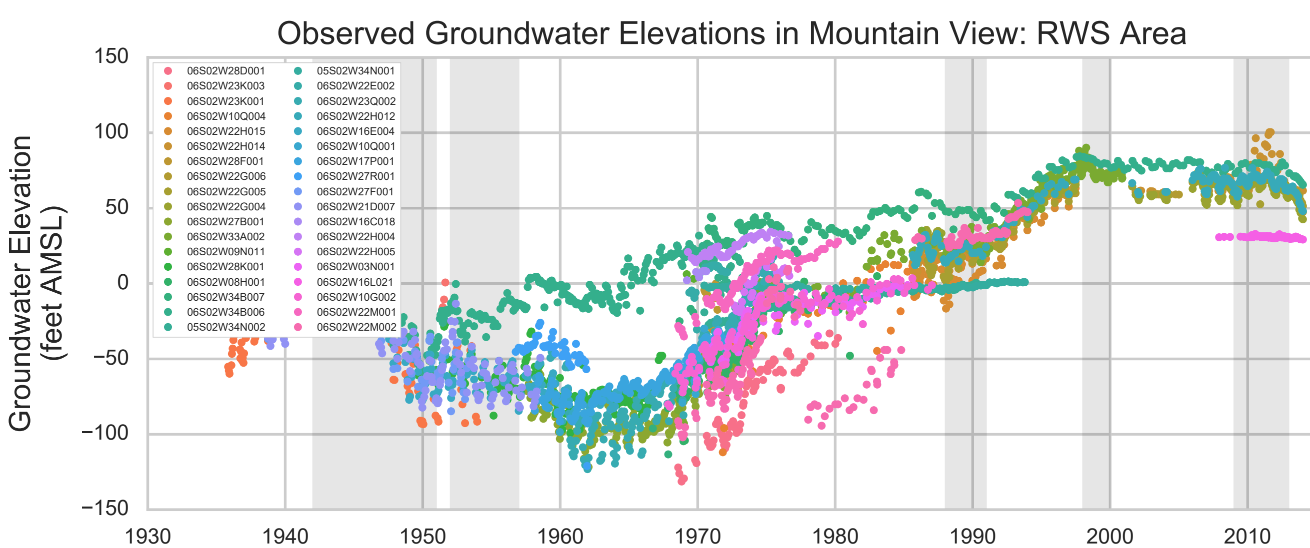

Pumping Area: Mountain View: TW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

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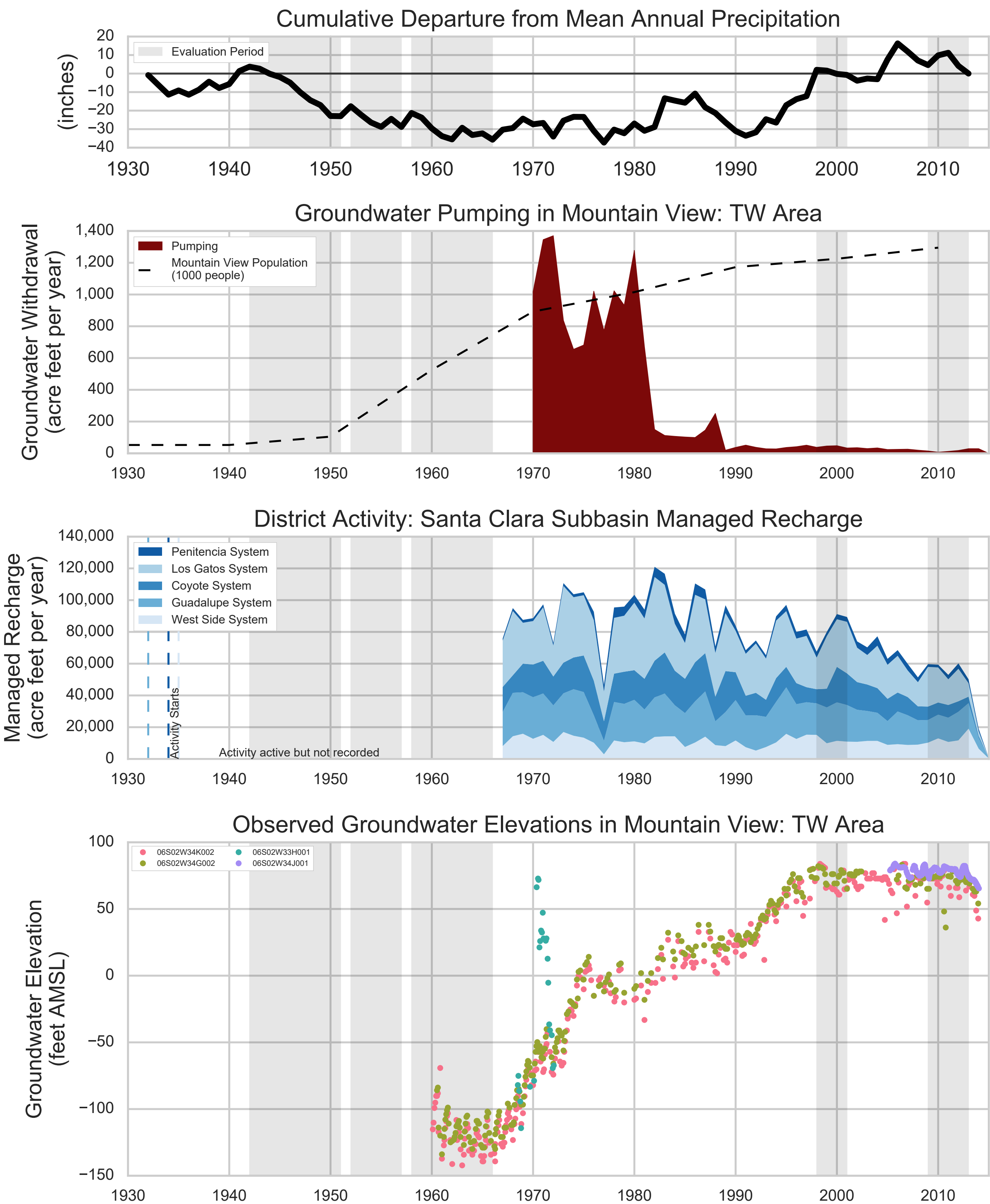

Pumping Area: North Morgan Hill:
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

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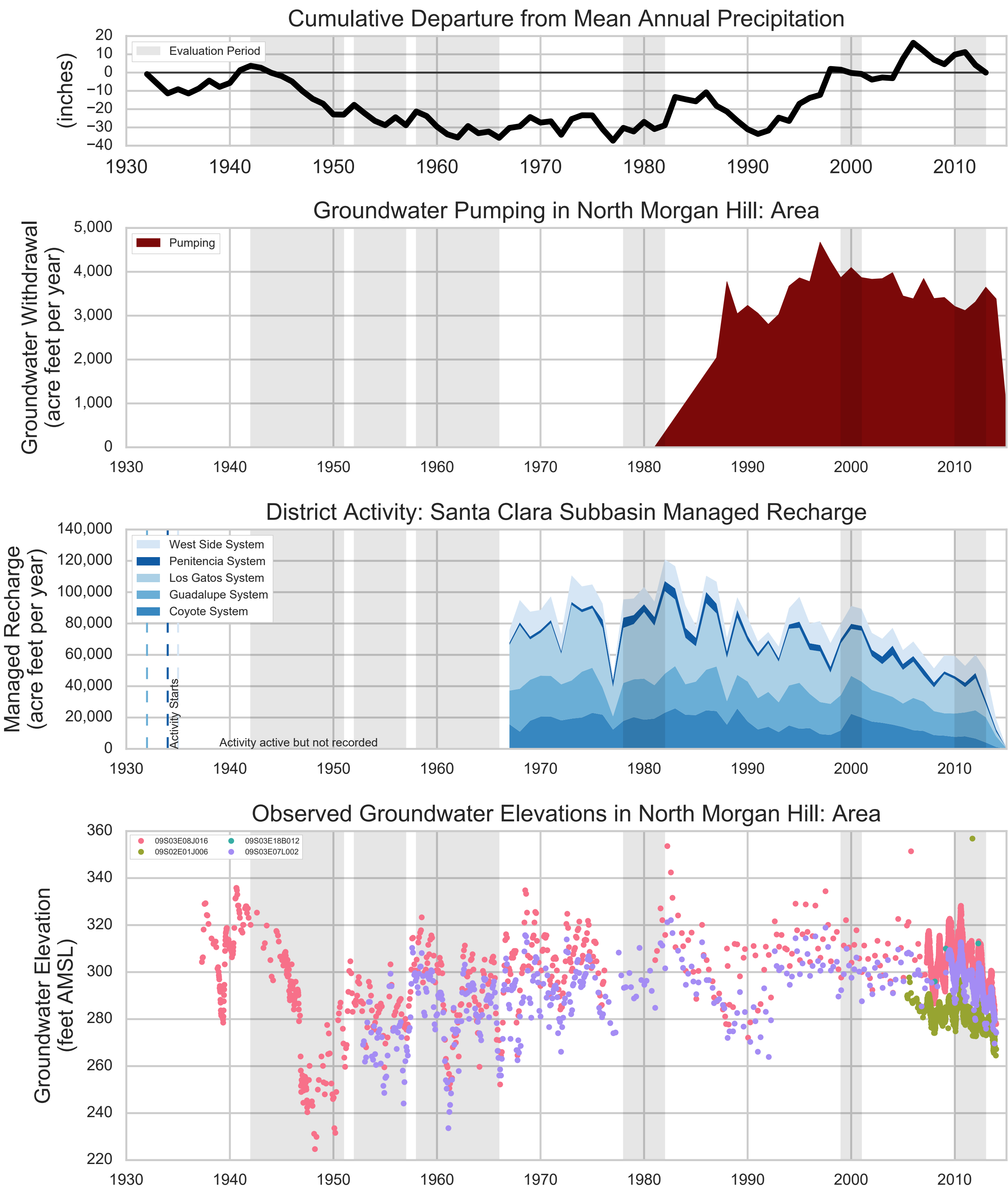

Pumping Area: Palo Alto: RWS
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

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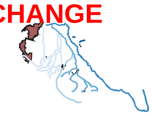
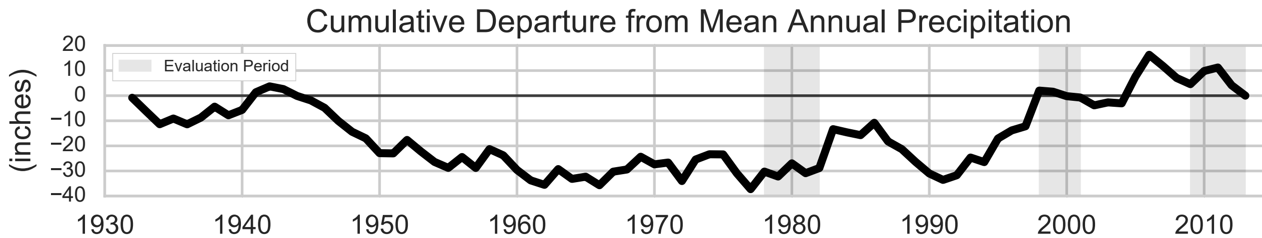
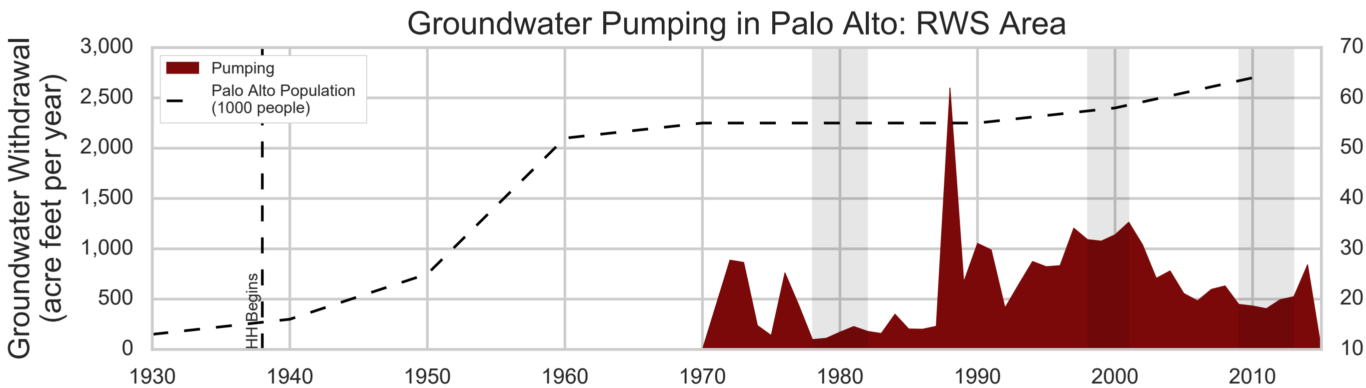
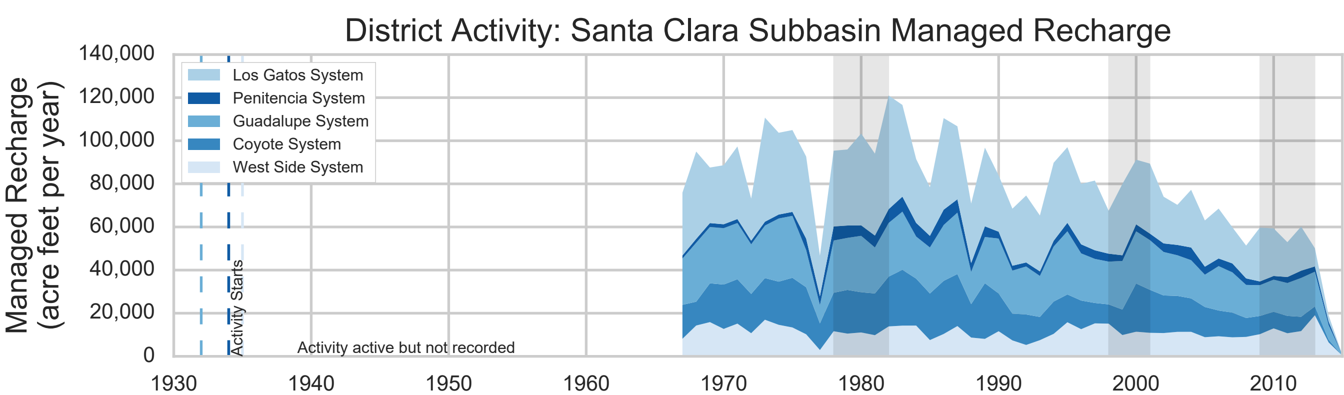
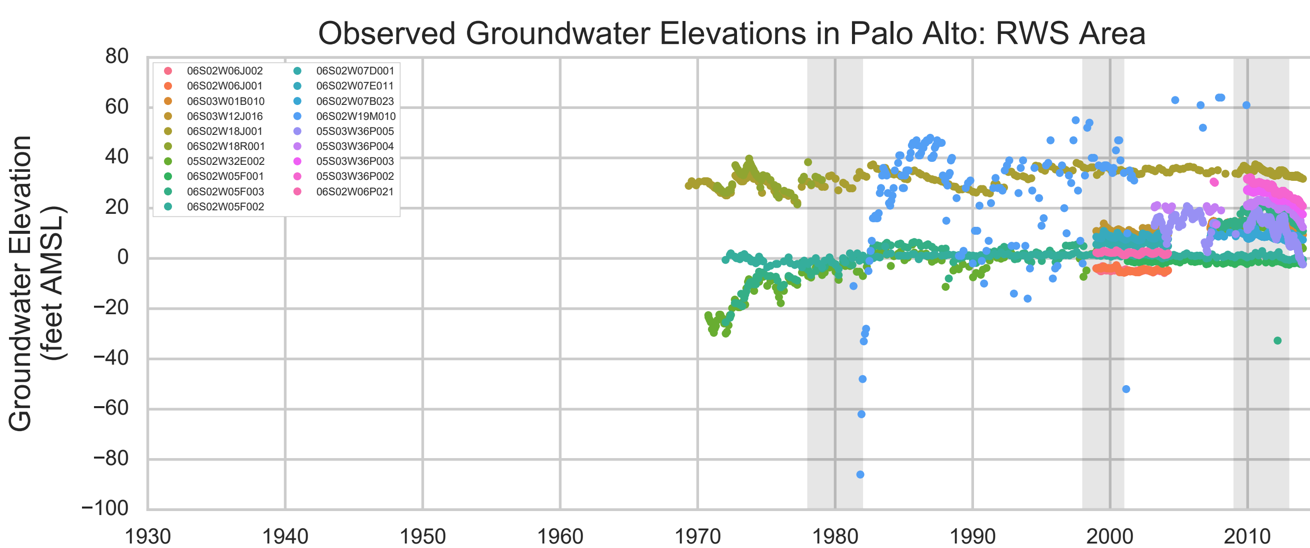




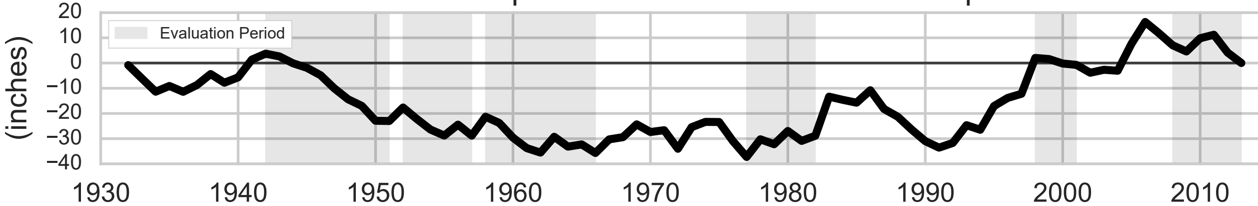




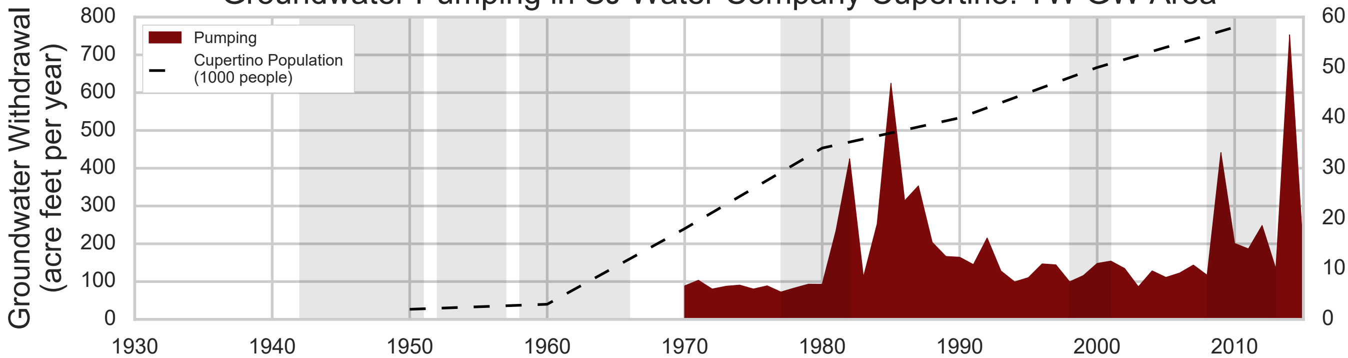


Pumping Area: SJ Water Company Cupertino: TW GW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

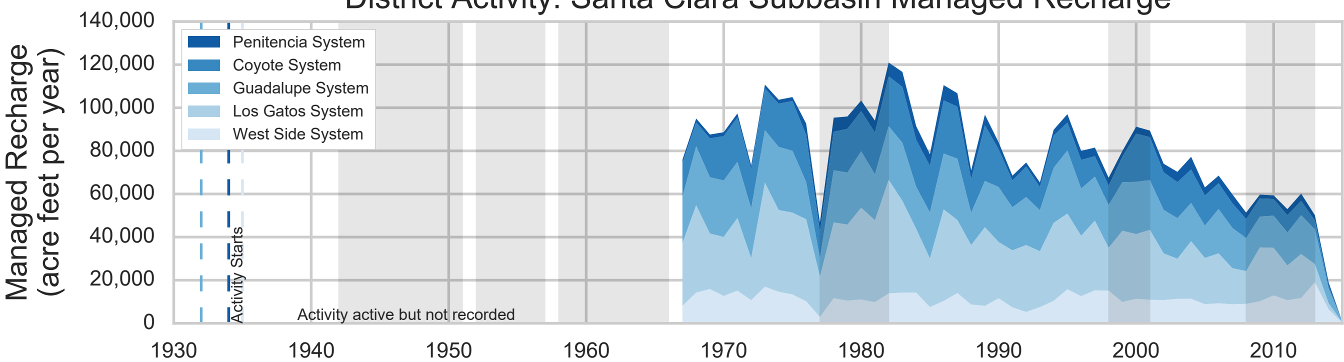
Cumulative Departure from Mean Annual Precipitation



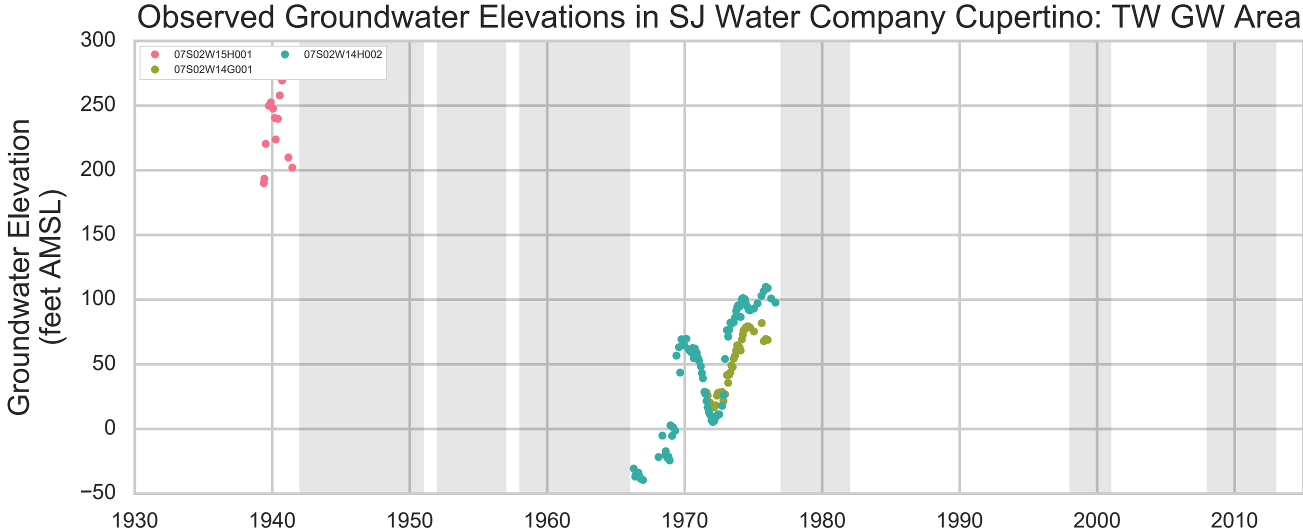
Groundwater Pumping in SJ Water Company Cupertino: TW GW Area



District Activity: Santa Clara Subbasin Managed Recharge



Observed Groundwater Elevations in SJ Water Company Cupertino: TW GW Area



Pumping Area: SJ Water Company East: TW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

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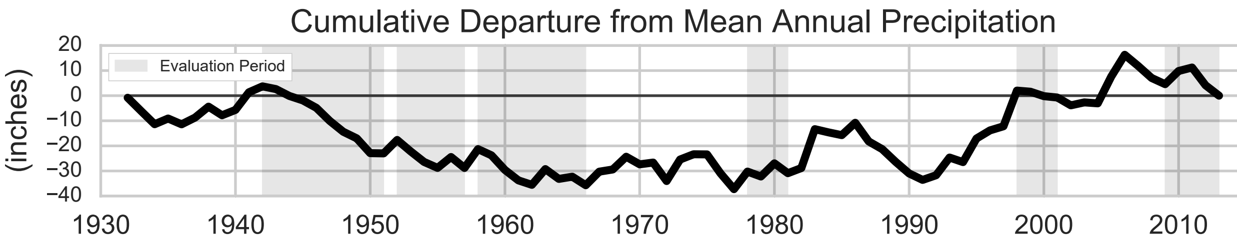
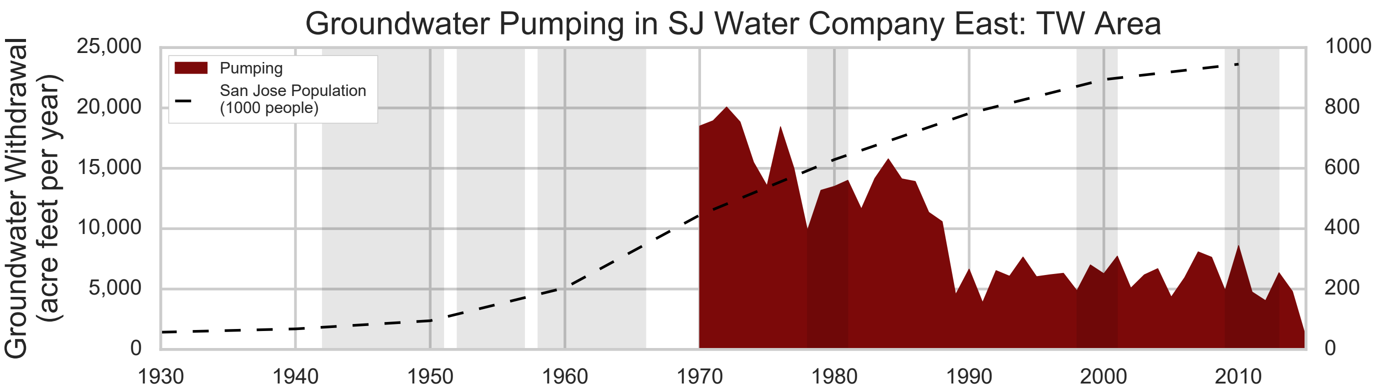
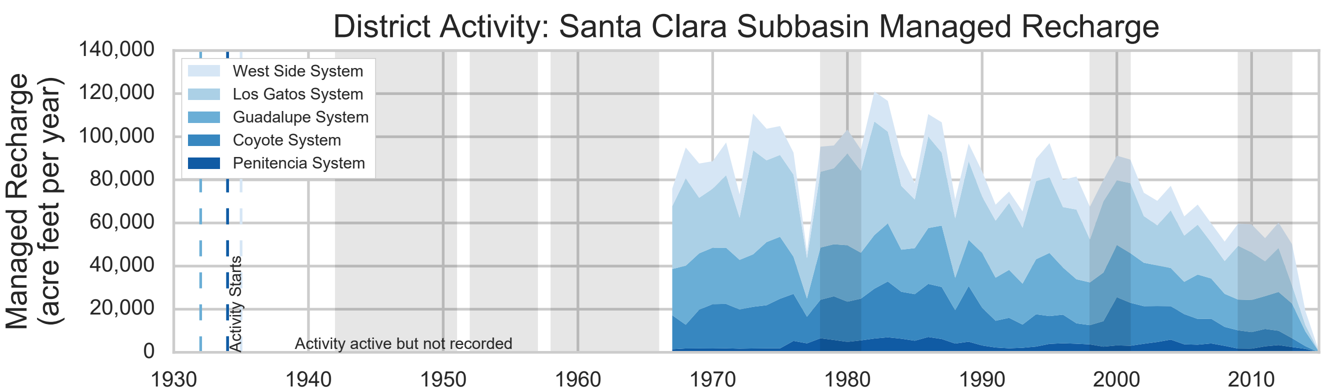
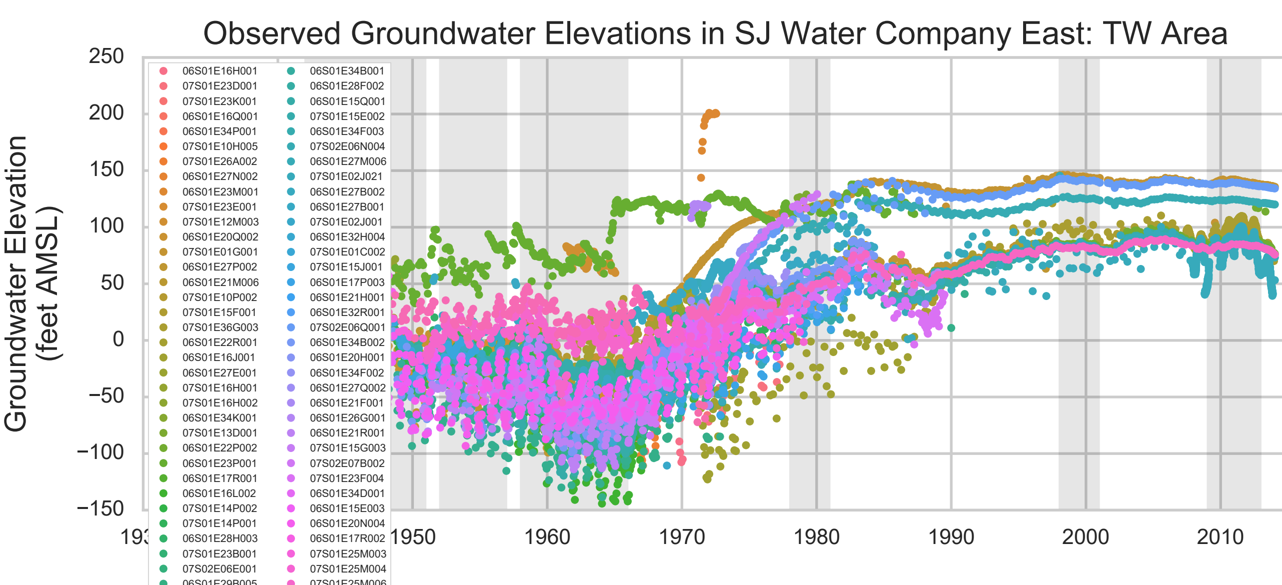




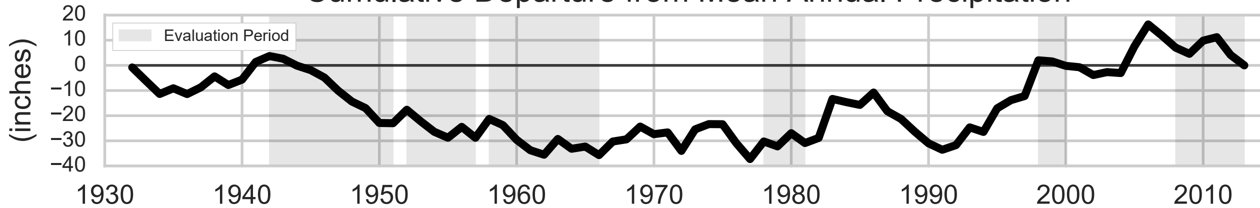




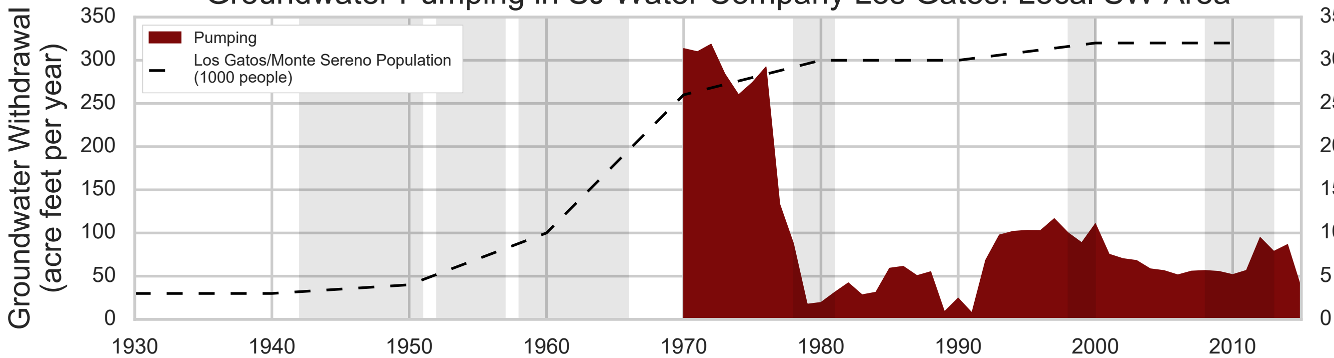
Pumping Area: SJ Water Company Los Gatos: Local SW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

DRAFT - SUBJECT TO CHANGE

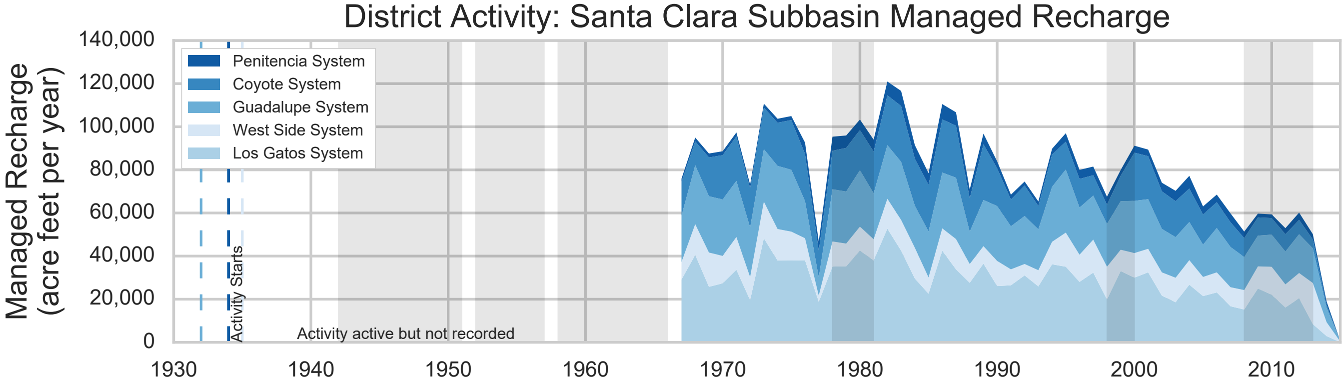
Cumulative Departure from Mean Annual Precipitation



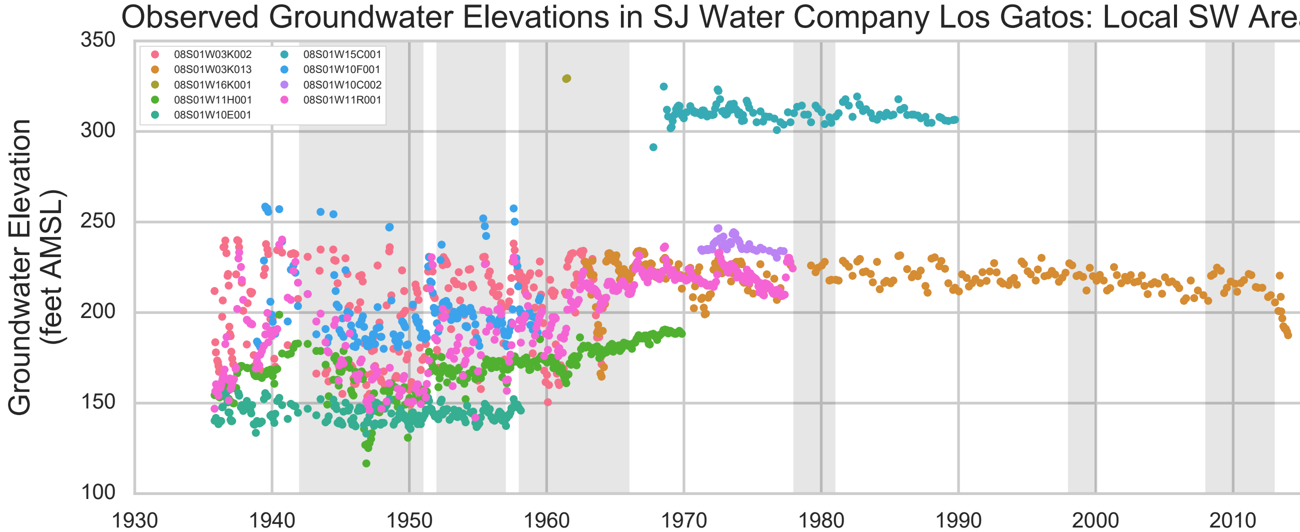
Groundwater Pumping in SJ Water Company Los Gatos: Local SW Area



District Activity: Santa Clara Subbasin Managed Recharge

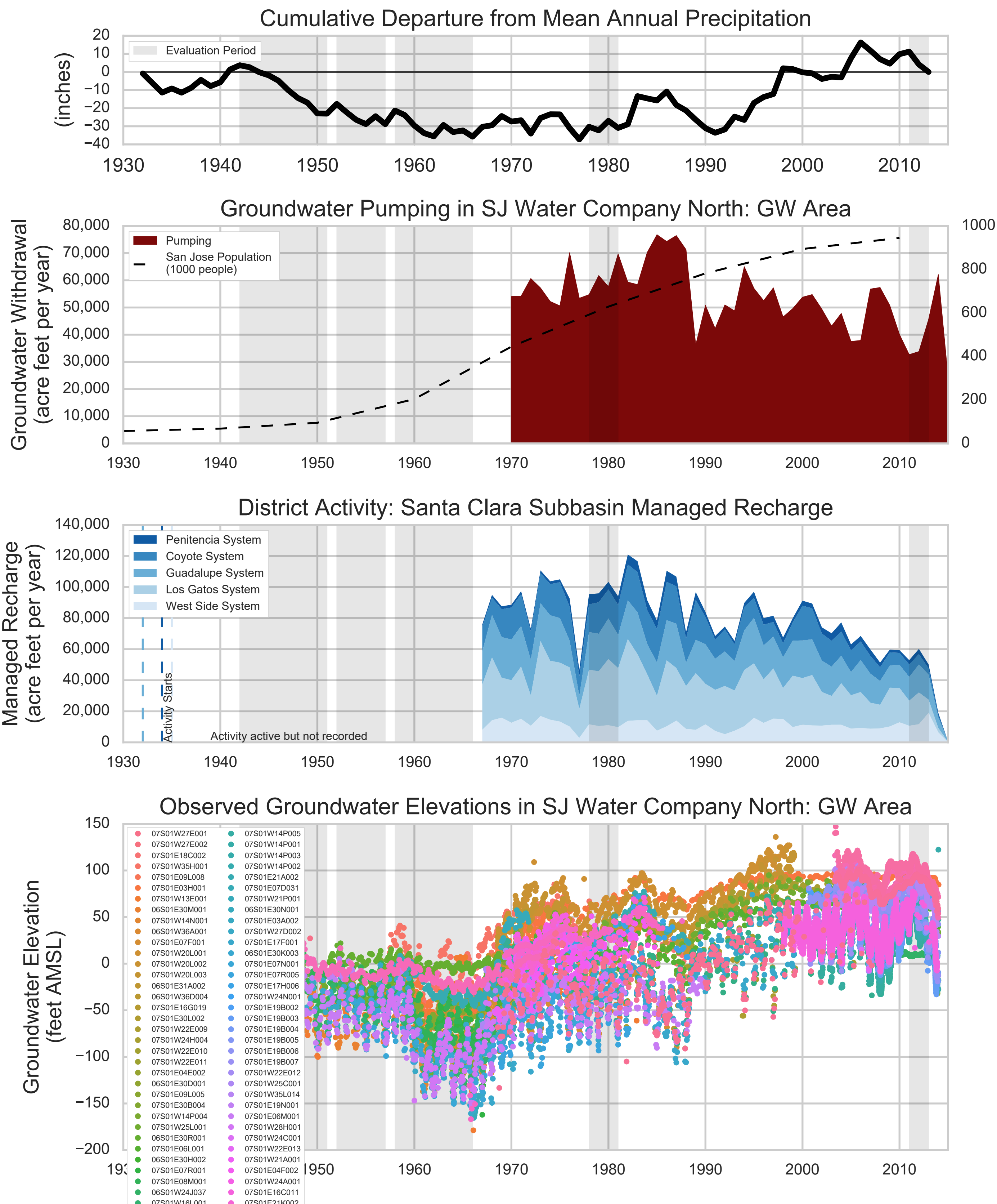


Observed Groundwater Elevations in SJ Water Company Los Gatos: Local SW Area



Pumping Area: SJ Water Company North: GW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

DRAFT - SUBJECT TO CHANGE



Pumping Area: SJ Water Company South: TW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

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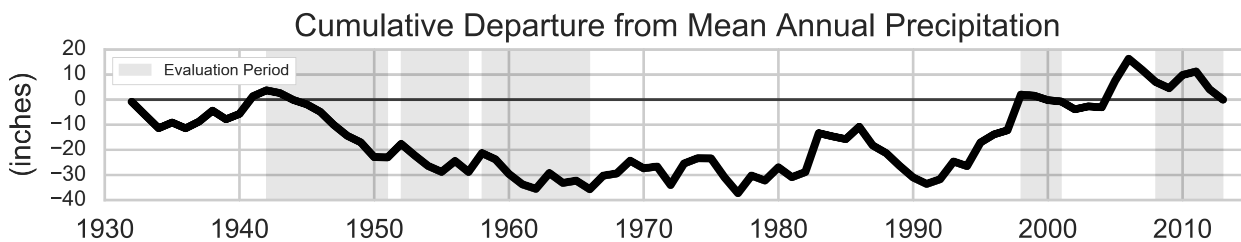
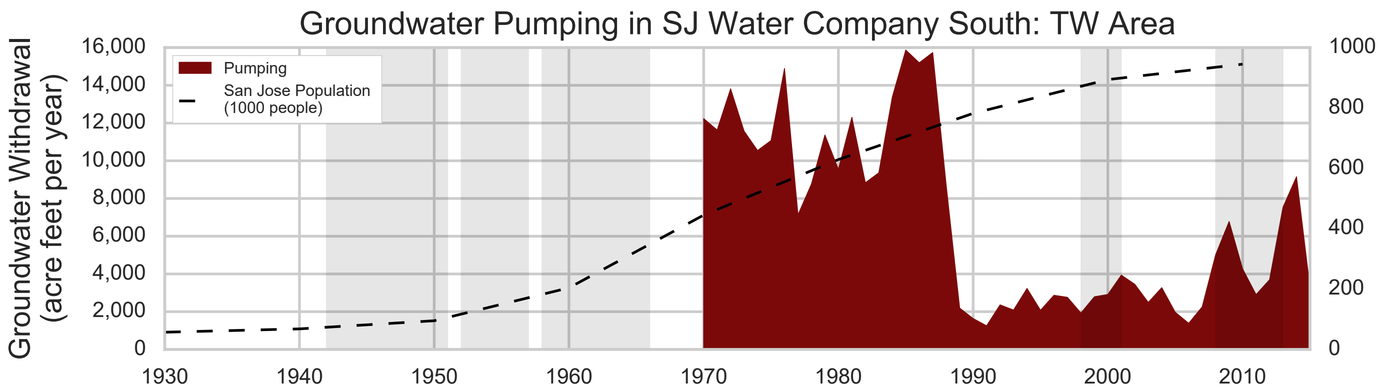
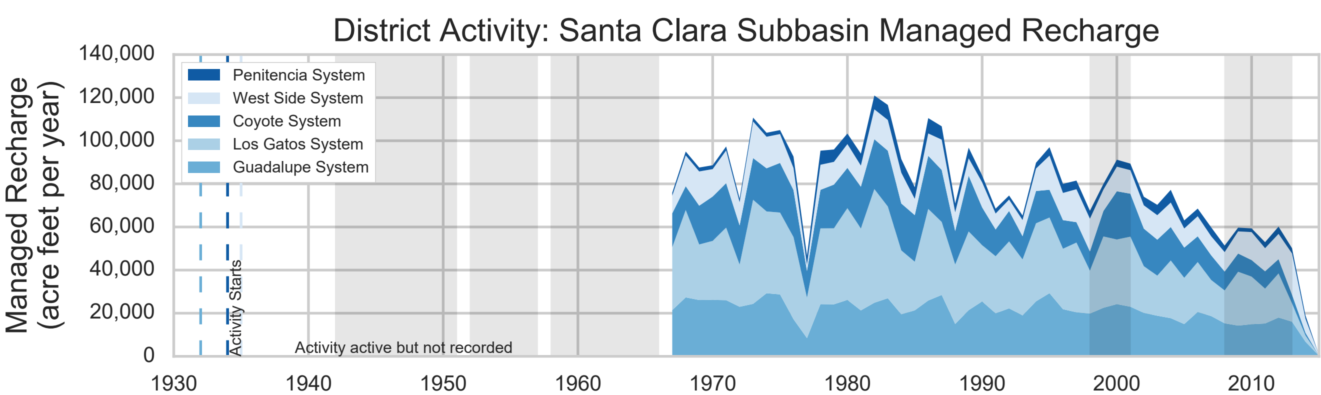
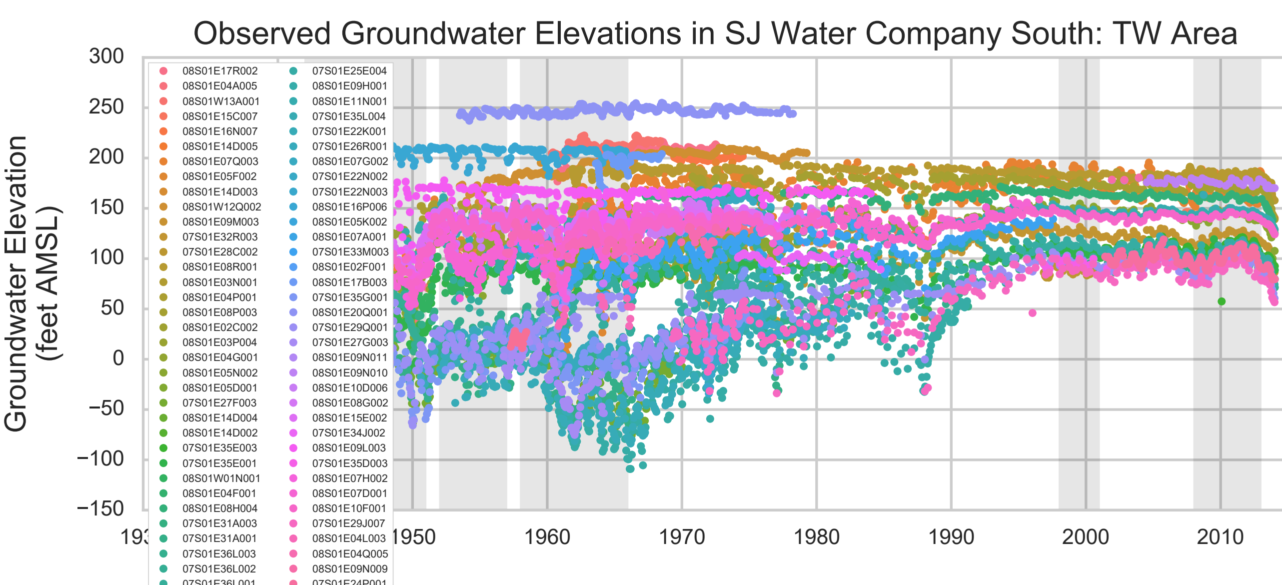


