

## **APPENDIX E**

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Groundwater Operational Yield Memorandum (City of Modesto, 2005)

# APPENDIX E GROUNDWATER OPERATIONAL YIELD MEMORANDUM

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## PREFACE

The attached memorandum entitled “Discussion on Operational Yield for the 2005 Urban Water Management Plan” was prepared by the City of Modesto and included in the Joint City of Modesto/MID 2005 and 2010 Urban Water Management Plans (UWMPs). The purpose of the memorandum was to describe the basis for estimating the “operational yield”, or annual groundwater pumping quantity, that could be extracted from the aquifer underlying the City’s water service area that includes the Modesto, Turlock and Delta-Mendota sub-basins. As described in the memorandum, the City’s Operational Yield was estimated to be 53,500 acre-feet per year.

The memorandum describes that the City had decreased its use of groundwater when Phase 1 of the Modesto Regional Water Treatment Plant (MRWTP) was completed in 1995; however, groundwater pumping increased from 2000 to 2005 to meet increasing demands in the City’s service area, and would need to continue to increase to meet the needs for near-term development until the MRWTP Phase 2 expansion was completed (the MRWTP Phase 2 expansion was completed in May 2016).

It should be noted that the United States Geological Survey (USGS) is currently in the process of developing a simulation/optimization model of the Modesto Area Groundwater Basin for use in evaluating water resources management alternatives. It is not known when the USGS study will be completed. The findings of the USGS study may result in changes to the City’s estimate of the Operational Yield. However, the City’s current estimate of the Operational Yield of 53,500 af/yr will continue to be assumed pending the USGS study findings.

# Memo

To: Nick Pinhey – Public Works Director  
Rolly Stevens – Assistant City Attorney  
Alison Barratt-Green – Senior Deputy City Attorney

From: William Wong – Associate Civil Engineer

CC: Rich Ulm, Jack Bond, Garner Reynolds, Jim Alves, Violet Jakab, Allen Lagarbo

Date:

Re: **FINAL** - Discussion on Operational Yield for the 2005 Urban Water Management Plan (UWMP)

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This memorandum establishes an empirical basis for estimating the “operational yield” for the rate of groundwater pumping within the City’s water service area that includes the Modesto, Turlock, and Delta-Mendota sub-basins. Information incorporated into this study includes water well pumping records, groundwater elevation data, and future demands based on land use densities at build-out.

For clarification, and as used in this report, the following terms are defined:

**Operational Yield** – is an amount (or rate in acre-feet per year) of localized groundwater withdrawn on an annual average basis by a given agency that does not exceed the long-term annual average recharge rate of the localized aquifer(s) from which the groundwater is being pumped.

**Sustainable Yield** – is similar to operational yield, but applies to an entire groundwater basin and all of the entities pumping from it as a whole, rather than just a localized area and a specific agency.

**Safe Yield** – is everything defined for sustainable yield, but also includes other considerations beyond just a quantity of water extracted or recharged, such as its quality and potential surface subsidence issues. Safe yield can be defined as the maximum amount of water that can be pumped without creating any long-term undesirable results. However, for the purposes of this report, safe yield is considered to be synonymous with sustainable yield.

**Overdraft** – is when the long-term annual average rate of extracted groundwater exceeds the annual average rate of recharge, as measured by groundwater levels (as measure of groundwater volume is difficult). Overdraft is also defined as the deficit between the water pumped from a groundwater basin and the long-term basin recharge.

The basis of previous estimates of the combined City’s “safe yield” of 50,000 AFY repeated in various City documents is not clear through researching of available literature. Previous documents reference a historic water budget, using data that was not directly measured, but estimated. The uncertainty of this data and the

determination of the safe yield are currently considered questionable, and recent data suggests that this value may not be correct.

This memorandum attempts to use existing data from various sources to reconcile an estimate of the City's current groundwater operational yield, instead of "safe yield" for the entire City of Modesto's Water Service Area.

**Establishing an Operational Yield:**

It is envisioned that the City will undertake a more comprehensive, hydro-geological groundwater yield study in the upcoming fiscal year where more resources can be devoted to the task of quantifying the City's groundwater operational yield. Until then, it is believed that the rate of extraction established in this report accurately reflects the best data readily available to staff and will be incorporated into the 2005 Urban Water Management Plan.

Prior to 1995, the City's sole source of domestic water was from groundwater pumping. The effect of long-term groundwater extraction consequently resulted in a decline of groundwater elevation, which led to temporary overdraft conditions, primarily in the downtown Modesto area. However, once the City began to implement conjunctive use by supplementing its water supplies with 33,602 AFY of treated surface water from Phase 1 of the MID Modesto Regional Water Treatment Plant (MRWTP) in 1995, the City has been able to reduce its groundwater extraction. As a result, groundwater levels began to rise correcting the temporary overdraft conditions. **Figure 1** shows that recent groundwater levels have decreased slightly as groundwater pumping increased over the last six years (2000 – 2005); however, until additional hydrogeologic studies are completed, it appears that current groundwater extractions and water levels are, to some extent, in a steady state condition.

The current annual water demands for the entire City of Modesto water system, in the Modesto and Turlock sub-basins, are over 79,000 AFY. The City's current rate of groundwater extractions is about 70% of the historically high pumping levels of 1994, and is not causing an overdraft condition.

**Table 1 – Current Annual Groundwater Extractions**

Year	Annual GW Extractions from the Modesto Subbasin (AFY) <sup>a</sup>	Annual GW Extractions from the Turlock Subbasin (AFY) <sup>a,b</sup>	Average GW Extractions from the Delta-Mendota Subbasin (AFY) <sup>a,c</sup>	Totals
2000	37,495	4,958	261	42,714
2001	40,857	4,837	297	45,991
2002	43,535	5,445	324	49,304
2003	41,990	5,053	287	47,330
2004	41,681	4,194	261	46,136
2005	41,090	4,849	237	46,176
Average Annual Groundwater Extractions	<b>41,108</b>	<b>4,889</b>	<b>278</b>	<b>46,275</b>

- a. Based on City of Modesto SCADA records
- b. Includes South Modesto, Hickman, portions of North Ceres and Turlock.
- c. The Community of Grayson is within the Delta-Mendota Subbasin

As shown in **Table 1**, current six-year average (between 2000 and 2005) of groundwater extractions for the entire City of Modesto water system is 46,275 AFY. These water demands also reflect some water conservation due to continuous implementation of Stage I restrictions from the City's Drought Contingency Plan in 2003.

The City maximizes its surface water allocation within the City's contiguous service area, and must rely on groundwater pumping to meet its maximum day and peak hour demands. To meet the demands of future development, the City will currently be working with the MID to double the capacity of the Modesto Regional Water Treatment Plant (MRWTP) to 67,204 AFY. However, the Phase 2 Expansion of the MRWTP is not anticipated to be on-line until mid- to late-2009, and therefore the City will need to increase its groundwater pumping to meet the demands for near-term development. This would be done by drilling new wells, rehabilitating currently out-of-service wells, or increasing the pumping from existing wells.

The movement of groundwater for both sub-basins is generally in a westward direction from the Sierra Nevada foothills. Recent analysis by the USGS and information from California's Groundwater Bulletin 118 has indicated that the geological characteristics of the Modesto and portions of Turlock sub-basins that are served by the City of Modesto appear to be similar. Although the Tuolumne River separates the Modesto and Turlock sub-basins, the USGS has determined that both groundwater and surface water systems are interconnected, and it can be reasonably assumed that groundwater flows between the two sub-basins. This has also been indirectly substantiated by analysis of the City's static well level data; the average groundwater elevations of the City's production wells between the Modesto and Turlock groundwater sub-basins are very comparable. Therefore, in this analysis, it is assumed that the cumulative groundwater extractions by the City apply to the entire City's water service area and no further distinctions are made between the two sub-basins (this does not apply to the Delta-Mendota sub-basin).