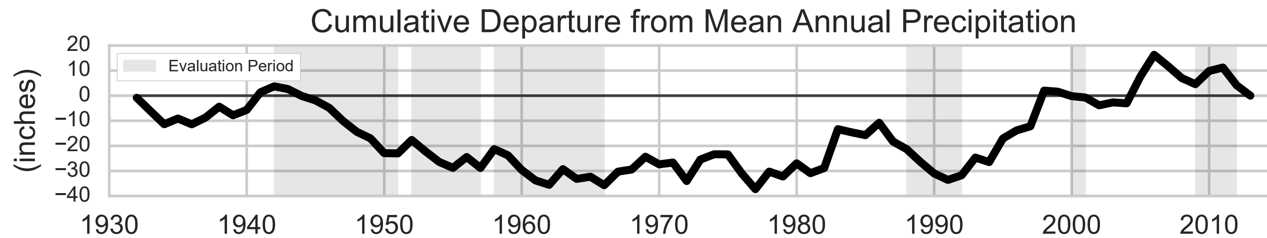


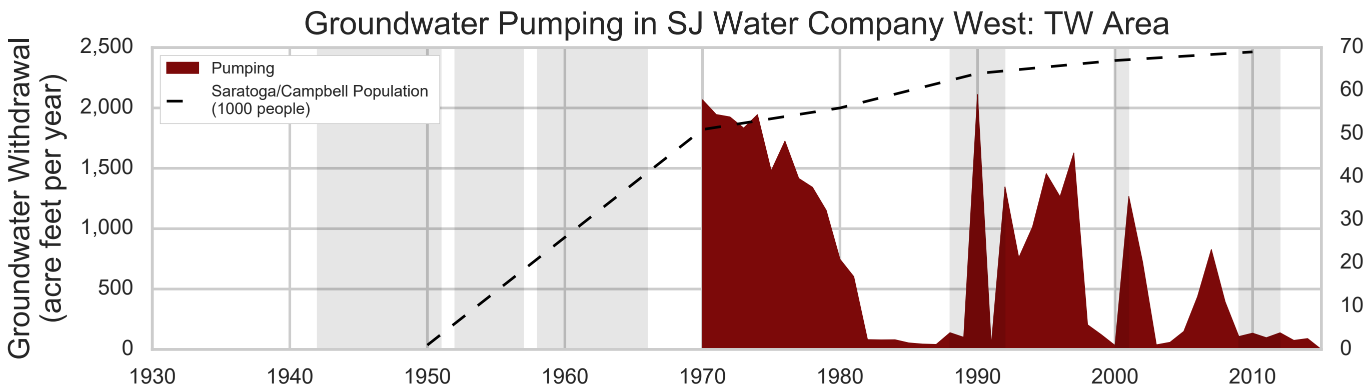


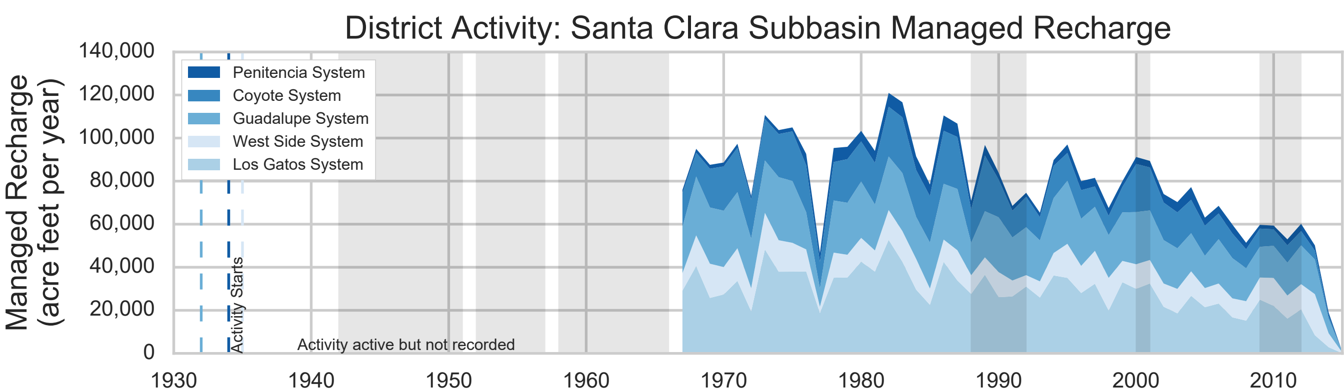


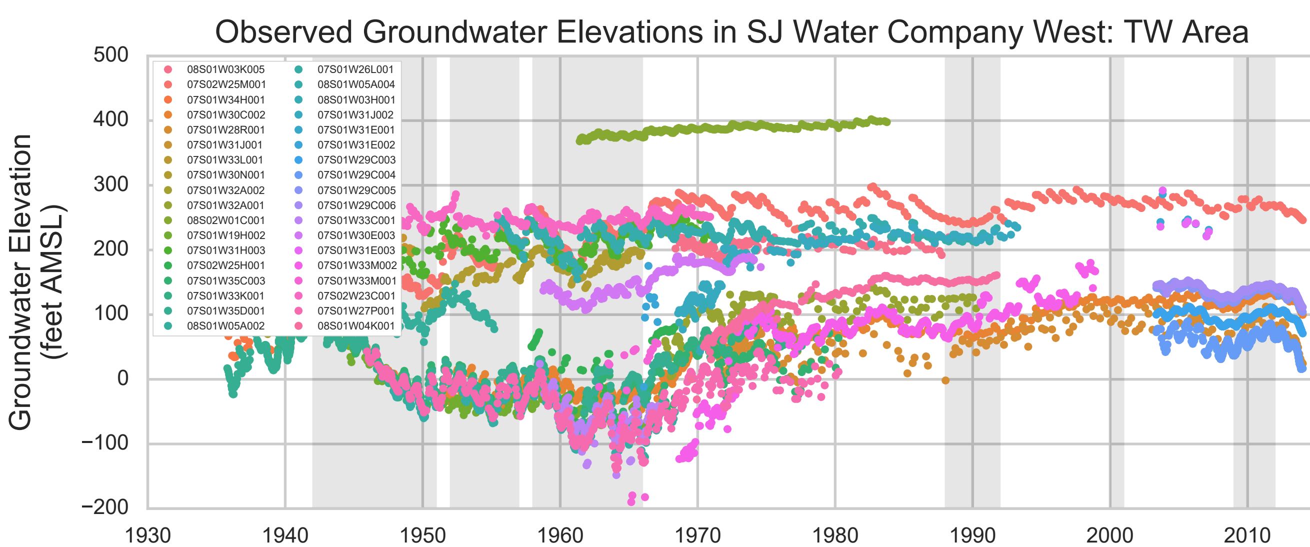
Pumping Area: SJ Water Company West: TW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

DRAFT - SUBJECT TO CHANGE



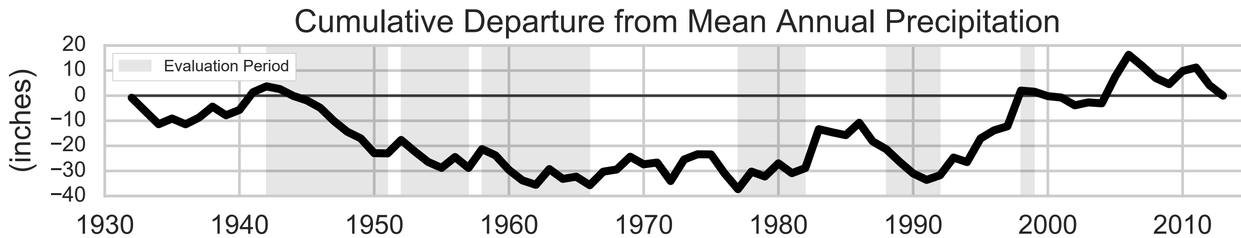


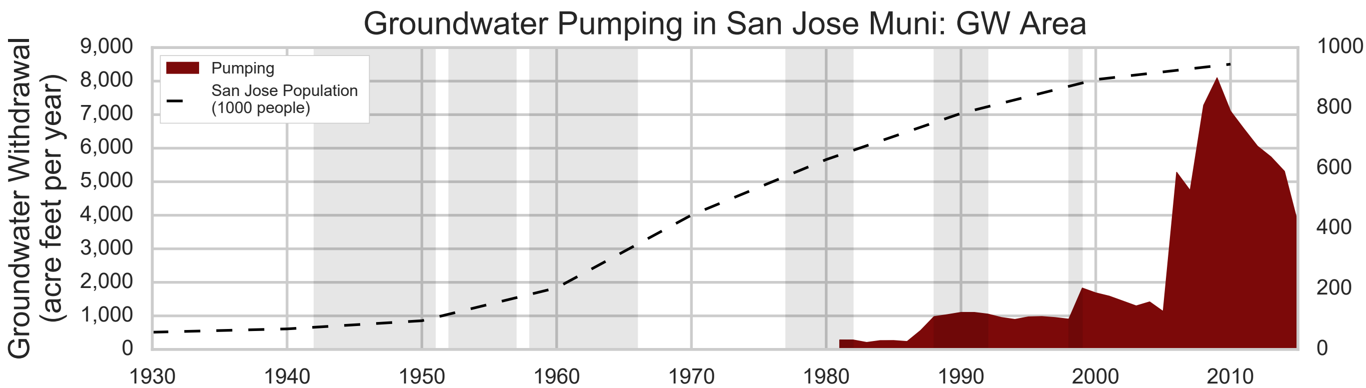


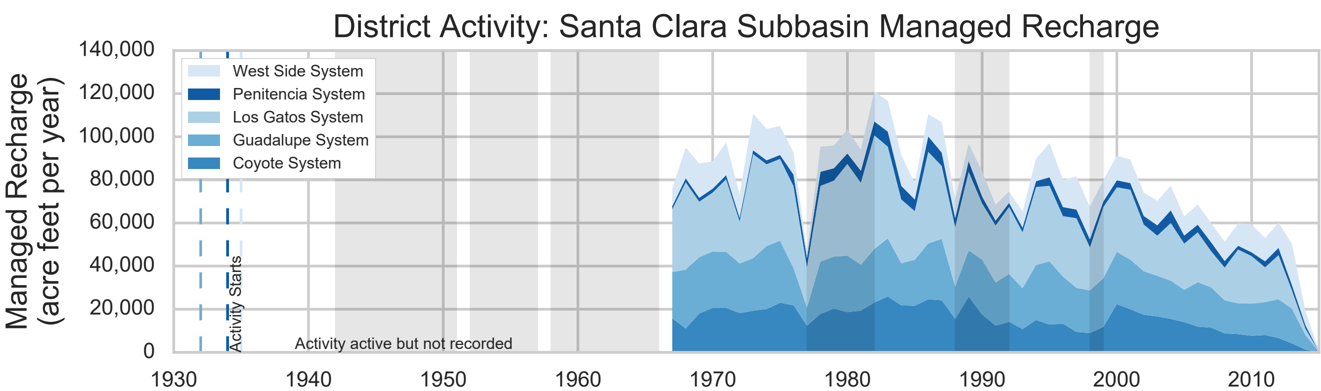


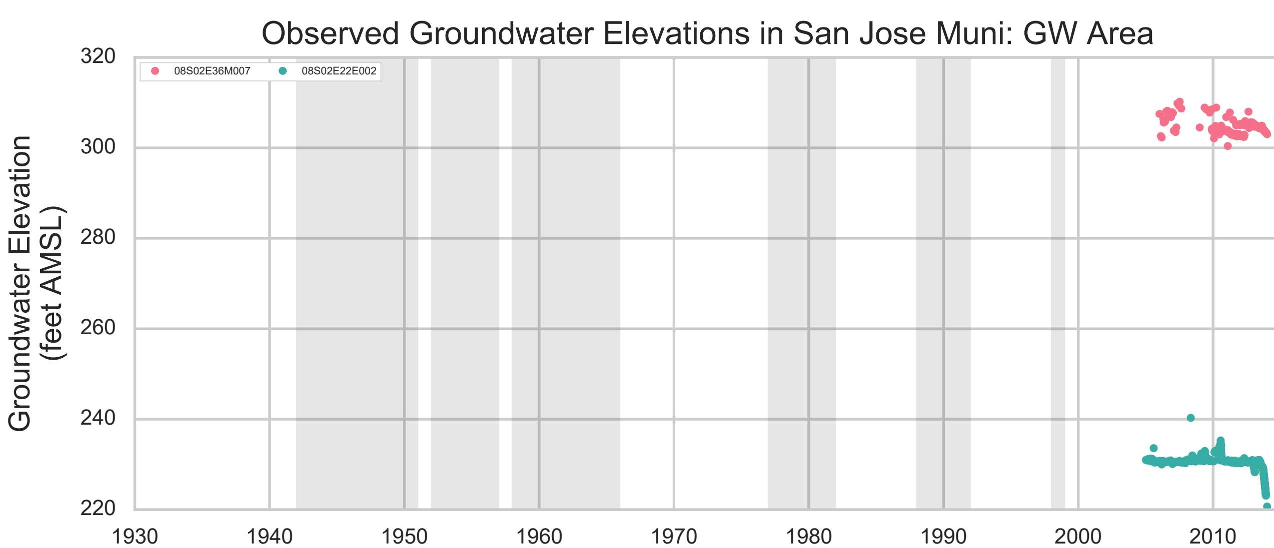
Pumping Area: San Jose Muni: GW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

DRAFT - SUBJECT TO CHANGE



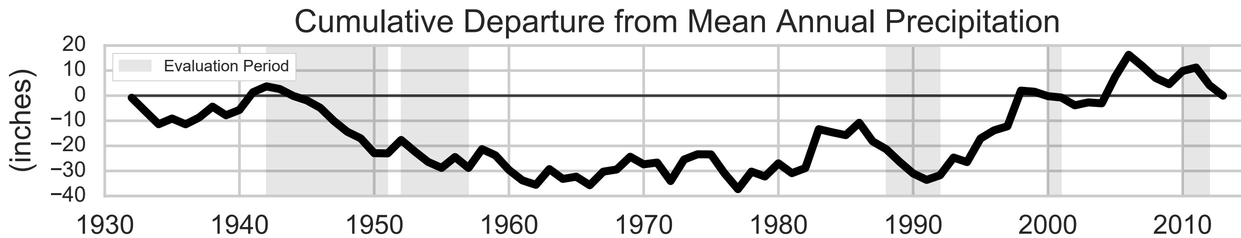


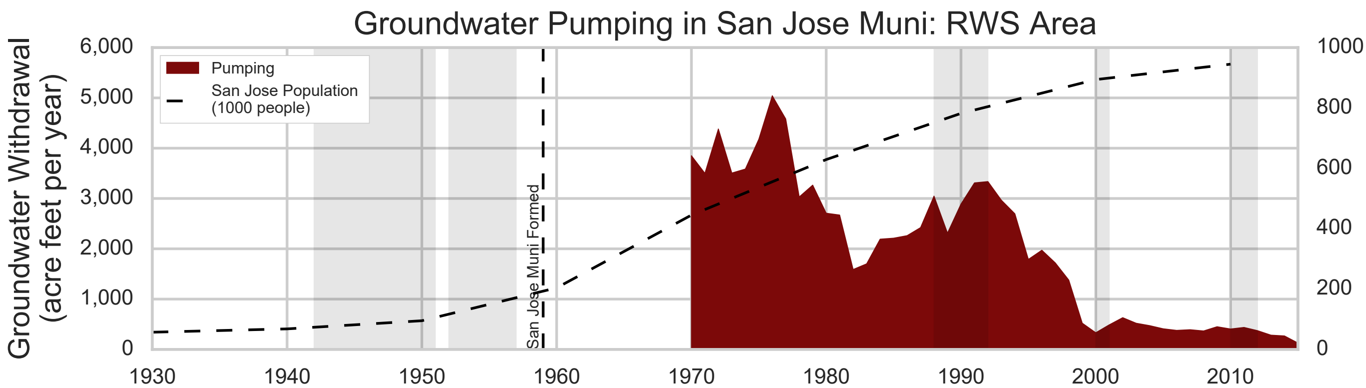


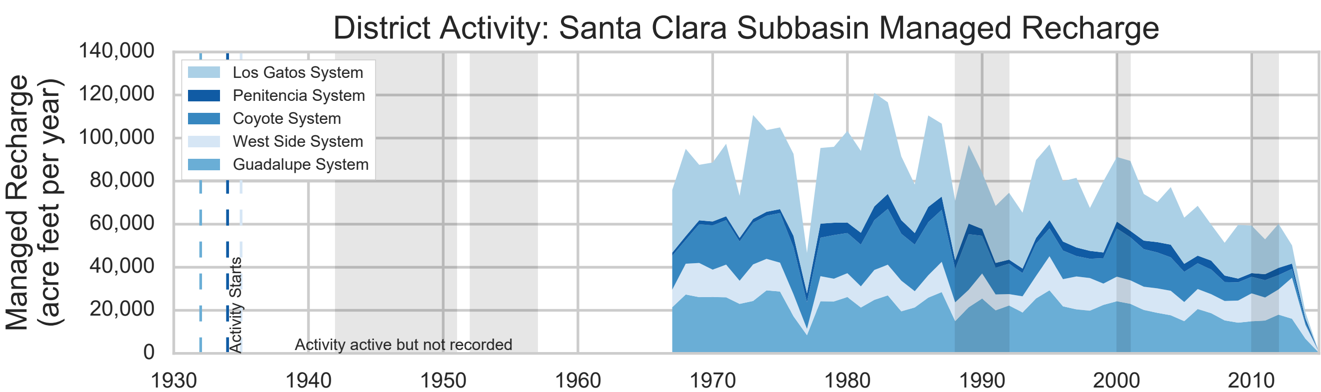


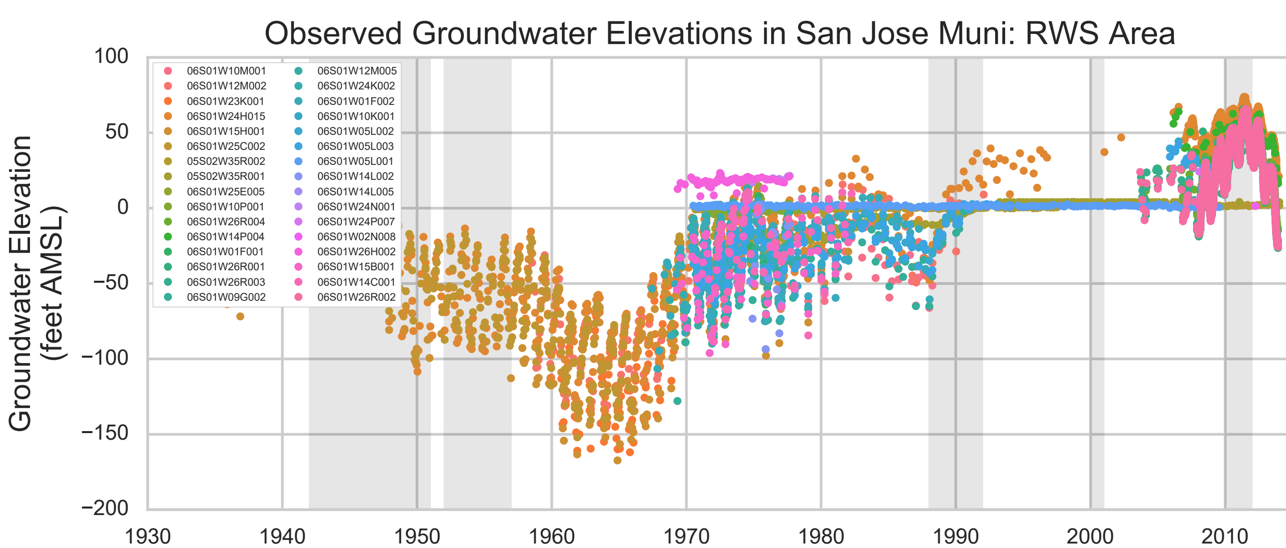
Pumping Area: San Jose Muni: RWS
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

DRAFT - SUBJECT TO CHANGE





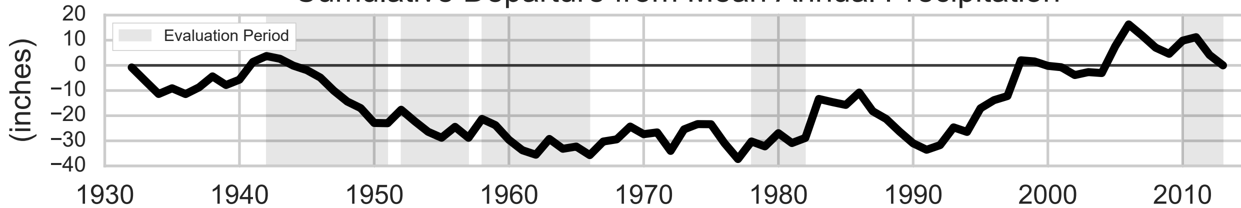




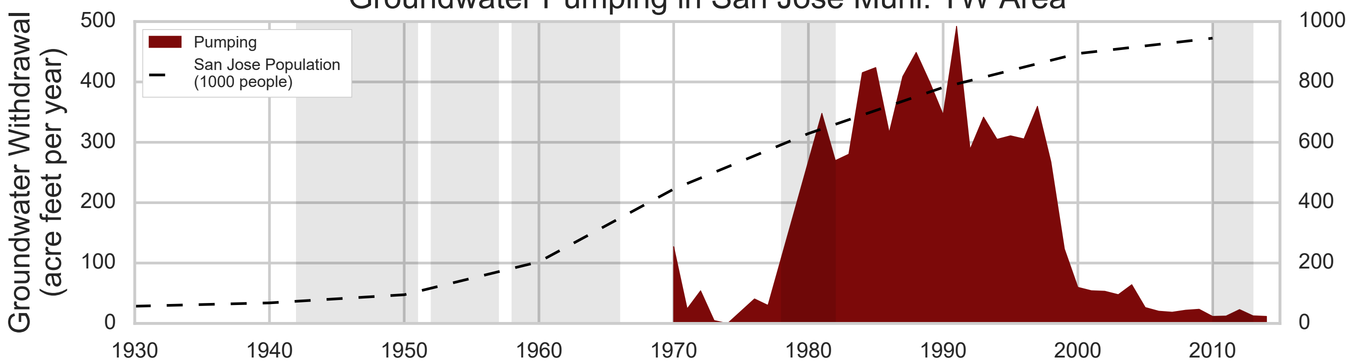
Pumping Area: San Jose Muni: TW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

DRAFT - SUBJECT TO CHANGE

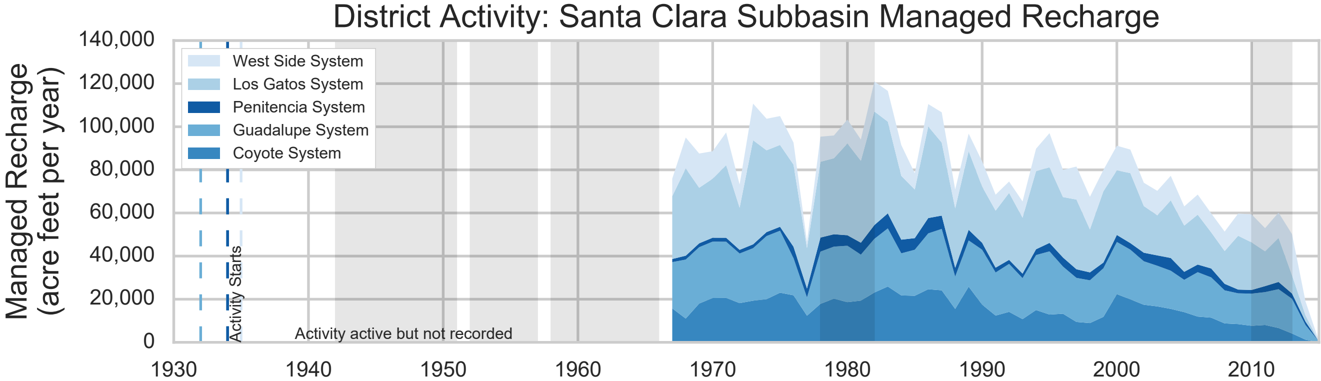
Cumulative Departure from Mean Annual Precipitation



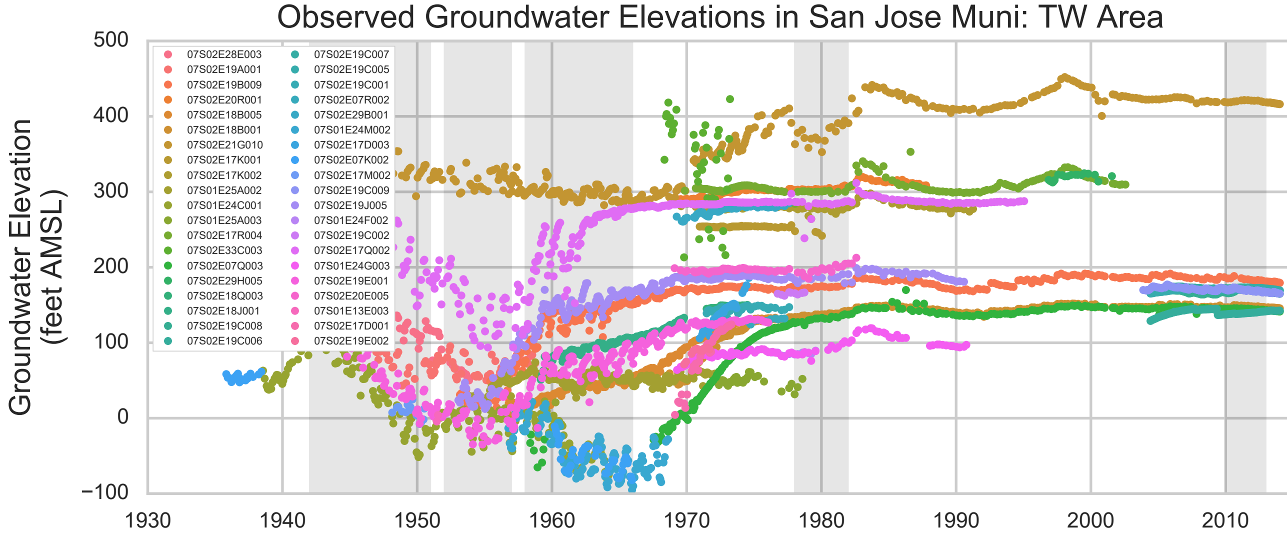
Groundwater Pumping in San Jose Muni: TW Area



District Activity: Santa Clara Subbasin Managed Recharge

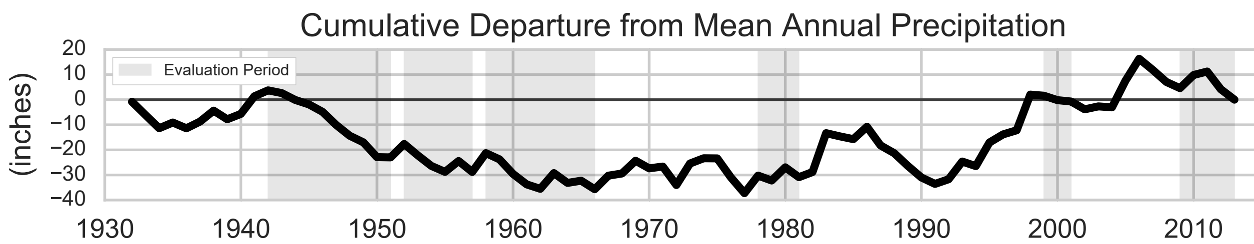


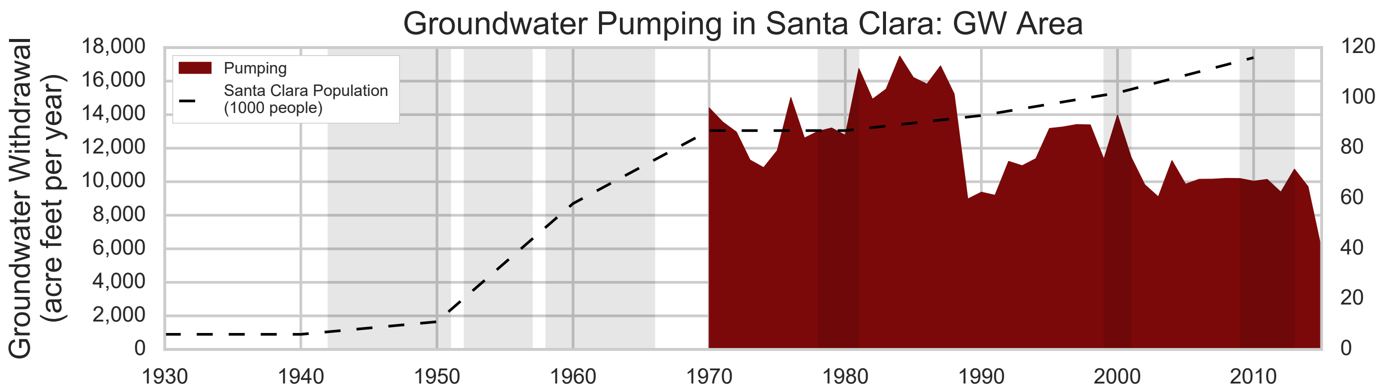
Observed Groundwater Elevations in San Jose Muni: TW Area

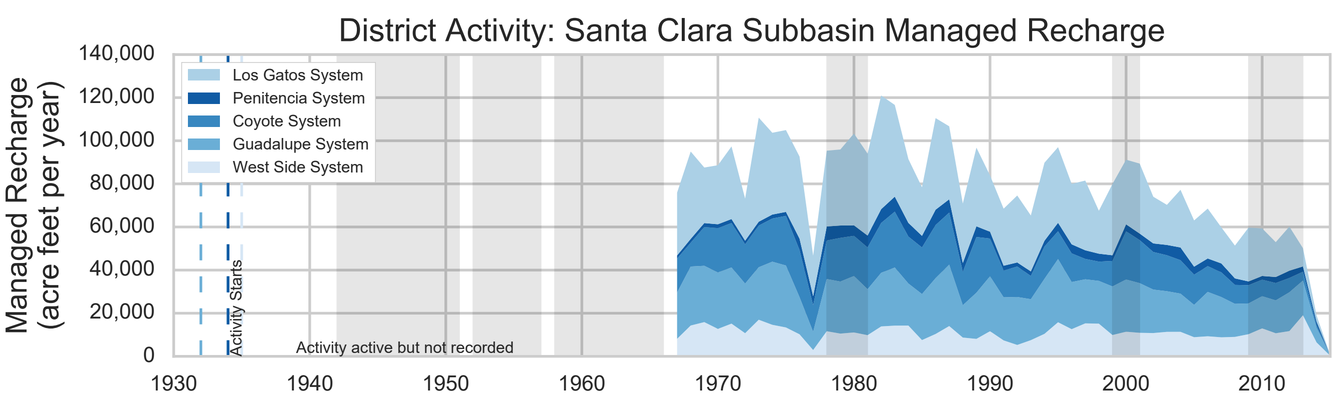


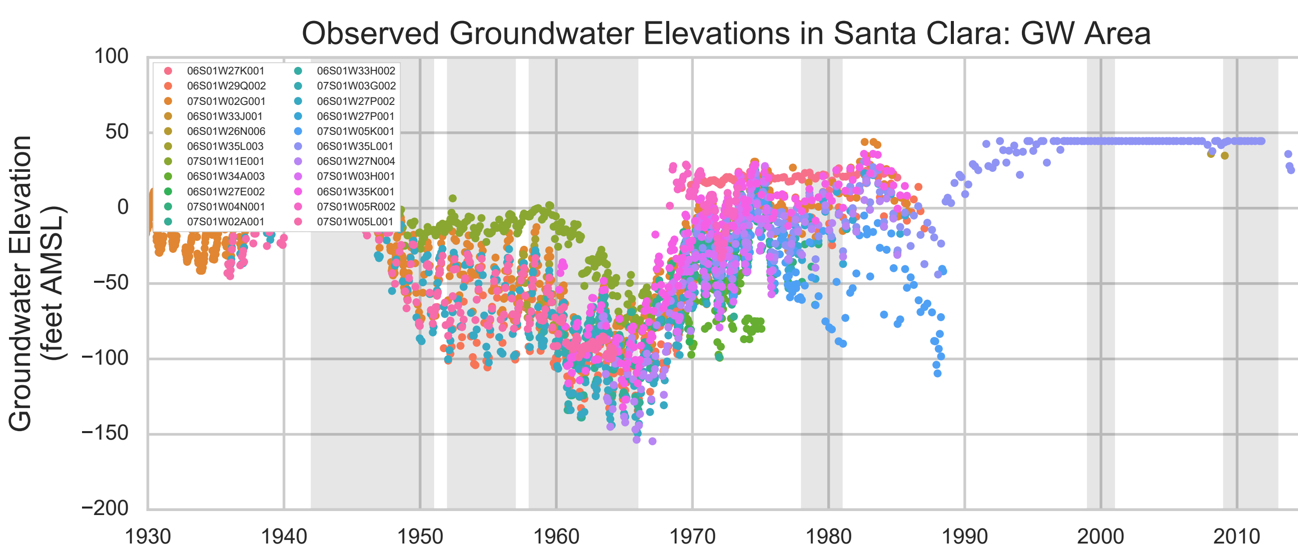
Pumping Area: Santa Clara: GW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

DRAFT - SUBJECT TO CHANGE



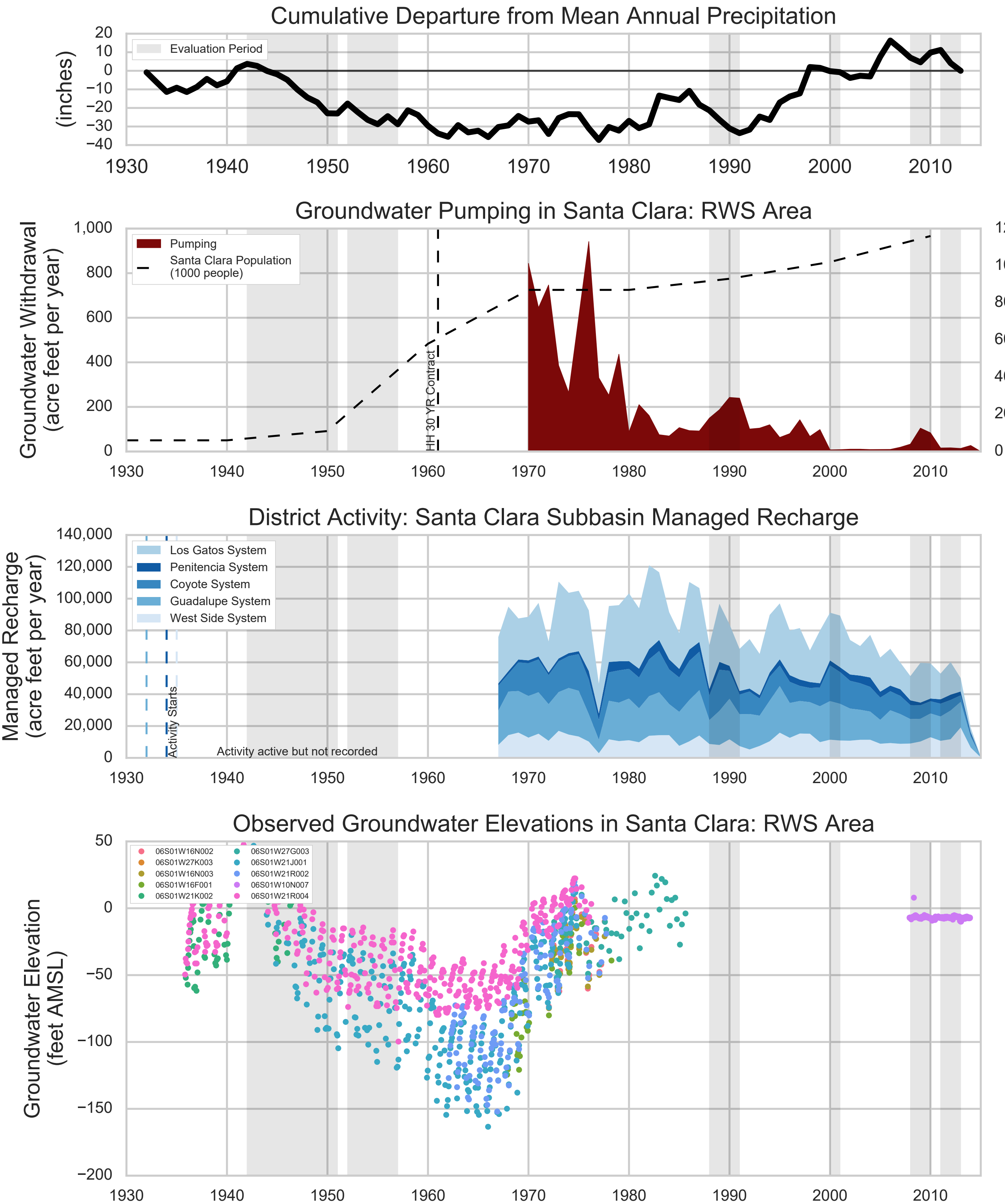






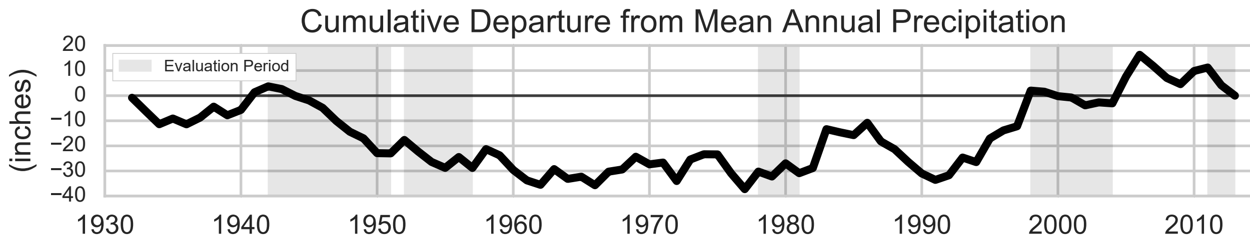
Pumping Area: Santa Clara: RWS
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

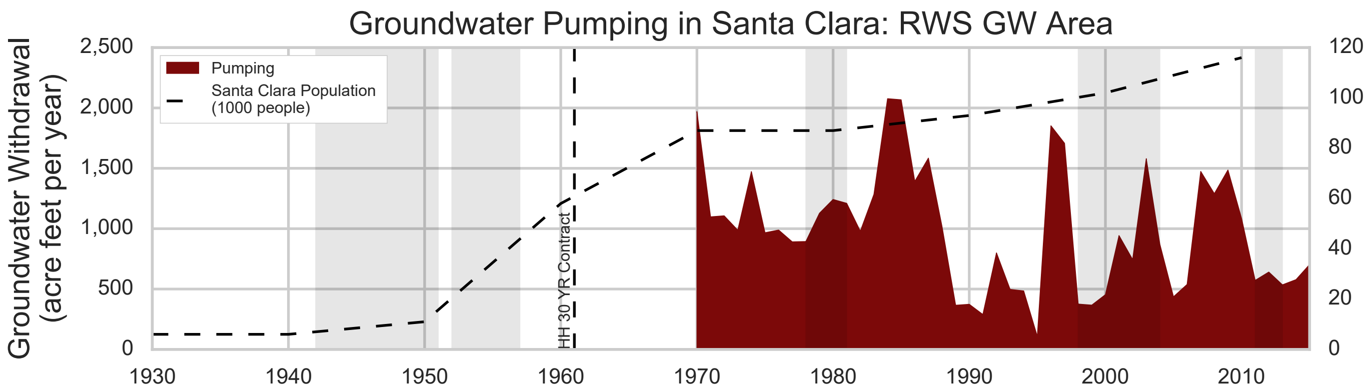
DRAFT - SUBJECT TO CHANGE

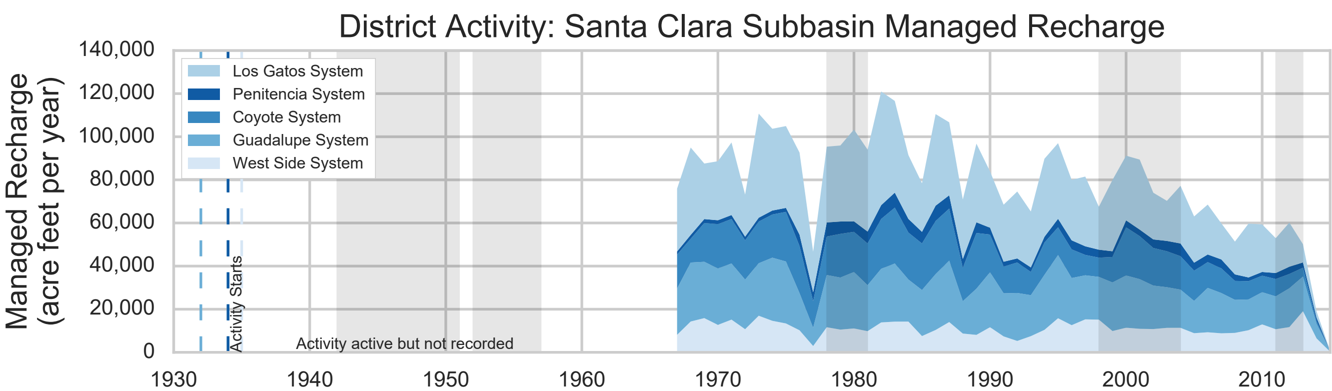


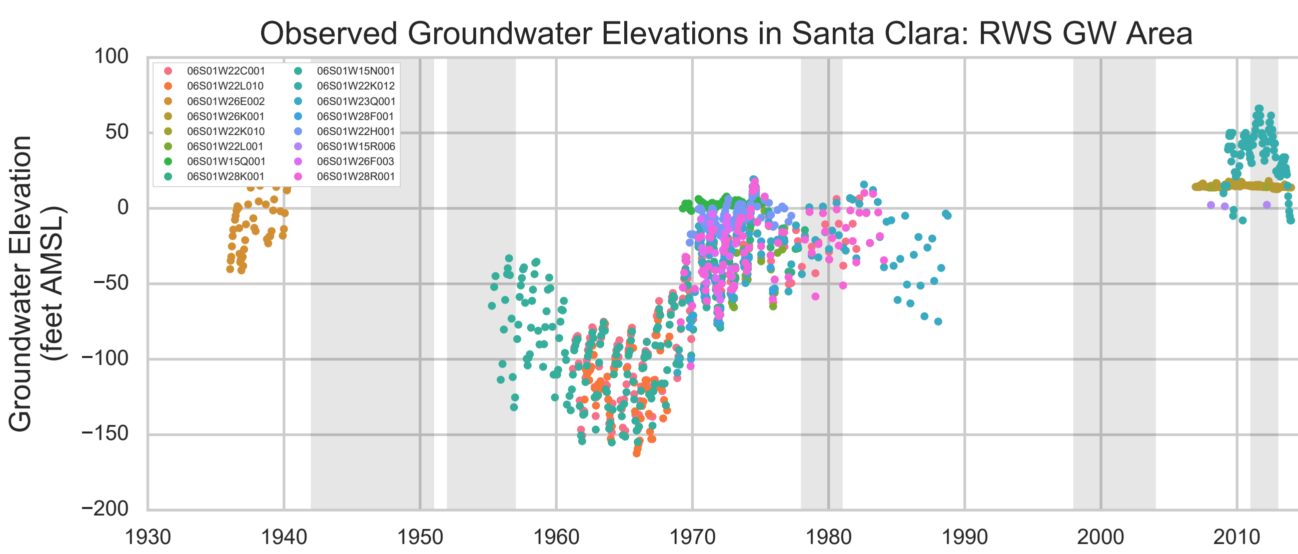
Pumping Area: Santa Clara: RWS GW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

DRAFT - SUBJECT TO CHANGE



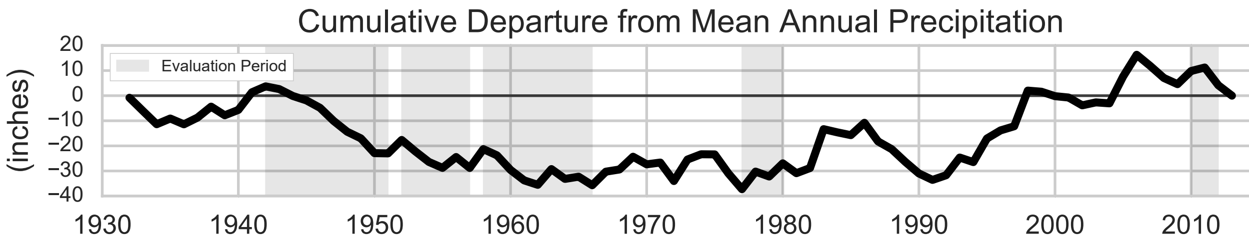


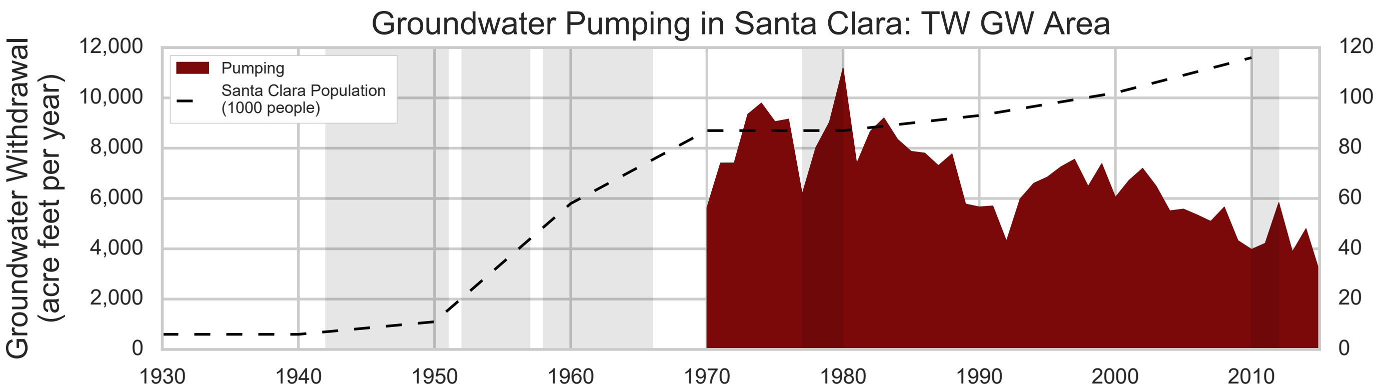


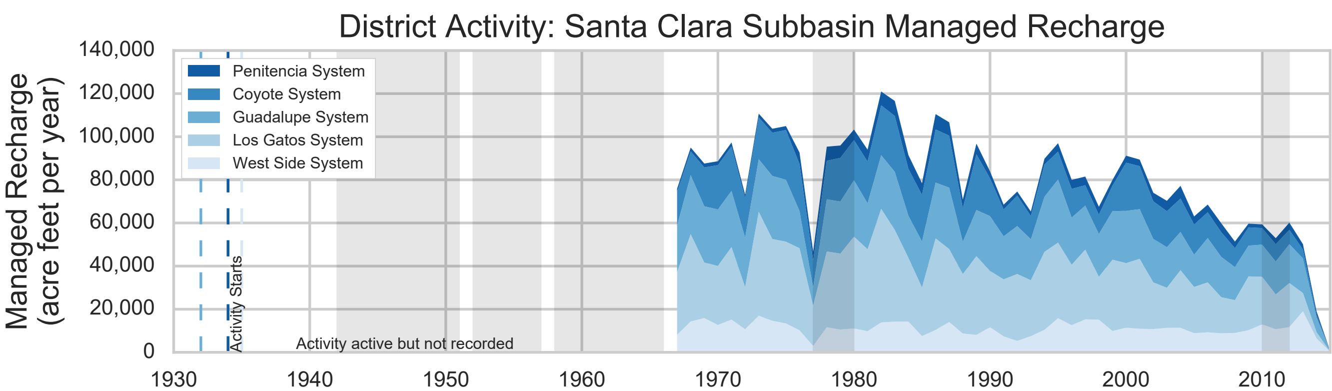


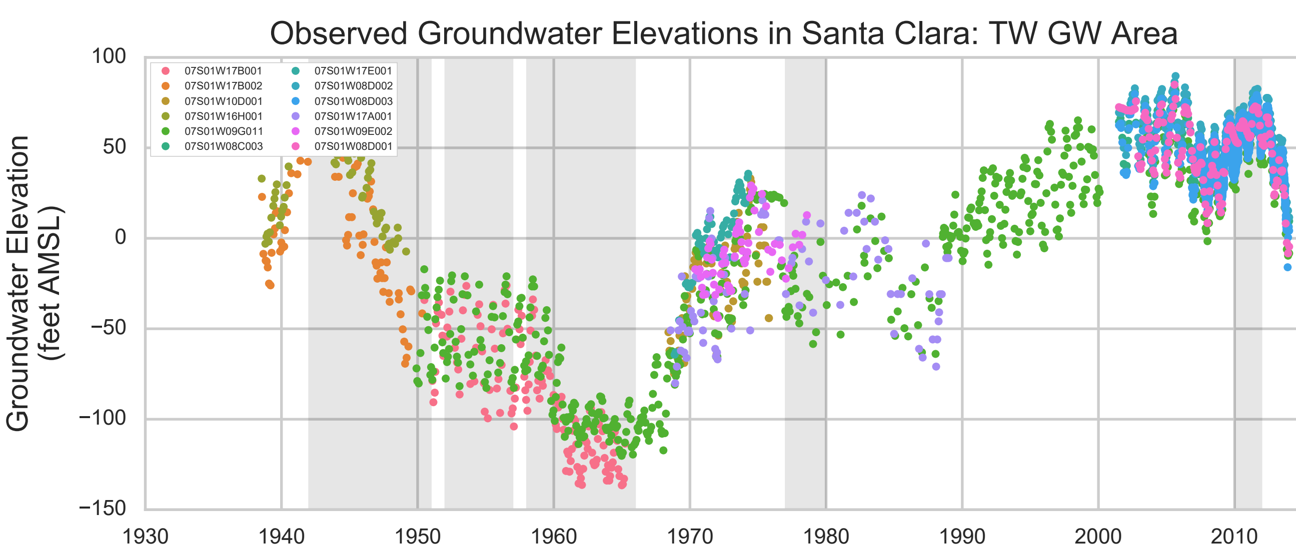
Pumping Area: Santa Clara: TW GW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