Based on California's Groundwater Bulletin 118 for the Modesto Sub-basin, as a result of long-term groundwater pumping, a cone of depression formed when the groundwater elevations reached around 30 feet above sea level (ASL) (see **Figure 2**). In order to extrapolate an operational yield using empirical data, a minimum groundwater elevation of 40 feet ASL was selected as the lowest elevation that the City will allow groundwater to reach. By establishing this minimum groundwater elevation allowable, the City can reasonably establish a conservative operational yield and be certain that the associated amount groundwater pumping should not result in an overdraft condition.

Based on a relative stabilization of groundwater elevations through the City's water service area, the City's current annual average groundwater pumping constitutes a non-overdraft condition, and therefore it can be assumed that the City is within its operational yield range. **Figure 3** plots the City's groundwater pumping and associated well levels between 1993 through 2006. It is apparent that there is not a linear relation between groundwater extractions to groundwater levels. Nevertheless, a linear factor rate was extrapolated from existing well information and can be considered a conservative representation of the effects of groundwater levels due to pumping. An empirical equation was extrapolated from these data points, which estimates that the groundwater levels will decline at a rate of approximately **0.685 feet/1,000 AFY** (or 1 foot per 1,430 AFY) of groundwater extracted over the entire water service area.

It is reasonable that, until hydrogeologic studies are complete, the City can use this estimated rate as the City's "**operational yield factor**". Using 40 ft ASL as the minimum allowable groundwater elevation, the associated **operational groundwater yield** is approximately **53,500 AFY**. This calculated operational yield is a projection of the City's water service area's groundwater pumping capacity (AFY) and is based on the following:

- Groundwater elevation data from 1993 to 2006 obtained from spring and fall field measurements by the City Water Department.
- Groundwater pumping data obtained from Water Department and from the City's SCADA from 2003 to current. Prior pumping records were obtained through Del Este and City of Modesto files.
- Assumes that Ag-to-Urban conversion accounted for in the calculated operational yield estimate.

The calculated operational yield does not account for:

- The City's ability to extract groundwater from the subbasins to meet demands.
- Seasonal peak water demands, and localized water distribution and pressure issues.

- Growth beyond the City's current water service area, either within the contiguous Modesto System or the outlying areas.
- Varying economic factors that could effect the projected growth assumptions.
- More stringent water quality standards would result in potential losses in well production from taking wells out-of-service due to contamination, such as from Arsenic, Nitrates and Uranium.

Additionally, once the City begins necessary groundwater studies to determine an actual operational yield (or specific yield) of the groundwater sub-basins, water budget and quality analyses for the groundwater sub-basins, the City would be able to develop procedures to optimize its groundwater extractions, and determine potential Aquifer Storage and Recovery (ASR) opportunities, where the City could potentially recharge the groundwater basins with surface water during seasonal low demand periods.

### **Conclusions:**

Recent projections from MID anticipate that Phase 2 of the MRWTP expansion will be complete by mid- to late-2009. However, until the additional 33,602 AFY of surface water is available to meet demands, the City will need to increase its groundwater extractions to meet water demands until Phase 2 is on-line.

More extensive studies and modeling will be required to quantify the City's operational yield and water budget for both the Modesto and Turlock sub-basins. However, based on self-imposed groundwater level limits, the City's current Operational Yield is estimated at **53,500 AFY**.

Recent information has indicated that the City has gradually increased its groundwater pumping over the last few years to meet growth demands. It is not anticipated that the City will continue to increase its groundwater extractions for an extended period of time, since Phase 2 is expected to be online by mid- to late- 2009. It is not expected that this short term increase of pumping would cause an overdraft condition in the Modesto Subbasin, which is typically a result from a cumulative effect of long-term over-pumping.