DRAFT - SUBJECT TO CHANGE



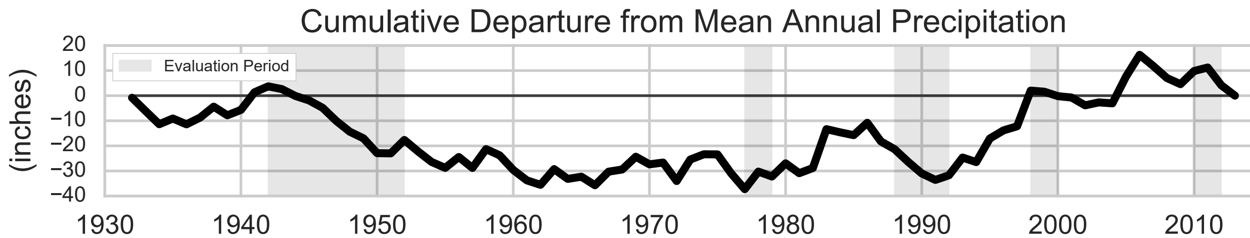


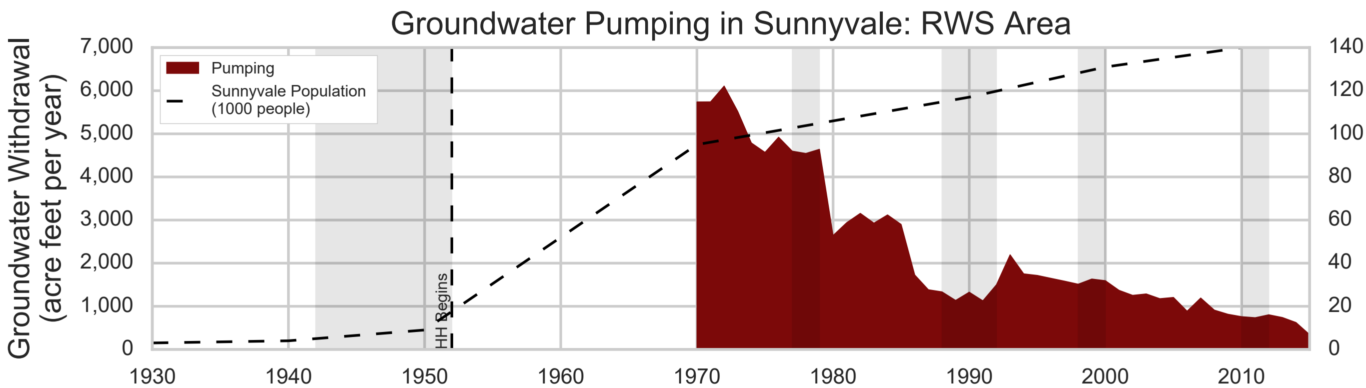


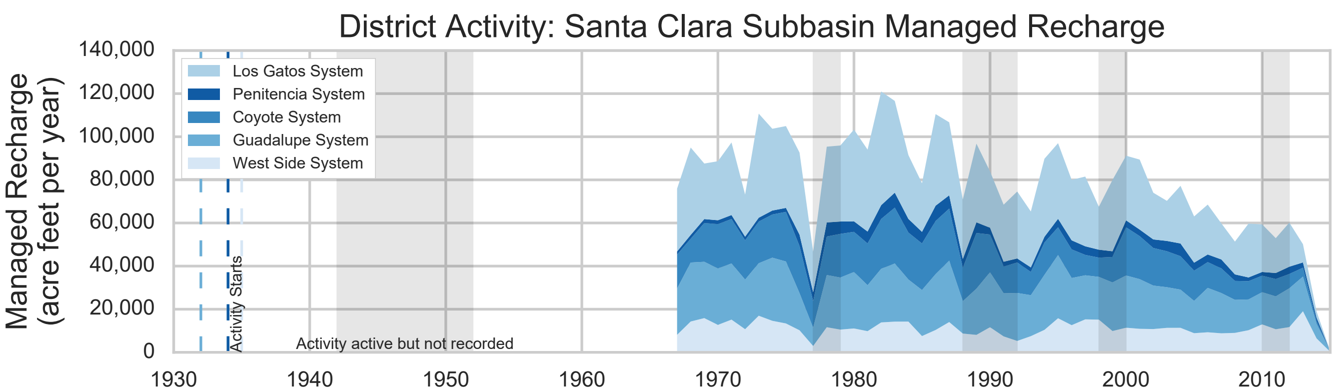


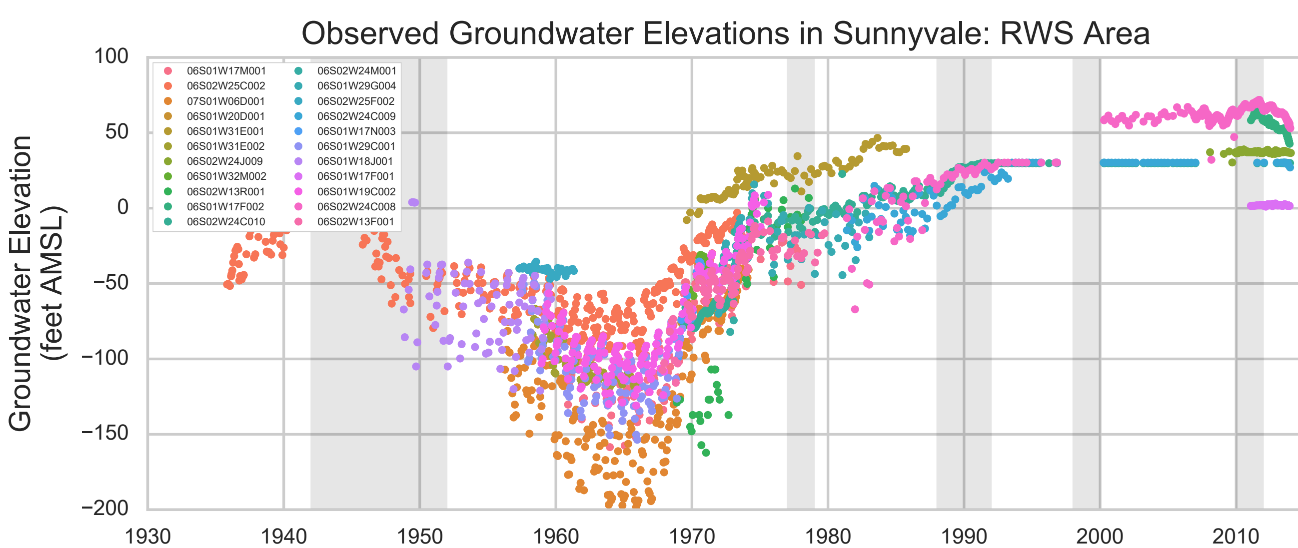
Pumping Area: Sunnyvale: RWS
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

DRAFT - SUBJECT TO CHANGE





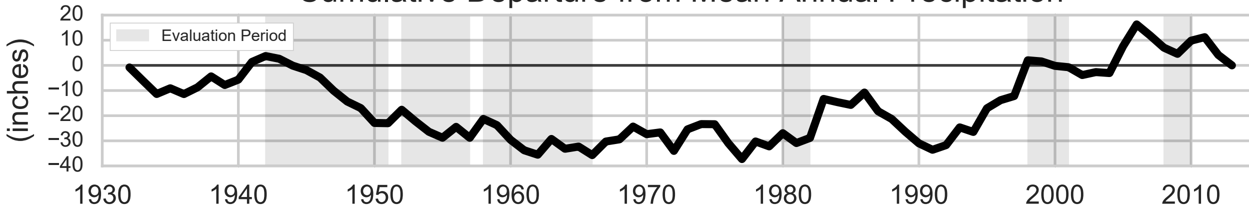




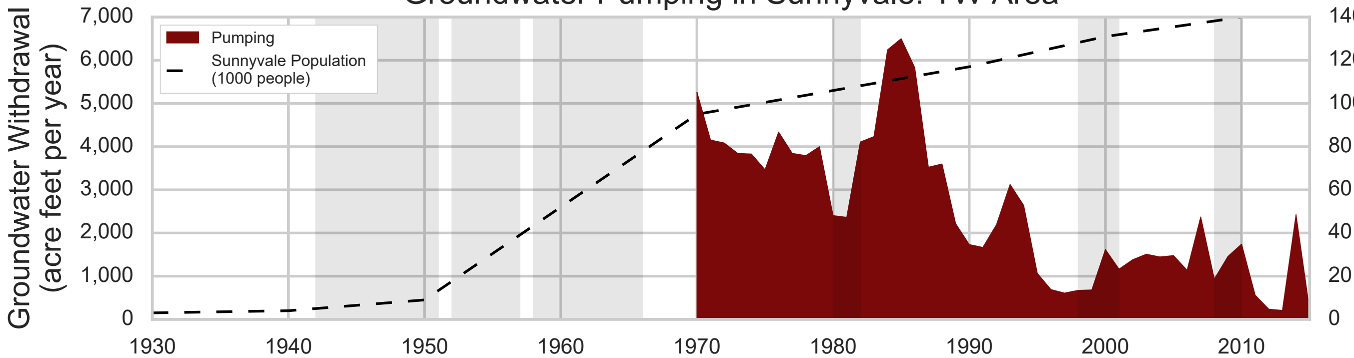
Pumping Area: Sunnyvale: TW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

DRAFT - SUBJECT TO CHANGE

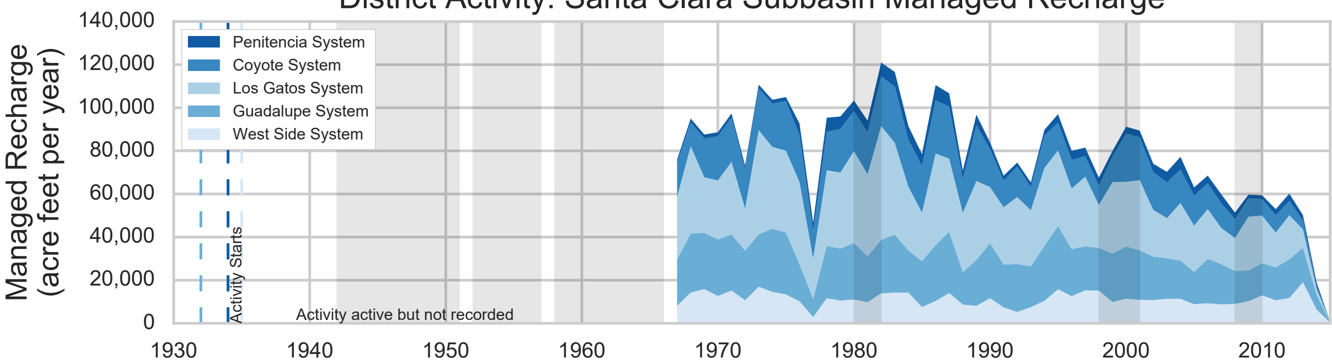
Cumulative Departure from Mean Annual Precipitation



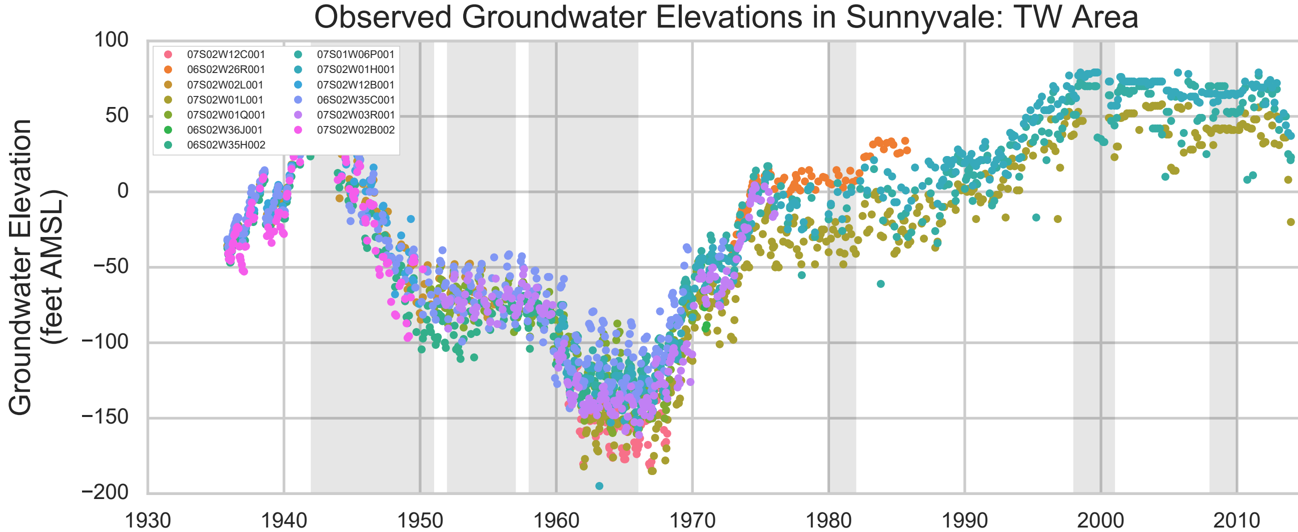
Groundwater Pumping in Sunnyvale: TW Area



District Activity: Santa Clara Subbasin Managed Recharge



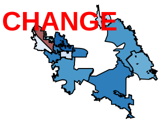
Observed Groundwater Elevations in Sunnyvale: TW Area

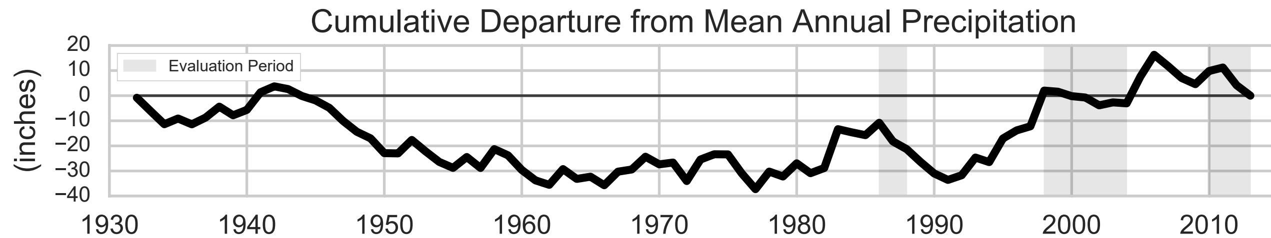


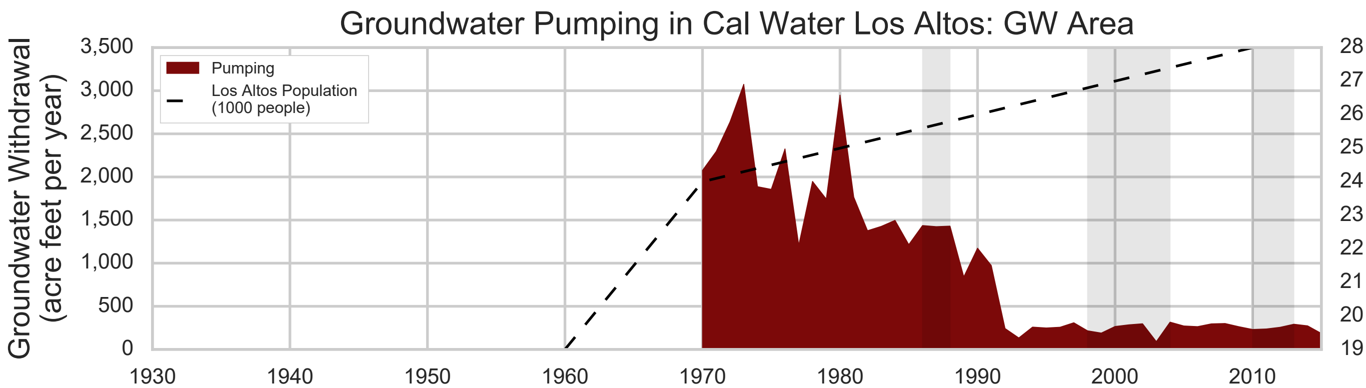
APPENDIX D: Groundwater Level Trends in Monitoring Wells to Evaluate Benefits from Treated Water Deliveries

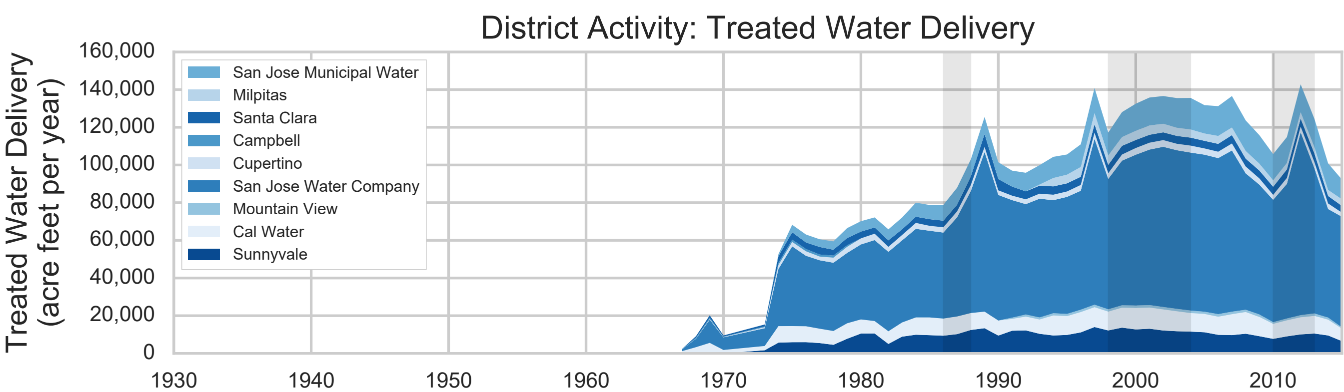
Pumping Area: Cal Water Los Altos: GW
Activity: Treated Water Delivery
Groundwater Level Data from: Monitoring Wells

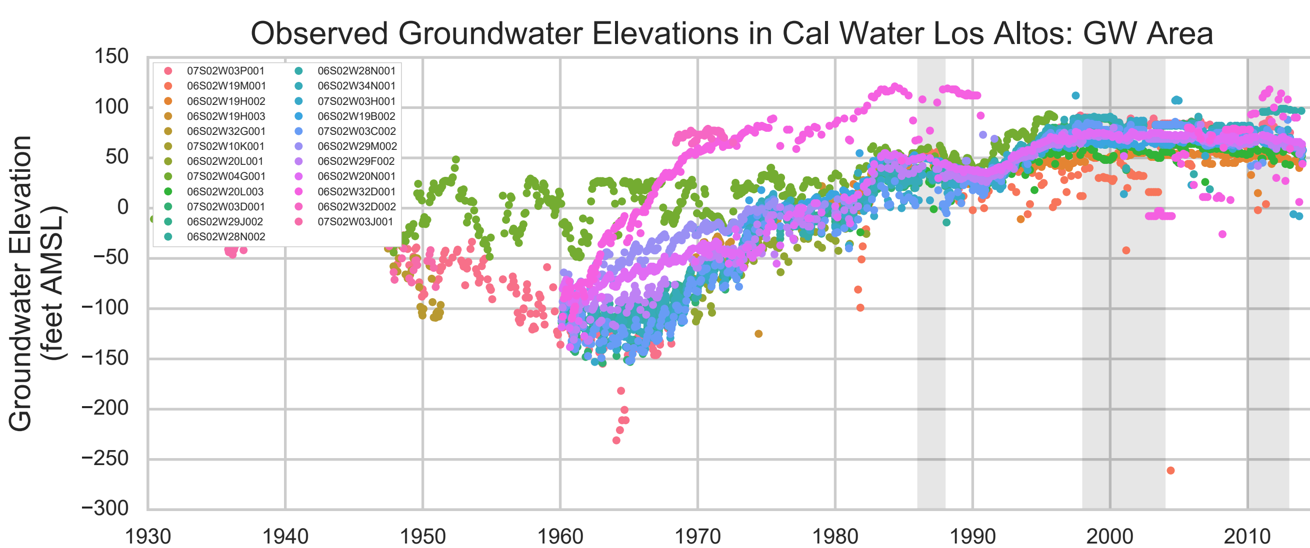
DRAFT - SUBJECT TO CHANGE





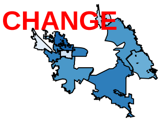


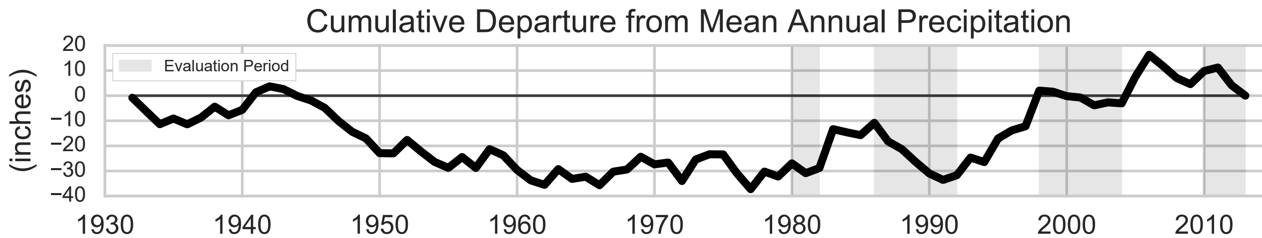


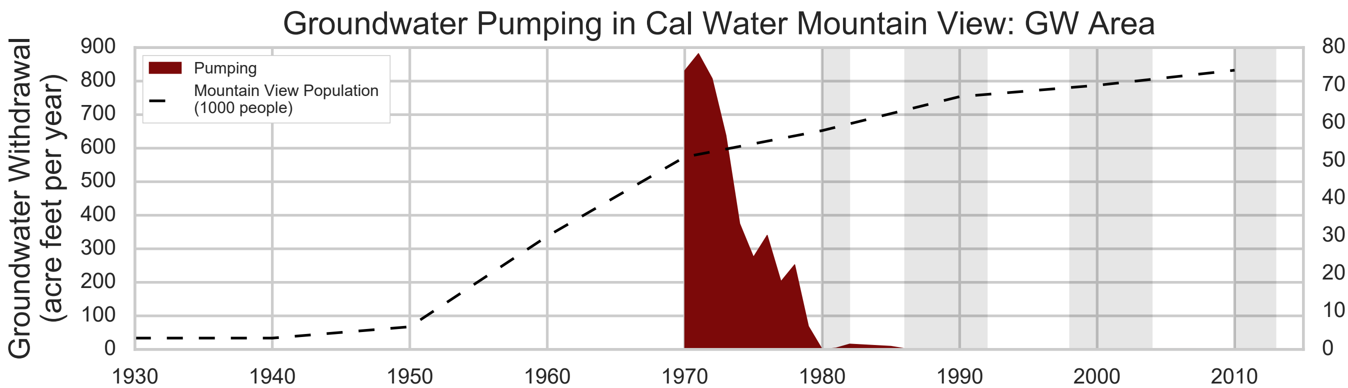


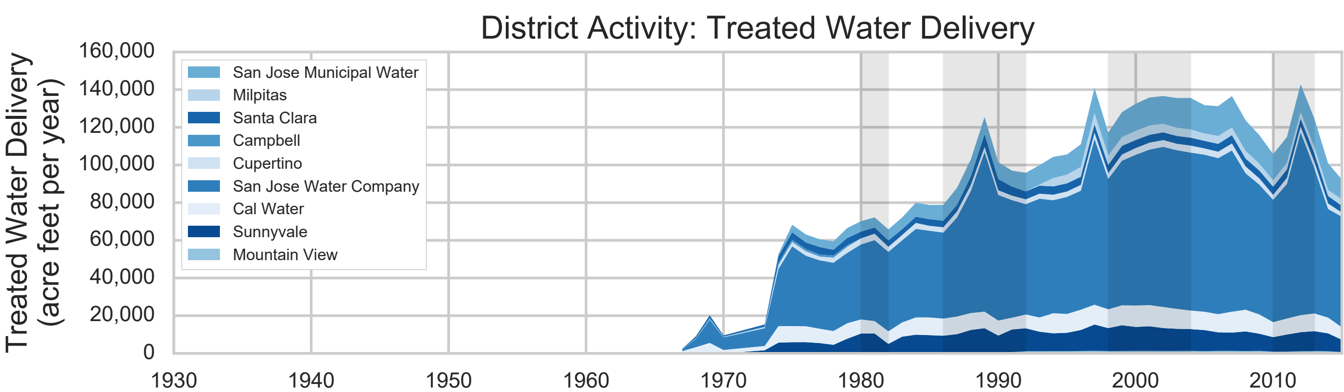
Pumping Area: Cal Water Mountain View: GW
Activity: Treated Water Delivery
Groundwater Level Data from: Monitoring Wells

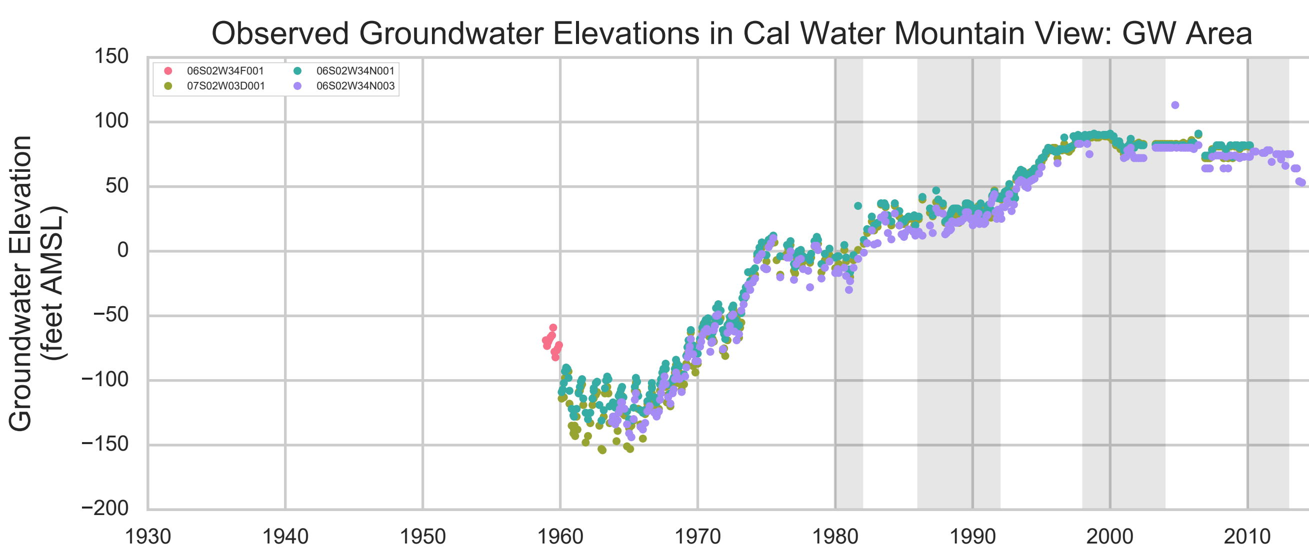
DRAFT - SUBJECT TO CHANGE





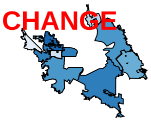


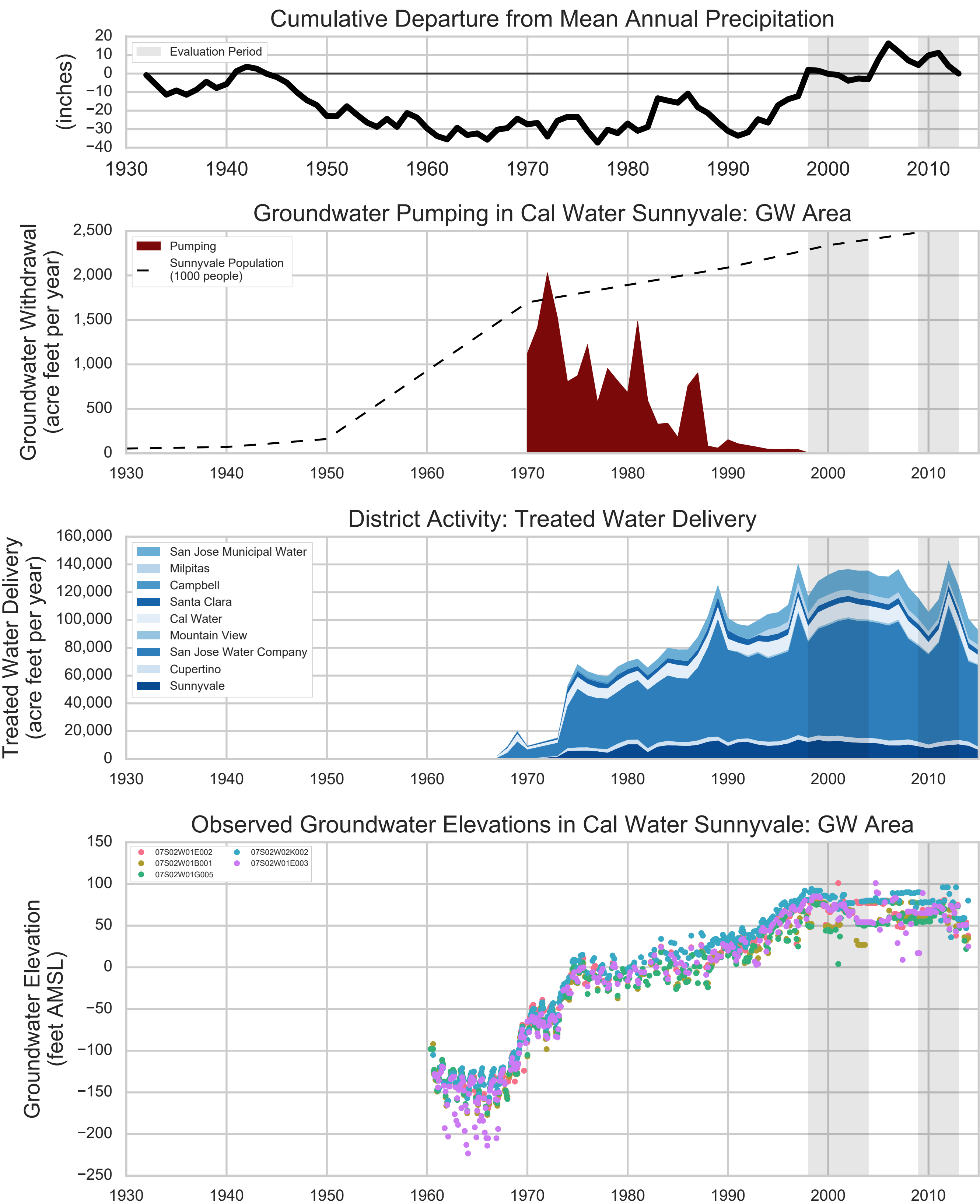




Pumping Area: Cal Water Sunnyvale: GW
Activity: Treated Water Delivery
Groundwater Level Data from: Monitoring Wells

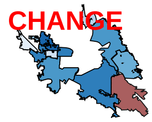
DRAFT - SUBJECT TO CHANGE

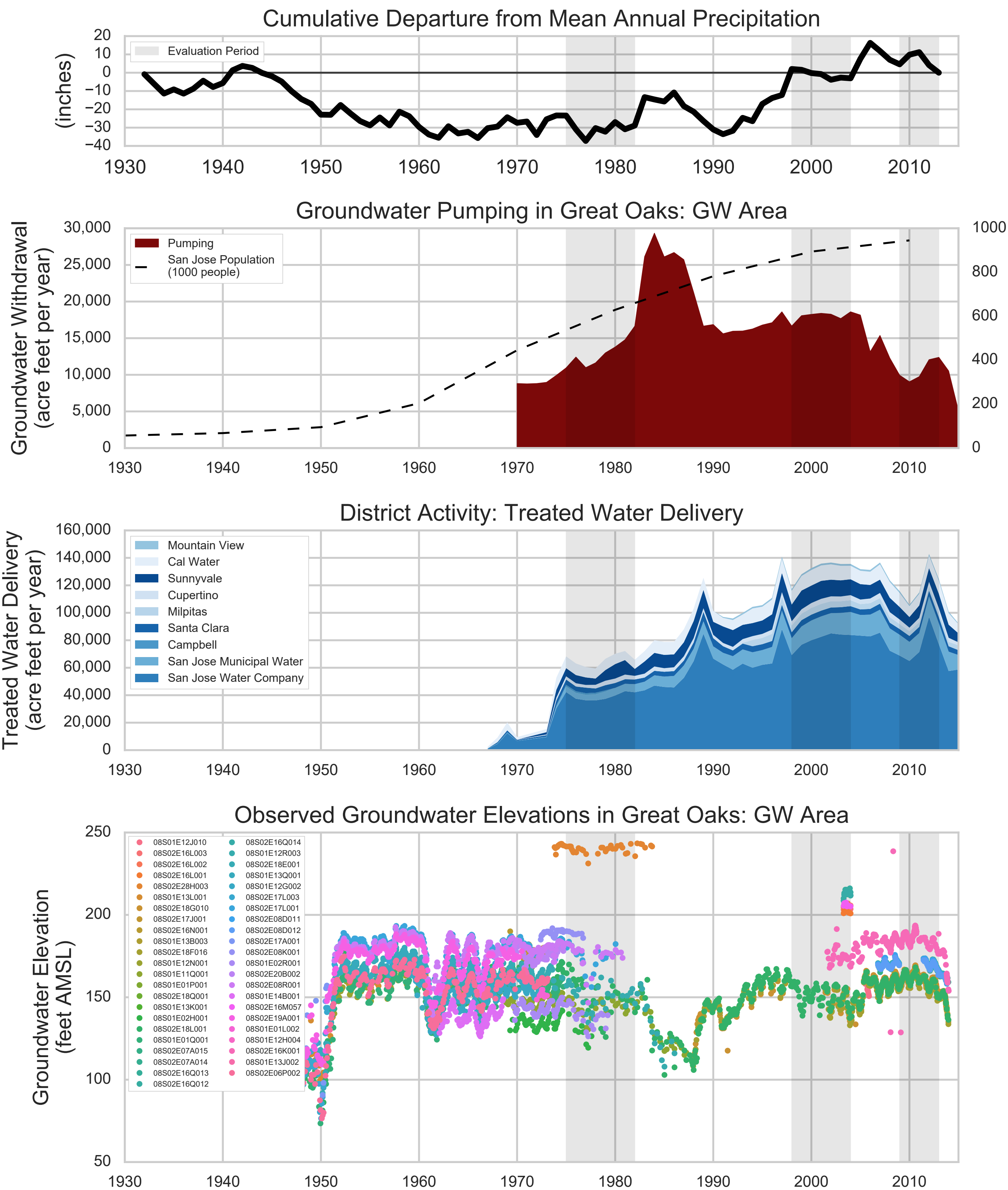




Pumping Area: Great Oaks: GW
Activity: Treated Water Delivery
Groundwater Level Data from: Monitoring Wells

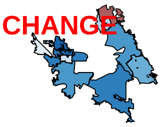
DRAFT - SUBJECT TO CHANGE



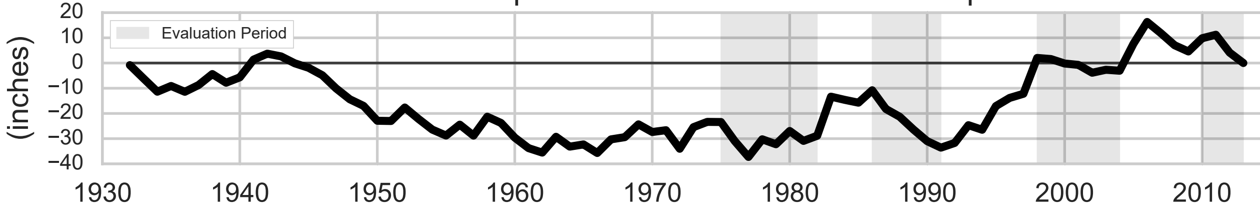


Pumping Area: Milpitas: RWS
Activity: Treated Water Delivery
Groundwater Level Data from: Monitoring Wells

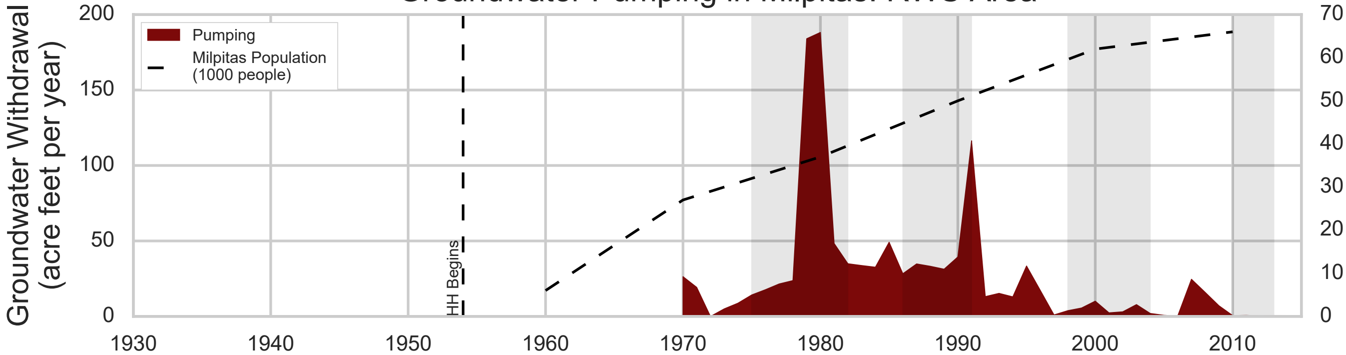
DRAFT - SUBJECT TO CHANGE



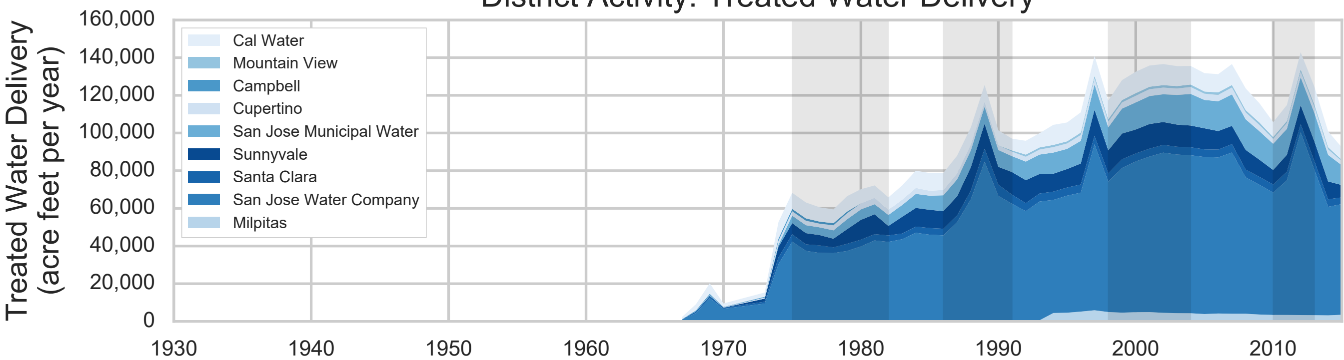
Cumulative Departure from Mean Annual Precipitation



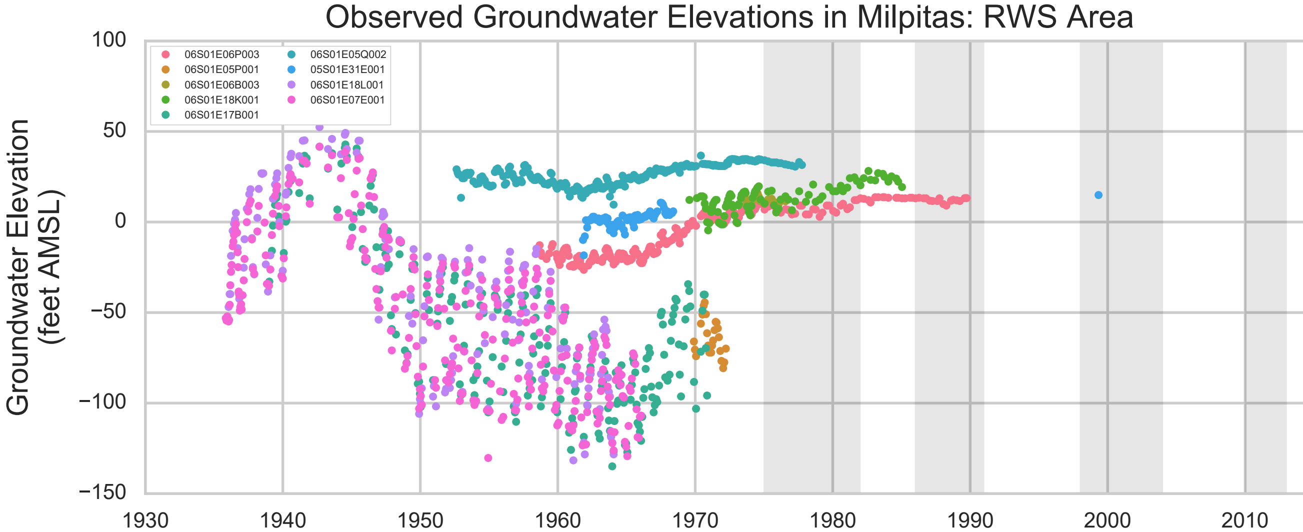
Groundwater Pumping in Milpitas: RWS Area



District Activity: Treated Water Delivery

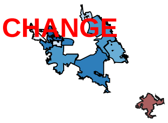


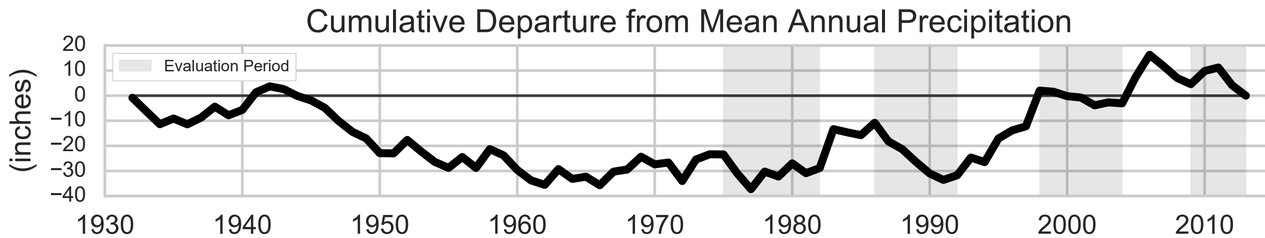
Observed Groundwater Elevations in Milpitas: RWS Area

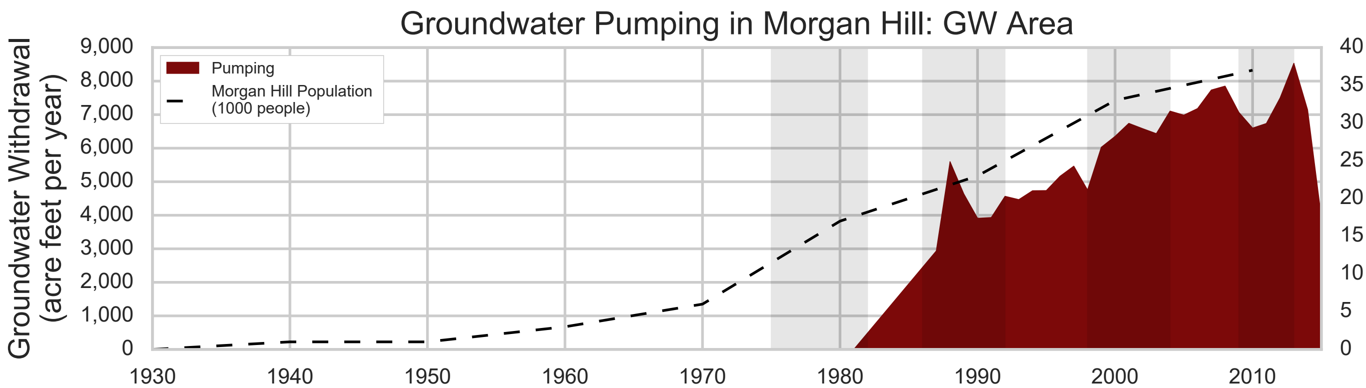


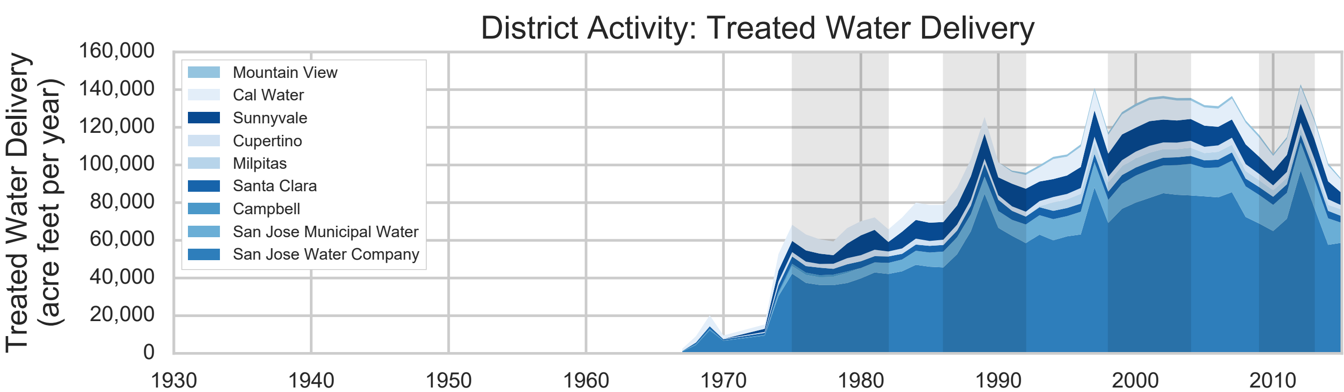
Pumping Area: Morgan Hill: GW
Activity: Treated Water Delivery
Groundwater Level Data from: Monitoring Wells

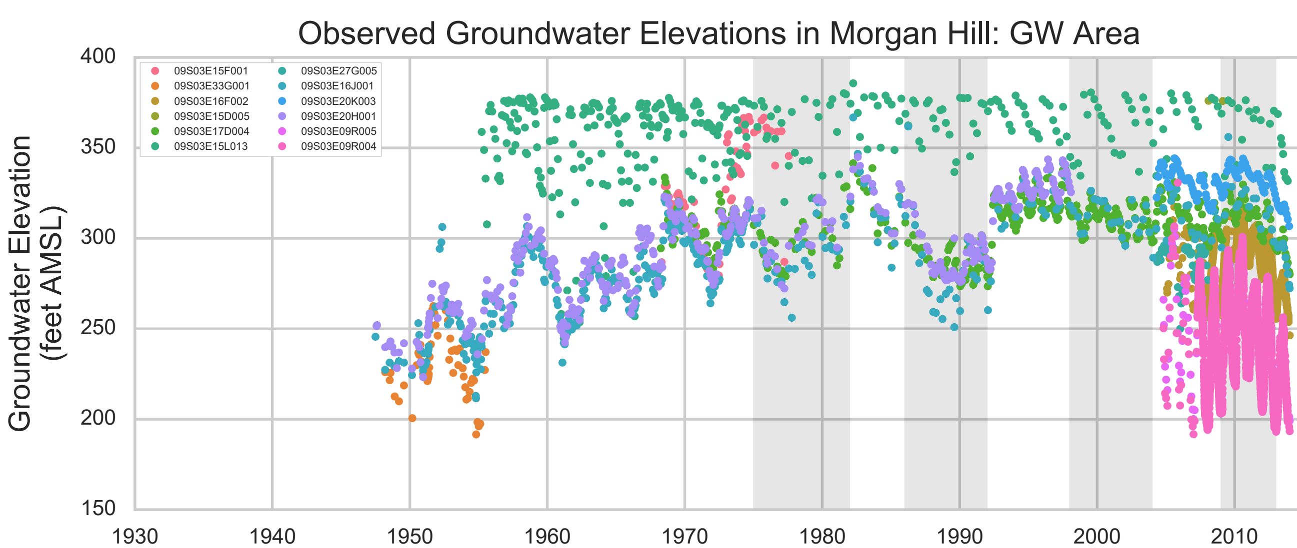
DRAFT - SUBJECT TO CHANGE





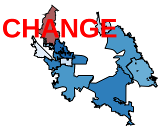


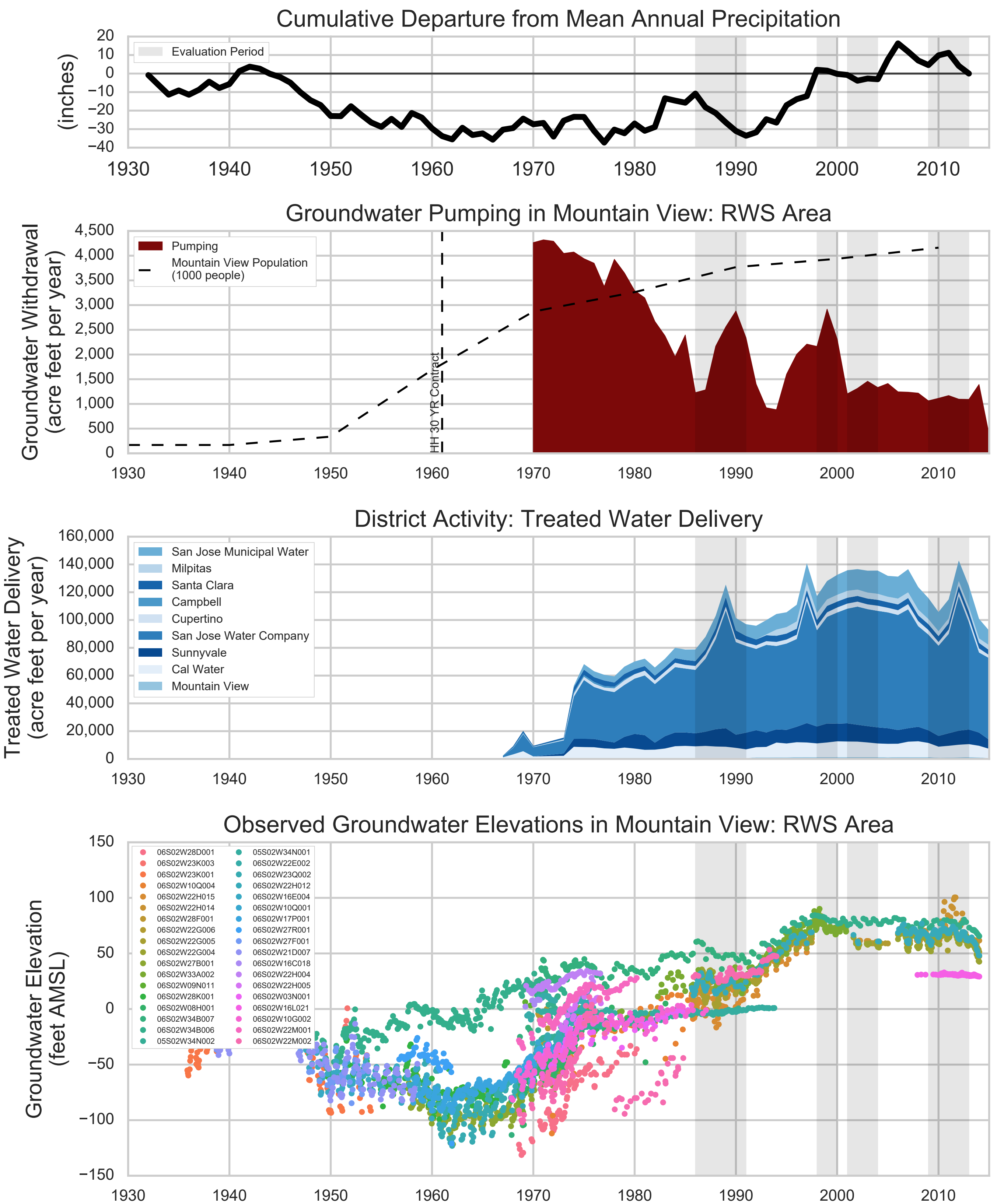




Pumping Area: Mountain View: RWS
Activity: Treated Water Delivery
Groundwater Level Data from: Monitoring Wells

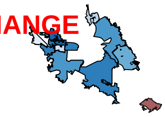
DRAFT - SUBJECT TO CHANGE

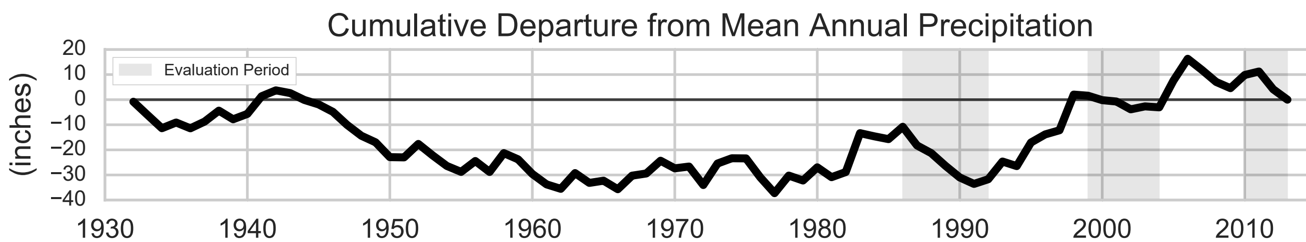


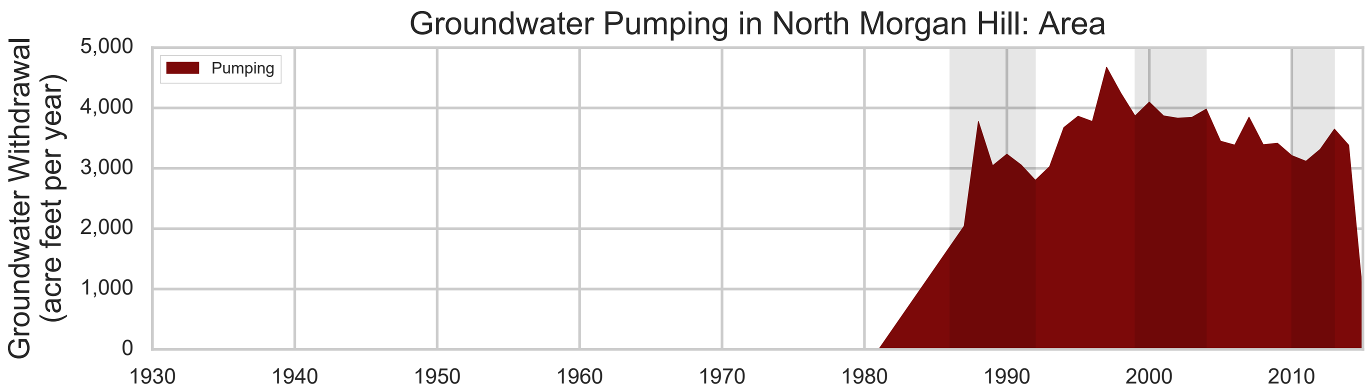


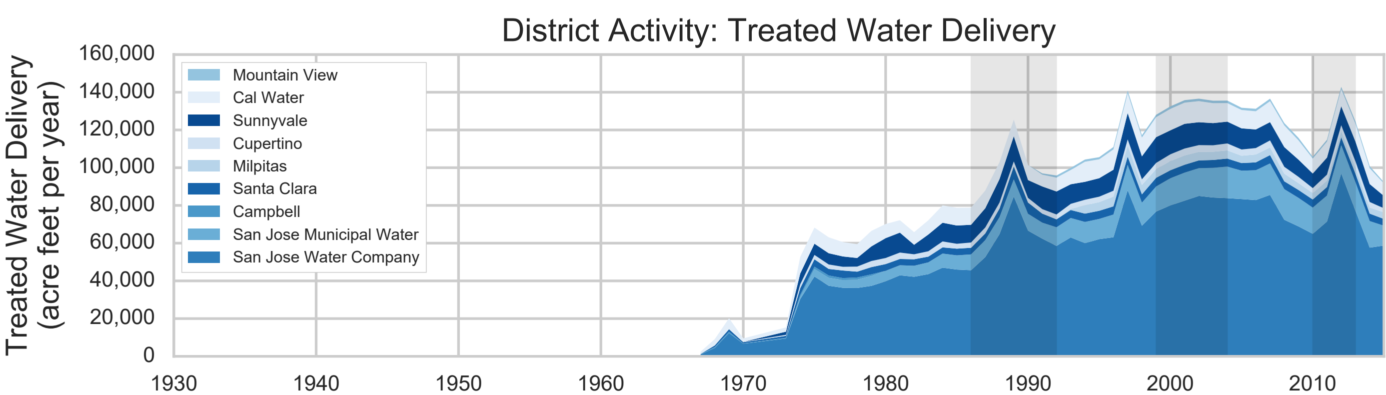
Pumping Area: North Morgan Hill:
Activity: Treated Water Delivery
Groundwater Level Data from: Monitoring Wells

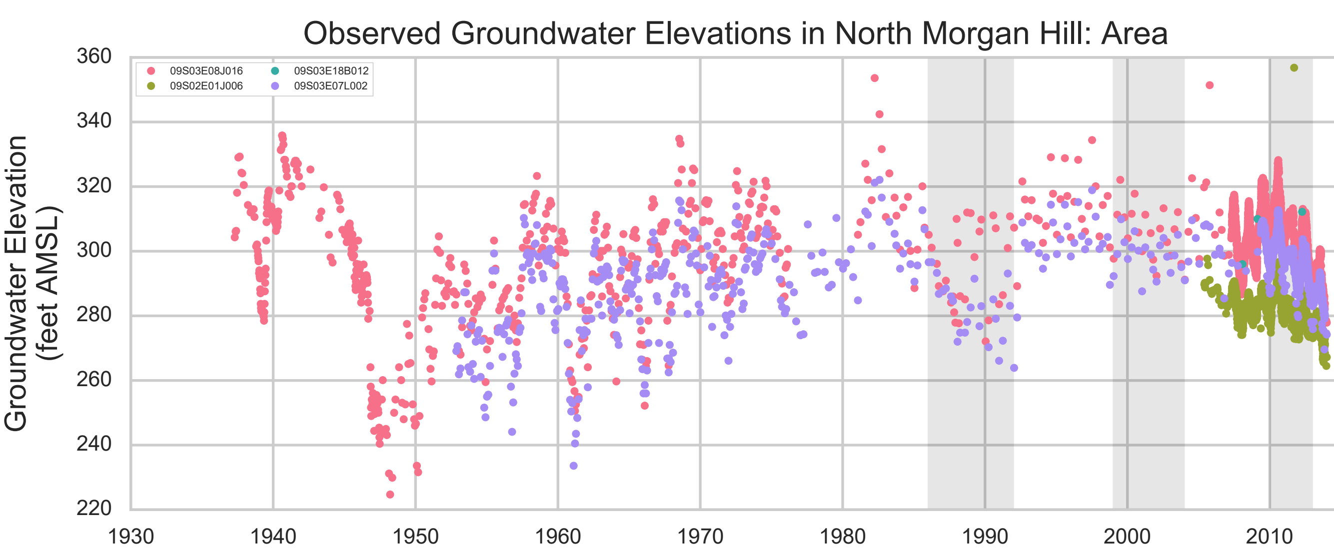
DRAFT - SUBJECT TO CHANGE





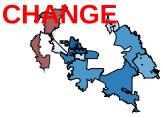


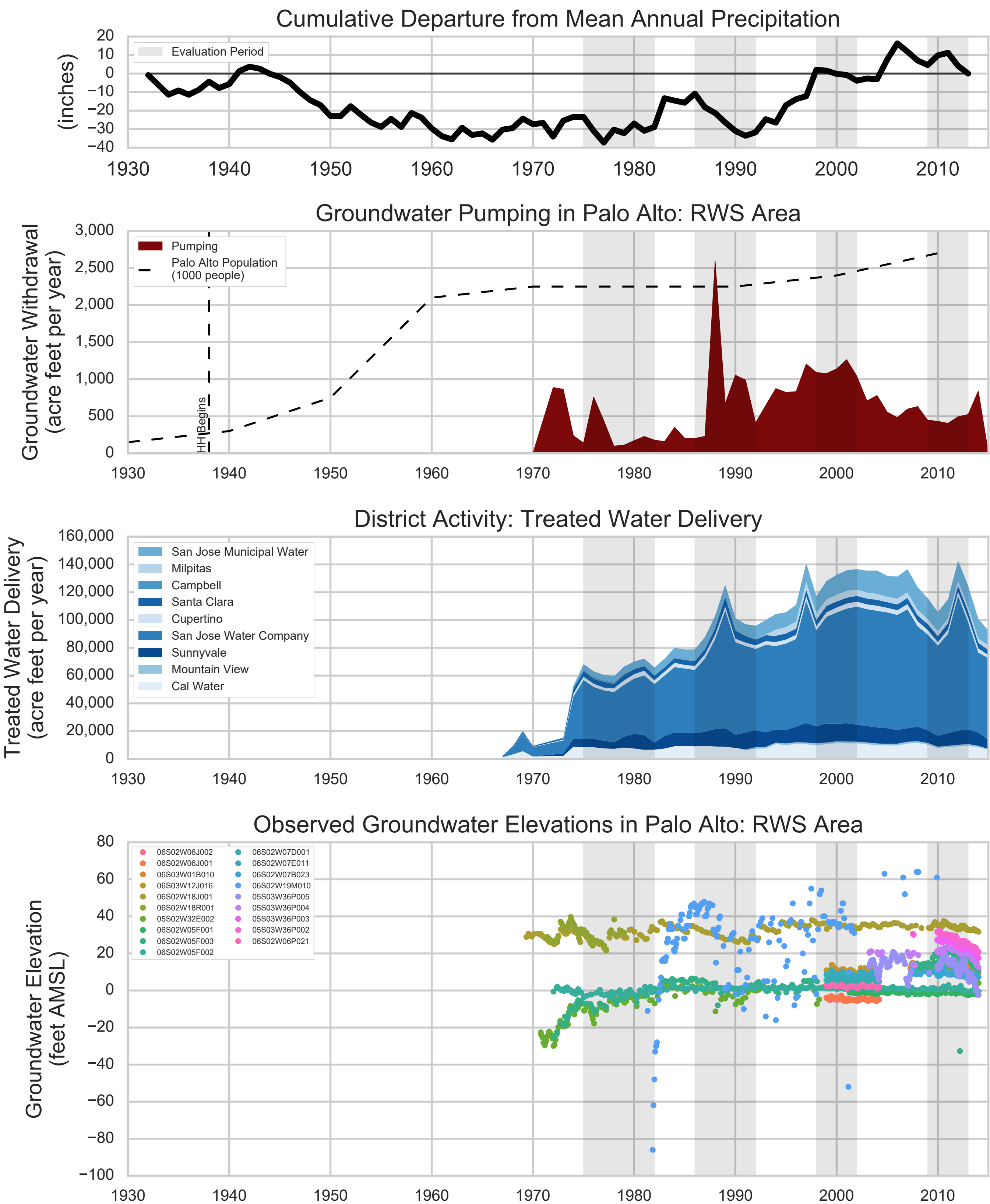




Pumping Area: Palo Alto: RWS
Activity: Treated Water Delivery
Groundwater Level Data from: Monitoring Wells

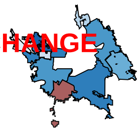
DRAFT - SUBJECT TO CHANGE

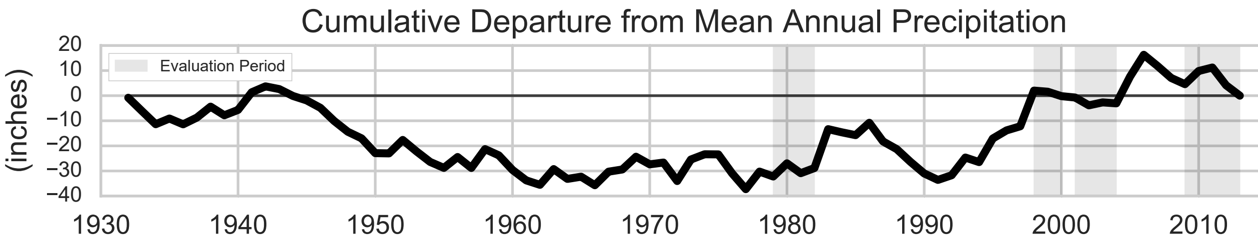


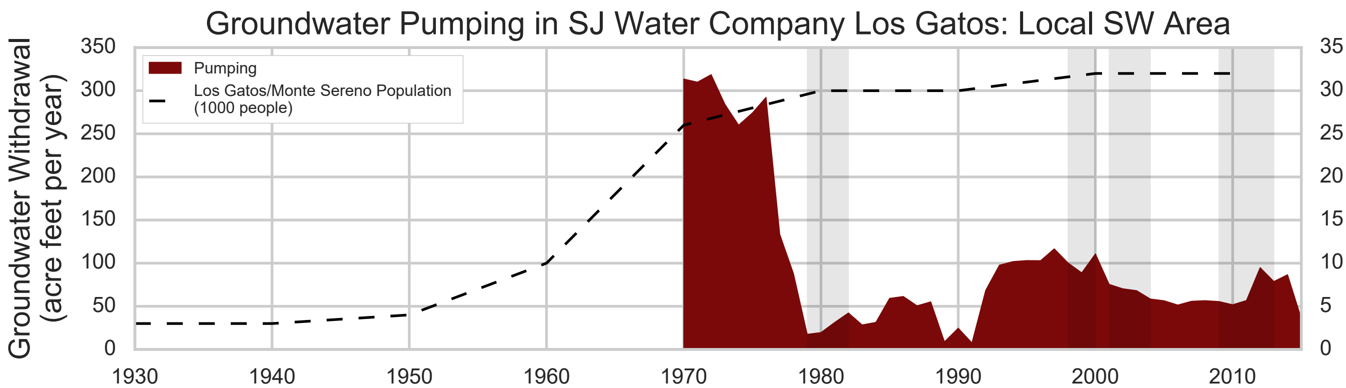


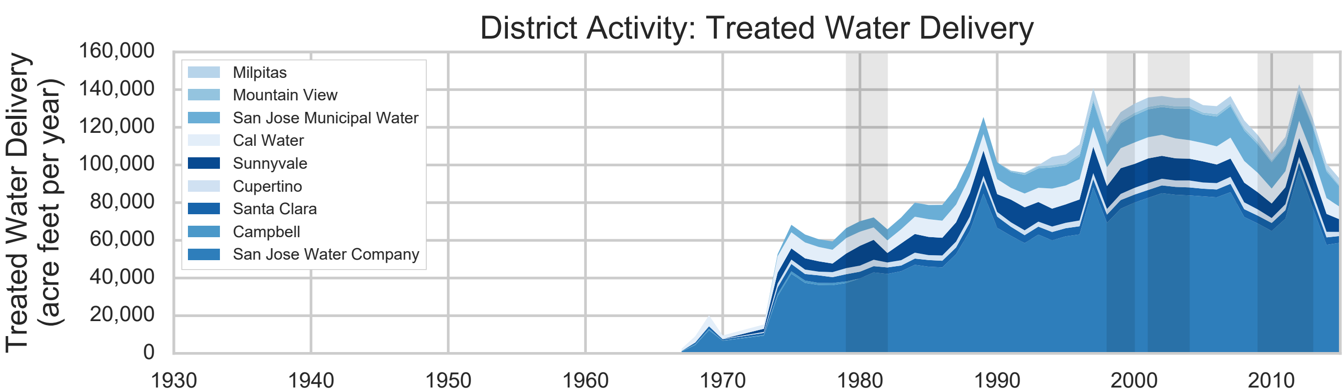
Pumping Area: SJ Water Company Los Gatos: Local SW
Activity: Treated Water Delivery
Groundwater Level Data from: Monitoring Wells

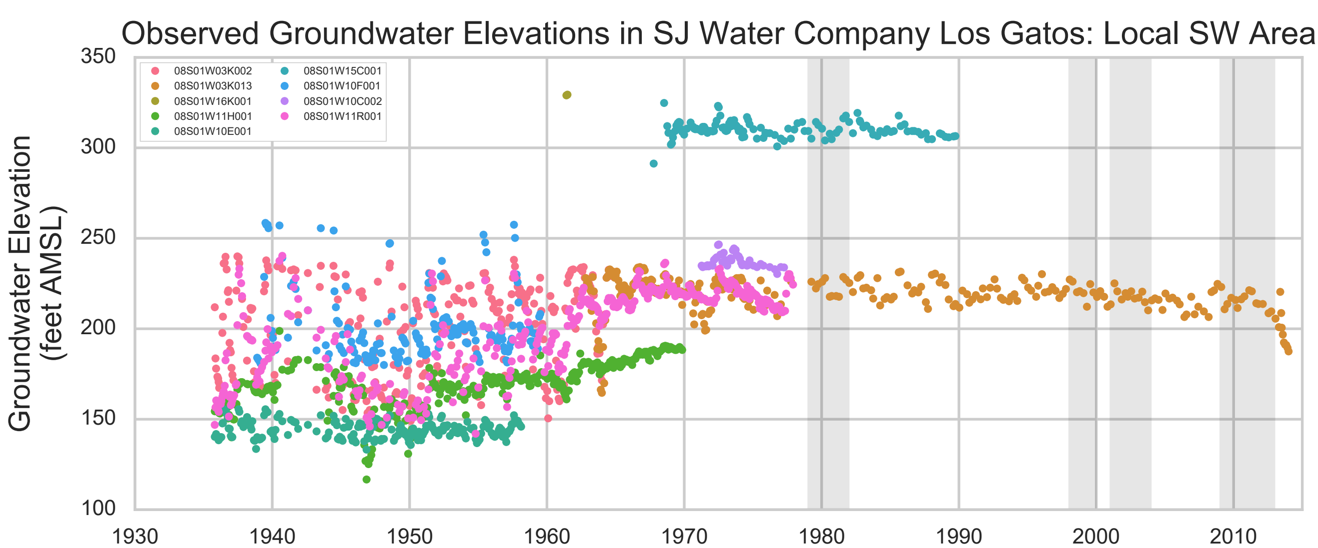
DRAFT - SUBJECT TO CHANGE





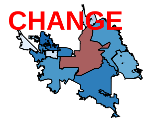


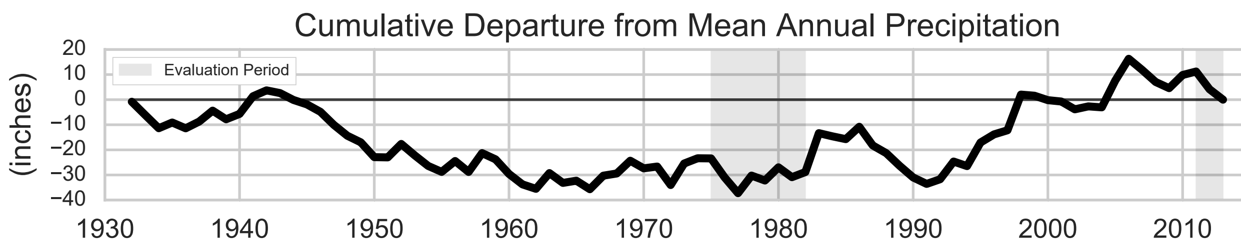


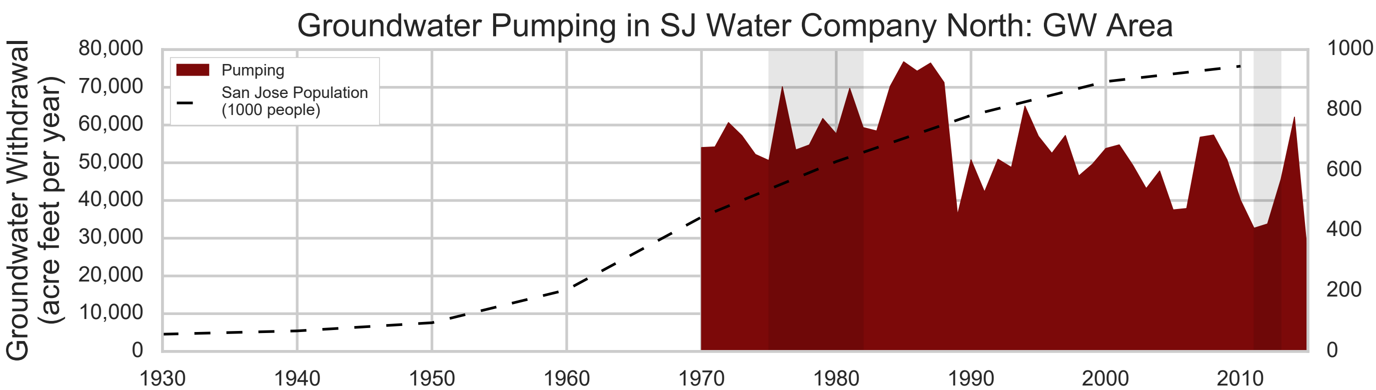


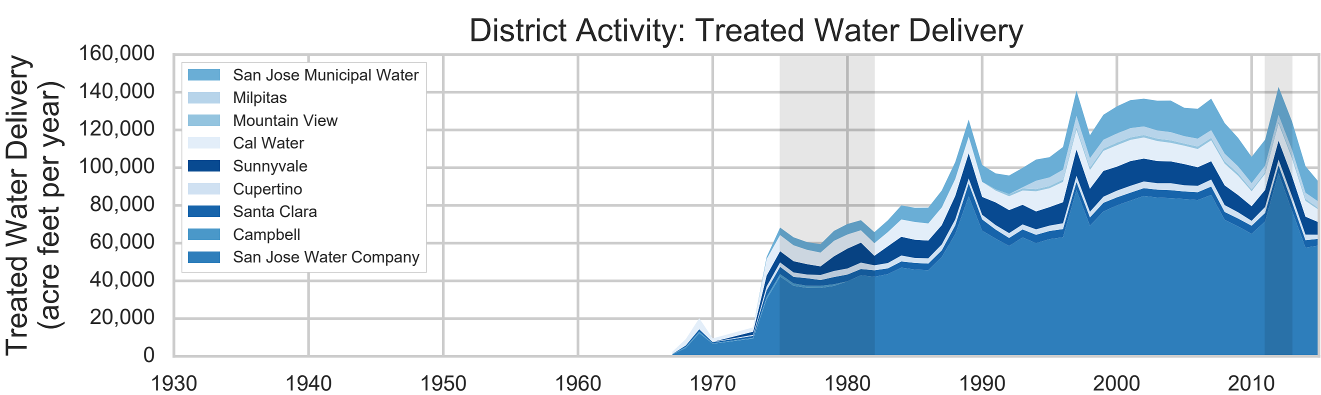
Pumping Area: SJ Water Company North: GW
Activity: Treated Water Delivery
Groundwater Level Data from: Monitoring Wells

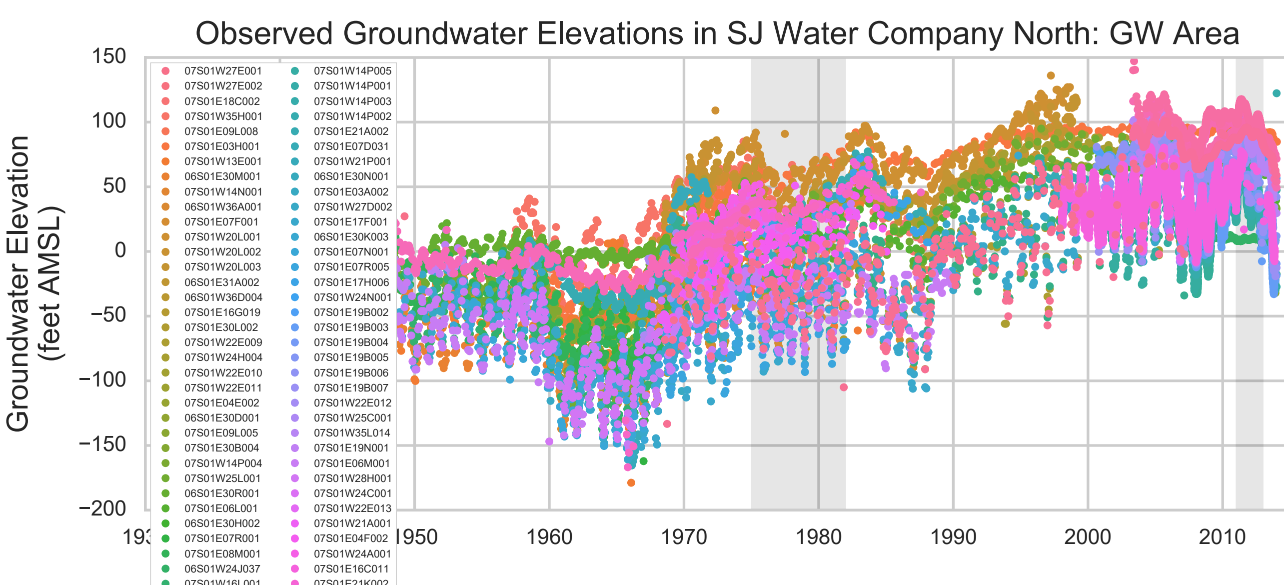
DRAFT - SUBJECT TO CHANGE





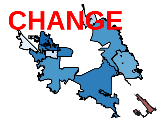


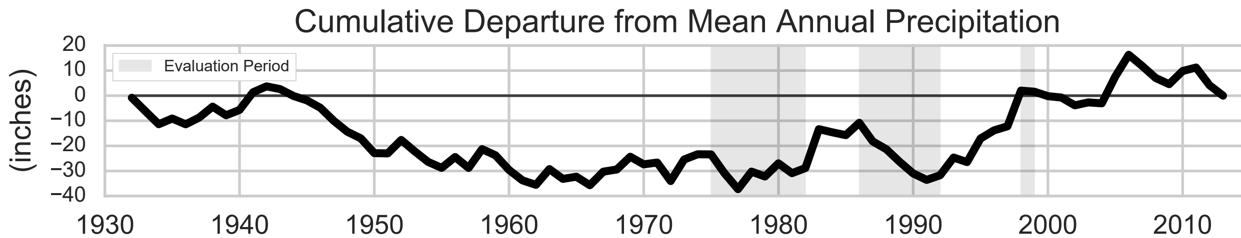


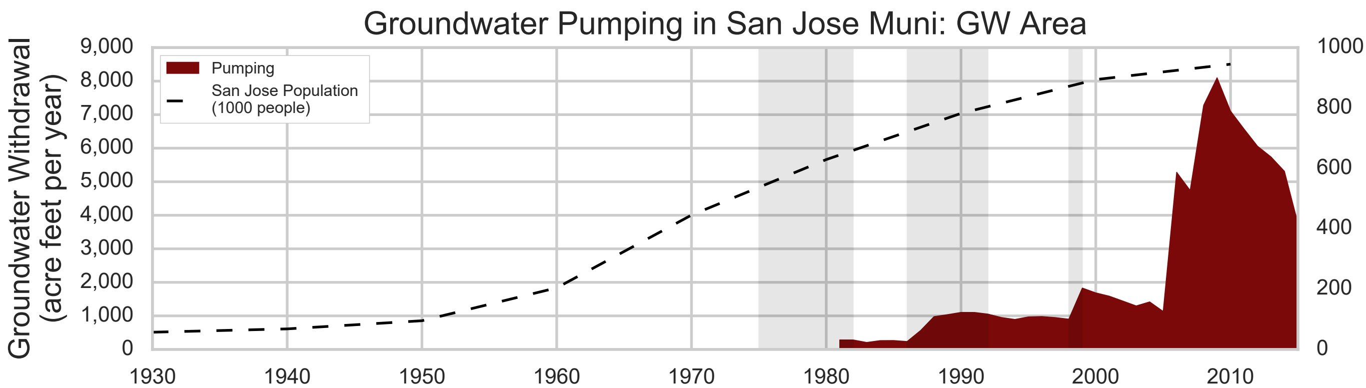


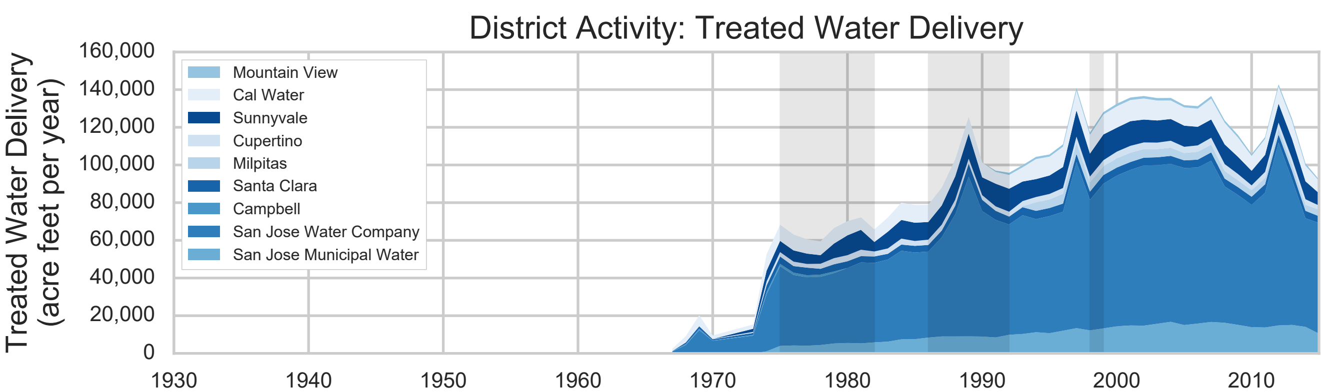
Pumping Area: San Jose Muni: GW
Activity: Treated Water Delivery
Groundwater Level Data from: Monitoring Wells

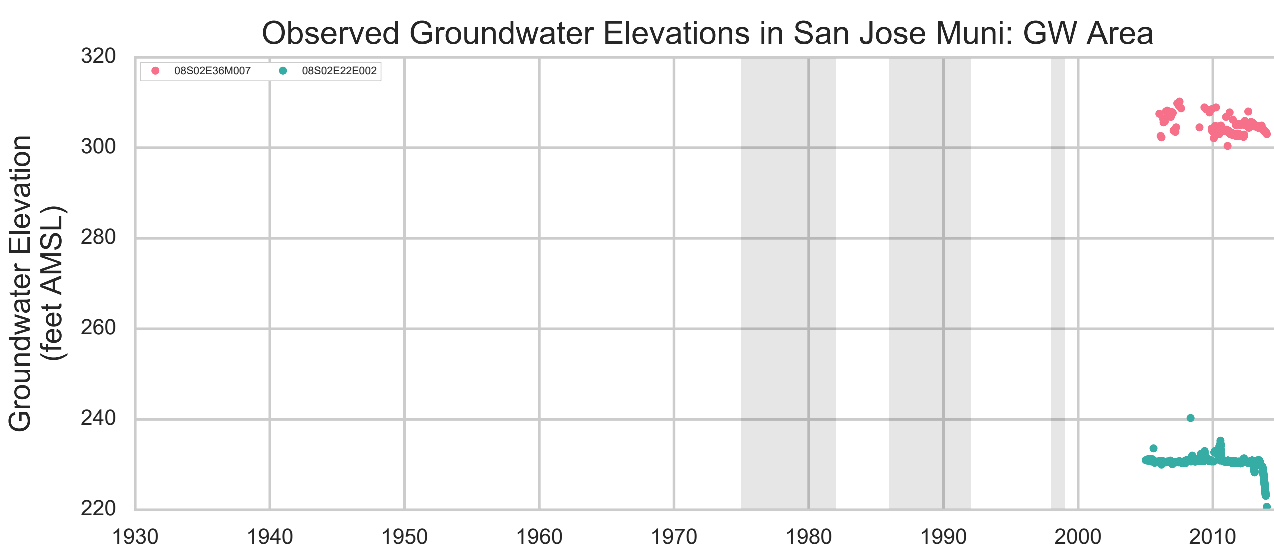
DRAFT - SUBJECT TO CHANGE





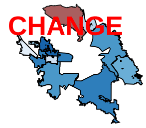


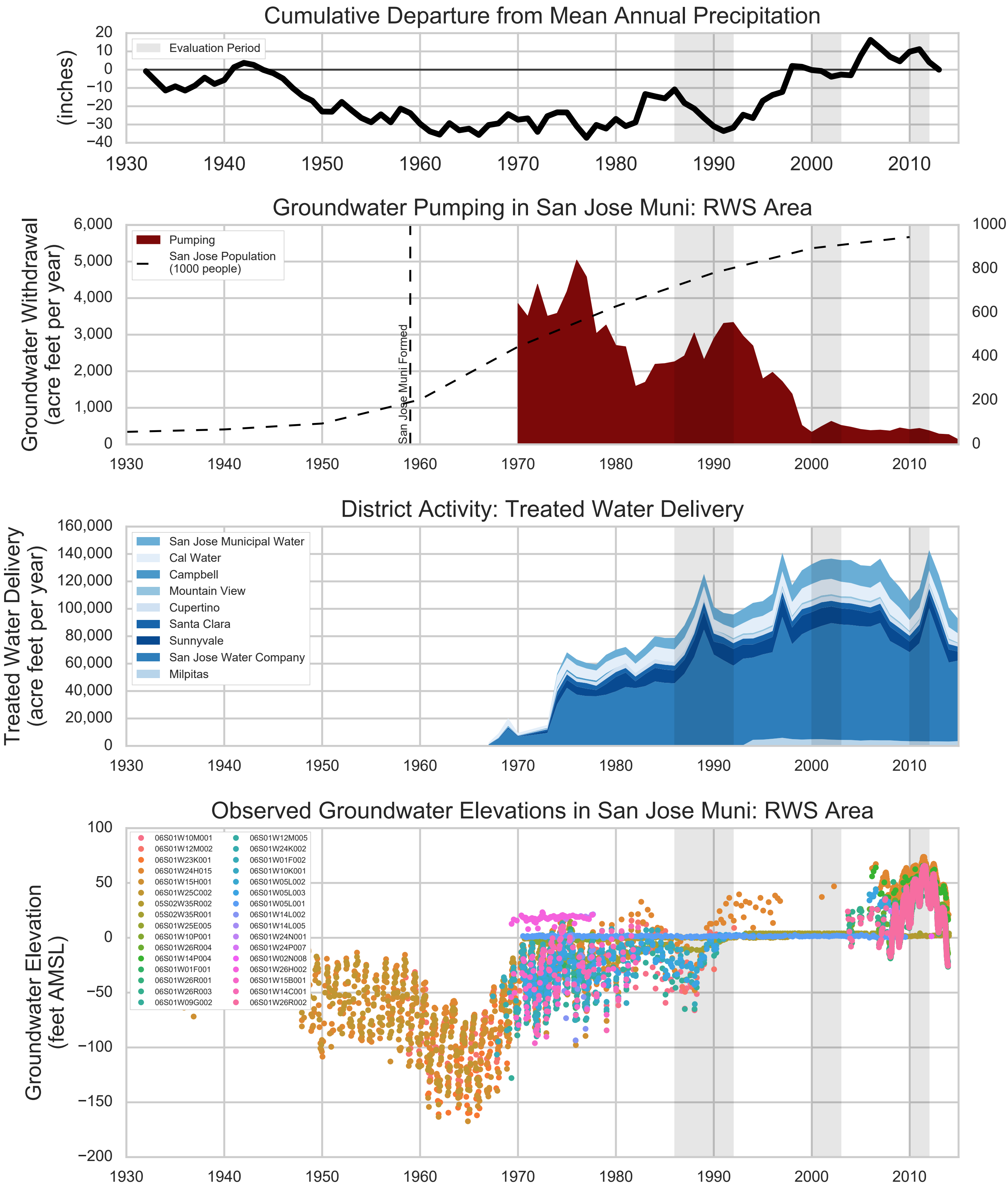




Pumping Area: San Jose Muni: RWS
Activity: Treated Water Delivery
Groundwater Level Data from: Monitoring Wells

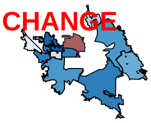
DRAFT - SUBJECT TO CHANGE

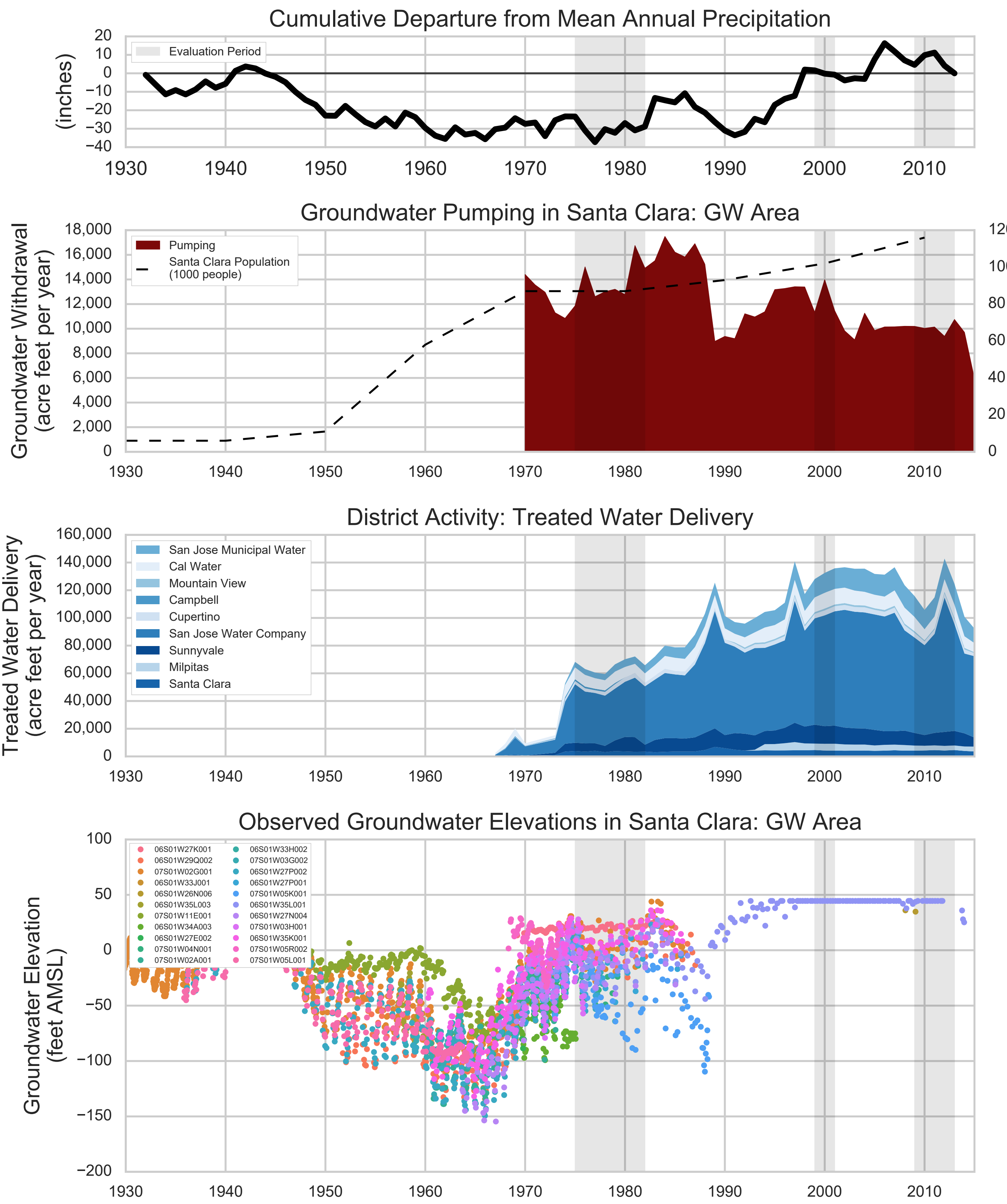




Pumping Area: Santa Clara: GW
Activity: Treated Water Delivery
Groundwater Level Data from: Monitoring Wells

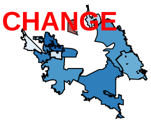
DRAFT - SUBJECT TO CHANGE

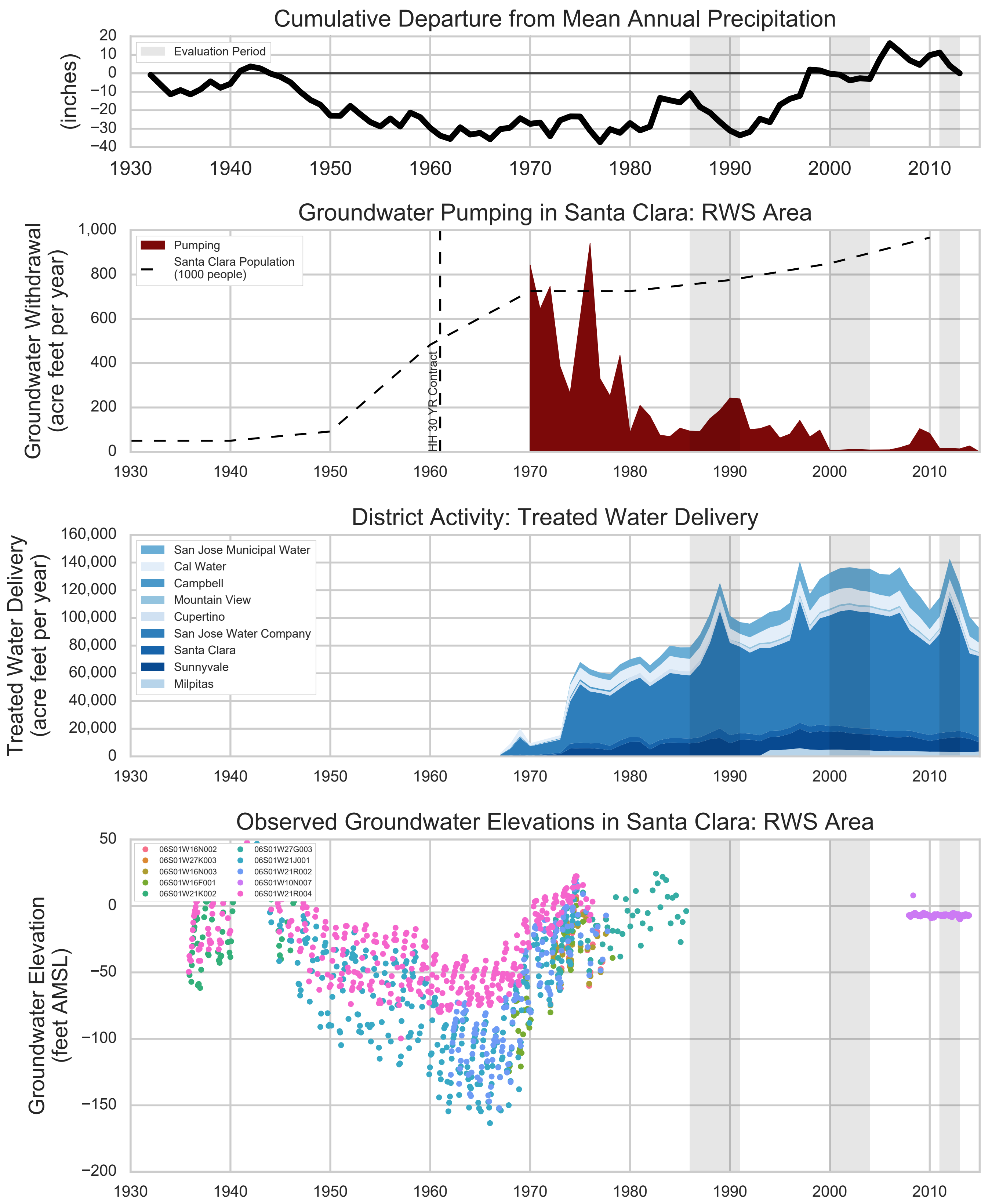




Pumping Area: Santa Clara: RWS
Activity: Treated Water Delivery
Groundwater Level Data from: Monitoring Wells