Figure 1 - 1993-2006 Groundwater Elevation and Pumping Data

# ESTIMATED ANNUAL GROUND WATER ELEVATION vs GROUND WATER PUMPING 1993 - 2006

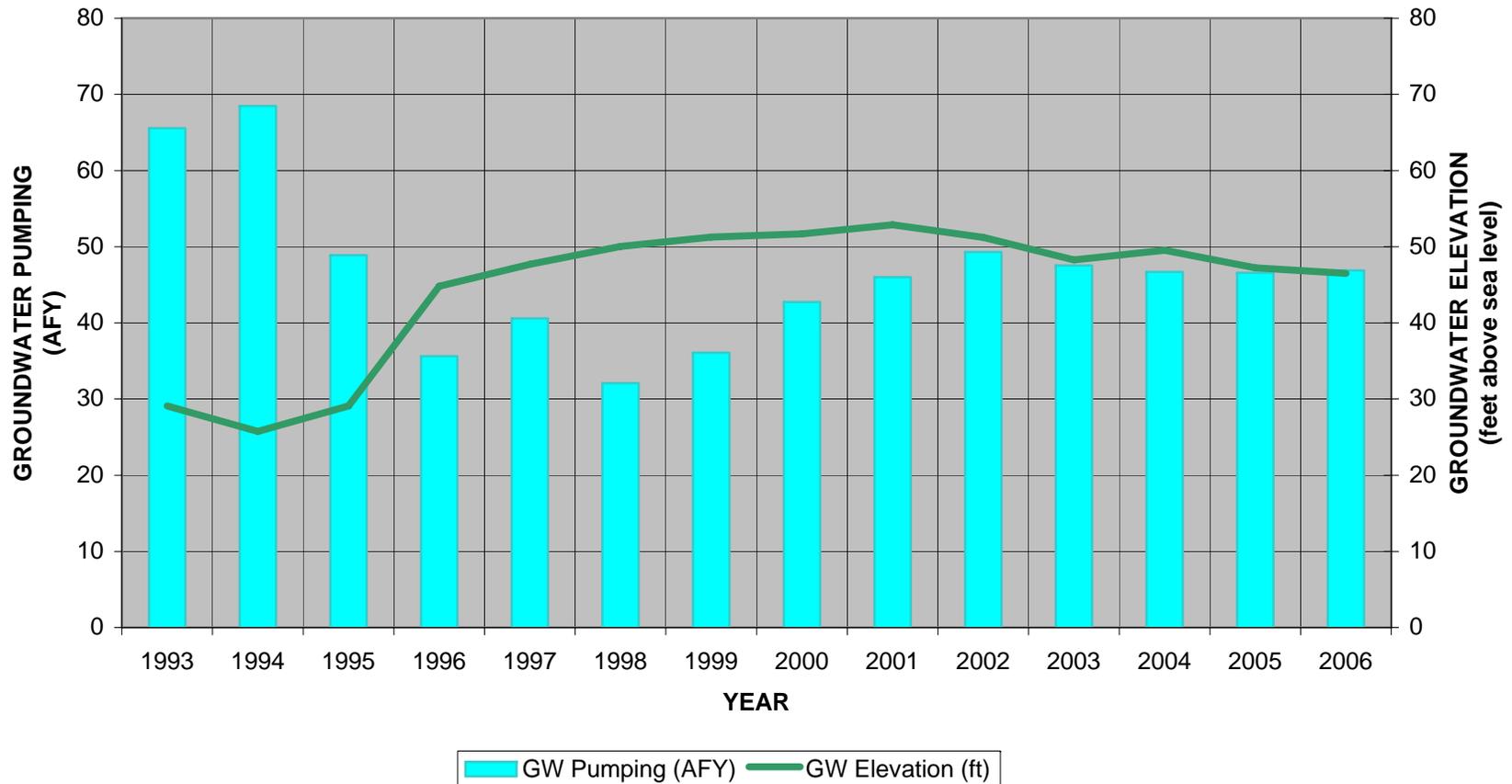
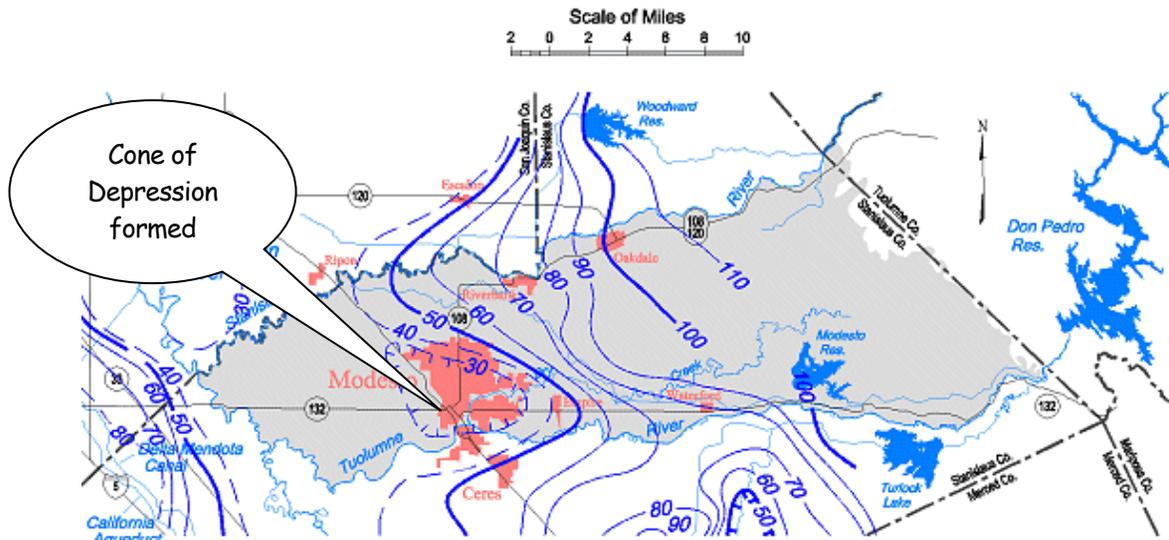