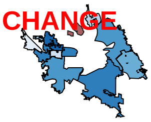
DRAFT - SUBJECT TO CHANGE

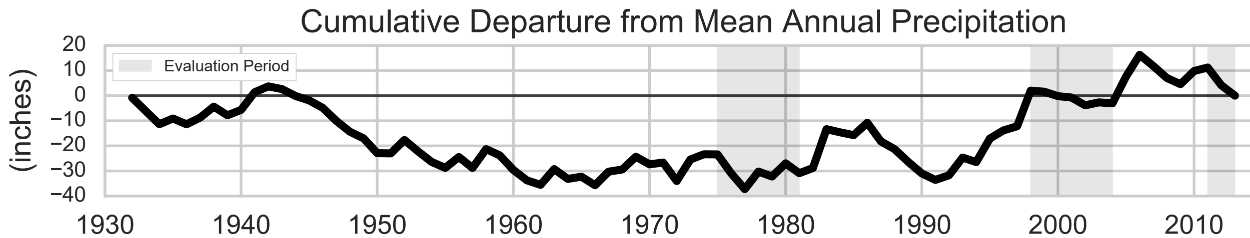


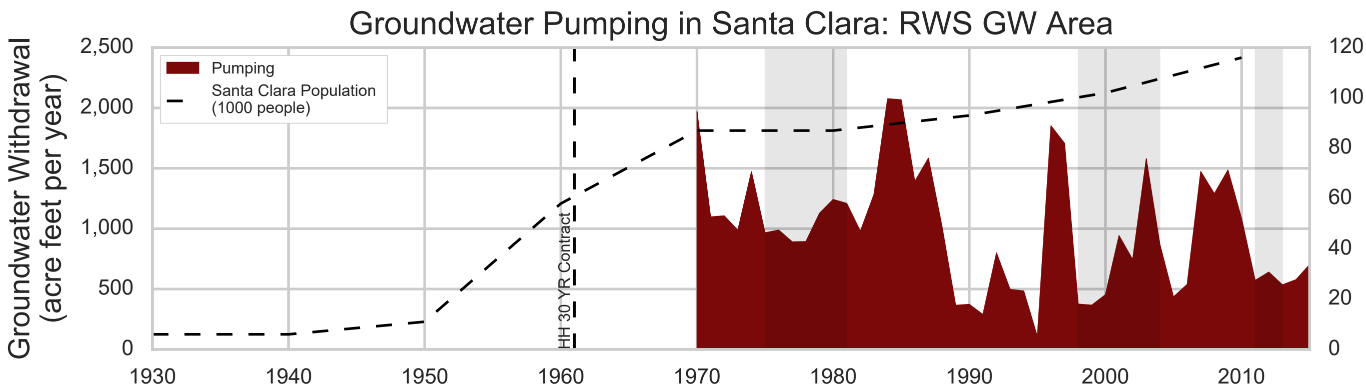


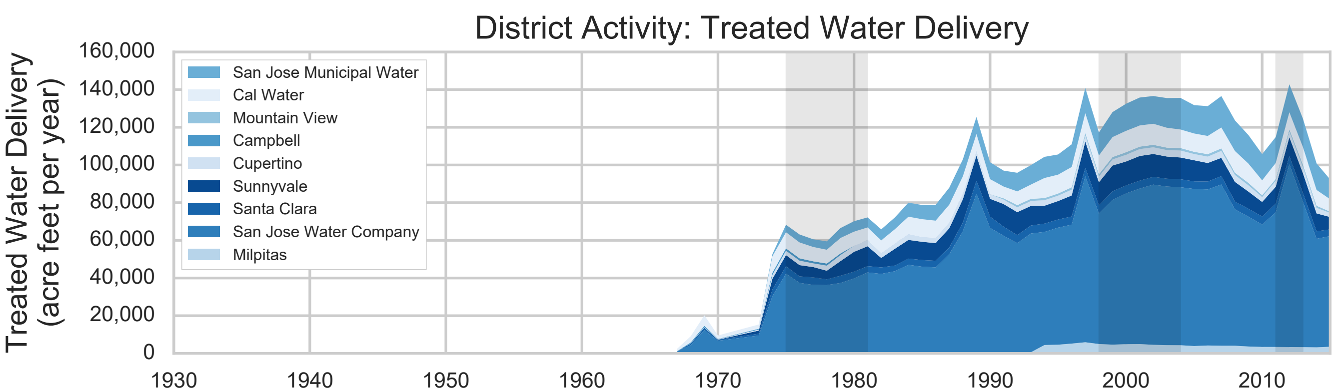
Pumping Area: Santa Clara: RWS GW
Activity: Treated Water Delivery
Groundwater Level Data from: Monitoring Wells

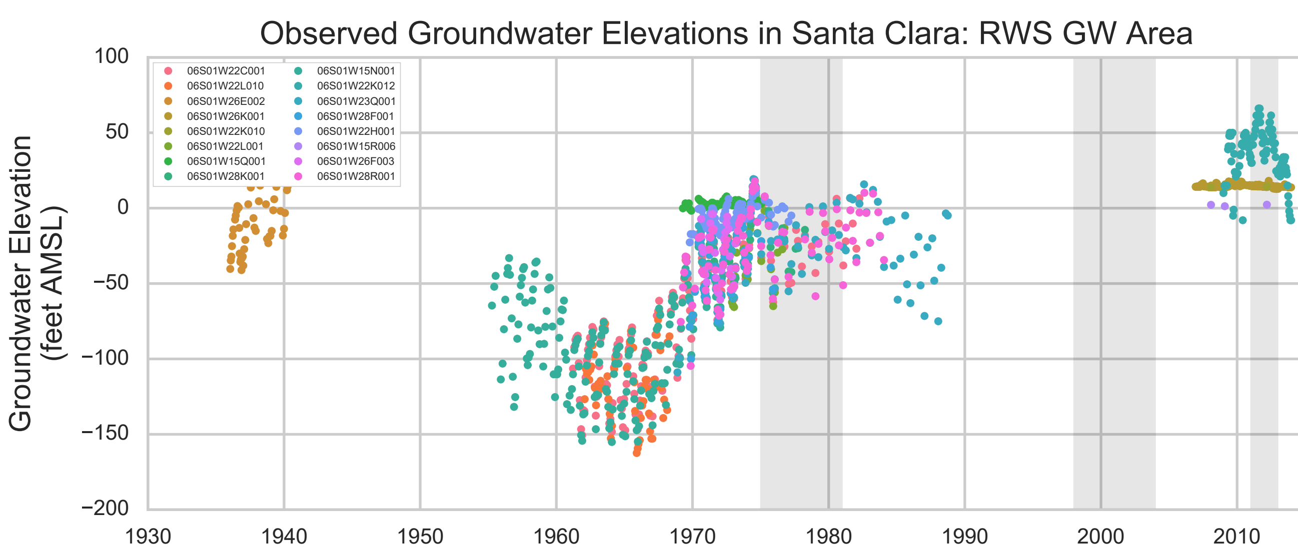
DRAFT - SUBJECT TO CHANGE





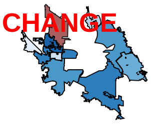


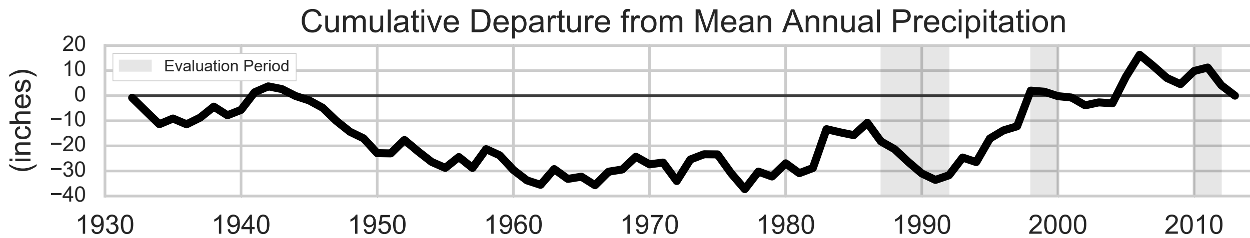


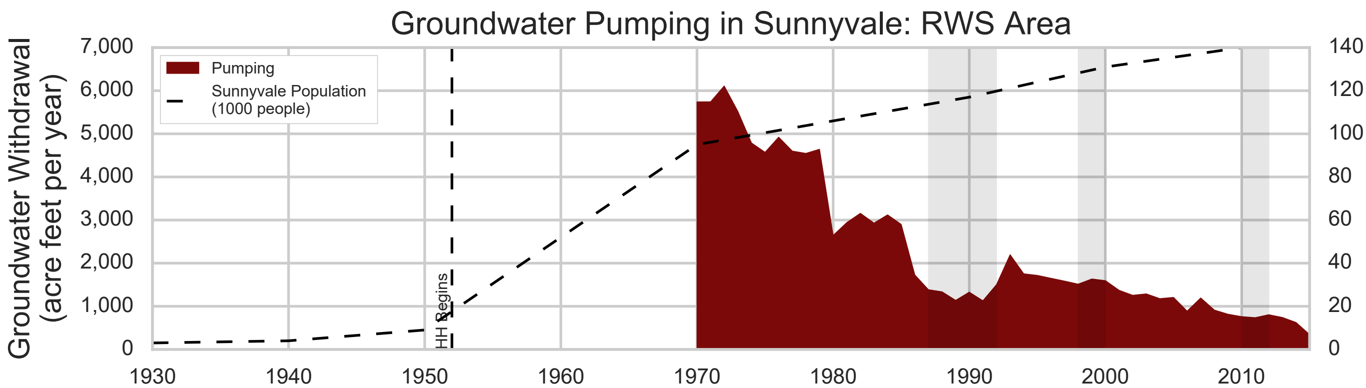


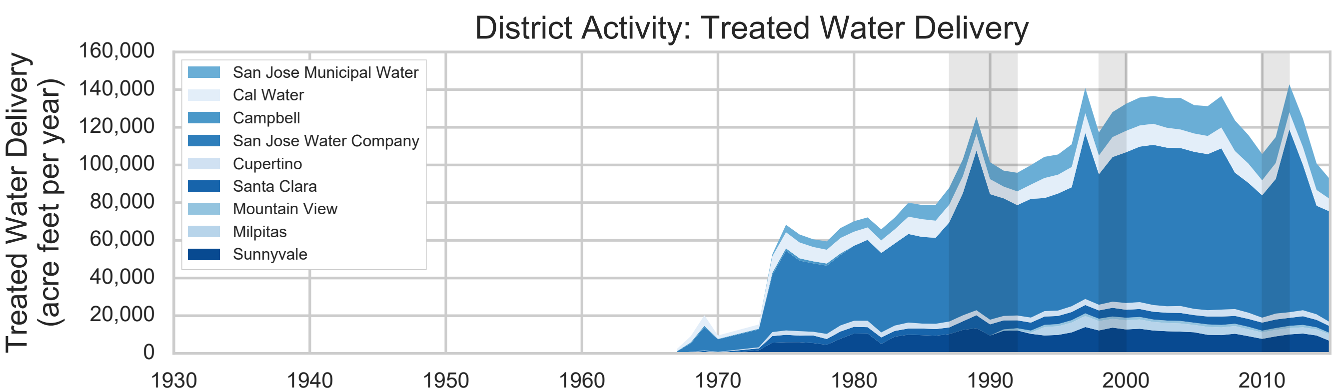
Pumping Area: Sunnyvale: RWS
Activity: Treated Water Delivery
Groundwater Level Data from: Monitoring Wells

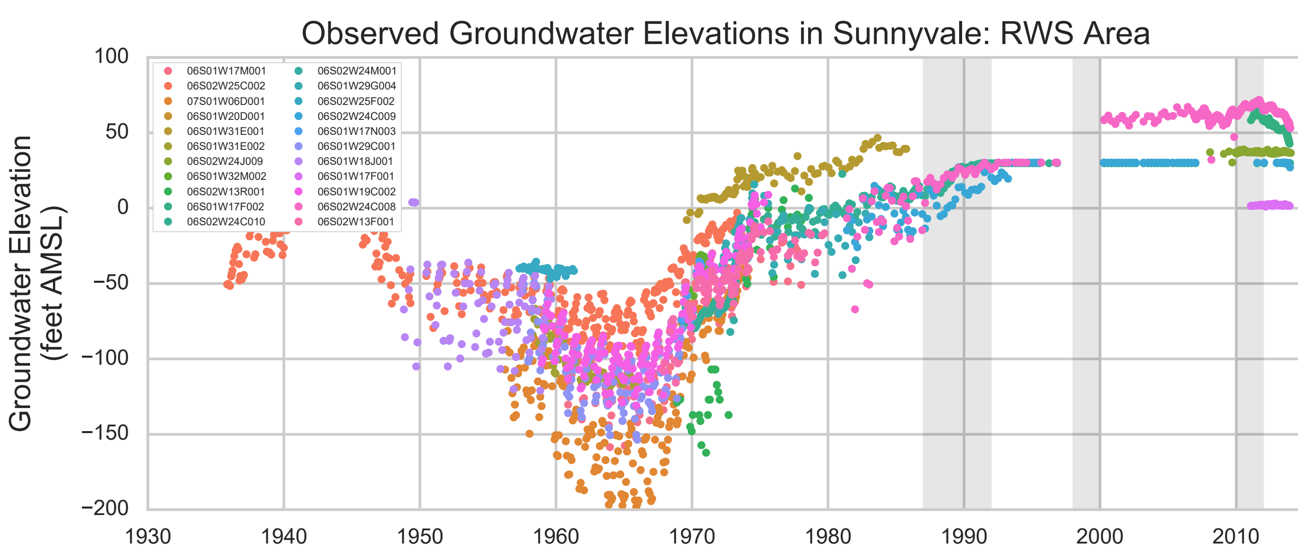
DRAFT - SUBJECT TO CHANGE







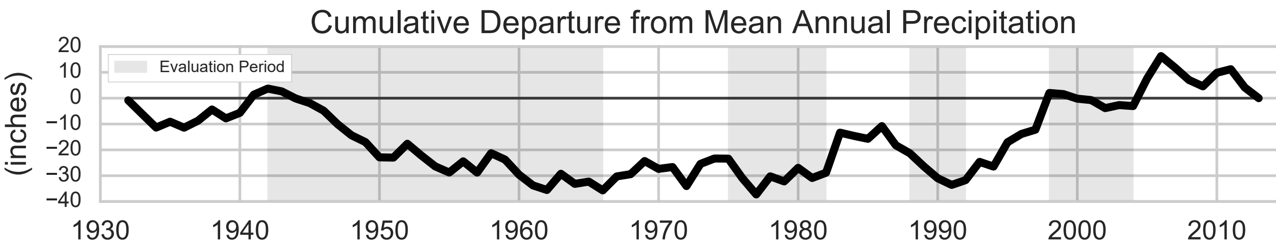


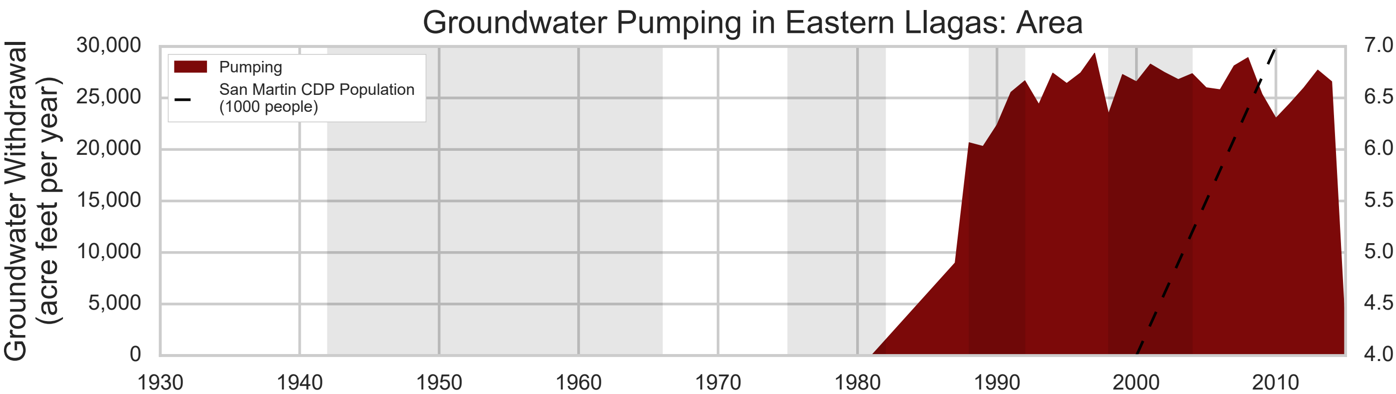


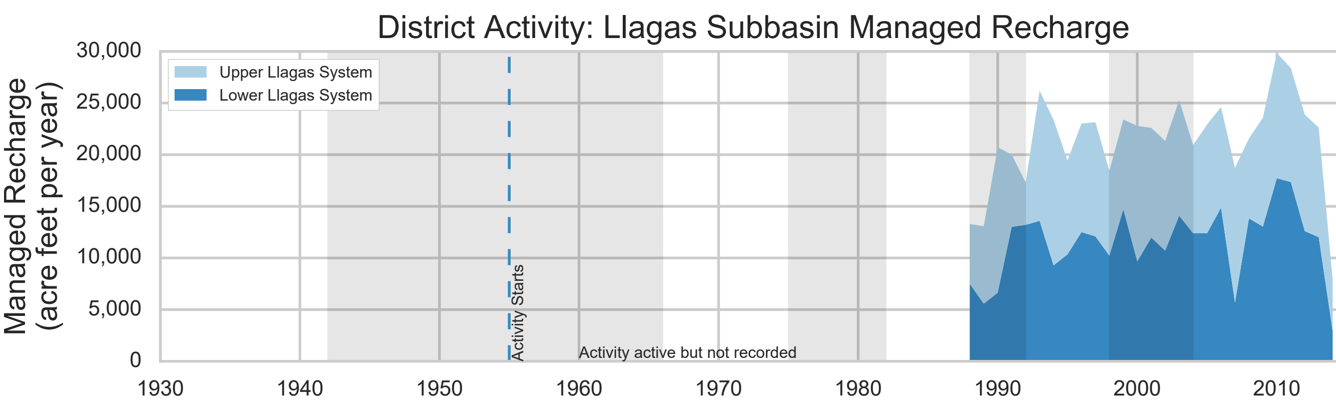
APPENDIX E: Groundwater Level Trends in Monitoring Wells to Evaluate Benefits from Managed Aquifer Recharge in Llagas Subbasin

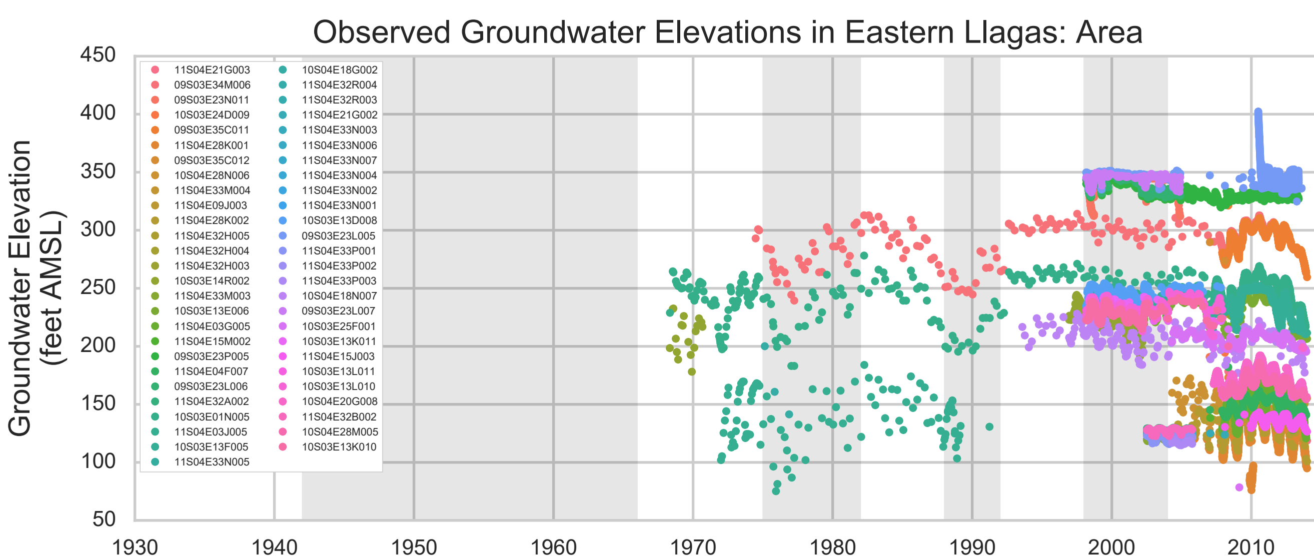
Pumping Area: Eastern Llagas:
Activity: Llagas Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

DRAFT - SUBJECT TO CHANGE



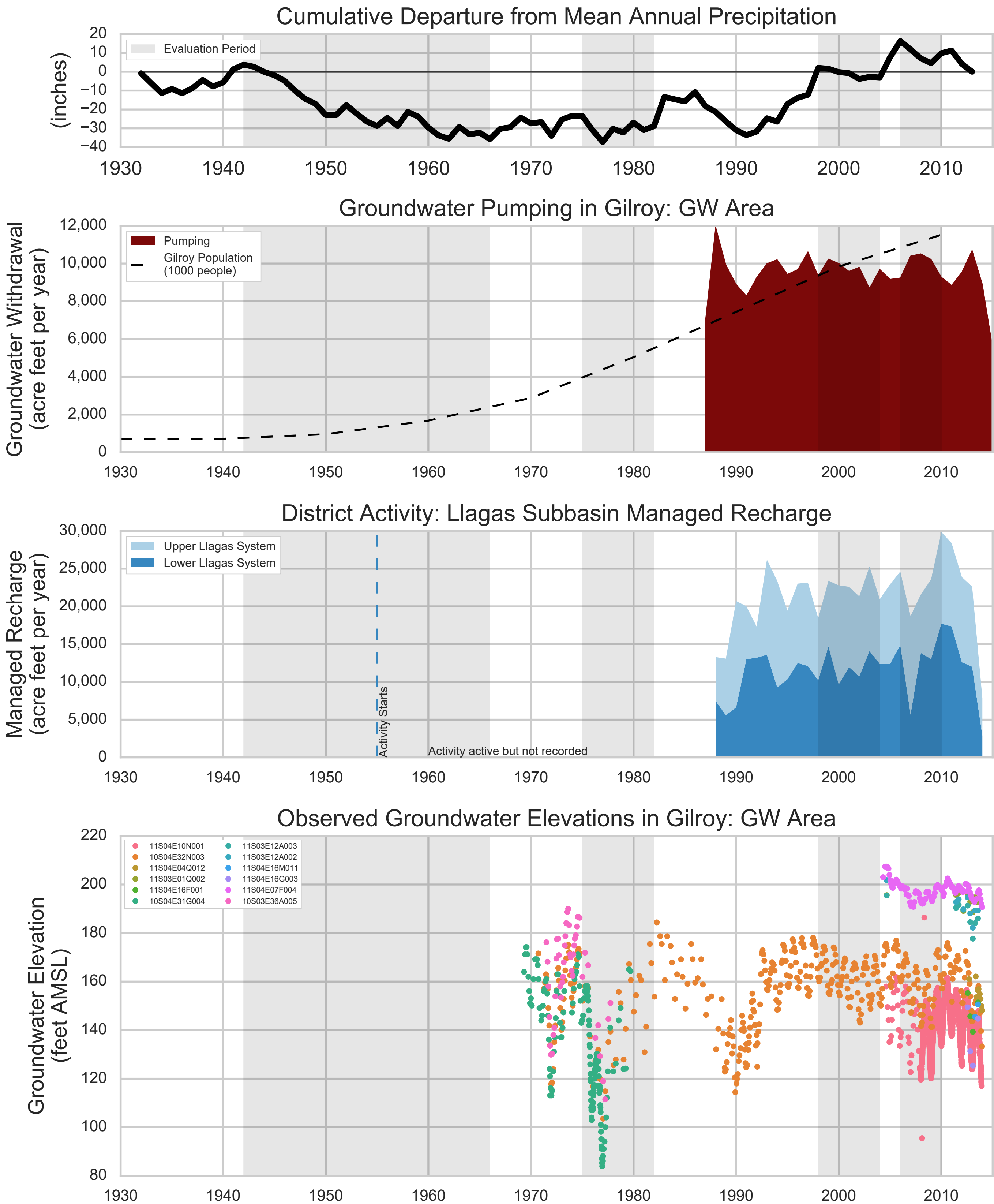






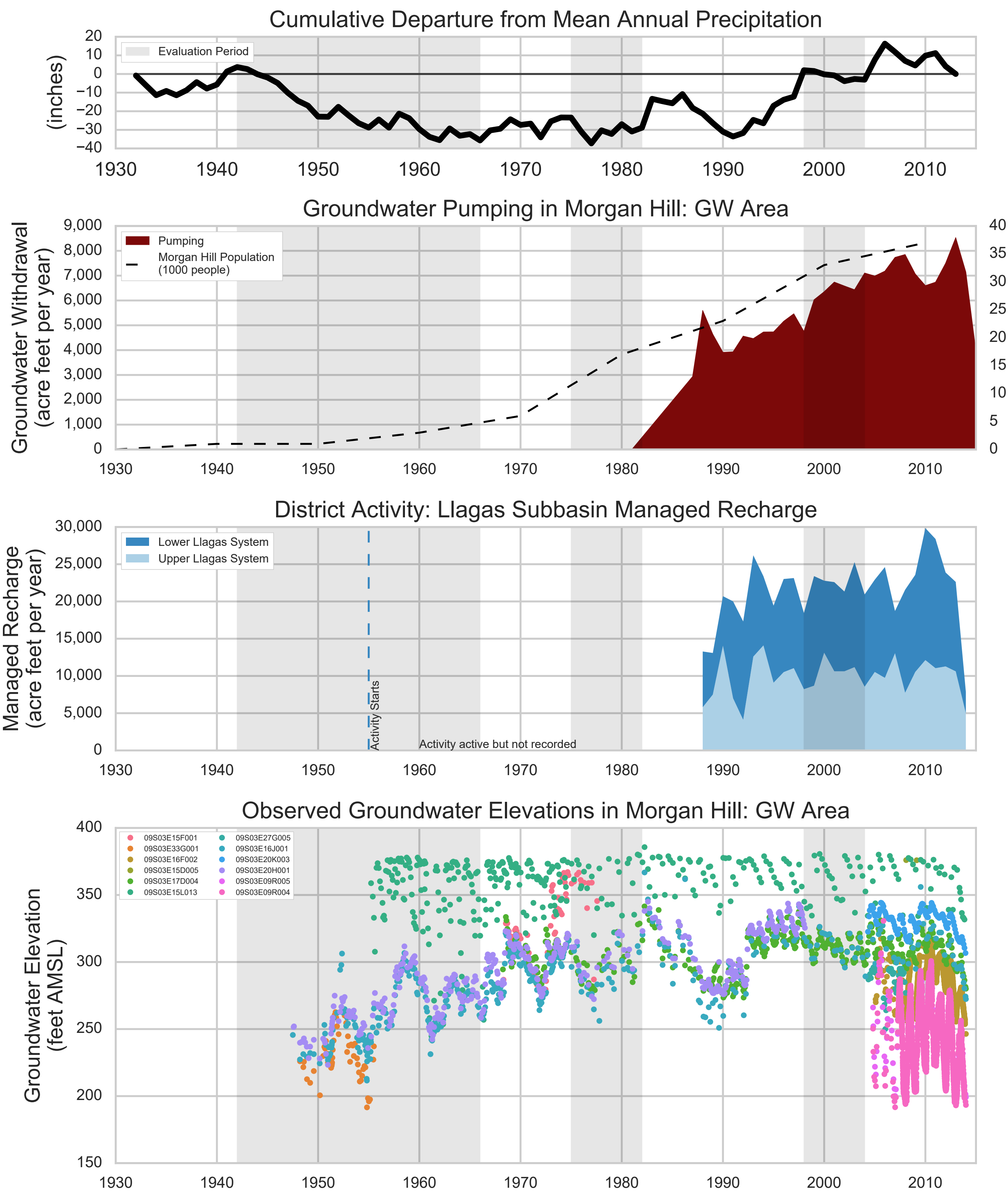
Pumping Area: Gilroy: GW
Activity: Llagas Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

DRAFT - SUBJECT TO CHANGE



Pumping Area: Morgan Hill: GW
Activity: Llagas Subbasin Managed Recharge
Groundwater Level Data from: Monitoring Wells

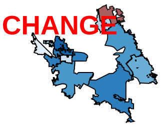
DRAFT - SUBJECT TO CHANGE

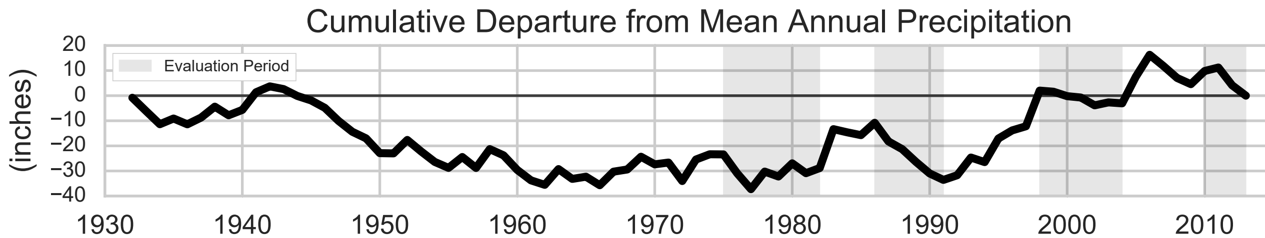


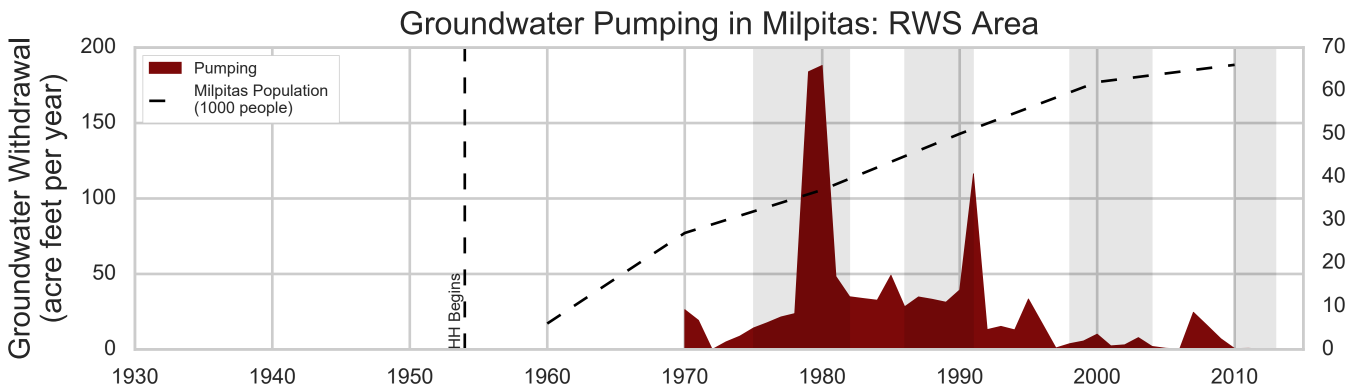
APPENDIX F: Groundwater Level Trends in Production Wells to Evaluate Benefits from District Activities in Select Pumping Areas

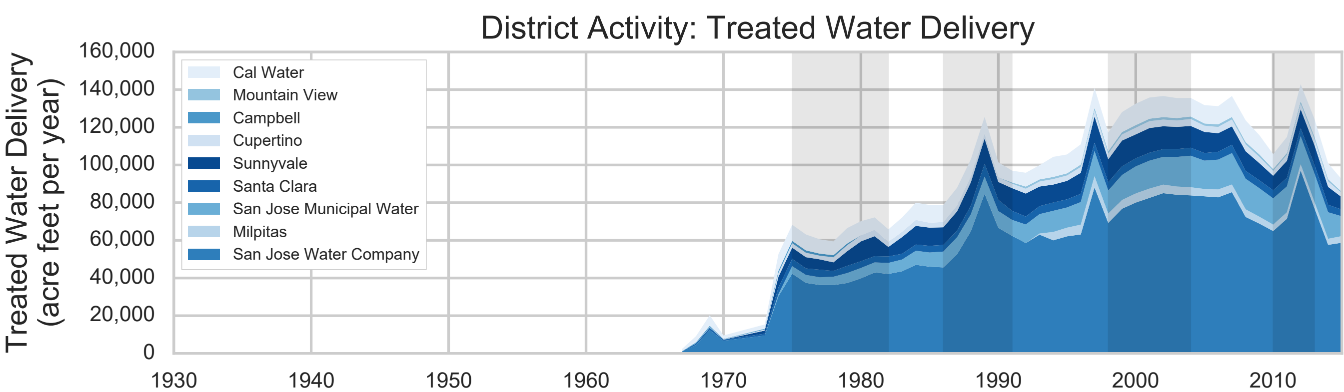
Pumping Area: Milpitas: RWS
Activity: Treated Water Delivery
Groundwater Level Data from: Monitored Pumping Wells

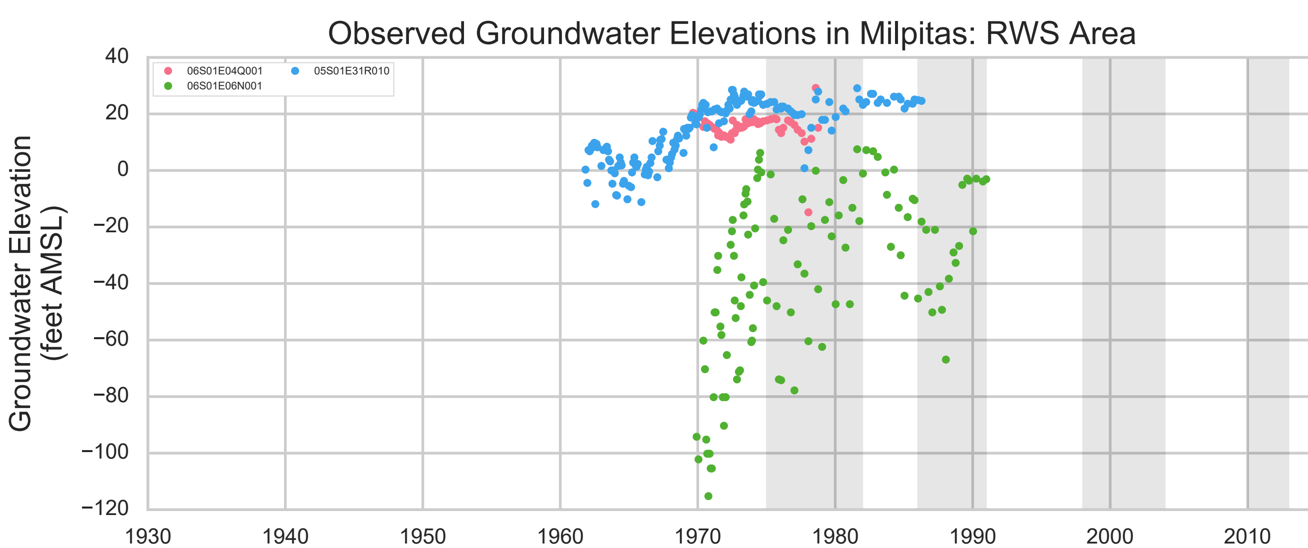
DRAFT - SUBJECT TO CHANGE





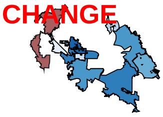




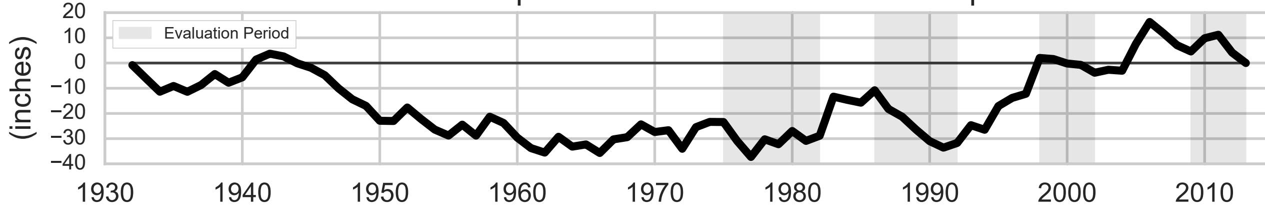


Pumping Area: Palo Alto: RWS
Activity: Treated Water Delivery
Groundwater Level Data from: Monitored Pumping Wells

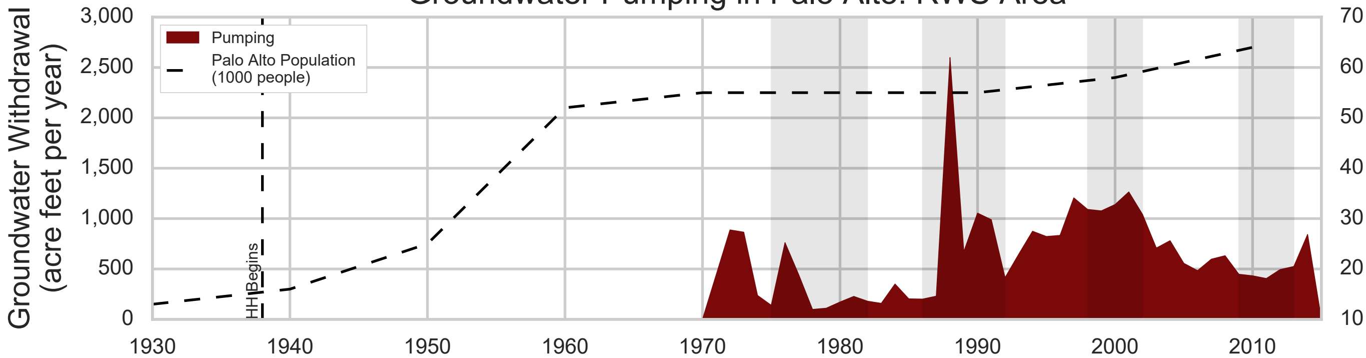
DRAFT - SUBJECT TO CHANGE



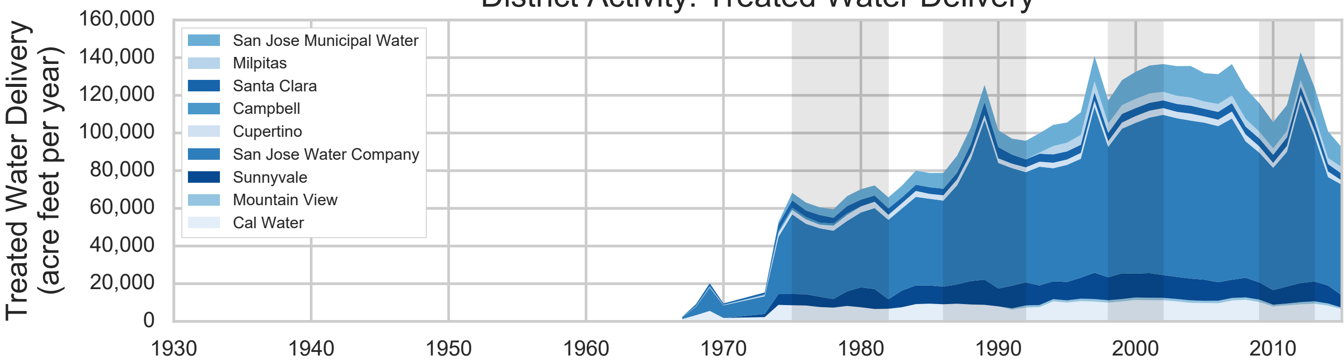
Cumulative Departure from Mean Annual Precipitation



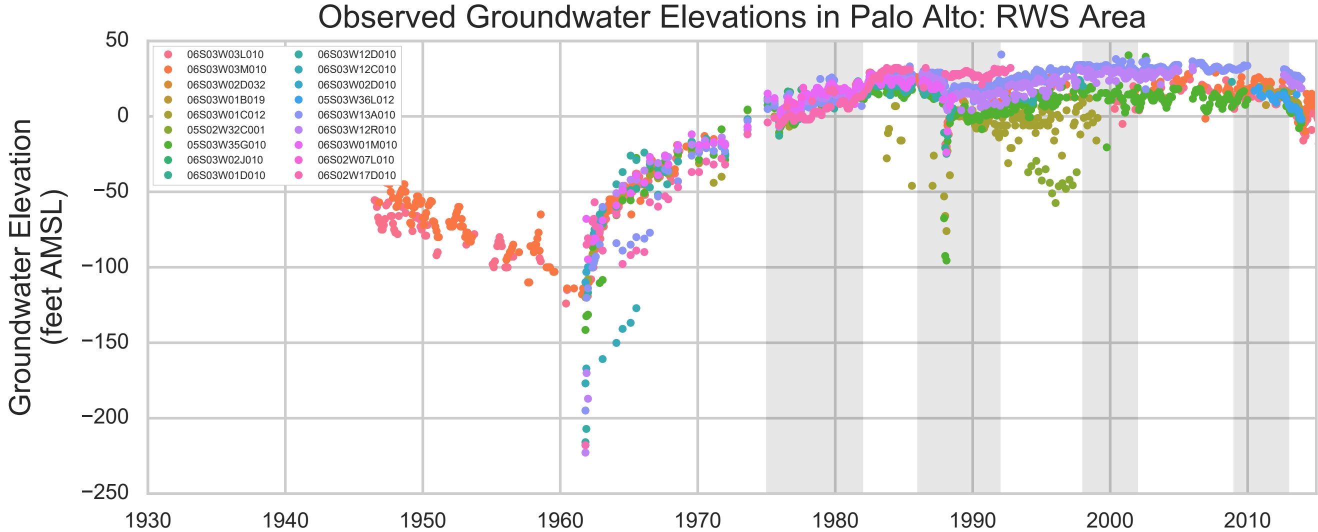
Groundwater Pumping in Palo Alto: RWS Area



District Activity: Treated Water Delivery

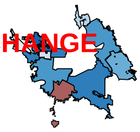


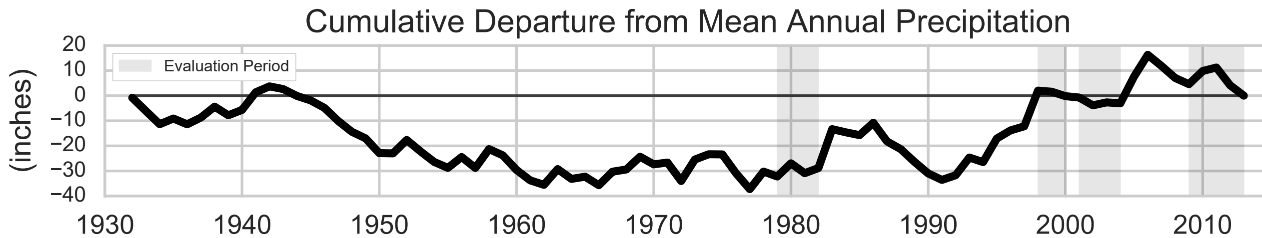
Observed Groundwater Elevations in Palo Alto: RWS Area

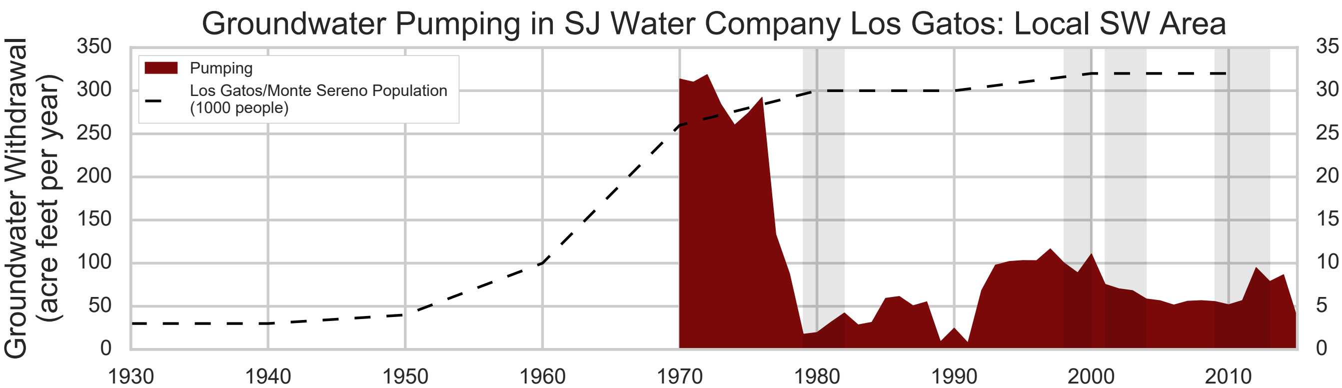


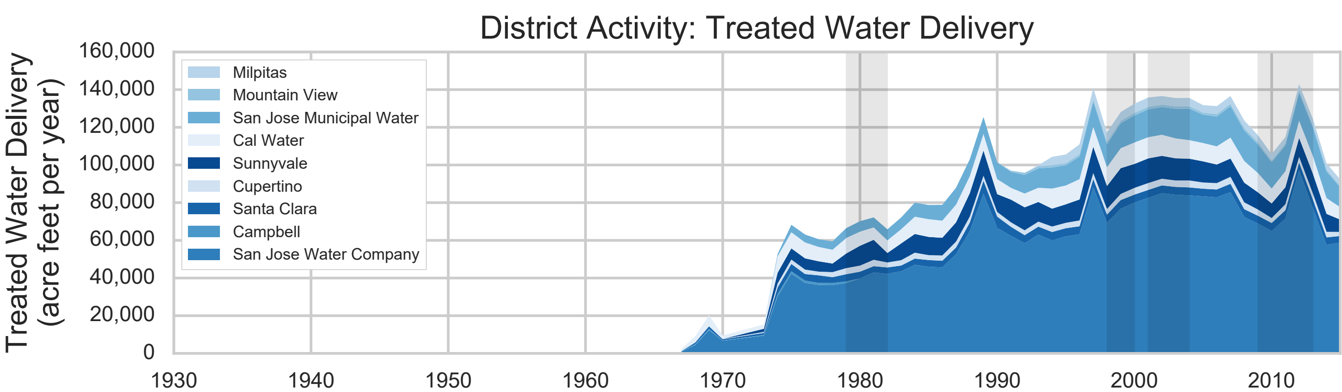
Pumping Area: SJ Water Company Los Gatos: Local SW
Activity: Treated Water Delivery
Groundwater Level Data from: Monitored Pumping Wells

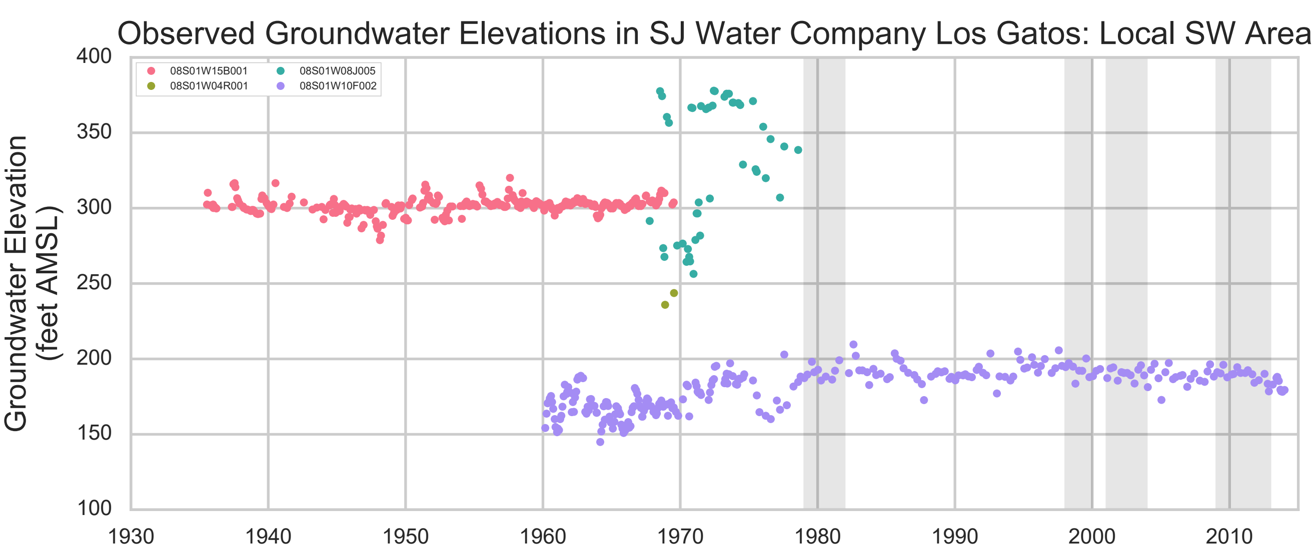
DRAFT - SUBJECT TO CHANGE





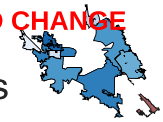


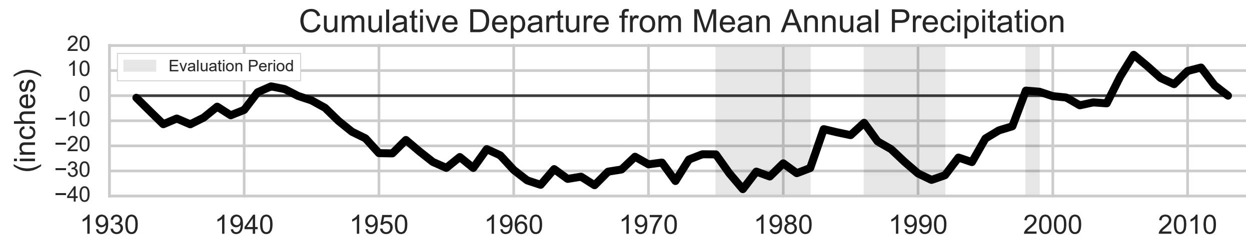


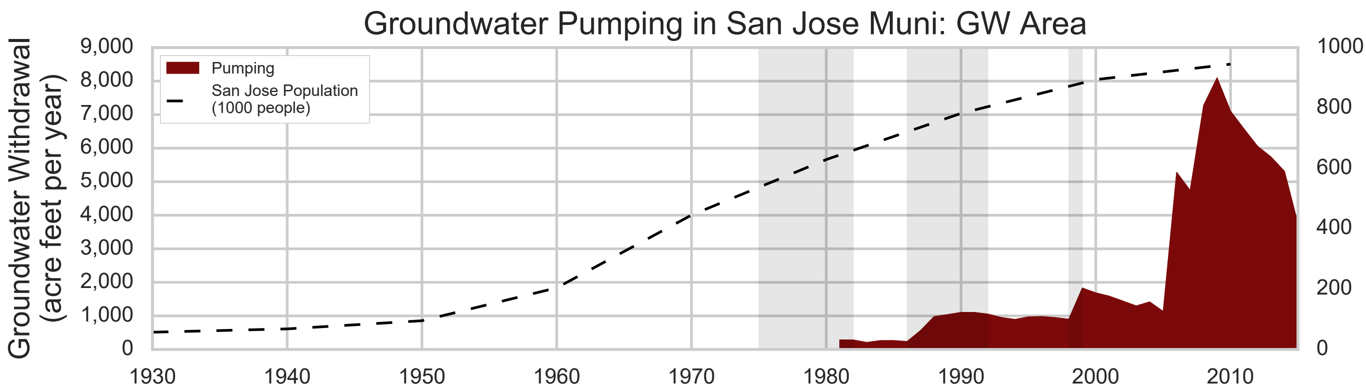


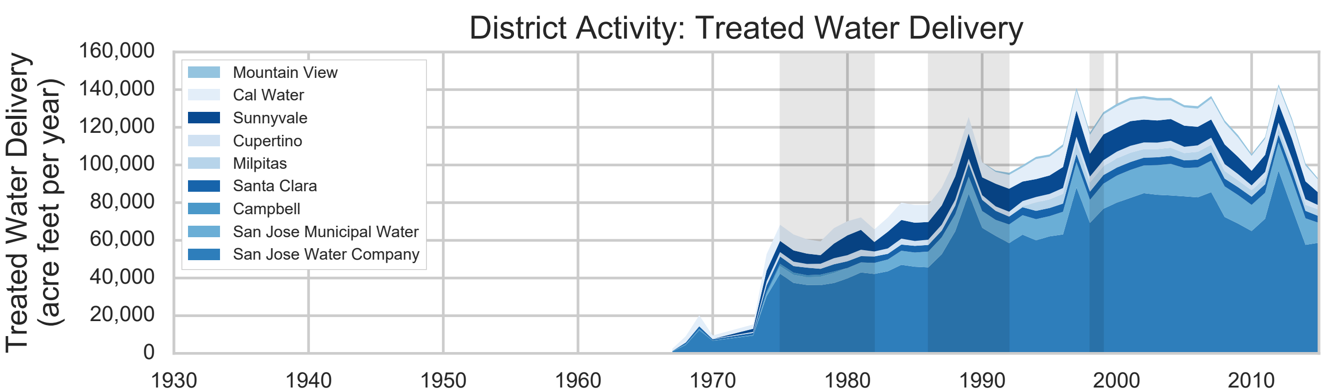
Pumping Area: San Jose Muni: GW
Activity: Treated Water Delivery
Groundwater Level Data from: Monitored Pumping Wells