Figure 2 – 1993 and 1998 Groundwater Elevations (above sea level)

Source: Department of Water Resources (DWR) Website - [http://www.sjd.water.ca.gov/groundwater/basin\\_maps/index.cfm](http://www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

# Modesto Groundwater Basin

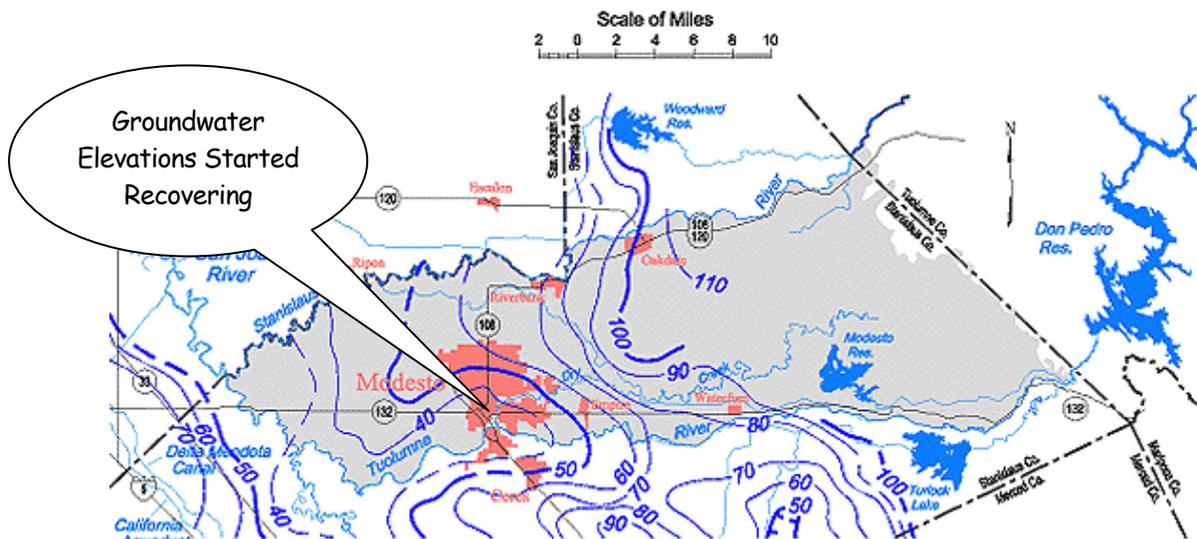
## Spring 1993, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



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

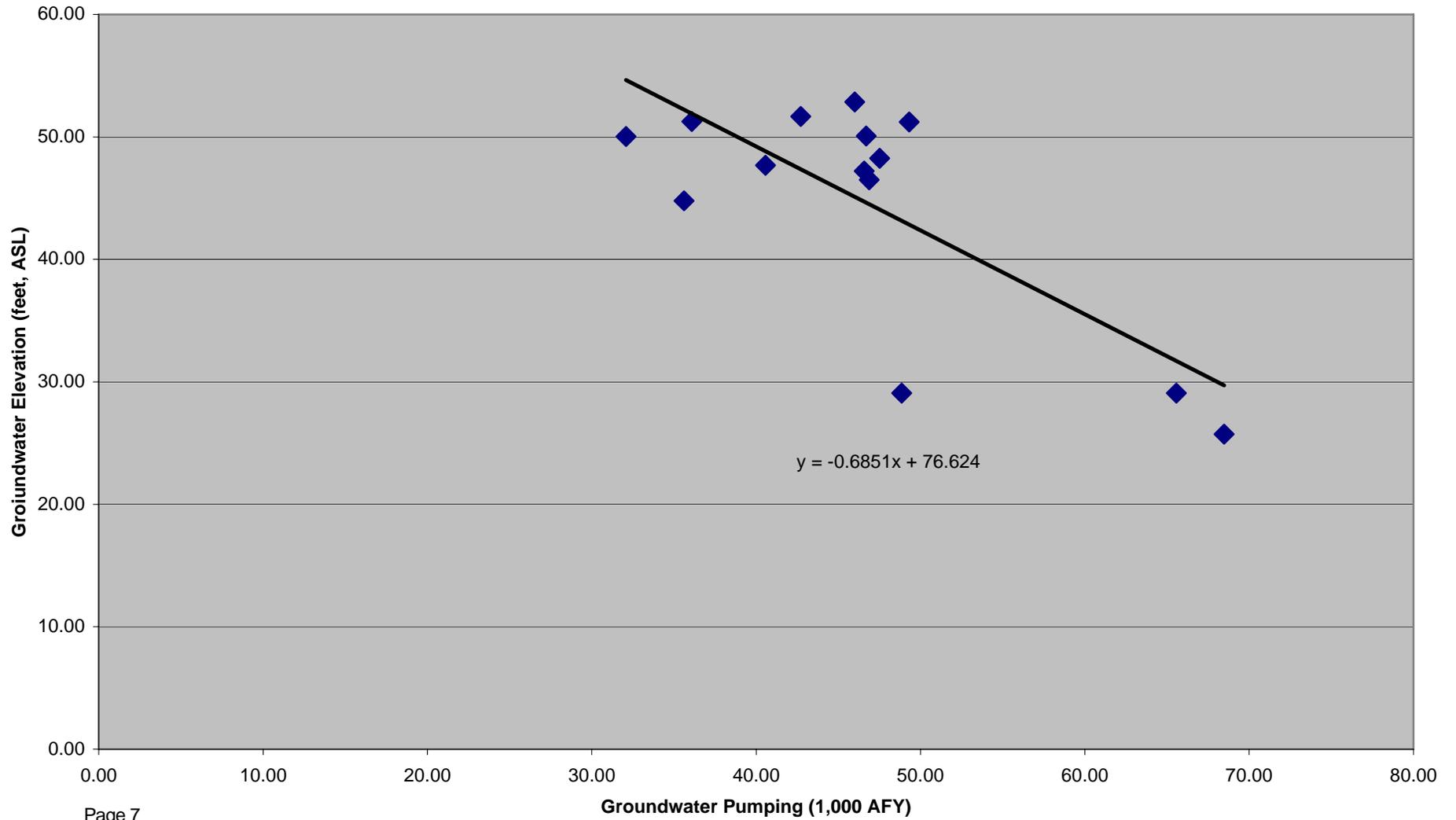
# Modesto Groundwater Basin

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



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

Groundwater Pumping vs Elevation (1993-2006)



# ACTUAL ANNUAL AND PROJECTED GROUND WATER ELEVATION vs GROUND WATER PUMPING