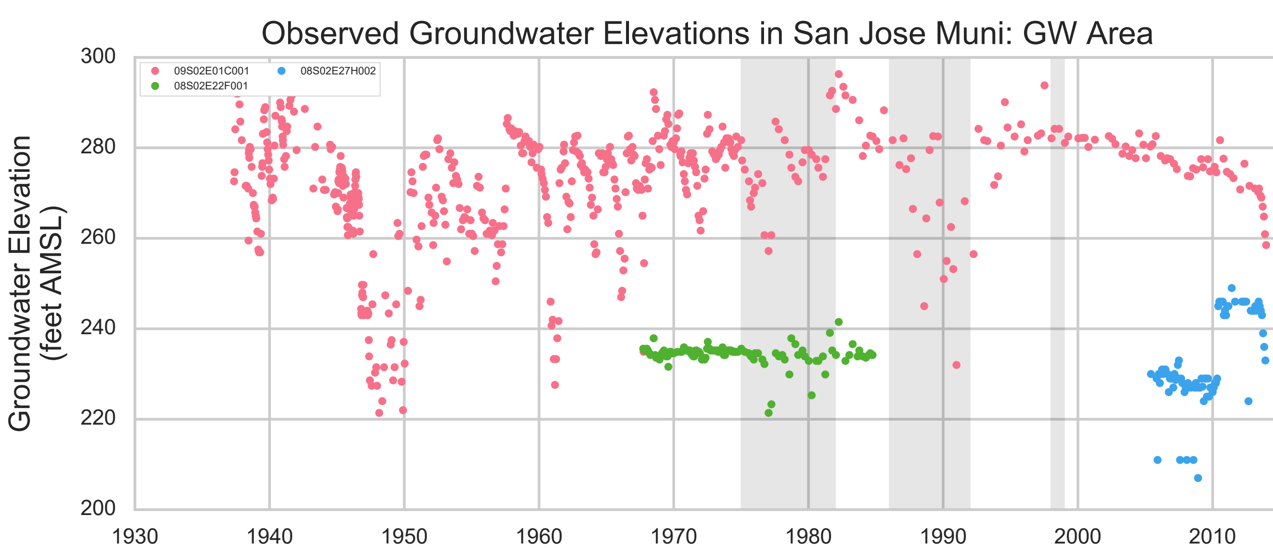
DRAFT - SUBJECT TO CHANGE





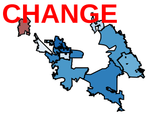




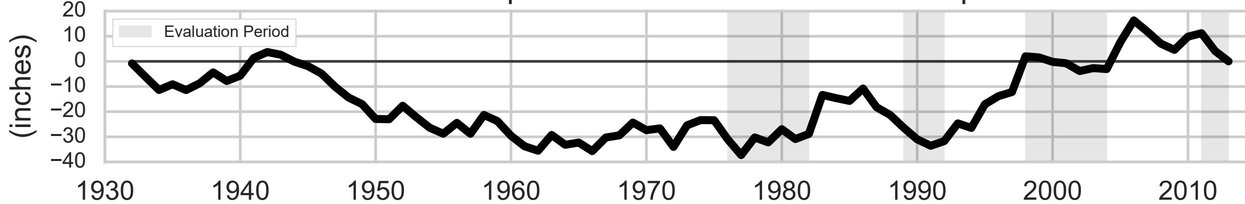


Pumping Area: Stanford: RWS
Activity: Treated Water Delivery
Groundwater Level Data from: Monitored Pumping Wells

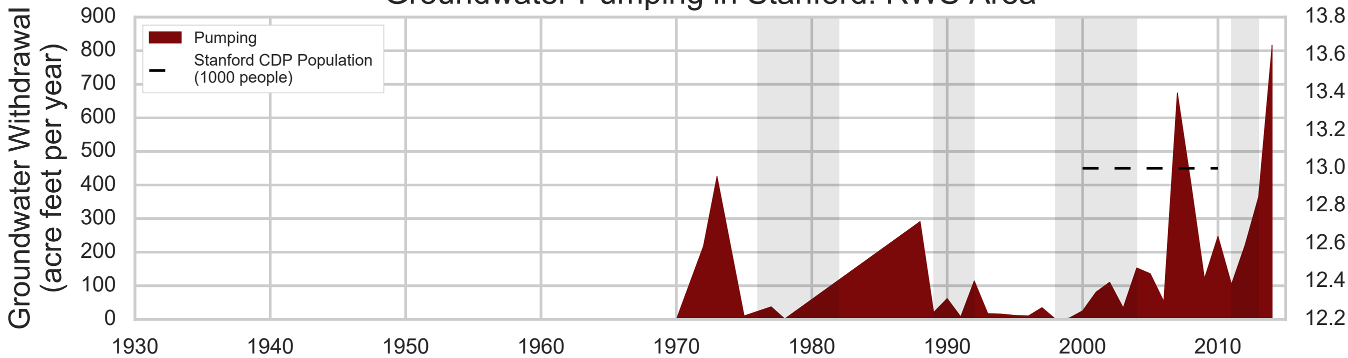
DRAFT - SUBJECT TO CHANGE



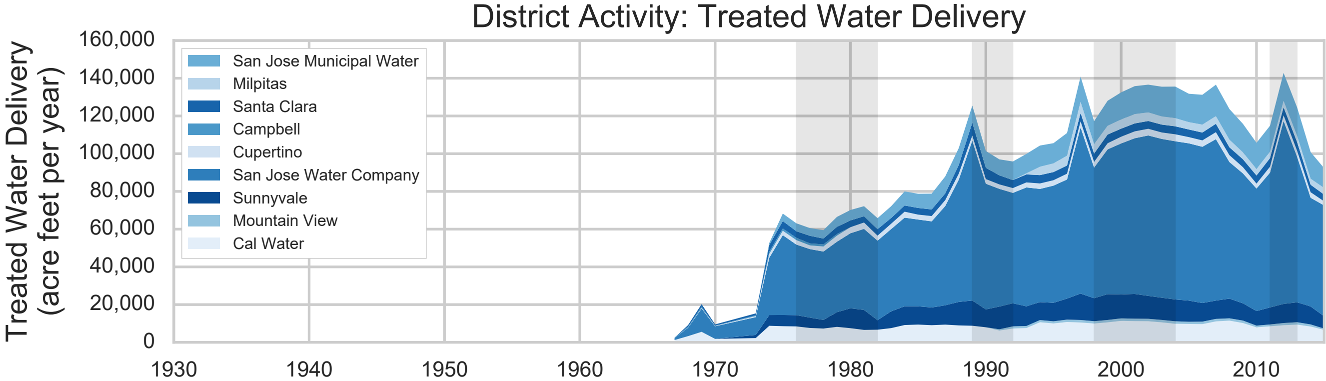
Cumulative Departure from Mean Annual Precipitation



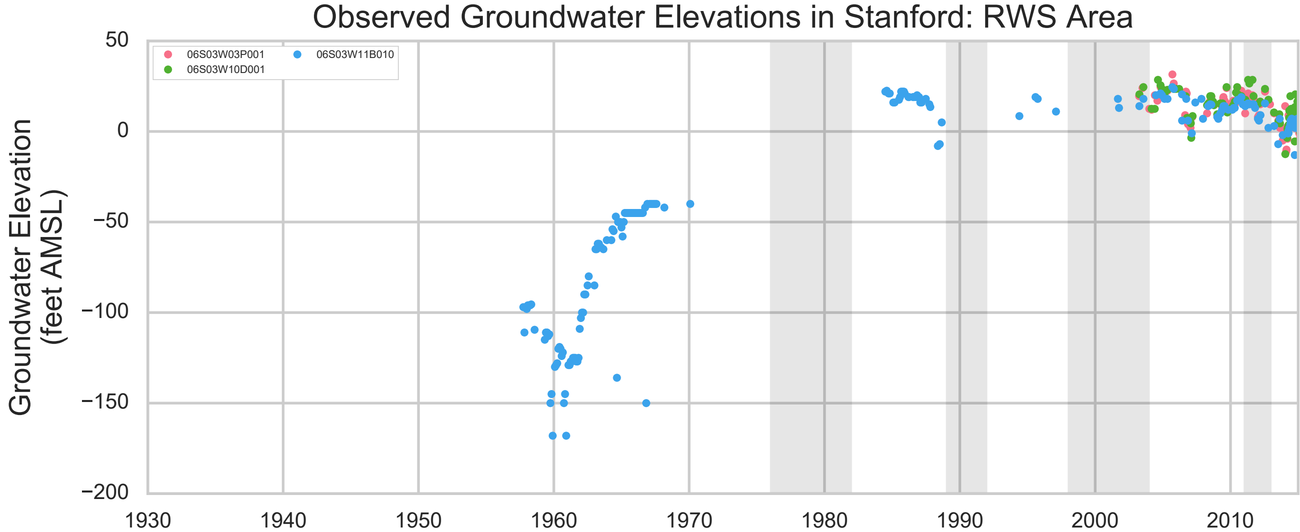
Groundwater Pumping in Stanford: RWS Area



District Activity: Treated Water Delivery

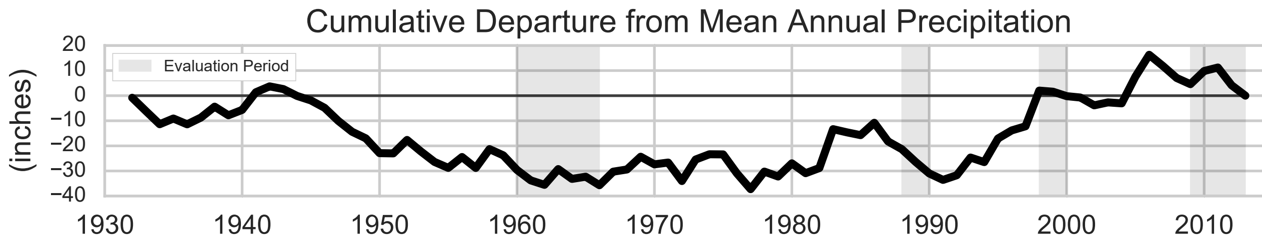


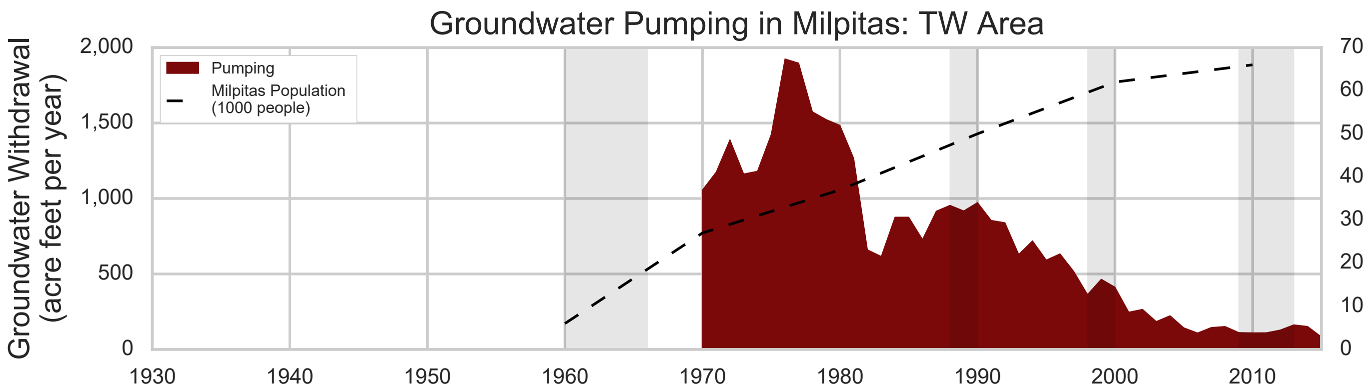
Observed Groundwater Elevations in Stanford: RWS Area

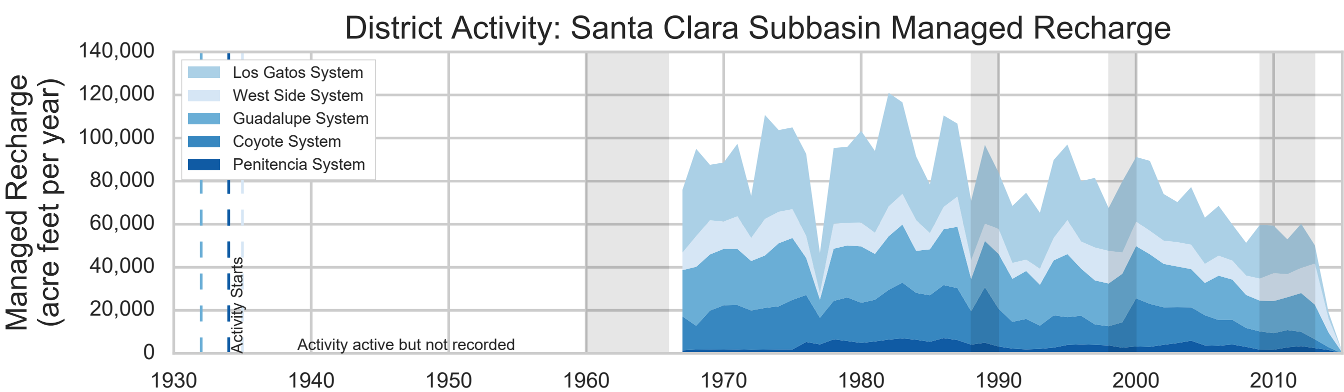


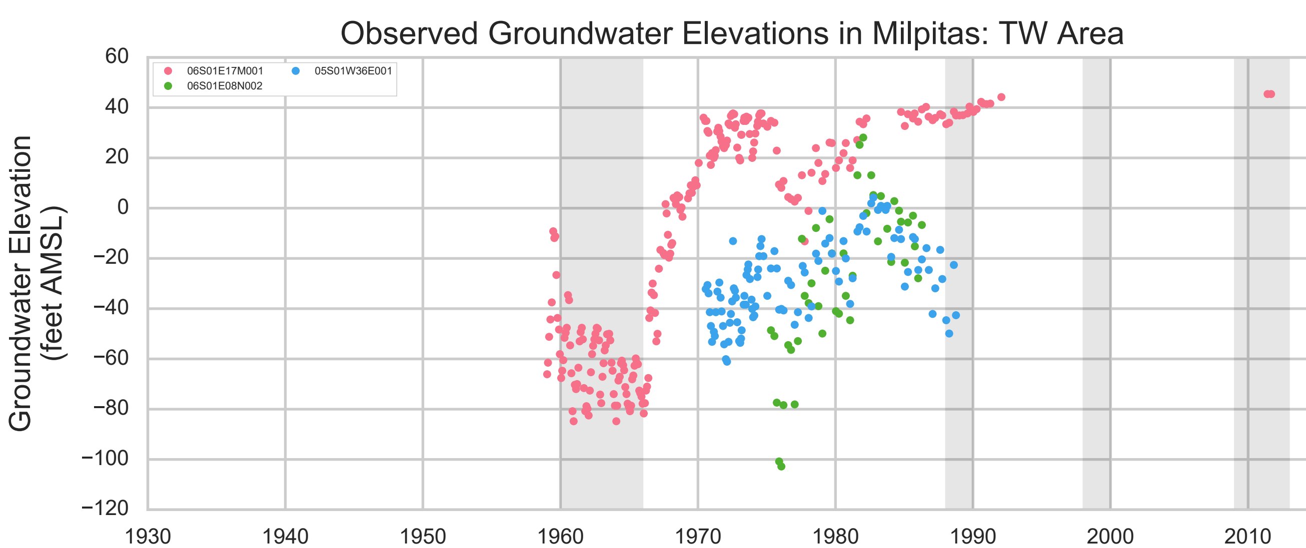
Pumping Area: Milpitas: TW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitored Pumping Wells

DRAFT - SUBJECT TO CHANGE



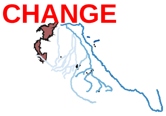


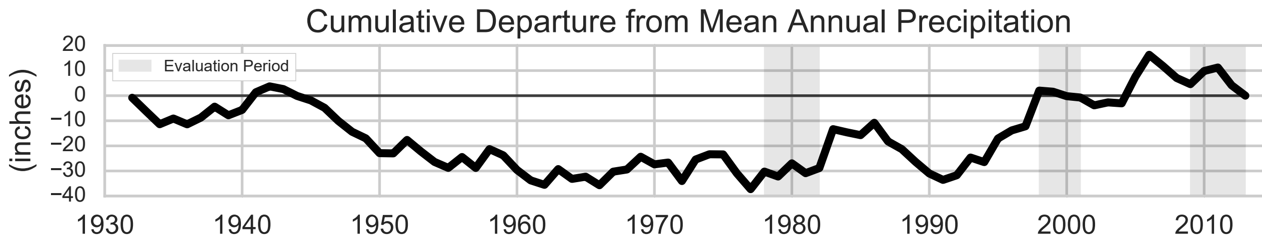


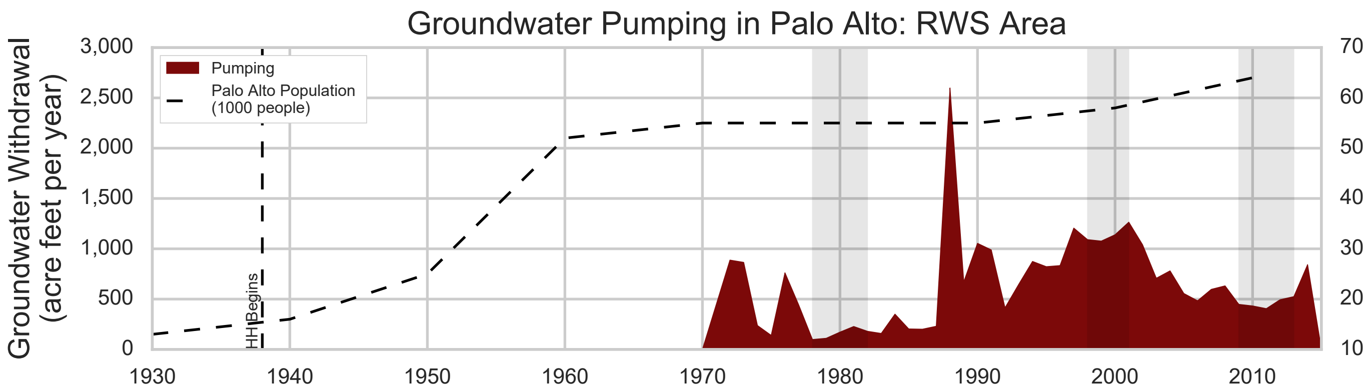


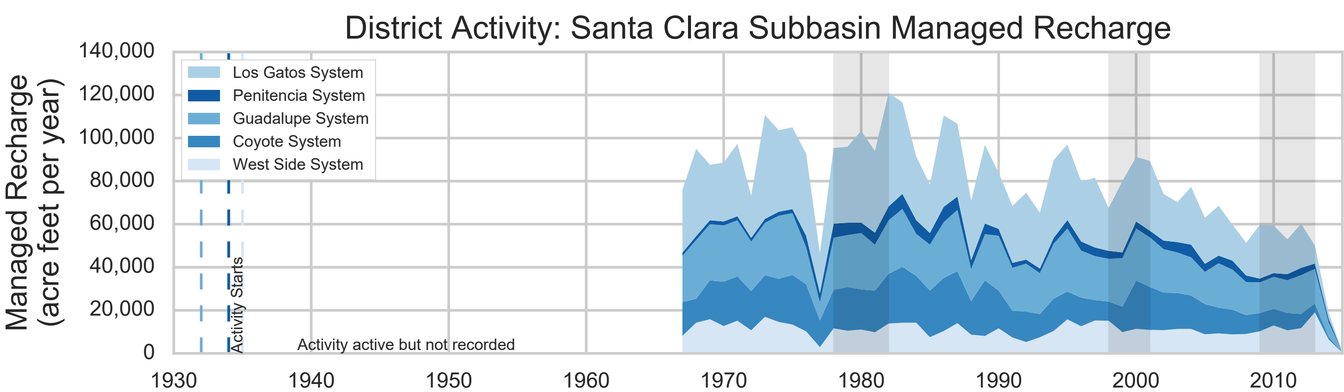
Pumping Area: Palo Alto: RWS
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitored Pumping Wells

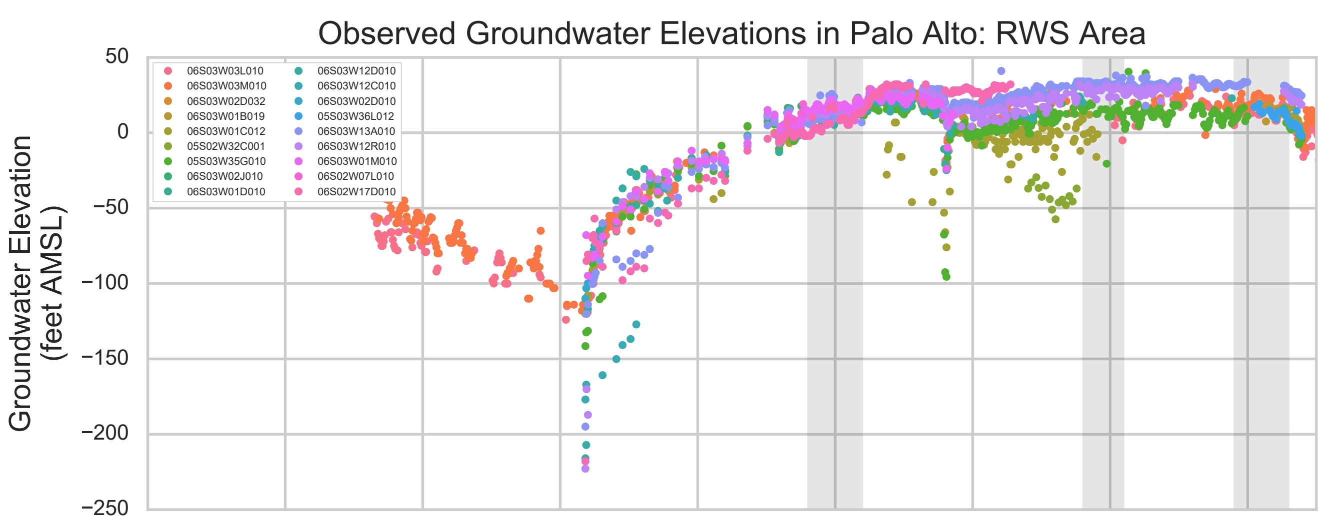
DRAFT - SUBJECT TO CHANGE











Pumping Area: SJ Water Company Los Gatos: Local SW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitored Pumping Wells

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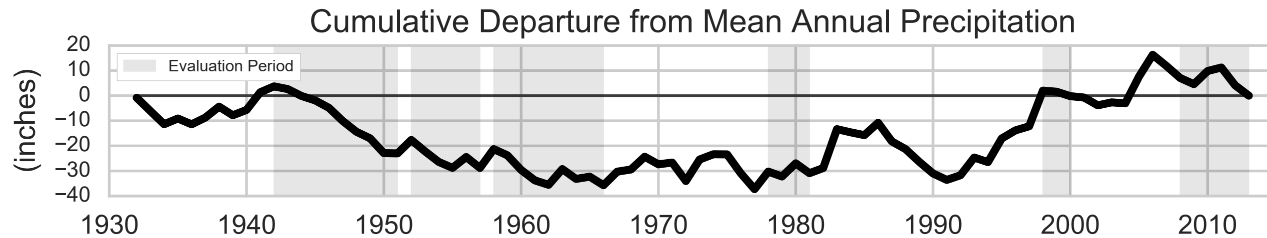

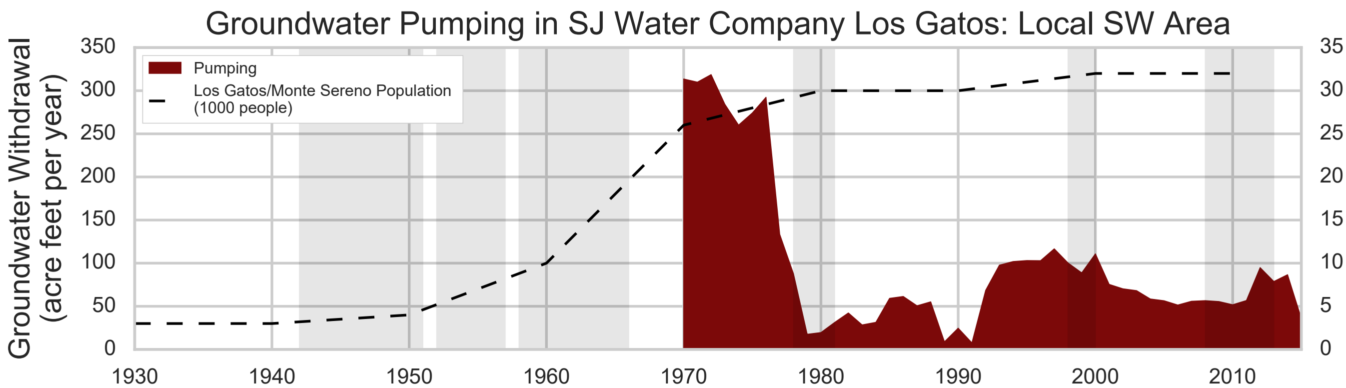

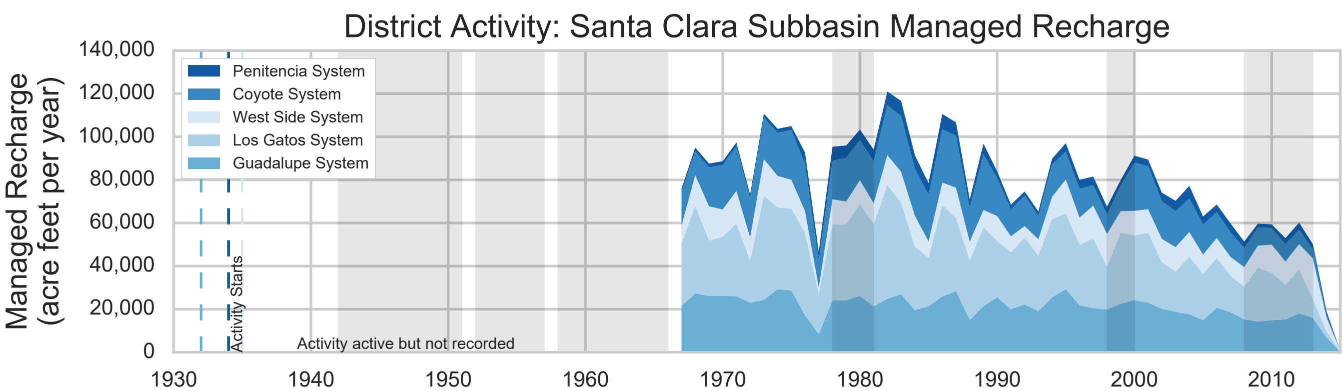

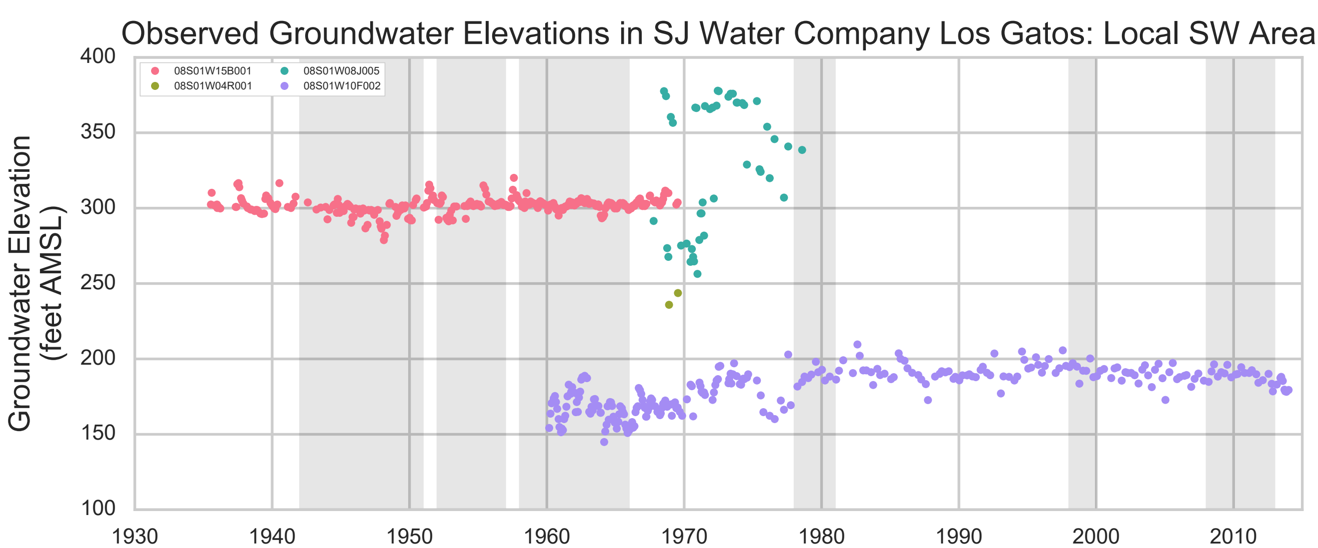

Pumping Area: San Jose Muni: GW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitored Pumping Wells

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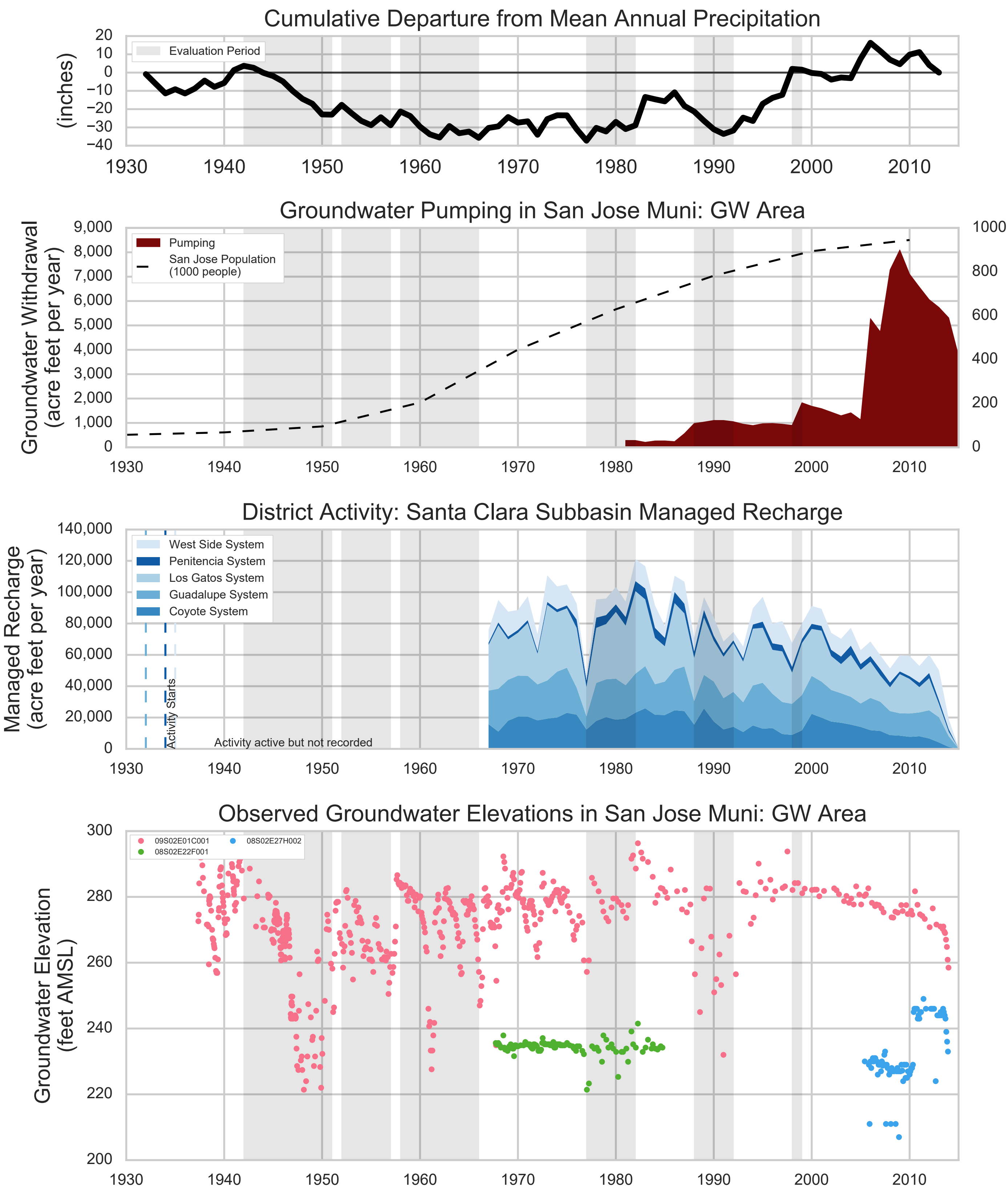

Pumping Area: San Jose Muni: TW
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitored Pumping Wells

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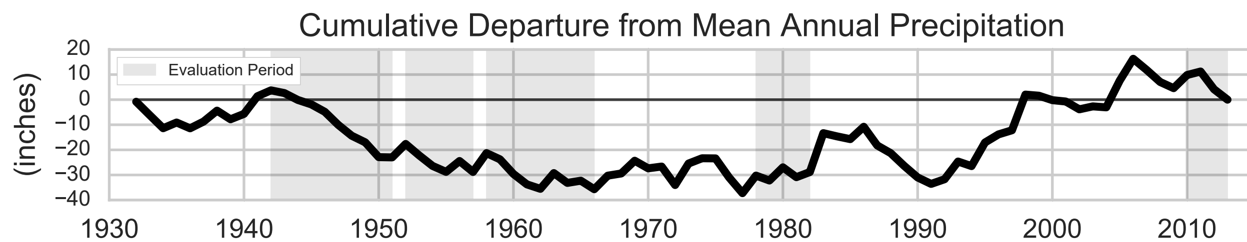

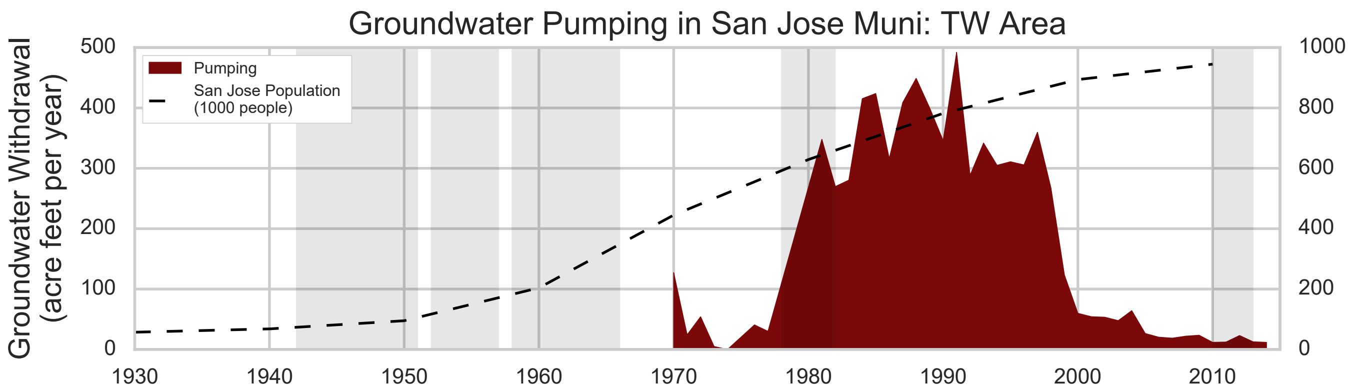

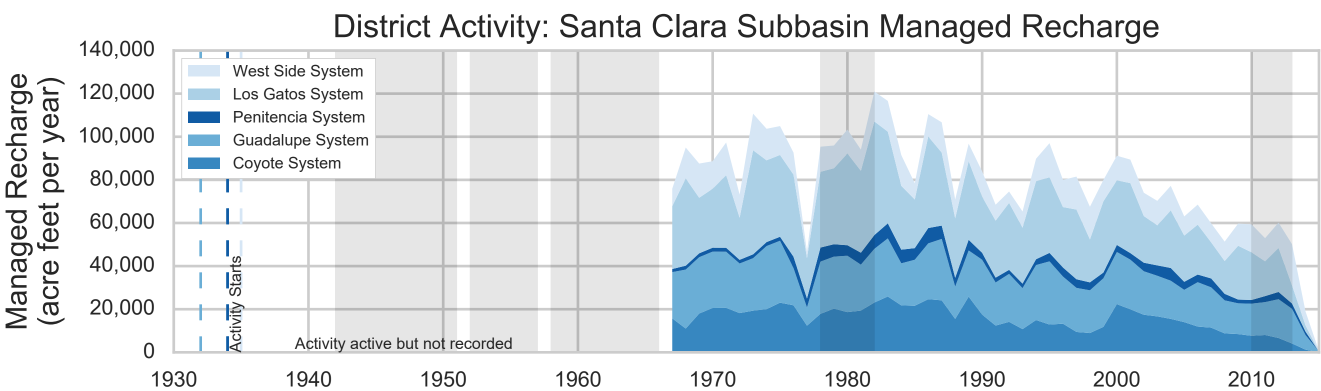

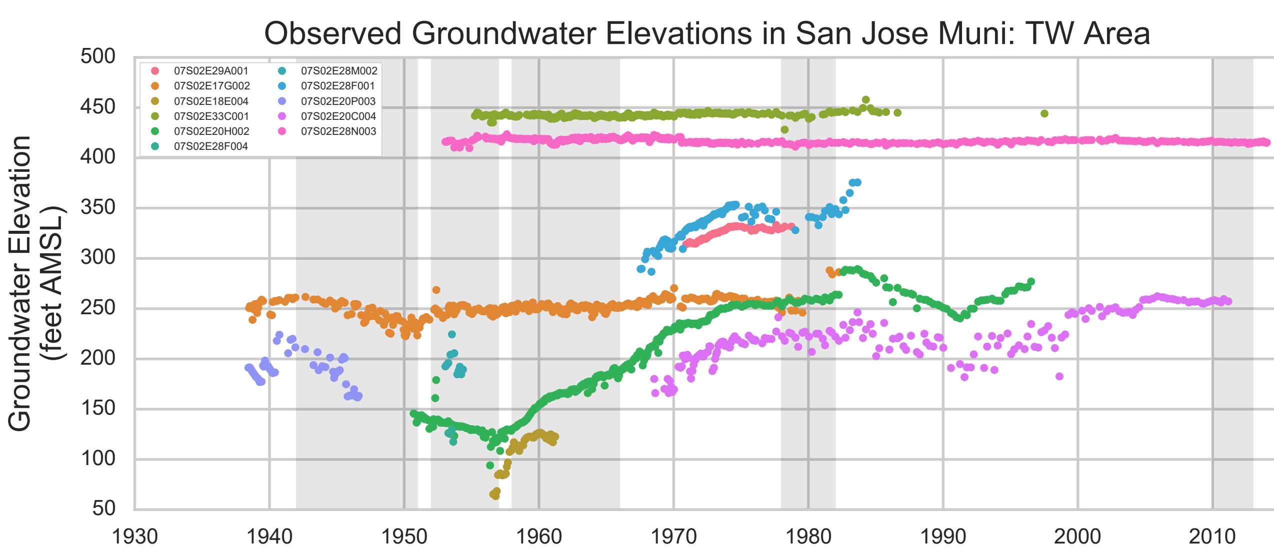

Pumping Area: Stanford: RWS
Activity: Santa Clara Subbasin Managed Recharge
Groundwater Level Data from: Monitored Pumping Wells

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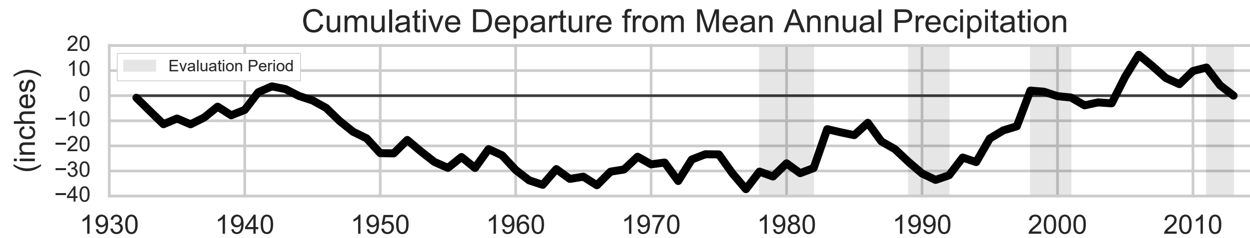

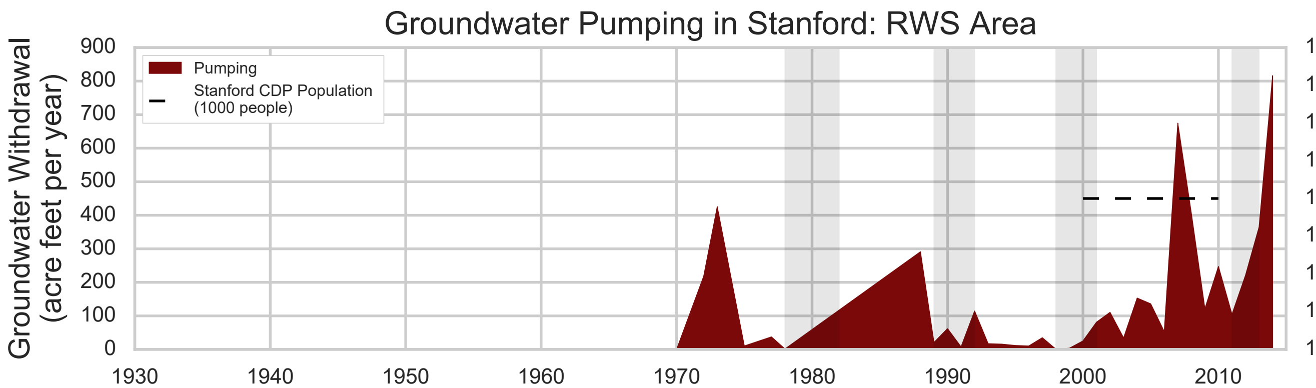

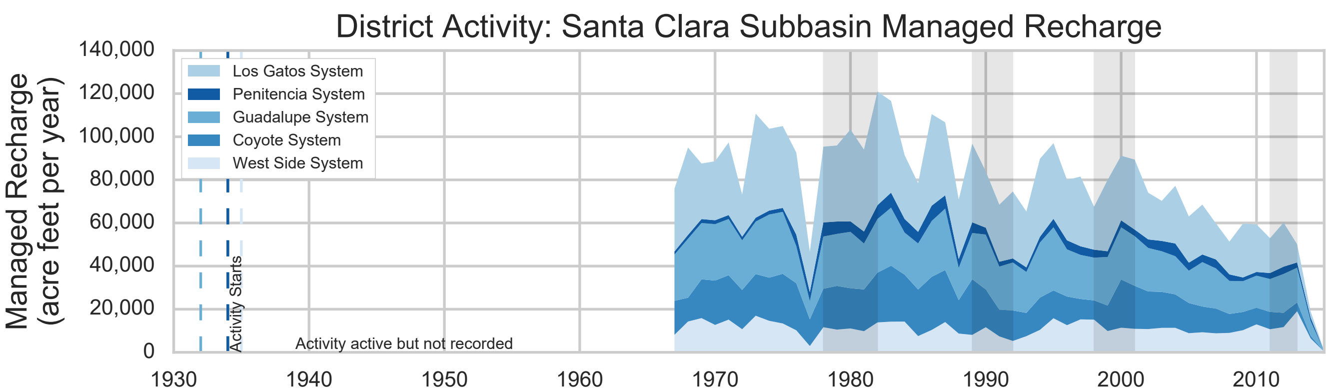

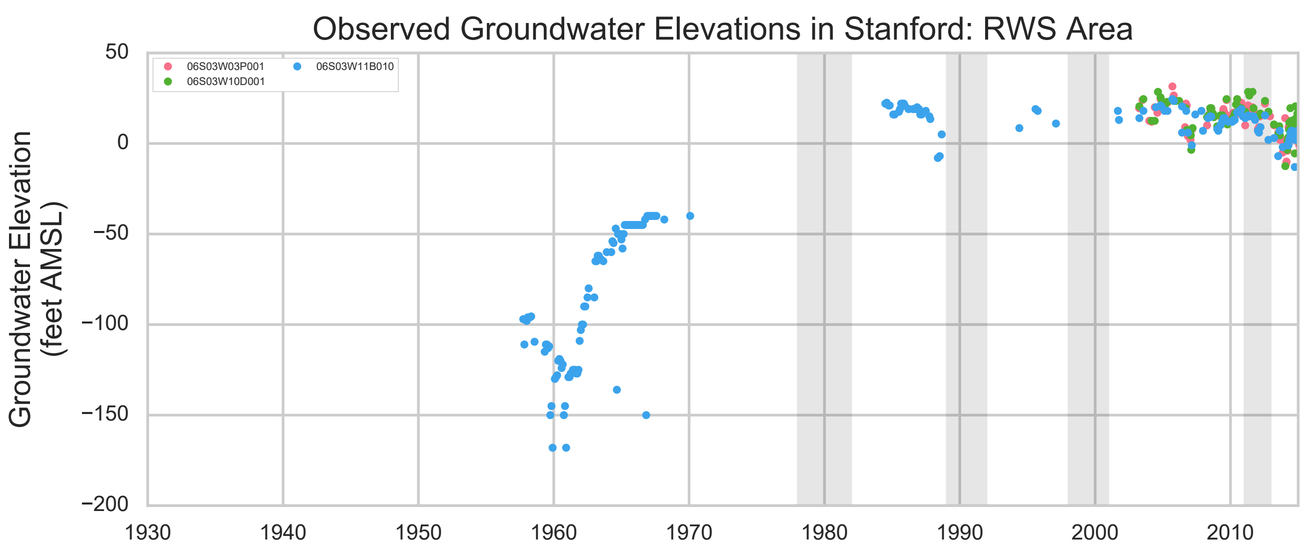

Pumping Area: Eastern Llagas:
Activity: Llagas Subbasin Managed Recharge
Groundwater Level Data from: Monitored Pumping Wells

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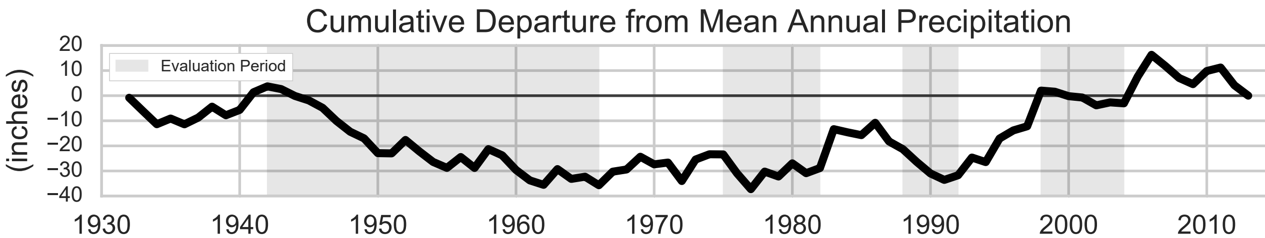

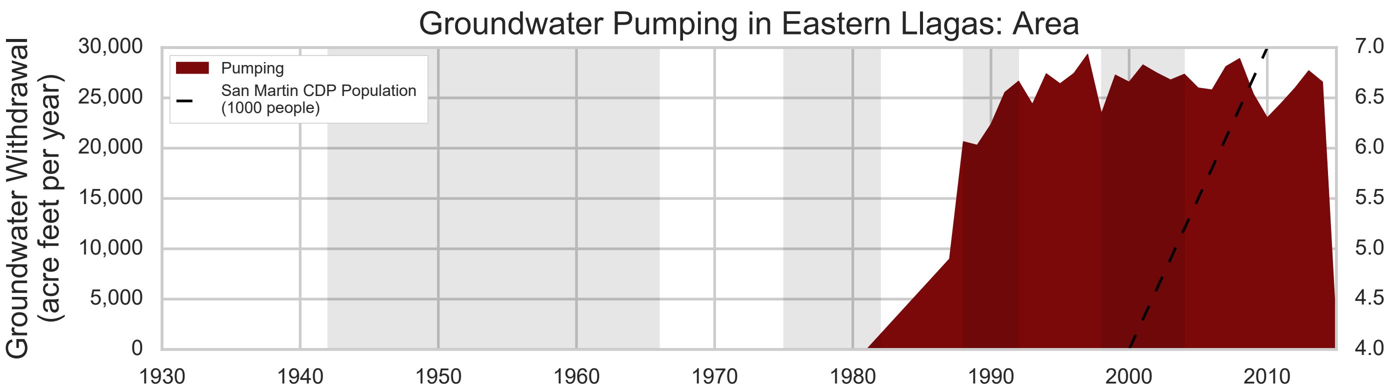

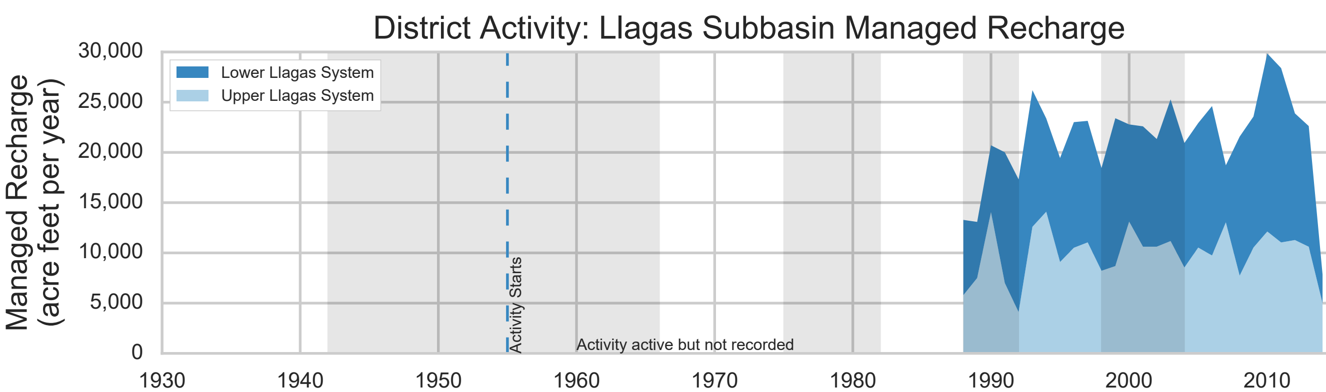

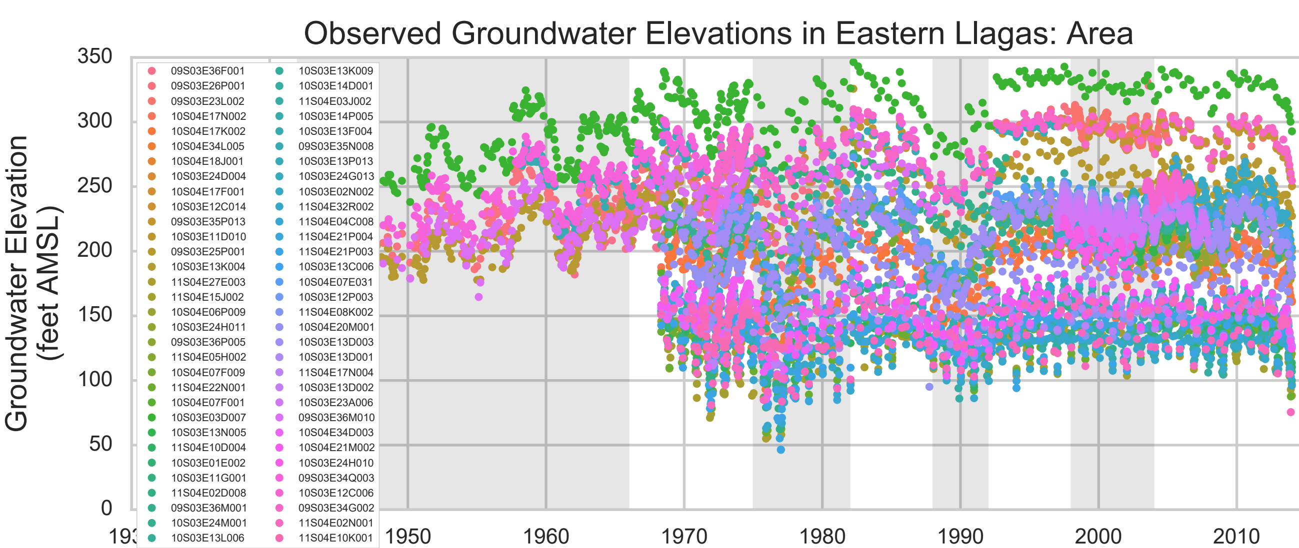

APPENDIX G: Mann-Kendall Statistics for Groundwater Level Data

Activity	Pumping Area	Evaluation Period	Well Type	Visual Trend	Count of wells with n > 8	Average tau	Max tau	Min tau	Num tau >= 0	Average padj for tau >= 0	Num tau <0	Average padj for tau < 0
Santa Clara Subbasin Managed Recharge	Cal Water Cupertino: TW	2008-2013	Monitoring Wells	Decreasing	1	0.18	0.18	0.18	1	0.65	0	0.00
Santa Clara Subbasin Managed Recharge	Cal Water Los Altos: GW	1998-2001	Monitoring Wells	Stable	4	-0.10	0.40	-0.60	1	0.22	3	0.67
Santa Clara Subbasin Managed Recharge	Cal Water Los Altos: GW	2010-2013	Monitoring Wells	Decreasing	4	-0.01	0.08	-0.20	3	1.00	1	0.43
Santa Clara Subbasin Managed Recharge	Great Oaks: GW	2009-2013	Monitoring Wells	Decreasing	7	-0.79	-0.50	-1.00	0	0.00	7	0.39
Santa Clara Subbasin Managed Recharge	Milpitas: RWS	1988-1991	Monitoring Wells	Stable	1	1.00	1.00	1.00	1	0.30	0	0.00
Santa Clara Subbasin Managed Recharge	Milpitas: TW	2009-2013	Monitoring Wells	Stable	1	-0.28	-0.28	-0.28	0	0.00	1	0.54
Santa Clara Subbasin Managed Recharge	Morgan Hill: GW	1975-1982	Monitoring Wells	Increasing	4	-0.13	0.14	-0.40	2	0.53	2	0.58
Santa Clara Subbasin Managed Recharge	Morgan Hill: GW	1998-2001	Monitoring Wells	Decreasing	2	-0.18	-0.13	-0.23	0	0.00	2	0.51
Santa Clara Subbasin Managed Recharge	Morgan Hill: GW	2009-2013	Monitoring Wells	Decreasing	5	-0.33	-0.21	-0.43	0	0.00	5	0.40
Santa Clara Subbasin Managed Recharge	Mountain View: RWS	1988-1991	Monitoring Wells	Increasing	11	0.47	1.00	-0.33	10	0.33	1	0.46
Santa Clara Subbasin Managed Recharge	Mountain View: RWS	1998-2000	Monitoring Wells	Decreasing	1	-0.67	-0.67	-0.67	0	0.00	1	0.25
Santa Clara Subbasin Managed Recharge	Mountain View: RWS	2009-2013	Monitoring Wells	Decreasing	6	0.06	0.43	-0.38	4	0.64	2	0.63
Santa Clara Subbasin Managed Recharge	Mountain View: TW	2009-2013	Monitoring Wells	Decreasing	1	0.07	0.07	0.07	1	0.83	0	0.00
Santa Clara Subbasin Managed Recharge	North Morgan Hill:	2010-2013	Monitoring Wells	Decreasing	1	-0.73	-0.73	-0.73	0	0.00	1	0.20
Santa Clara Subbasin Managed Recharge	Palo Alto: RWS	1978-1982	Monitoring Wells	Stable	4	0.32	0.78	-0.19	3	0.20	1	0.71
Santa Clara Subbasin Managed Recharge	Palo Alto: RWS	1998-2001	Monitoring Wells	Stable	9	-0.37	0.17	-1.00	2	0.81	7	0.55
Santa Clara Subbasin Managed Recharge	Palo Alto: RWS	2009-2013	Monitoring Wells	Decreasing	11	-0.32	0.21	-1.00	3	0.86	8	0.42
Santa Clara Subbasin Managed Recharge	San Jose Muni: RWS	1988-1992	Monitoring Wells	Increasing	7	0.62	1.00	0.06	7	0.38	0	0.00
Santa Clara Subbasin Managed Recharge	San Jose Muni: RWS	2010-2012	Monitoring Wells	Increasing	6	0.94	1.00	0.67	6	0.37	0	0.00
Santa Clara Subbasin Managed Recharge	San Jose Muni: TW	1978-1982	Monitoring Wells	Increasing	7	0.59	1.00	-0.38	6	0.20	1	0.18
Santa Clara Subbasin Managed Recharge	San Jose Muni: TW	2010-2013	Monitoring Wells	Stable	7	0.00	1.00	-0.78	3	0.36	4	0.56
Santa Clara Subbasin Managed Recharge	Santa Clara: GW	1978-1981	Monitoring Wells	Stable	4	-0.35	0.33	-1.00	1	0.37	3	0.33
Santa Clara Subbasin Managed Recharge	Santa Clara: GW	1999-2001	Monitoring Wells	Lacks Data	1	0.00	0.00	0.00	1	1.00	0	0.00
Santa Clara Subbasin Managed Recharge	Santa Clara: GW	2009-2013	Monitoring Wells	Decreasing	1	0.33	0.33	0.33	1	0.54	0	0.00
Santa Clara Subbasin Managed Recharge	Santa Clara: RWS	2008-2010	Monitoring Wells	Stable	1	0.00	0.00	0.00	1	1.00	0	0.00
Santa Clara Subbasin Managed Recharge	Santa Clara: RWS	2011-2013	Monitoring Wells	Stable	1	0.00	0.00	0.00	1	1.00	0	0.00
Santa Clara Subbasin Managed Recharge	Santa Clara: RWS GW	1978-1981	Monitoring Wells	Increasing	3	0.53	0.67	0.43	3	0.26	0	0.00
Santa Clara Subbasin Managed Recharge	Santa Clara: RWS GW	2011-2013	Monitoring Wells	Stable	2	-0.75	-0.67	-0.83	0	0.00	2	0.39
Santa Clara Subbasin Managed Recharge	Santa Clara: TW GW	1977-1980	Monitoring Wells	Decreasing	1	0.11	0.11	0.11	1	1.00	0	0.00
Santa Clara Subbasin Managed Recharge	Santa Clara: TW GW	2010-2012	Monitoring Wells	Increasing	4	1.00	1.00	1.00	4	0.30	0	0.00
Santa Clara Subbasin Managed Recharge	SJ Water Company East: TW	1978-1981	Monitoring Wells	Increasing	11	0.41	1.00	-0.58	10	0.44	1	0.22
Santa Clara Subbasin Managed Recharge	SJ Water Company East: TW	1998-2001	Monitoring Wells	Stable	6	-0.38	0.20	-0.90	1	0.85	5	0.41
Santa Clara Subbasin Managed Recharge	SJ Water Company East: TW	2009-2013	Monitoring Wells	Stable	6	0.15	0.47	-0.33	4	0.39	2	0.57
Santa Clara Subbasin Managed Recharge	SJ Water Company Los Gatos: Local SW	1978-1981	Monitoring Wells	Stable	1	-0.33	-0.33	-0.33	0	0.00	1	0.60
Santa Clara Subbasin Managed Recharge	SJ Water Company North: GW	1978-1981	Monitoring Wells	Increasing	17	0.22	1.00	-0.40	12	0.45	5	0.55
Santa Clara Subbasin Managed Recharge	SJ Water Company North: GW	2011-2013	Monitoring Wells	Decreasing	21	-0.64	0.50	-1.00	3	0.77	18	0.53
Santa Clara Subbasin Managed Recharge	SJ Water Company South: TW	1998-2001	Monitoring Wells	Decreasing	8	-0.57	-0.20	-0.89	0	0.00	8	0.35
Santa Clara Subbasin Managed Recharge	SJ Water Company South: TW	2008-2013	Monitoring Wells	Stable	10	0.23	0.57	-0.52	7	0.25	3	0.32
Santa Clara Subbasin Managed Recharge	SJ Water Company West: TW	1988-1992	Monitoring Wells	Stable	5	0.31	0.83	-0.33	3	0.05	2	0.68
Santa Clara Subbasin Managed Recharge	SJ Water Company West: TW	2009-2012	Monitoring Wells	Increasing	5	0.86	1.00	0.71	5	0.12	0	0.00
Santa Clara Subbasin Managed Recharge	Sunnyvale: RWS	1977-1979	Monitoring Wells	Stable	4	0.33	1.00	-0.33	2	0.37	2	1.00
Santa Clara Subbasin Managed Recharge	Sunnyvale: RWS	1988-1992	Monitoring Wells	Increasing	3	0.94	1.00	0.91	3	0.06	0	0.00
Santa Clara Subbasin Managed Recharge	Sunnyvale: RWS	2010-2012	Monitoring Wells	Stable	2	0.33	1.00	-0.33	0	0.00	1	0.82
Santa Clara Subbasin Managed Recharge	Sunnyvale: TW	1980-1982	Monitoring Wells	Stable	1	-0.33	-0.33	-0.33	0	0.00	1	1.00

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Activity	Pumping Area	Evaluation Period	Well Type	Visual Trend	Count of wells with n > 8	Average tau	Max tau	Min tau	Num tau >= 0	Average padj for tau >= 0	Num tau <0	Average padj for tau < 0
Treated Water Delivery	Cal Water Los Altos: GW	1986-1988	Monitoring Wells	Stable	7	-0.52	0.00	-1.00	1	1.00	6	0.62
Treated Water Delivery	Cal Water Los Altos: GW	1998-2004	Monitoring Wells	Stable	14	-0.17	0.50	-0.62	3	0.69	11	0.38
Treated Water Delivery	Cal Water Los Altos: GW	2010-2013	Monitoring Wells	Decreasing	12	-0.10	0.20	-0.42	6	1.00	6	0.56
Treated Water Delivery	Cal Water Mountain View: GW	1980-1982	Monitoring Wells	Increasing	3	0.33	0.33	0.33	3	1.00	0	0.00
Treated Water Delivery	Cal Water Mountain View: GW	1986-1992	Monitoring Wells	Increasing	3	0.41	0.60	0.30	3	0.19	0	0.00
Treated Water Delivery	Cal Water Mountain View: GW	1998-2004	Monitoring Wells	Decreasing	3	-0.21	0.39	-0.62	1	0.53	2	0.14
Treated Water Delivery	Cal Water Mountain View: GW	2010-2013	Monitoring Wells	Stable	1	-0.08	-0.08	-0.08	0	0.00	1	1.00
Treated Water Delivery	Cal Water Sunnyvale: GW	1998-2004	Monitoring Wells	Decreasing	5	-0.36	-0.02	-0.79	0	0.00	5	0.29
Treated Water Delivery	Cal Water Sunnyvale: GW	2009-2013	Monitoring Wells	Stable	5	0.27	0.58	-0.14	4	0.20	1	0.66
Treated Water Delivery	Great Oaks: GW	1975-1982	Monitoring Wells	Stable	9	-0.37	0.21	-1.00	1	0.26	8	0.38
Treated Water Delivery	Great Oaks: GW	1998-2004	Monitoring Wells	Decreasing	4	-0.14	0.00	-0.24	1	1.00	3	0.67
Treated Water Delivery	Great Oaks: GW	2009-2013	Monitoring Wells	Decreasing	8	-0.77	-0.50	-1.00	0	0.00	8	0.36
Treated Water Delivery	Milpitas: RWS	1975-1982	Monitoring Wells	Increasing	4	-0.19	0.64	-1.00	2	0.26	2	0.25
Treated Water Delivery	Milpitas: RWS	1986-1991	Monitoring Wells	Lacks Data	1	-0.28	-0.28	-0.28	0	0.00	1	0.46
Treated Water Delivery	Morgan Hill: GW	1975-1982	Monitoring Wells	Increasing	5	0.03	0.24	-0.40	3	0.44	2	0.77
Treated Water Delivery	Morgan Hill: GW	1986-1992	Monitoring Wells	Decreasing	4	-0.29	-0.16	-0.40	0	0.00	4	0.24
Treated Water Delivery	Morgan Hill: GW	1998-2004	Monitoring Wells	Decreasing	3	-0.19	0.13	-0.48	1	0.58	2	0.17
Treated Water Delivery	Morgan Hill: GW	2009-2013	Monitoring Wells	Decreasing	7	-0.31	0.00	-0.56	1	1.00	6	0.37
Treated Water Delivery	Mountain View: RWS	1986-1991	Monitoring Wells	Increasing	11	0.01	0.60	-0.53	5	0.46	6	0.55
Treated Water Delivery	Mountain View: RWS	1998-2000	Monitoring Wells	Decreasing	2	-0.83	-0.67	-1.00	0	0.00	2	0.27
Treated Water Delivery	Mountain View: RWS	2001-2004	Monitoring Wells	Stable	4	0.43	1.00	-0.50	3	0.64	1	0.72
Treated Water Delivery	Mountain View: RWS	2009-2013	Monitoring Wells	Decreasing	7	0.04	0.43	-0.38	4	0.64	3	0.75
Treated Water Delivery	North Morgan Hill:	1986-1992	Monitoring Wells	Decreasing	2	-0.31	-0.11	-0.50	0	0.00	2	0.27
Treated Water Delivery	North Morgan Hill:	1999-2004	Monitoring Wells	Decreasing	2	-0.47	-0.31	-0.64	0	0.00	2	0.16
Treated Water Delivery	North Morgan Hill:	2010-2013	Monitoring Wells	Decreasing	3	-0.78	-0.73	-0.87	0	0.00	3	0.18
Treated Water Delivery	Palo Alto: RWS	1975-1982	Monitoring Wells	Stable	5	0.47	0.78	0.16	5	0.19	0	0.00
Treated Water Delivery	Palo Alto: RWS	1986-1992	Monitoring Wells	Decreasing	5	-0.46	-0.13	-0.80	0	0.00	5	0.22
Treated Water Delivery	Palo Alto: RWS	1998-2002	Monitoring Wells	Stable	9	-0.55	-0.28	-0.87	0	0.00	9	0.24
Treated Water Delivery	Palo Alto: RWS	2009-2013	Monitoring Wells	Decreasing	11	-0.32	0.21	-1.00	3	0.86	8	0.42
Treated Water Delivery	San Jose Muni: RWS	1986-1992	Monitoring Wells	Increasing	10	0.36	0.75	-0.33	8	0.22	2	0.41
Treated Water Delivery	San Jose Muni: RWS	2000-2003	Monitoring Wells	Lacks Data	3	0.50	1.00	0.00	3	0.48	0	0.00
Treated Water Delivery	San Jose Muni: RWS	2010-2012	Monitoring Wells	Increasing	7	0.90	1.00	0.67	7	0.35	0	0.00
Treated Water Delivery	Santa Clara: GW	1975-1982	Monitoring Wells	Stable	11	-0.12	0.21	-0.80	7	0.64	4	0.12
Treated Water Delivery	Santa Clara: GW	1999-2001	Monitoring Wells	Lacks Data	1	0.00	0.00	0.00	1	1.00	0	0.00
Treated Water Delivery	Santa Clara: GW	2009-2013	Monitoring Wells	Lacks Data	1	0.33	0.33	0.33	1	0.54	0	0.00
Treated Water Delivery	Santa Clara: RWS	2011-2013	Monitoring Wells	Lacks Data	1	0.00	0.00	0.00	1	1.00	0	0.00
Treated Water Delivery	Santa Clara: RWS GW	1975-1981	Monitoring Wells	Increasing	6	-0.13	0.31	-0.50	3	0.55	3	0.54
Treated Water Delivery	Santa Clara: RWS GW	2011-2013	Monitoring Wells	Stable	2	-0.75	-0.67	-0.83	0	0.00	2	0.39
Treated Water Delivery	SJ Water Company Los Gatos: Local SW	1979-1982	Monitoring Wells	Stable	2	-0.02	0.11	-0.14	1	1.00	1	1.00
Treated Water Delivery	SJ Water Company Los Gatos: Local SW	1998-2000	Monitoring Wells	Decreasing	1	-1.00	-1.00	-1.00	0	0.00	1	0.30
Treated Water Delivery	SJ Water Company Los Gatos: Local SW	2001-2004	Monitoring Wells	Decreasing	1	-0.13	-0.13	-0.13	0	0.00	1	1.00
Treated Water Delivery	SJ Water Company Los Gatos: Local SW	2009-2013	Monitoring Wells	Decreasing	1	-0.53	-0.53	-0.53	0	0.00	1	0.22
Treated Water Delivery	SJ Water Company North: GW	1975-1982	Monitoring Wells	Increasing	31	0.04	0.46	-0.83	20	0.48	11	0.45
Treated Water Delivery	SJ Water Company North: GW	2011-2013	Monitoring Wells	Decreasing	23	-0.65	0.50	-1.00	3	0.77	20	0.53
Treated Water Delivery	Sunnyvale: RWS	1987-1992	Monitoring Wells	Increasing	3	0.85	0.89	0.78	0	0.00	0	0.00
Treated Water Delivery	Sunnyvale: RWS	2010-2012	Monitoring Wells	Increasing	2	0.33	1.00	-0.33	0	0.00	1	0.82
Llagas Subbasin Managed Recharge	Eastern Llagas:	1975-1982	Monitoring Wells	Increasing	3	0.45	0.54	0.34	3	0.09	0	0.00
Llagas Subbasin Managed Recharge	Eastern Llagas:	1988-1992	Monitoring Wells	Decreasing	3	0.13	0.56	-0.50	2	0.35	1	0.58
Llagas Subbasin Managed Recharge	Eastern Llagas:	1998-2004	Monitoring Wells	Stable	28	-0.15	0.33	-0.74	10	0.99	18	0.38
Llagas Subbasin Managed Recharge	Gilroy: GW	1975-1982	Monitoring Wells	Increasing	3	0.05	0.45	-0.50	2	0.32	1	0.43
Llagas Subbasin Managed Recharge	Gilroy: GW	1998-2004	Monitoring Wells	Decreasing	1	-0.50	-0.50	-0.50	0	0.00	1	0.06
Llagas Subbasin Managed Recharge	Gilroy: GW	2006-2010	Monitoring Wells	Stable	3	-0.02	0.29	-0.21	1	0.40	2	0.71
Llagas Subbasin Managed Recharge	Morgan Hill: GW	1975-1982	Monitoring Wells	Increasing	2	-0.13	0.14	-0.40	1	0.53	1	0.58
Llagas Subbasin Managed Recharge	Morgan Hill: GW	1998-2004	Monitoring Wells	Decreasing	1	-0.23	-0.23	-0.23	0	0.00	1	0.24

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Activity	Pumping Area	Evaluation Period	Well Type	Visual Trend	Count of wells with n > 8	Average tau	Max tau	Min tau	Num tau >= 0	Average padj for tau >= 0	Num tau <0	Average padj for tau < 0
Santa Clara Subbasin Managed Recharge	Great Oaks: GW	1998-2001	Monitored Pumping Wells	Decreasing	16	-0.20	0.60	-1.00	7	0.65	9	0.37
Santa Clara Subbasin Managed Recharge	Milpitas: RWS	1988-1991	Monitored Pumping Wells	Increasing	1	0.83	0.83	0.83	1	0.10	0	0.00
Santa Clara Subbasin Managed Recharge	Morgan Hill: GW	1975-1982	Monitored Pumping Wells	Increasing	2	0.35	0.35	0.35	2	0.12	0	0.00
Santa Clara Subbasin Managed Recharge	Morgan Hill: GW	1998-2001	Monitored Pumping Wells	Decreasing	21	-0.07	0.67	-0.55	9	0.78	12	0.49
Santa Clara Subbasin Managed Recharge	Mountain View: RWS	1998-2000	Monitored Pumping Wells	Decreasing	3	-0.61	-0.33	-1.00	0	0.00	3	0.72
Santa Clara Subbasin Managed Recharge	Mountain View: TW	1998-2001	Monitored Pumping Wells	Decreasing	2	-0.57	-0.40	-0.73	0	0.00	0	0.35
Santa Clara Subbasin Managed Recharge	North Morgan Hill:	1978-1982	Monitored Pumping Wells	Increasing	2	-0.27	-0.11	-0.43	0	0.00	2	0.44
Santa Clara Subbasin Managed Recharge	North Morgan Hill:	1999-2001	Monitored Pumping Wells	Decreasing	5	0.07	0.33	-0.33	4	1.00	1	1.00
Santa Clara Subbasin Managed Recharge	Palo Alto: RWS	1978-1982	Monitored Pumping Wells	Increasing	9	0.66	1.00	0.40	9	0.11	0	0.00
Santa Clara Subbasin Managed Recharge	Palo Alto: RWS	1998-2001	Monitored Pumping Wells	Stable	4	-0.46	-0.17	-1.00	0	0.00	4	0.68
Santa Clara Subbasin Managed Recharge	Palo Alto: RWS	2009-2013	Monitored Pumping Wells	Decreasing	6	-0.59	0.25	-1.00	2	0.55	4	0.40
Santa Clara Subbasin Managed Recharge	San Jose Muni: GW	1977-1982	Monitored Pumping Wells	Increasing	1	0.12	0.12	0.12	1	0.70	0	0.00
Santa Clara Subbasin Managed Recharge	San Jose Muni: TW	1978-1982	Monitored Pumping Wells	Stable	2	0.33	0.83	-0.17	1	0.20	1	0.72
Santa Clara Subbasin Managed Recharge	Santa Clara: GW	1978-1981	Monitored Pumping Wells	Stable	9	0.37	0.71	-0.11	8	0.55	1	1.00
Santa Clara Subbasin Managed Recharge	Santa Clara: GW	1999-2001	Monitored Pumping Wells	Decreasing	13	-0.33	0.67	-1.00	4	0.74	9	0.50
Santa Clara Subbasin Managed Recharge	Santa Clara: RWS GW	1978-1981	Monitored Pumping Wells	Stable	2	0.55	0.60	0.50	2	0.46	0	0.00
Santa Clara Subbasin Managed Recharge	Santa Clara: RWS GW	1998-2004	Monitored Pumping Wells	Lacks Data	1	-0.70	-0.70	-0.70	0	0.00	1	0.20
Santa Clara Subbasin Managed Recharge	Santa Clara: TW GW	1977-1980	Monitored Pumping Wells	Stable	7	0.23	0.40	0.00	7	0.65	0	0.00
Santa Clara Subbasin Managed Recharge	SJ Water Company East: TW	1978-1981	Monitored Pumping Wells	Increasing	11	0.27	1.00	-0.80	9	0.53	2	0.11
Santa Clara Subbasin Managed Recharge	SJ Water Company East: TW	1998-2001	Monitored Pumping Wells	Stable	10	-0.32	0.60	-1.00	3	0.54	7	0.28
Santa Clara Subbasin Managed Recharge	SJ Water Company North: GW	1978-1981	Monitored Pumping Wells	Increasing	11	0.17	1.00	-0.67	8	0.70	3	0.45
Santa Clara Subbasin Managed Recharge	Stanford: RWS	2011-2013	Monitored Pumping Wells	Stable	2	-0.67	-0.33	-1.00	0	0.00	0	0.75

Activity	Pumping Area	Evaluation Period	Well Type	Visual Trend	Count of wells with n > 8	Average tau	Max tau	Min tau	Num tau >= 0	Average padj for tau >= 0	Num tau <0	Average padj for tau < 0
Treated Water Delivery	Great Oaks: GW	1975-1982	Monitored Pumping Wells	Stable	13	-0.18	0.45	-1.00	6	0.48	7	0.26
Treated Water Delivery	Great Oaks: GW	1998-2004	Monitored Pumping Wells	Decreasing	19	-0.29	0.60	-1.00	5	0.64	14	0.30
Treated Water Delivery	Great Oaks: GW	2009-2013	Monitored Pumping Wells	Decreasing	13	-0.21	0.44	-0.79	3	0.34	0	0.40
Treated Water Delivery	Milpitas: RWS	1975-1982	Monitored Pumping Wells	Increasing	3	-0.16	0.38	-0.58	1	0.11	2	0.19
Treated Water Delivery	Milpitas: RWS	1986-1991	Monitored Pumping Wells	Increasing	1	0.54	0.54	0.54	1	0.13	0	0.00
Treated Water Delivery	Morgan Hill: GW	1975-1982	Monitored Pumping Wells	Increasing	6	0.25	0.41	-0.02	5	0.22	1	0.95
Treated Water Delivery	Morgan Hill: GW	1986-1992	Monitored Pumping Wells	Decreasing	5	-0.31	-0.16	-0.38	0	0.00	5	0.29
Treated Water Delivery	Morgan Hill: GW	1998-2004	Monitored Pumping Wells	Decreasing	16	-0.28	0.33	-0.59	2	0.84	14	0.36
Treated Water Delivery	Morgan Hill: GW	2009-2013	Monitored Pumping Wells	Decreasing	2	0.23	0.67	-0.21	1	0.06	0	0.56
Treated Water Delivery	Mountain View: RWS	1986-1991	Monitored Pumping Wells	Increasing	5	-0.10	0.48	-0.81	2	0.29	3	0.51
Treated Water Delivery	Mountain View: RWS	1998-2000	Monitored Pumping Wells	Decreasing	3	-0.61	-0.33	-1.00	0	0.00	3	0.72
Treated Water Delivery	Mountain View: RWS	2001-2004	Monitored Pumping Wells	Stable	3	-0.47	0.20	-1.00	1	0.67	2	0.34
Treated Water Delivery	Mountain View: RWS	2009-2013	Monitored Pumping Wells	Decreasing	5	0.16	0.67	-0.33	3	0.35	1	0.81
Treated Water Delivery	North Morgan Hill:	1986-1992	Monitored Pumping Wells	Decreasing	7	-0.56	-0.02	-0.70	0	0.00	7	0.17
Treated Water Delivery	North Morgan Hill:	1999-2004	Monitored Pumping Wells	Decreasing	9	-0.46	0.00	-0.72	1	1.00	8	0.16
Treated Water Delivery	North Morgan Hill:	2010-2013	Monitored Pumping Wells	Decreasing	6	-0.43	-0.25	-0.60	0	0.00	0	0.47
Treated Water Delivery	Palo Alto: RWS	1975-1982	Monitored Pumping Wells	Increasing	9	0.74	1.00	0.57	9	0.04	0	0.00
Treated Water Delivery	Palo Alto: RWS	1986-1992	Monitored Pumping Wells	Decreasing	9	-0.55	0.21	-1.00	1	0.58	6	0.26
Treated Water Delivery	Palo Alto: RWS	1998-2002	Monitored Pumping Wells	Stable	4	-0.14	1.00	-0.70	1	0.62	3	0.16
Treated Water Delivery	Palo Alto: RWS	2009-2013	Monitored Pumping Wells	Decreasing	6	-0.59	0.25	-1.00	2	0.55	0	0.40
Treated Water Delivery	San Jose Muni: GW	1975-1982	Monitored Pumping Wells	Increasing	2	0.07	0.27	-0.14	1	0.23	0	0.50
Treated Water Delivery	San Jose Muni: GW	1986-1992	Monitored Pumping Wells	Decreasing	1	-0.55	-0.55	-0.55	0	0.00	0	0.12
Treated Water Delivery	San Jose Muni: RWS	1986-1992	Monitored Pumping Wells	Increasing	12	0.42	0.91	-1.00	9	0.12	1	0.43
Treated Water Delivery	San Jose Muni: RWS	2000-2003	Monitored Pumping Wells	Decreasing	2	0.67	0.67	0.67	2	0.25	0	0.00
Treated Water Delivery	San Jose Muni: RWS	2010-2012	Monitored Pumping Wells	Increasing	3	0.33	1.00	-1.00	2	0.38	0	0.62
Treated Water Delivery	Santa Clara: GW	1975-1982	Monitored Pumping Wells	Stable	13	-0.03	0.44	-0.56	5	0.50	8	0.52
Treated Water Delivery	Santa Clara: GW	1999-2001	Monitored Pumping Wells	Decreasing	14	-0.33	0.67	-1.00	4	0.74	0	0.55
Treated Water Delivery	Santa Clara: GW	2009-2013	Monitored Pumping Wells	Decreasing	18	0.26	0.67	-0.17	17	0.53	0	0.67
Treated Water Delivery	Santa Clara: RWS GW	1975-1981	Monitored Pumping Wells	Increasing	2	0.08	0.16	0.00	2	0.78	0	0.00
Treated Water Delivery	Santa Clara: RWS GW	1998-2004	Monitored Pumping Wells	Lacks Data	1	-0.70	-0.70	-0.70	0	0.00	1	0.20
Treated Water Delivery	Santa Clara: RWS GW	2011-2013	Monitored Pumping Wells	Decreasing	1	-0.33	-0.33	-0.33	0	0.00	0	0.82
Treated Water Delivery	SJ Water Company Los Gatos: Local SW	1979-1982	Monitored Pumping Wells	Stable	1	-0.14	-0.14	-0.14	0	0.00	1	1.00
Treated Water Delivery	SJ Water Company Los Gatos: Local SW	1998-2000	Monitored Pumping Wells	Decreasing	1	-1.00	-1.00	-1.00	0	0.00	1	0.30
Treated Water Delivery	SJ Water Company Los Gatos: Local SW	2001-2004	Monitored Pumping Wells	Decreasing	1	-0.33	-0.33	-0.33	0	0.00	1	0.54
Treated Water Delivery	SJ Water Company Los Gatos: Local SW	2009-2013	Monitored Pumping Wells	Decreasing	1	-0.47	-0.47	-0.47	0	0.00	0	0.32
Treated Water Delivery	SJ Water Company North: GW	1975-1982	Monitored Pumping Wells	Increasing	26	0.13	0.59	-1.00	21	0.25	5	0.48
Treated Water Delivery	SJ Water Company North: GW	2011-2013	Monitored Pumping Wells	Decreasing	3	-0.89	-0.67	-1.00	0	0.00	0	0.46
Treated Water Delivery	Stanford: RWS	2011-2013	Monitored Pumping Wells	Stable	2	-0.67	-0.33	-1.00	0	0.00	0	0.75
Llagas Subbasin Managed Recharge	Eastern Llagas:	1975-1982	Monitored Pumping Wells	Increasing	26	0.33	0.56	-0.50	24	0.17	2	0.64
Llagas Subbasin Managed Recharge	Eastern Llagas:	1988-1992	Monitored Pumping Wells	Decreasing	26	-0.13	0.47	-0.79	12	0.65	14	0.39
Llagas Subbasin Managed Recharge	Eastern Llagas:	1998-2004	Monitored Pumping Wells	Decreasing	41	-0.52	0.00	-1.00	1	1.00	0	0.13
Llagas Subbasin Managed Recharge	Gilroy: GW	1975-1982	Monitored Pumping Wells	Increasing	5	0.36	0.45	0.27	5	0.15	0	0.00
Llagas Subbasin Managed Recharge	Gilroy: GW	1998-2004	Monitored Pumping Wells	Decreasing	1	-0.65	-0.65	-0.65	0	0.00	40	0.03
Llagas Subbasin Managed Recharge	Gilroy: GW	2006-2010	Monitored Pumping Wells	Decreasing	2	-0.17	-0.13	-0.21	0	0.00	0	0.77
Llagas Subbasin Managed Recharge	Morgan Hill: GW	1975-1982	Monitored Pumping Wells	Increasing	1	0.35	0.35	0.35	1	0.12	0	0.00
Llagas Subbasin Managed Recharge	Morgan Hill: GW	1998-2004	Monitored Pumping Wells	Decreasing	12	-0.26	0.33	-0.55	2	0.84	10	0.39

APPENDIX H: Santa Clara Plain Groundwater Model Simulations Memo

DRAFT - SUBJECT TO CHANGE

Santa Clara Valley Water District

MEMORANDUM

TO: George Cook

FROM: Yaping Liu
Xiaoyong Zhan

SUBJECT: Santa Clara Plain Groundwater Modeling For the Zone of Benefit Study

DATE: August 5, 2016

The purpose of this memo is to summarize Santa Clara Plain groundwater model simulations performed for the Zone of Benefit study. Current Santa Clara Plain groundwater flow model is used to simulate groundwater conditions for six scenarios. The simulation period is from January 1970 to December 2015 with a monthly stress period for all scenarios. Table 1 summarizes modeling assumptions, input data, and the name of model output head files for each scenario. The simulation assumptions in Table 1 are only assumptions that are different from the baseline. The quantified differences are listed in Table 2. In addition, shapefiles that are related to modeling assumptions are saved in G:\GWMU_Projects\GW_Charge_Zone\ModelingResults\SantaClaraPlain\Shapefile.

Table 1. Modeling Summary

Scenario	Activity	Simulation Assumption	Output Head File
1	Baseline	➢ Pumping input data: actual data. ➢ Managed recharge input data: actual data. ➢ Treated water input data: actual data. ➢ Recycled water input data: actual data.	Scenario_1.hed
2	Treated water reduction	➢ Pumping input data: • Actual data from Jan. 1970 to Dec. 2015. • Additional pumping equal to one half of actual treated water of the same month in selected wells of retailers who received treated water from Jan. 1980 to Dec. 2015. ➢ Treated water input data: • Reduced treated water equal to one half of actual treated water volume of the same month from Jan. 1980 to Dec. 2015.	Scenario_2.hed
3	Managed recharge reduction 1	➢ Managed recharge input data: • Actual data from Jan. 1970 to Dec. 2004. • Actual import water data only (zero local water) from Jan. 2005 to Dec. 2015.	Scenario_3.hed
4	Managed recharge reduction 2	➢ Managed recharge input data: • Actual data from Jan. 1970 to Dec. 2004. • Actual local water data only (zero import water) from Jan. 2005 to Dec. 2015.	Scenario_4.hed
5	Managed recharge reduction 3	➢ Managed recharge input data: • Actual data from Jan. 1970 to Dec. 2004. • Zero from Jan. 2005 to Dec. 2015.	Scenario_5.hed
6	Recycled water reduction	➢ Pumping input data: • Actual data from Jan. 1970 to Dec. 2015. • Additional pumping equal to actual recycled water of the same month in Palo Alto system from selected retailer wells in Palo Alto area from Jan. 2000 to Dec. 2015. • Additional pumping equal to actual	Scenario_6.hed

		recycled water of the same month in Sunnyvale system from selected retailer wells in Sunnyvale area from Jan. 2000 to Dec. 2015. • Additional pumping equal to actual recycled water of the same month in South Bay Water Recycling (SBWR) from selected retailer wells in other Santa Clara Plain area ➢ Recycled input data: • Actual from Jan. 1970 to Dec. 1999. • Zero from Jan. 2000 to Dec. 2015.	

DRAFT - SUBJECT TO CHANGE

Table 2. Partial Input Data.

Scenario	2	3	4	5	6		
	Additional Pumping equal to 50% Treated Water Reduction	Managed Recharge Reduction 1	Managed Recharge Reduction 2	Managed Recharge Reduction 3	Additional Pumping equal to 100% Recycled Water Reduction from Jan. 2000 – Dec. 2015		
Year	From Jan. 1980 – Dec. 2015	Import Water Only	Local Water Only	Zero	Palo Alto Area	Sunnyvale Area	Other San Clara Plain Area
1980	36,139						
1981	35,341						
1982	33,569						
1983	36,410						
1984	39,920						
1985	40,103						
1986	40,190						
1987	46,896						
1988	52,527						
1989	59,623						
1990	52,596						
1991	48,575						
1992	46,822						
1993	50,968						
1994	51,289						
1995	53,414						
1996	60,270						
1997	66,178						
1998	61,016						
1999	65,409						
2000	64,843				64	317	4,842
2001	67,087				64	1,320	6,002
2002	71,884				76	1,347	6,355
2003	65,297				87	1,822	6,297
2004	67,314				263	1,844	7,191
2005	66,967	16,297	50,856	0	1,306	1,851	8,035
2006	65,811	18,043	50,983	0	1,549	1,928	8,734
2007	65,709	51,489	9,865	0	1,436	1,874	10,084
2008	62,524	35,111	19,439	0	1,513	1,230	10,321
2009	55,378	40,414	25,666	0	1,849	1,454	9,901
2010	54,099	22,609	35,934	0	2,827	1,518	8,612
2011	61,160	14,861	39,960	0	2,960	1,057	9,085
2012	68,174	35,532	20,410	0	3,075	640	11,586
2013	63,390	46,104	17,717	0	2,523	658	15,296
2014	45,751	4,973	5,976	0	3,243	947	20,345
2015	47,247	23,155	5,003	0	3,296	967	18,461

APPENDIX I: Llagas Groundwater Model Simulations Memo

Santa Clara Valley Water District

MEMORANDUM

TO: George Cook, Vanessa De La Piedra

FROM: Chanie Abuye

SUBJECT: Llagas subbasin modeling results for Groundwater Charge ZOB study

DATE: July 29, 2016

The purpose of this memorandum is to document the modeling assumptions and data used to run the Llagas groundwater flow model to support the groundwater charge zone of benefit (ZOB) study. Existing Llagas groundwater flow model is used to assess the subbasin groundwater condition using actual groundwater pumping and recharge data from the beginning of October 1987 to the end of 2015 in one month increments. The groundwater demands and recharge conditions are based on the asumptions provided in the attached excel sheet, which are also listed below.

Assumptions, Scenarios and Results

Using the modeling assumptions described in detail below, a total of five different model runs were performed to produce the model output and the model outputs in MODFLOW binary head file format are presented as follows:

Scenarios	Assumptions	Outputs or Results
Baseline	➢ Simulation period: Oct87 to Dec15 ➢ Actual groundwater pumping ➢ Actual recharge (managed and natural)	Baseline.hds
Scenario1: Eliminate local water managed recharge	➢ Simulation period: Oct87 to Dec15 ➢ Actual groundwater pumping ➢ Actual recharge (managed and natural): **Oct87 to Dec04** ➢ **Eliminate local water managed recharge: Jan05 to Dec15**	EliminateLocalWaterManagedRecharge.hds
Scenario2: Eliminate upper Llagas imported water managed recharge	➢ Simulation period: Oct87 to Dec15 ➢ Actual groundwater pumping ➢ Actual recharge (managed and natural): **Oct87 to Dec04** ➢ **Eliminate Upper Llagas imported water managed recharge: Jan05 to Dec15**	EliminateImportedWaterManagedRecharge.hds
Scenario3: Eliminate all managed recharge	➢ Simulation period: Oct87 to Dec15 ➢ Actual groundwater pumping ➢ Actual recharge (managed and natural): **Oct87 to Dec04** ➢ **Eliminate all managed recharge: Jan05 to Dec15**	EliminateAllManagedRecharge.hds
Scenario4: Increased groundwater pumping by	➢ Simulation period: Oct87 to Dec15 ➢ Actual recharge (managed and natural) ➢ Actual groundwater pumping: **Oct87 to Dec98**	IncreasedGWPumpingByAmountsOfRWDelivery.hds

amounts of recycled water (RW) delivery	➢ **Increased groundwater pumping by the amounts of monthly recycled water delivery: Jan99 to Dec15. A total of 58 groundwater pumping wells (Ag and MI) within half mile distance of the recycled water pipeline are used to distribute increased pumping evenly. 58 wells are selected from 2015 groundwater pumping distribution.**	

For reference purpose, measured and simulated groundwater hydrographs from model layer 1 for San Martin well are included in the attachment. The hydrographs are generated to confirm the model assumptions input data are reasonably applied into the model for the intended simulation period. A location map is also included in the attachment to provide the approximate location of recycled water pipeline, half mile buffer outline, instream recharge, percolation ponds, groundwater extraction wells and San Martin groundwater monitoring well in Llagas Subbasin.

Please let me know if you have any questions or comments regarding this memo or the attached files.

Attachments:

1. Baseline.hds
2. EliminateLocalWaterManagedRecharge.hds
3. EliminateImportedWaterManagedRecharge.hds
4. EliminateAllManagedRecharge.hds
5. IncreasedGWPumpingByAmountsOfRWDelivery.hds
6. LlagasSanMartinWellHydrographs
7. Location map of recycled water pipeline and other reference features in Llagas Subbasin

1. Baseline		
Calendar Year	All managed recharge water in baseline model, AF	
2005	22,920	
2006	24,614	
2007	18,719	
2008	21,572	
2009	23,574	
2010	29,845	
2011	28,393	
2012	23,883	
2013	22,622	
2014	7,855	
2015	19,311	

Scenario 1. Eliminate Llagas local managed recharge		
Calendar Year	Managed recharge water applied in the model, AF	Eliminated Llagas local managed recharge, AF
2005	9,820	13,100
2006	6,621	17,993
2007	12,736	5,983
2008	11,531	10,041
2009	9,668	13,906
2010	9,548	20,297
2011	7,672	20,721
2012	11,158	12,725
2013	11,601	11,022
2014	5,328	2,528
2015	10,713	8,599

Scenario 2. Eliminate Upper Llagas imported water managed recharge		
CY	Managed recharge water applied in the model, AF	Eliminated Upper Llagas imported water managed recharge, AF
2005	18,408	4,512
2006	21,993	2,621
2007	9,844	8,875
2008	17,436	4,136
2009	19,254	4,320
2010	25,964	3,881
2011	25,410	2,983
2012	18,614	5,269
2013	17,179	5,443
2014	4,476	3,380
2015	13,612	5,699

Scenario 3. Eliminate all managed recharge		
Calendar Year	Managed recharge water applied in the model, AF	Eliminated All Managed recharge Water, AF
2005	0	22,920
2006	0	24,614
2007	0	18,719
2008	0	21,572
2009	0	23,574
2010	0	29,845
2011	0	28,393
2012	0	23,883
2013	0	22,622
2014	0	7,855
2015	0	19,311

Scenario 4. Increased groundwater pumping by amounts of recycled water delivery, AF		
Calendar Year	Increased Groundwater Pumping applied in the model, AF	Recycled water delivery, AF
1999	651	651
2000	746	746
2001	635	635
2002	495	495
2003	569	569
2004	1,162	1,162
2005	1,639	1,639
2006	1,782	1,782
2007	2,140	2,140
2008	2,183	2,183
2009	2,072	2,072
2010	1,761	1,761
2011	1,633	1,633
2012	1,940	1,940
2013	2,040	2,040
2014	2,015	2,015
2015	2,367	2,367

APPENDIX J: Possible Approach to Simplification of Boundaries and Boundary Uncertainty

HydroMetrics WRI

1814 Franklin St, Suite 501
Oakland, CA 94612

DRAFT TECHNICAL MEMORANDUM

To: George Cook, Santa Clara Valley Water District

From: Cameron Tana and Georgina King

Date: October 31, 2017

Subject: Possible Approach to Simplification of Boundaries and Boundary Uncertainty

1. Background

Technical Review Committee member Rebecca Nelson commented on the preliminary zone of benefit study on August 4, 2017 as follows:

> **Issue: simplification of boundaries**
> I understood the practical need to simplify complicated boundaries dictated by geology into something more amenable to efficient legal description. To help justify this process, it would be useful to give some indication/evidence of the difficulty/cost of having legal descriptions that mirror geological boundaries to head off any argument about arbitrariness of the simplified boundaries.
>
> I saw this as an area of particular challenge in terms of minimizing the number of pumpers on the margins of charge zones who might want to challenge the drawing of the boundaries. It seems desirable to try to head off as many of these challenges as possible at the outset. It would be possible to draw a link between the simplification of boundaries, and a spatial representation of the uncertainty of boundaries (see below), eg if a parcel of land lies mostly within an 'error band' around a particular boundary, a conservative approach may be to exclude it from a charge zone. This could be contrasted with a parcel of land, most of which lies within an area of high confidence as being within a zone of benefit on the basis of geology.
>
> **Issue: explicit treatment of uncertainty**
> It is worth mentioning that policy-related reports about groundwater seem to have an increasing tendency explicitly to reflect information about uncertainty, and

> how the uncertainty has been dealt with. Here, I distinguish uncertainty (eg relating to geological interpretation or using production wells for monitoring purposes) from conservative assumptions in terms of benefits (which I understand was the approach of the report). This is an unusual context for considering uncertainty, since it would not deal with uncertainty in terms of a variation in groundwater levels or volumes, but variation in a spatial boundary. I'm not entirely sure how one would represent it - but it would be worth some consideration. See one idea about the potential application of this to simplification of boundaries above.

This technical memorandum describes a possible approach to addressing these comments when simplifying boundaries for legal descriptions.

2. Possible Approach to Simplification

As a response to this comment, we propose that simplification of boundaries does not result in any well included in a zone of benefit or a zone of benefit with higher groundwater charges as a result of the simplification. First note that simplification will only be applied to zone boundaries based on geologic boundaries as other boundaries such as the County, basin boundaries, and delivery areas generally consist of straight line segments. Therefore, we propose the simplified boundary will lie within the mapped geology that defines the zone of benefit. No well that is outside the mapped geology that defines the zone will be in the zone. This does mean there could be wells located in the mapped geology that could be excluded from the zone. This is a conservative approach given the uncertainty of the mapped geologic boundaries.

2.1. Possible Steps for Simplification

The methodology below details how this possible approach will be implemented. The methodology involves two basic steps:

1. Simplify the boundaries based on mapped geology using the Douglas-Peucker algorithim using a tolerance of 50 feet.
2. Shift simplified boundaries inwards at least 50 feet reducing size of zone.

A 50 foot simplification tolerance is selected to reduce number of line segments of the largest Zone A to under 2,000 line segments. Current Zone W-2 has approximately 1,750 line segments so a 50 foot tolerance achieves a similar level of generalization as the current zones. These are more lines than requested by Towill in its draft scope of work for defining metes and bounds (attached) for the largest zones so the cost of Towill's scope may be higher than estimated. This higher cost may be offset by the zones smaller than Zone A having less lines than the Towill assumptions.

With respect to step 2, boundaries are shifted inwards into the zone if the boundary is with non-zone area, i.e., at the outer edge of the total area of zones of benefit. If the boundary is between two zones, the boundaries are shifted inwards into the zone that is expected to have a higher groundwater charge because it is demonstrated to have benefits from more District activities:

- Where Zone A (treated water delivery and managed recharge) shares geologic boundaries with Zones B1 and B2 (treated water delivery only) and Zone C (managed recharge only), boundaries will be shifted into Zone A.
- Where Zone D (managed recharge from local runoff and imported water) shares geologic boundaries with Zone E (managed recharge from imported water), boundaries will be shifted into Zone D.

An inward shift of at least 50 feet was selected so that the simplified boundary would always be within the unsimplified zone of benefit boundary and within the mapped geologic boundary. An inward shift of greater than 50 feet could abe used that accounts for uncertainty, as discussed below.

2.2. Simplification Methodology Details

The polygon boundaries representing the zones of benefit will be simplified into a version with a reduced number of line segments to facilitate the creation of a zone boundary legal description or metes and bounds. The Douglas-Peucker algorithm in ArcMap will be used to simplify the zone of benefit boundaries. This algorithm retains critical points by identifying and removing relatively redundant vertices to simplify data. The algorithm is based on the Douglas-Peucker algorithm: Douglas, David and Peucker, Thomas, "Algorithms for the reduction of the number of points required to represent a digitized line or its caricature," The Canadian Cartographer. 10(2), 112–22 (1973). This simplification algorithm is preferred over the Wang-Müller algorithm also available in ArcMap. The Wang-Müller algorithm identifies and eliminates relatively insignificant bends to simplify data. Although it is more faithful to the input geometry than the Douglas-Peucker algorithm, its level of simplification is not enough for a simplified version that needs to limit the number of straight lines in the largest zone boundary (Zone A) to under 2,000 lines.

The simplification tolerance parameter value in the simplification algorithm determines the degree of simplification. The larger the tolerance, the more coarse the resulting geometry is. Smaller tolerances generate geometry more faithful to the input. Preliminary tests indicate that a tolerance of 50 foot may be optimal. This will limit the simplified polygons to being no more than 50 feet away from the unsimplified polygon boundaries. Once the simplification algorithm has been run, the outermost boundaries of the simplified lines will have some portions that are outside of the original polygons (but not more than 50 feet). These are areas where the unsimplified polygons are concave. To ensure that the simplified line is always within the unsimplified charge zone polygon and the mapped geology, we propose to shift the outermost boundaries inwards by at least 50 feet. This will ensure that wells within any zone are located where geology associated with the zone is mapped.

3. Accounting for Uncertainty of Geologic Boundaries

In response to Rebecca Nelson's second comments, we attempt to identify uncertainty associated with the boundaries that define the preliminary zones of benefit. Then, we propose an adjustment to the simplification approach that accounts for uncertainty.

3.1. Sources of Uncertainty Associated with Zone Boundaries

Geologic boundaries on a map have several sources of uncertainty (Lark et al. 2015):

1. Conceptual uncertainty is "the uncertainty attached to a mapped boundary which represents a division of spatially continuous variation rather than a contact between two unambiguously different geological units". For example, this would occur where there is a lateral facies change.
2. Scale-dependent uncertainty occurs because "Even where a boundary is conceptually unambiguous, the precise position at which it should be described as a continuous line may depend on the spatial scale at which it is observed, and entails some degree of generalization of fine-scale variation".
3. Cartographic uncertainty is introduced when the geologist's mapped boundaries are converted to a cartographic product.
4. Interpretation uncertainty is the most obvious of the uncertainties and occurs when direct observation of a contact is not possible. Over most of the mapped length of a boundary, the line position is based on the mapper's interpretation of available information. Available information includes direct observation, geophysical surveys, inferring between observations, using constraining information such as topography. Therefore, the mapped position of the boundary is the geologist's best expert interpretation of the available information.

Conceptual, scale-dependent and cartographic uncertainty certainly exist in the geologic data from which the draft charge zones were derived, however they are not quantified by their mappers. Some of the data do have the interpreted uncertainty provided in map documentation or metadata. The table below summarizes the sources of data used to derive the draft charge zones. Some of these data have interpretation uncertainty specified in their map documentation or metadata, others have no mention of uncertainty.

<table>
<tr><th>Data Source</th><th colspan="2">Uncertainty Specified in Map Documentation</th><th>Measure of Uncertainty</th></tr>
<tr><td>Bedrock-Alluviumcontact</td><td colspan="2">1. contact, well located = depositional contact, location uncertainty less than about ±100 m
2. contact, approx. located = depositional contact, location uncertainty greater than about ±100 m</td><td>Attribute of each line in dataset from USGS</td></tr>
<tr><td>Geology (Santa Clara Formation and bedrock contacts)</td><td>San Jose 1:100,000
1. contact, certain
2. contact, approx. located
3. contact, inferred
4. contact, inferred, queried
5. contact, concealed
No other uncertainty metrics are provided in map documentation or metadata</td><td>Palo Alto 1:24,000
1. contact, certain
2. contact, approx. located
3. contact, concealed
No other uncertainty metrics are provided in map documentation or metadata</td><td>Not available</td></tr>
<tr><td>SCVWD Treated Water area</td><td colspan="2">The boundaries used for treated water areas were from a number of sources, some of which likely do not correspond with parcel boundaries. Reducing uncertainty of these areas could occur during process of defining metes and bounds.</td><td>Not available</td></tr>
<tr><td>County</td><td colspan="2">None – county line represents the true limit of the zone</td><td>No uncertainty</td></tr>
<tr><td>Alluvial cut offs</td><td colspan="2">These were delineated based on evaluation of surface evaluation but removes areas of alluvium from the zone so more likely to conservatively exclude wells that benefit</td><td>Not available</td></tr>
<tr><td>DWR Basin boundary at Coyote Narrows</td><td colspan="2">The DWR basin boundary is based on the groundwater divide which changes over time. However, the basin boundary itself is a defined</td><td>No uncertainty</td></tr>
</table>

	legal boundary and represents the true boundary of the zone	

We have identified that the SCVWD treated water area data used for the draft charge zones is not fully accurate. Although, there is no measure of uncertainty for those boundaries, ensuring that the boundary aligns with the served parcels will improve accuracy and uncertainty considerably.

3.2. Adjustments to Possible Simplification Approach to Account for Uncertainty

In conclusion, we propose the following:

1. Shift simplified geologic boundaries by 100 meters inwards, instead of the 50 foot inward shift in the GIS example provided. The metric of 100 meters is the only measure of uncertainty we have in the geological data used to derive the draft charge zones.
2. Use unsimplified County boundary in north.
3. Use unsimplified DWR basin boundary at Coyote Narrows
4. Use parcel boundaries to delineate treated water areas. This will mean those boundaries will not need to simplified or shifted inwards.
5. Use unsimplified alluvial cutoffs.

4. References

Lark, R. M., R. S. Lawley, A. J. M. Barron, D. T. Aldiss, K. Ambrose, A. H. Cooper, J. R. Lee, and C. N. Waters. 2015. *Uncertainty in mapped geological boundaries held by a national geological survey: eliciting the geologists' tacit error model.* Solid Earth, 6, p. 727–745. Web access: https://www.solid-earth.net/6/727/2015/se-6-727-2015.pdf

Preliminary geologic map of the San Jose 30 x 60 minute quadrangle, California. 1999. https://pubs.usgs.gov/of/1998/of98-795/of98-795_2a.txt

Geologic map and map database of the Palo Alto 30' X 60' quadrangle, California. 2000. https://pubs.usgs.gov/mf/2000/mf-2332/mf2332p.pdf

APPENDIX K: Groundwater Zone of Benefit Exemption Process

HydroMetrics WRI

1814 Franklin St, Suite 501
Oakland, CA 94612

DRAFT TECHNICAL MEMORANDUM

To: George Cook, Santa Clara Valley Water District

From: Cameron Tana

Date: October 31, 2017

Subject: Groundwater Zone of Benefit Well Exemption Process

1. Purpose and Scope

This memorandum provides a process for Santa Clara Valley Water District (District) staff to evaluate requests for exemption from a groundwater zone of benefit and, therefore, exempt water produced from the well from groundwater charges. The requests will be evaluated by the District staff to assess whether, in light of the submitted evidence, the District's determination to include the production well in the zone because it receives a benefit from District activities is reasonable and supported by evidence. The District staff's evaluation will be provided to the District's Board of Directors, which will decide whether the well should be exempt from the zone of benefit or re-assigned to a different zone of benefit.

2. General Changes from Current Process

This process includes the following general changes from the current process of groundwater charge zone modification, detailed in Document No. SOP465-103 from December 28, 2011:

1. This process assesses requests to exempt wells from a zone of benefit as opposed to exempting parcels. Document No. SOP465-103 provides a method for removing parcels from the zone of benefit.
2. Exemptions will be evaluated based on any relevant evidence that indicates the mapped boundary used to define the zone of benefit should be moved such that the well would be excluded from a zone or re-assigned to a different zone.
3. An evaluation that a well should be exempt from a zone of benefit will result in modification of zones of benefit but the modification will not be based on removing parcels from a zone of benefit. Instead, the modification will involve modification of zone boundary reflecting the relevant evidence indicating the

mapped boundary should be moved. The modification will also be consistent with boundary simplification approach used to facilitate legal descriptions of the zones. An example of a possible boundary simplification approach is summarized in section 9.2 and Appendix J of the Preliminary Zone of Benefit Study Report dated October 2017.

4. This process does not govern general modification of the zone of benefit resulting from changes to District activities or a revised understanding of the hydrogeology in the District, which is conducted pursuant to a separate process describing reviews of the zones of benefit.
5. The well may not be fully exempt from zones of benefit, and may be re-assigned with a different zone of benefit that is associated with a different set of District activities.

3. Basis for Well Exemption

Wells will be exempted or re-assigned from zones of benefit based only any relevant evidence that the boundaries used to define the zones of benefit are not accurately mapped relative to the well location. The boundaries used to define the proposed zones are as follows (Section 8 of preliminary zone of benefit study report):

1. Bedrock/Alluvium contact
2. DWR basin boundary approximating groundwater divide between Santa Clara and Llagas Subbasins.
3. Coyote Narrows between Santa Clara Plain and Coyote Valley.
4. Santa Clara Formation outcrops.
5. Retailer areas where District treated water is delivered
6. Narrows between bedrock outcrops in Llagas Subbasin
7. Western boundaries of Morgan Hill and Gilroy.
8. Constrictions where alluvial channels are upstream of areas hydrogeologically connected to District activities.

There is uncertainty with these mapped boundaries, particularly with the geologic boundaries as discussed in Appendix J of the preliminary zone of benefit study. Local information at and around the well may show that the boundary is mapped incorrectly relative to the well. Any such local information will be evaluated to assess whether the boundary is mapped incorrectly and should be modified to exempt or re-assign the well.

Other approaches used to evaluate benefits in the zone of benefit study do not apply to individual wells. For example, groundwater elevations at a single well may not clearly demonstrate a benefit from District's activities, even if that benefit is occurring. As explained in the zone of benefit study, groundwater level benefits are evaluated by comparing groundwater level trends to the trends that would be expected if the District activity was not occurring. If a groundwater level trend is expected to decline without a District activity, a declining groundwater level trend could occur at any individual well even as a benefit from the District activity is demonstrated in the area based on multiple lines of evidence. Although groundwater level data from that well may not show an absolute improvement, a benefit is still realized because groundwater level declines would be greater without the District activity.

4. Submittal Information

The following information should be provided by the well owner requesting exemption or re-assignment:

- Well Owner Name
- Well Owner Mailing Address
- Well Owner Phone Number
- Well Owner Email Address (optional)
- Well Address or Parcel Number (if Different from Owner Mailing Address)
- Well Number
- Field Visit Request to Check Mapped Location or Observe Surficial Geology and Obtain Information Requested by Well Owner
- Claim of Geologic Formation (optional, e.g. bedrock, Santa Clara Formation)
- Any Relevant Information to Support Request

The well owner should also provide any other available documentation of the well's, nearby wells' or the area geology, such as drillers logs completed by a C-57-permitted drilling contractor, geologic logs by a registered California Professional Geologist, a geophysical logs, geophysical surveys, visual evidence of surface outcrops of geologic formations.

If the request for exemption is based on a claim that delivery area boundaries (i.e. retailer areas where District treated water is delivered and the western boundaries of Morgan Hill and Gilroy) are inaccurate relative to the well, the well owner should provide any available documentation supporting the claim.

5. District Evaluation Procedure

5.1. Receive Request

The existing procedure for receiving a request in Document No. SOP465-103 from December 28, 2011 should continue to be followed. The main District activities in this step are:

- Compare submitted information to District records, including District copies of well logs.
- Confirm well is located in the correct groundwater zone of benefit and correct any discrepancies.

Before undergoing additional evaluation, the District should also confirm that a new evaluation of boundary near the well would change the well's zone of benefit assignment, based on the location of District activities assessed in the zone of benefit study. Some areas of bedrock have in-lieu benefits from the District's treated water deliveries to that area of the bedrock.

5.2. Field Visit

If requested in the submission, a District Professional Geologist will visit the well with the well owner present. The Professional Geologist should take the following actions on the visit:

- Compare well location with District mapped location.
- Record well coordinates with handheld Global Positioning System (GPS) unit
- Take photographs of well head and any surficial geologic features in surroundings
- Obtain any other information as requested by the well owner

Based on the field visit, District staff should update District records with any corrections to well locations and confirm the well is located in the correct groundwater zone of benefit. If the well is not located in the correct groundwater zone of benefit, any discrepancies should be corrected. Removing a well from a zone due to well location update is considered a record update as opposed to a well exemption requiring modification of the zone of benefit.

5.3. Conduct Evaluation of Boundary

If the well is located in the correct groundwater zone of benefit according to existing maps and the field visit, a Professional Geologist in the GMAU should conduct an evaluation of information pertaining to the boundary location. The evaluation will be based on information provided by the well owner, information in District records, and observations from a field visit.

Some geologic boundaries will be more difficult to evaluate than others. Identifying the various bedrock units should be relatively clear for evaluating the mapped location of the Bedrock/Alluvium contact, the location of Coyote Narrows, and the location of narrows between bedrock outcrops in the Llagas Subbasin. In contrast, identifying the Santa Clara Formation will likely be more challenging. Visual distinction between the Santa Clara Formation and Unconsolidated Alluvium can be difficult. To identify Santa Clara Formation, the Professional Geologist will compare the subject well information to well log information from nearby wells in the zone representing Santa Clara Formation, and in the zone representing Unconsolidated Alluvium. The Professional Geologist will make a professional judgement about which set of wells has geology most similar to the geology observed at the subject well. If the subject well is more like the geology of the wells in the Santa Clara Formation, boundary modification and well exemption or re-assignment should be evaluated. If the Professional Geologist is unable to make this distinction, the evaluation will conclude that the Santa Clara Formation has not been identified and boundary modification and well exemption or re-assignment should not be recommended.

To evaluate boundaries based on constrictions where alluvial channels are upstream of areas hydrogeologically connected to District activities, the Professional Geologist will evaluate information related to ground surface elevations, stream levels, and alluvial thicknesses. The Professional Geologist will make a professional judgement about whether these characteristics are more similar to the valley floor or the alluvial channels downstream of District reservoirs or alluvial areas that have been removed from the zone. If these characteristics around the well or more like areas that have been removed from the zone, boundary modification and well exemption or re-assignment should be evaluated. If the Professional Geologist is unable to make this distinction, the evaluation will conclude that alluvial channels upstream of areas hydrogeologically connected to District activities have not been identified and boundary modification and well exemption or re-assignment should not be recommended.

To evaluate boundaries based on retailer areas (areas that deliver District treated water, Morgan Hill, and Gilroy), GMAU staff will confirm information provided with the retailer and if the new information indicates that the boundary should be corrected, boundary modification and well exemption or re-assignment should be evaluated.

Boundary based on the DWR basin boundary representing the groundwater divide between the Santa Clara Plain and Llagas Subbasins will not be evaluated for adjustment based on local information. The groundwater divide is a regional characteristic of hydrogeology in the Basin and will not be revised based on local information. Evaluation of long-term changes to the groundwater divide will follow the process of zone of benefit review.

5.4. Modify Boundary and Recommend Exemption or Re-assignment

If the Professional Geologist determines that information warrants modification of the boundary, the Professional Geologist will recommend revised boundary based on all available information. The recommended boundary will also be consistent with boundary simplification approach used to facilitate legal descriptions of the zones. Based on the recommended revised boundary, the Professional Geologist will recommend whether the well should be in zone of benefit and what zone of benefit it should be assigned.

5.5. Documentation of Evaluation

District staff will produce a draft technical memorandum that includes:

- Summary of findings
- Comparison of submitted information to District records
- Documentation of field visit
- Evaluation of geologic data
- Recommendation of revised boundary modification if any
- Evaluation of zone exemption or re-assignment
- Appropriate figures with map locations and layers evaluated.

As directed in Document No. SOP465-103 , the draft technical memorandum will be reviewed by the Groundwater Management Unit manager and other appropriate staff, and comments from that review will be incorporated into a Final Technical Memorandum to be presented to Board for consideration

6. Board Consideration

The Board will consider input from the requestor and the evaluation and recommendation from Staff. If the Board approves a modification of the boundary, Staff will revise the metes and bounds. The revised metes and bounds will be taken to the Board for adoption.

APPENDIX L: Process to Conduct Future Reviews of Groundwater Zones of Benefit

HydroMetrics WRI

1814 Franklin St, Suite 501
Oakland, CA 94612

DRAFT TECHNICAL MEMORANDUM

To: George Cook, Santa Clara Valley Water District

From: Cameron Tana

Date: October 31, 2017

Subject: Process to Conduct Future Reviews of Groundwater Zones of Benefit

1. Purpose and Scope

This memorandum provides a process for Santa Clara Valley Water District (District) staff to conduct future reviews of the groundwater zones of benefit. It describes when the District Groundwater Monitoring and Analysis Unit (GMAU) should undertake reviews, and what those reviews should include. Reviews are based on changes to District activities and new information about hydrogeology in the District. All reviews should be documented, even if no modification of zones of benefit results. If the review results in a recommended modification to the zones of benefit, the recommendation will be presented to the District Board of Directors, and such a recommended modification will not take effect until approved by the Board. If approved by the Board of Directors, the modification will be codified by a revision of the zones' metes and bounds.

2. Background

The preliminary draft zones of benefit are primarily defined based on demonstrated benefits from the two District activities: managed aquifer recharge and delivery of treated surface water. These are the District activities that are the largest contributors to Santa Clara County's water resources. In addition, the zones distinguish between managed aquifer recharge systems that only recharge local runoff and those that can also recharge imported water. Other District activities, such as recycled water delivery support, untreated surface water deliveries, indirect potable reuse, and potential direct potential reuse, provide a benefit but have contributions to the County's water budgets that are either small, difficult to measure, or difficult to separate from the benefits of the two primary District activities. Therefore these other activities were not used for defining zones of benefit in the preliminary zone of benefit study. However, changes to the location of these activities could change the zones of benefit. Therefore, although these other activities were not used to initially define zones of benefit, we have included a discussion in this document about ways in which they could modify the zones of benefit in the future.

3. General Changes from Process for Well Exemption

This process includes the following differences from the current process of groundwater charge zone exemption, detailed in Document No. SOP465-103 from December 28, 2011, and the proposed process for well exemption (Appendix L of the preliminary zone of benefit study):

1. This process to review zones of benefit does not occur in response to requests for exemption from a zone of benefit from a well owner. A separate process describes exemption or re-classification of individual wells from a zone of benefit that focuses on local information that may justify revising zone boundaries near wells requested for exemption.
2. Currently, reviews are only initiated at District staff's discretion, and upon receipt of new information. This new process requires a review of zones of benefit if either of the following specified situations occur:
    a. Substantial changes to the type of District activities that provide the zone's benefits
    b. New hydrogeologic data become available

    Initiating review under these specified situations helps ensure the zones of benefit represent current District activities and the best available hydrogeologic information. The District can also set a scheduled interval to evaluate whether these specified situations have occurred.
3. The review tasks differ based on the situation that initiates the review.

4. Zone of Benefit Review Triggers

The preliminary draft zones of benefit are based on the areas where benefits are derived from the current locations of District activities. Therefore, the zones of benefit should be reviewed if existing District activities have a substantial geographic change, District activities are eliminated, or new District activities are added. Changes to the magnitude of District activities should not necessitate a review of zones of benefit.

The definition and extent of zones of benefit should be reviewed, and potentially revised, when any of the following changes to District activities occurs, or when any significant new hydrogeologic data become available.

4.1. Reviews Triggered by Changes to District Activities

Changes to any one of six District activities that provide groundwater benefits triggers a review of the zones of benefit when they entail a substantial geographic change. The definition of substantial geographic change is described for each activity in the following subsections.

4.1.1. Triggers Based on Changes to Managed Aquifer Recharge Programs

A substantial geographic change of the District's managed aquifer recharge activities would entail either:

- An addition or subtraction of managed aquifer recharge infrastructure that alters the geographic area benefited from managed aquifer recharge; or
- A change in the ability of a system to recharge imported water.

4.1.2. Triggers Based on Changes to Treated Water Delivery

A substantial geographic change of the District's treated water delivery area would entail a retailer adding or removing District treated water as a source of water for any of its service subareas. Adding or subtracting parcels or a subdivision to retailer's existing service subareas would not be considered a substantial geographic change in the alluvium areas because the area of hydrogeologic connection to treated water delivery areas will not have changed. However, adding or subtracting parcels or a subdivision to retailer's existing service subareas in bedrock would be considered a substantial geographic change because the zone of benefit boundary is based on the delivery area.

4.1.3. Triggers Based on Changes to Recycled Water Delivery

The preliminary draft zones of benefit are not based on the extent of demonstrated benefits from recycled water delivery. Instead, benefits from the District's recycled water activities are assigned to the existing zones of benefit in which the recycled water is delivered. Consistent with the zone of benefit study's assignment of recycled water activity to existing zones, the only substantial geographic changes that warrant a review of zones of benefit are:

- Removing an existing recycled water system from District activities; or
- Delivering recycled water to an area outside the zones currently receiving recycled water.

4.1.4. Triggers Based on Changes to Untreated Surface Water Delivery

The preliminary draft zones of benefit are not based on the extent of demonstrated benefits from the District's untreated surface water delivery. Instead, benefits from the District's untreated surface water delivery activities are assigned to the preliminary zones of benefit in which the untreated surface water is delivered. Untreated surface water delivery occurs to specific parcels, and was therefore considered not to be large enough to evaluate in the zone of benefit study. Consistent with the zone of benefit study, a substantial geographic change to untreated surface water delivery that warrants a review of the zones of benefit is delivery to an area outside the zones currently receiving untreated surface water.

4.1.5. Triggers Based on Changes to Indirect Potable Reuse Activities

The preliminary draft zones of benefit are not based on the extent of demonstrated benefits from planned indirect potable reuse; i.e., the replenishment of highly purified recycled water into the basin. Instead, the District's indirect potable reuse activities are assigned to preliminary draft zones based on existing and planned locations. A substantial geographic change to the planned locations may warrant a review of the zones of benefit.

4.1.6. Triggers Based on Changes to Direct Potable Reuse Activities

The preliminary draft zones of benefit are not based on the extent of demonstrated benefits from planned direct potable reuse. Instead, the District's planned direct potable reuse activities will be assigned to existing zones of benefit based on the location of the planned deliveries. A substantial geographic change to direct potable reuse activities that warrants a review of the zones of benefit is when the locations of the delivery areas for direct potable reuse are finalized.

4.2. Reviews Triggered by New Hydrogeologic Information

New hydrogeologic information may either change the District's understanding of groundwater flow within an existing zone of benefit or between adjacent zones of benefit. The triggering information for each of these two types of hydrogeologic information are described in the following subsections.

4.2.1. Triggers Based on Hydrogeologic Information within Existing Zones of Benefit

A new understanding that no reasonable basis supports the determination of a hydrogeologic connection within a zone of benefit could warrant subdividing the zone into multiple zones of benefit. The hydrogeologic information that would warrant a review of the zones of benefit include:

- Identifying a fault as a barrier to flow that could substantially reduce hydrogeologic connection within a zone;
- Identifying a pinching out of primary aquifer units; or
- Other information about subsurface geology that warrants substantial changes to an existing conceptual model of groundwater flow supporting a zone of benefit.

4.2.2. Triggers Based on Hydrogeologic Information between Existing Zones of Benefit

A new understanding of increased connection between zones of benefit could warrant expanding the zones, or combining multiple zones of benefit into a single zone. In some cases, such as the northern and southern boundaries of the Coyote Valley zone, new information could identify changed groundwater flow conditions. In other cases, such as the zones based on the extent of the Santa Clara Formation and Llagas and Uvas Creek Quaternary deposits west of Morgan Hill and Gilroy, new information could provide evidence of hydrogeologic connections with an adjacent zone where evidence of such a connection is currently lacking.

The hydrogeologic information that would warrant a review of the zones of benefit include:

- Changes to groundwater gradients at zone of benefit boundaries, such as the gradients in Coyote Narrows;
- Changes to the location of groundwater divides, such as that between Coyote Valley and Llagas Sub-basin;
- New hydrogeologic data in areas that lack any existing data, such as in and around the Santa Clara Formation;
- Changes to City service areas. The boundary of the zone of benefit representing the Quaternary deposits of Llagas and Uvas Creek with the zone of benefit representing the rest of Llagas Subbasin is partially based on the western boundaries of the cities of Morgan Hill and Gilroy. Without a documented geologic boundary in these areas, the cities' service area boundaries are used because the cities distribute groundwater pumped from the rest of the Llagas Subbasin throughout their systems. If the cities change the western boundaries of their service areas, the zone boundaries should be adjusted.

5. Process for Reviewing Zones of Benefit

The draft zones of benefit are based on available groundwater level, subsidence, and saltwater intrusion data measured over time, as well as groundwater modeling results where available. When changes are made to District activities, however, historical data regarding groundwater levels, subsidence, and saltwater intrusion will not be immediately available. As a result, it will be necessary to use other metrics to evaluate any resulting changes to the zones of benefit.

Groundwater modeling will be the preferred, primary tool, but can only be applied in areas where the groundwater model was adequate to define zones of benefit in the first instance. Groundwater modeling cannot be used to define the extent of benefits from District activities in certain circumstances, however. In particular, data and groundwater modeling results were not available when defining the zones of benefit in specific geologic formations. As described in the zones of benefit study, where modeling and data are not available, the preliminary draft zones of benefit are based on District activities occurring in those geologic formations and the interpreted hydrogeologic connection within those formations. In these areas where groundwater modeling is inadequate to define zones of benefit, the District will have to rely on evidence of hydrogeologic connections as the best available measure of changes in the geographic areas where wells are benefitted by District activities.

5.1. Zone of Benefit Reviews Using the Groundwater Model for Changes to District Activities

The following discussion applies to all areas where the groundwater model was adequate for defining zones of benefit.

Groundwater modeling should be performed in a manner consistent with modeling for the preliminary zone of benefit study. Model runs demonstrating the benefit of any substantial geographic change to District activity should be conducted for the same time period as the modeling in the zone of benefit study. Model runs simulating the changed District activity should be compared to model runs without the District activity to evaluate the extent of benefits from the changed District activity. Model runs will not evaluate the marginal effect of the changed activity by comparing the changed District activity to the unchanged District activity.

In general, the groundwater level results of the run with the changed District activities will be compared to the groundwater level results of the run performed for the zone of benefit study that simulates removal or reduction of District activities. If this comparison shows a substantial change in the area benefiting from the activity, the zone of benefit will be revised to reflect that substantial change.

Modeling for changes to specific District Activities are discussed in the following subsections.

5.1.1. Modeling Changes to Managed Aquifer Recharge Programs

The modeled groundwater levels incorporating the changed managed aquifer recharge activities should be compared to the modeled groundwater levels of the run performed for the zone of benefit study that simulates no managed recharge.

5.1.2. Modeling Changes to Treated Water Delivery Programs

The modeled groundwater levels incorporating changed pumping based on the changed delivery area will be compared to the modeled groundwater level of the run for the zone of benefit study that simulates increased pumping based on less in-lieu recharge throughout the current delivery area. The zone of benefit study assumed that the removal of delivered water would increase pumping in an amount equivalent to 50% of delivered water quantities. Modeling to reflect changes in District deliveries should be structured consistently, such that the addition of water deliveries to an area will decrease pumping by an amount equivalent to 50% of anticipated new deliveries, and the removal of water deliveries from an area will increase pumping by an amount equivalent to 50% of the removed deliveries.

5.1.3. Modeling Changes to Recycled Water Delivery Programs

If a recycled water system is removed from District supported activities, a model run will be conducted with increased pumping equaling the reduction of recycled water deliveries. If a recycled water system is added to District supported activities, a model run will be conducted with decreased pumping equaling the increase of recycled water deliveries. The modeled groundwater levels incorporating the changed pumping should be compared to the modeled groundwater levels of the run performed for the zone of benefit study that simulates no recycled water deliveries.

5.1.4. Modeling Changes to Untreated Surface Water Deliveries

The modeled groundwater levels incorporating reduced pumping due to changed untreated surface water deliveries should be compared to the results of another new run that simulates pumping without in-lieu recharge throughout the changed delivery area.

5.1.5. Modeling Changes to Indirect Potable Reuse

The modeled groundwater levels incorporating the pumping and injection changes related to new indirect potable reuse locations should be compared to the modeled groundwater levels of the historical baseline run performed for the zone of benefit study that simulates no indirect potable reuse.

5.1.6. Modeling Changes to Direct Potable Reuse

The modeled groundwater levels incorporating the pumping changes related to new deliveries of direct potable reuse water should be compared to the modeled groundwater levels of the historical baseline run performed for the zone of benefit study that simulates no direct potable reuse.

5.2. Modeling New Hydrogeologic Information

The model will also be used to model new hydrologic information where feasible.

5.2.1. Modeling New Hydrogeologic Information within Existing Zones of Benefit

New hydrogeologic data that suggest potentially reduced hydrogeologic connection within an existing zone of benefit should be incorporated into the District's groundwater model. Model simulations to compare runs with a District activity and with eliminated or reduced District activity should be performed with revised model. If model comparison results show a spatial break in areas where benefits occur from District activities, subdividing the zone into multiple zones may be warranted.

5.2.2. Modeling New Hydrogeologic Information between Existing Zones of Benefit

The District's groundwater model may be used to verify specific hydrogeologic changes between existing zones of benefit. These include:

- Verifying changes to groundwater gradients in Coyote Narrows will likely involve using runs of both the Santa Clara Plain and Coyote Valley groundwater models.
- Any new hydrogeologic data in areas that lack any existing data should be incorporated into the District's groundwater model to reflect the new hydrogeologic understanding. The revised groundwater model should be used to evaluate the revised extent of benefits from District activities.

5.3. Zone of Benefit Reviews Using Hydrogeologic Connections

The following discussion applies to all areas where the groundwater model was inadequate for defining zones of benefit.

For the areas where modeling of changed activities cannot be used to define the extent of benefits, changes to District activities must result in a review of the hydrogeologic connection between the District activity and the area in question based on assessment of hydrogeologically connected areas in the preliminary zone of study report. The report defined the Santa Clara Formation, Unconsolidated Alluvium of Coyote Valley and

Unconsolidated Alluvium along Llagas Creek and Uvas Creek west of cities of Morgan Hill and Gilroy as separate hydrogeologically connected areas that are not modeled. In general, the locations of any substantial geographic changes in District activities should be compared to the boundaries of these hydrogeologically connected areas to determine the geographic area and extent of impact from the change in District activities.

The following subsections address the review necessary for changes to specific District activities.

5.3.1. Managed Aquifer Recharge

In the preliminary draft zones of benefit, the geologic formations outside the models used for the study that receives a benefit from managed aquifer recharge included the Coyote Valley Unconsolidated Alluvium, and Llagas and Uvas Creek Unconsolidated Alluvium west of Morgan Hill and Gilroy. Removal of a managed aquifer recharge system could reduce the areas that has a hydrogeologic connection with managed aquifer recharge. Addition of a system could increase the areas that has a hydrogeologic connection with managed aquifer recharge.

5.3.2. Treated Water Delivery

In the preliminary draft zones of benefit, the geologic formation outside the models used for the study that receives a benefit from treated water delivery is the Santa Clara Formation. Removing District treated water as a source to a retailer subarea could reduce the area of the Formation that has a hydrogeologic connection with District's treated water.

In bedrock areas, the preliminary draft zones of benefit are based on the retailer areas receiving District treated water. If the retailer areas receiving District treated water in bedrock expand or contract, the zone of benefit should be revised to match those revised retailer areas.

5.3.3. Recycled Water Delivery

In the preliminary draft zones of benefit, there is no geologic formation outside the models used for the study receiving a benefit from recycled water deliveries. If recycled water is delivered to a new area outside all existing zones of benefit, the zones of benefit will need to be redefined to differentiate between the new area that is hydrogeologically connected to recycled water deliveries, and areas within the existing zones of benefit. If the areas within the existing zones of benefit receiving recycled water change, the zones of benefit will not change because it is defined by benefits from larger District activities but the assignment of recycled water benefits to zones will change.

If recycled water is delivered to bedrock in areas that do not match the areas in bedrock receiving treated water, the bedrock will have at least one additional zone that benefits from recycled water limited to the areas receiving recycled water.

5.3.4. Untreated Surface Water Delivery

In the preliminary draft zones of benefit study, the geologic formations receiving a benefit from untreated surface water deliveries included the Coyote Valley Unconsolidated Alluvium, and Llagas and Uvas Creek Unconsolidated Alluvium west of Morgan Hill and Gilroy. If the District delivers untreated surface water to a service area in non-bedrock areas, the zones of benefit will need to be redefined to differentiate between the new area that is hydrogeologically connected to the new untreated surface water deliveries and areas in the previous zones of benefit. If the areas within the existing zones of benefit receiving untreated surface water change, the zones of benefit will not change because it is defined by benefits from larger District activities but the assignment of untreated surface water benefits to zones will change.

Currently, deliveries of untreated surface water to parcels in bedrock areas are not assigned to zones of benefit. However, if untreated surface water is delivered to service areas in bedrock larger than parcels, those service areas will define a zone that benefits from this District activity. If the service areas receiving untreated surface water do not match the areas in bedrock receiving treated water, the bedrock will have at least one additional zone that benefits from untreated surface water limited to the areas receiving untreated surface water.

5.3.5. Indirect Potable Reuse

In the preliminary draft zones of benefit, the geologic formations receiving a benefit from indirect potable reuse included the Santa Clara Formation, Coyote Valley Unconsolidated Alluvium, and Llagas and Uvas Creek Unconsolidated Alluvium west of Morgan Hill and Gilroy. If the District expands its indirect potable reuse program to areas outside the existing zones of benefit, the zones of benefit will need to be redefined to differentiate between the new area that is hydrologically connected to the new indirect potable reuse deliveries and areas in the previous zones of benefit. If the areas within the existing zones of benefit where indirect potable reuse occurs or is planned change, the zones of benefit will not change because it is defined by benefits from larger District activities but the assignment of indirect potable reuse benefits to zones will change.

5.3.6. Direct Potable Reuse

If direct potable reuse delivery is established outside of existing zones of benefit, the zones of benefit will need to be redefined to differentiate between the new areas that are hydrogeologically connected to direct potable reuse and areas within existing zones of benefit. If no differences occur, the zones of benefit will not be revised; direct potable reuse will be assigned to the zone of benefit that is hydrologically connected to the direct potable reuse location. If the areas within the existing zones of benefit where direct potable reuse occurs or is planned change, the zones of benefit will not change because it is defined by benefits from larger District activities but the assignment of direct potable reuse benefits to zones will change.

5.4. Evaluating New Hydrogeologic Information in Areas that are not Modeled

Some new hydrogeologic information that becomes available may be related to the hydrogeologic connection outside the modeled area and will be assessed independently of the model.

5.4.1. New Hydrogeologic Information within Existing Zones of Benefit

For areas without groundwater level data or groundwater modeling results new hydrogeologic data could show less extent of connection within a geologic formation such as the Santa Clara Formation, Coyote Valley Unconsolidated Alluvium, and Llagas and Uvas Creek Unconsolidated Alluvium west of Morgan Hill and Gilroy. If the new understanding shows that some of these areas have substantially reduced hydrogeologic connection to locations of District activities, subdividing the zone into multiple zones is warranted.

5.4.2. New Hydrogeologic Information between Existing Zones of Benefit

Analyzing hydrogeologic connections between district activities and zones of benefit may be necessary to verify effects of new hydrogeologic data in specific areas. These include:

- Changes to the location of groundwater divides, such as that between Coyote Valley and Llagas Sub-basin will likely change the hydrogeologic connection between District activities and the boundaries of various zones of benefit
- Changes to City service areas will change the hydrogeologic connection between District activities and the boundaries of various zones of benefit

6. Documentation

When the District determines that a review of the zone of benefit study is warranted and undergoes the review, the District should document the review in a draft technical memorandum with the following information for District Board consideration.

1. The situation that led to the review;
2. Summary of review evaluation, including new data, model results, and maps.
3. Recommended changes to zones of benefit, if any.

If the District Board approves a modification the zones of benefit, the District will revise the metes and bounds defining the zones.

APPENDIX M: Technical Review Committee Comments on Study

Cameron Tana

From: Rebecca Louise Nelson <rebecca.nelson@unimelb.edu.au>
Sent: Friday, August 04, 2017 3:33 AM
To: Cameron Tana
Subject: RE: SCVWD zone of benefit study draft comments by Friday

Dear Cameron,

Thanks for the reminder. And thanks again for involving me in the project - it has been incredibly interesting, and I heartily congratulate everyone involved!

More than adding anything new, these comments capture what I understood to be some very helpful statements that responded to the questions that I had during the teleconference. I think it would be great to include clarifying information to this effect in the report.

Issue: simplification of boundaries
I understood the practical need to simplify complicated boundaries dictated by geology into something more amenable to efficient legal description. To help justify this process, it would be useful to give some indication/evidence of the difficulty/cost of having legal descriptions that mirror geological boundaries to head off any argument about arbitrariness of the simplified boundaries.
I saw this as an area of particular challenge in terms of minimizing the number of pumpers on the margins of charge zones who might want to challenge the drawing of the boundaries. It seems desirable to try to head off as many of these challenges as possible at the outset. It would be possible to draw a link between the simplification of boundaries, and a spatial representation of the uncertainty of boundaries (see below), eg if a parcel of land lies mostly within an 'error band' around a particular boundary, a conservative approach may be to exclude it from a charge zone. This could be contrasted with a parcel of land, most of which lies within an area of high confidence as being within a zone of benefit on the basis of geology.

Issue: Exemption procedures
The report describes a process for a pumper to apply for an exemption from a charge zone, and that there would be a shift from granting exemptions by parcel to exemptions by well. It would be useful to include the explanation that the reason for this change was to align with a greater focus on geology in the rest of the charge zone rationale. It would also be worth explicitly considering how to deal with a situation where one parcel holder has multiple wells. One consideration may be the burden that would be borne by one parcel holder having to pay high costs of producing geological information for multiple wells.

Issue: explicit treatment of uncertainty
It is worth mentioning that policy-related reports about groundwater seem to have an increasing tendency explicitly to reflect information about uncertainty, and how the uncertainty has been dealt with. Here, I distinguish uncertainty (eg relating to geological interpretation or using production wells for monitoring purposes) from conservative assumptions in terms of benefits (which I understand was the approach of the report). This is an unusual context for considering uncertainty, since it would not deal with uncertainty in terms of a variation in groundwater levels or volumes, but variation in a spatial boundary. I'm not entirely sure how one would represent it - but it would be worth some consideration. See one idea about the potential application of this to simplification of boundaries above.

Issue: Benefits of conservation activities/demand management
I found this part of the report particularly fascinating. It would be worth including the clarification that these benefits are treated as uniform not only because they are dispersed throughout the relevant regions, but also because the rebates were equally available to all. This could help deal with any criticism that focuses on the distribution of the actual take-up

of these rebates, ie that the volumetric benefit of the rebates in the groundwater context might be spatially non-uniform (eg on account of larger areas of irrigated open space in some neighbourhoods that results in a rebate leading to greater conservation, or a different mix of imported surface water vs groundwater in different regions etc).

Again, thank you very much for involving me in the project. I very much look forward to seeing the next stages. I noted down that there would be a stakeholder meeting and a Board meeting in October and November - I look forward to seeing the results.

Best regards,
Bec

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-----Original Message-----
From: Cameron Tana [mailto:cameron@hydrometricswri.com]
Sent: Tuesday, 1 August 2017 3:13 AM
To: Carl Hauge <tuleluke@hcc.net>; Rebecca Louise Nelson <rebecca.nelson@unimelb.edu.au>; rebeccalouisenelson@gmail.com
Cc: George Cook <GCook@valleywater.org>; Laura Brown <laura@hydrometricswri.com>
Subject: RE: SCVWD zone of benefit study draft comments by Friday

Carl, Rebecca-

Thank you again for your participation and feedback last week on our call discussing this study. As requested, this is a reminder that we have requested written comments by this Friday, August 4. I look forward to seeing them. Thank you.

Best, Cameron

-----Original Message-----
From: Carl Hauge [mailto:tuleluke@hcc.net]
Sent: Sunday, July 23, 2017 9:52 AM
To: Cameron Tana <cameron@hydrometricswri.com>
Cc: Rebecca Louise Nelson <rebecca.nelson@unimelb.edu.au>; rebeccalouisenelson@gmail.com; George Cook <GCook@valleywater.org>; Laura Brown <laura@hydrometricswri.com>
Subject: Re: SCVWD zone of benefit study draft download

Cameron—I have downloaded the draft report and have started reviewing it. I have not yet looked at the appendices.

11 August 2017

To: Cameron Tana

From: Carl Hauge

Subject: Comments on draft report, *Santa Clara Valley Water District Zone of Benefit Study*

First of all I will say that the amount of data that you have collected, evaluated and displayed in hydrographs, graphs, cross-sections and maps is mind-boggling. However, such an effort is necessary if groundwater management is to be effective, and user fees for that management are to be assessed equitably. The report provides the detail necessary to determine in which areas action by the District benefits groundwater users, and the hydrographs give some idea of the scale of that benefit.

I have not looked into the methodology that was used by the agencies you describe in Appendix A to develop their zones of benefit. You have outlined a detailed, data-driven method. As we commented during our telephone committee meeting, the methodology used in this report will serve as an example for the Groundwater Sustainability Agencies formed under SGMA. SCVWD has a municipal revenue source. Not all agencies have such a source of revenue. Nevertheless, I think this report provides useful guidelines.

Finally I repeat that I think that you and the District have done a remarkable job of collecting the data that are available, collating it appropriately, evaluating it, and coming to defendable conclusions to establish the 6 zones of benefit you have delineated. You will no doubt get a lot of comments during your workshops, but what is important is that you have begun a process that can only lead to better water management. And we need a lot more of such leadership!

I hope my comments below are useful.

1. Listing what is known about the different hydrogeologic properties of different rock types provides realistic parameters for differentiating zones of benefit.

2. Using these properties your delineation of potential zones of benefit appears to be reasonable. In Section 4.1 you describe Quaternary Alluvium. You might want to consider including brief geologic – hydrogeologic descriptions of the Santa Clara Formation and what you are calling bedrock to give the reader some information about the rock types that surround the basins and their hydraulic properties.

3. Figure ES-3 is an important figure but the explanations at the bottom are essentially illegible (I think even to younger people). I suggest you print the map on 1 page and the explanations on a separate page in a larger font.

4. A list of the variables that must be considered in evaluating zones of benefit would help the reader better understand:

   a. the complexity of defining zones of benefit, and
   b. the degree of precision or lack of precision of each of the estimated properties or values.

5. My count of the variables that affect groundwater availability includes:

   a. local precipitation
   b. local recharge
   c. amount of treated water available
   d. amount of recycled water available
   e. amount of local surface water available
   f. water saved thru conservation
   g. amount of groundwater extracted
   h. change in groundwater levels
   i. groundwater quality (although I understand quality is not a consideration in evaluating zones of benefit in this report)
   j. actions of local retailing water agencies
   k. hydrogeologic connectivity of aquifers and rock types
   l. bedrock boundaries
   m. population affecting water use
   n. number of active wells in retail agency areas

6. I would expect that some of your deduced values will be challenged during the public hearing procedures.

7. While I understand why inclusion of water quality in your list of variables would add another level of complexity, I do not think that groundwater quality can be ignored. The bottled water industry is reaping millions of dollars because of people's concerns about drinking water quality. You might want to more effectively highlight the District's actions to protect water quality. The State Water Board's recent setting of an MCL for TCP as a result of contamination in San Joaquin Valley reinforces people's concerns.

8. Appendix A: The description of other agencies' adoption of zones of benefit is a very useful reference.

9. Other appendices containing hydrographs show trends that are useful in establishing benefits. Appendix C shows a very clear increase in groundwater levels in all pumping areas with increased treated water delivery; Appendix D shows a very clear decreasing trend of managed recharge in all pumping areas in the Santa Clara subbasin; Appendix E shows no decrease of managed recharge in the Llagas subbasin. These are excellent tools for understanding the effects of variations that require management because the affect groundwater levels and availability.

10. The data sets available to you cover relatively short periods of time. While these data are useful, data collected over a longer period of time might be more representative of the variable being monitored. However, you have to work with what is available. This is a good example of the need for long-term monitoring to more efficiently manage water resources.

11. Table 10 in the report: You might consider adding “subsidence” and “salt water intrusion.”