

Appendix 1-A

Central Sacramento County Groundwater Management Plan
(February 2006)

Appendices

Appendix A

Summary of the process used for arriving at the long-term average annual sustainable yield of 273,000 AF/year that was negotiated by the Central Basin.

Appendix A – Summary of the process used for arriving at the long-term annual average sustainable yield of 273,000 AF/year that was negotiated for the Central Basin

This appendix describes how the Groundwater Negotiation Team (GWNT) developed the long-term annual average sustainable yield for the Central Basin.

The first step taken was development of the baseline models. The buildup of water demands for each model is shown in **Figure A-1**. Groundwater extractions range from approximately 250,000 AF/year in 1990 to 350,000 AF/year in 2030. One additional demand condition was evaluated to consider if 1990 levels of water demand were sustained with 25 percent levels of water conservation applied. This demand condition is not represented in **Figure A-1** to avoid confusion, but is represented in each of the model result graphs that follow.

Figure A-1. Baseline Groundwater Demand Build-up in Central Basin

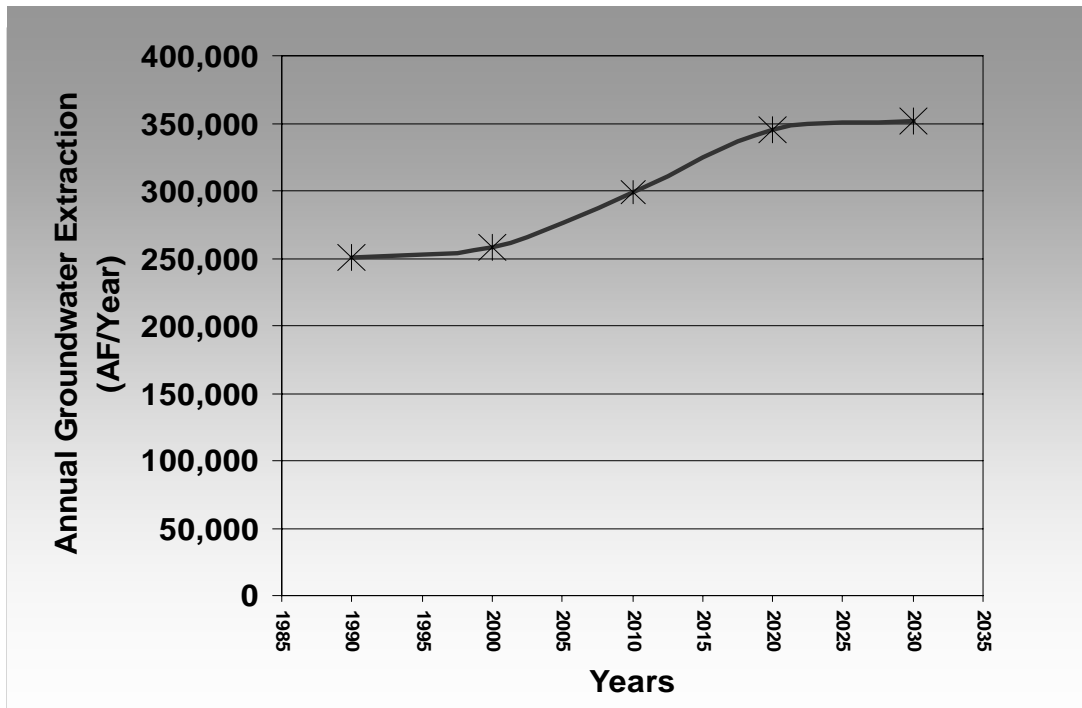
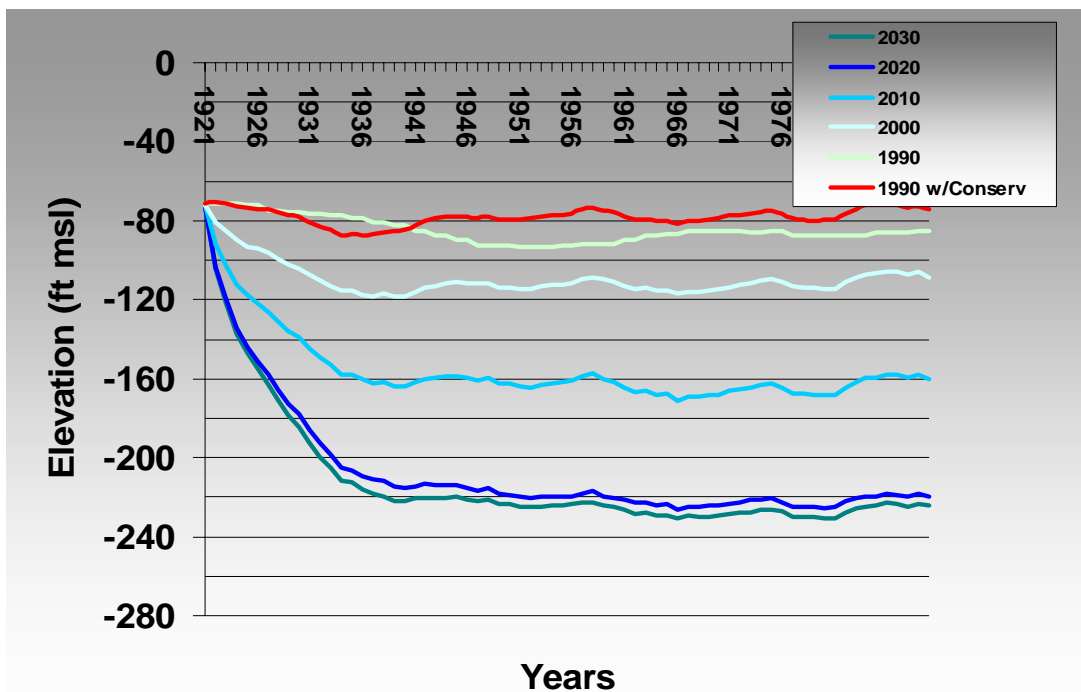


Figure A-2 illustrates the response of groundwater elevations to the simulated demands from the computer model using 70-years of historical hydrology for each 10-year growth increment. This collection of model runs comprises the baseline runs used for negotiation of the sustainable yield.

Each baseline model run begins at the same initial condition of approximately 73 feet below sea level (**Figure A-2**). This initial condition simply represents a starting point and should not be construed as a measured groundwater elevation. It is only after 15 to 20 years in the model run that the model begins to reflect what the groundwater elevation pattern might look like under the varying hydrologic period. From the initial condition, the direction and severity of the groundwater elevation curve as it moves forward in time through the historical hydrologic years depends on the use of groundwater and the imposed land use conditions.

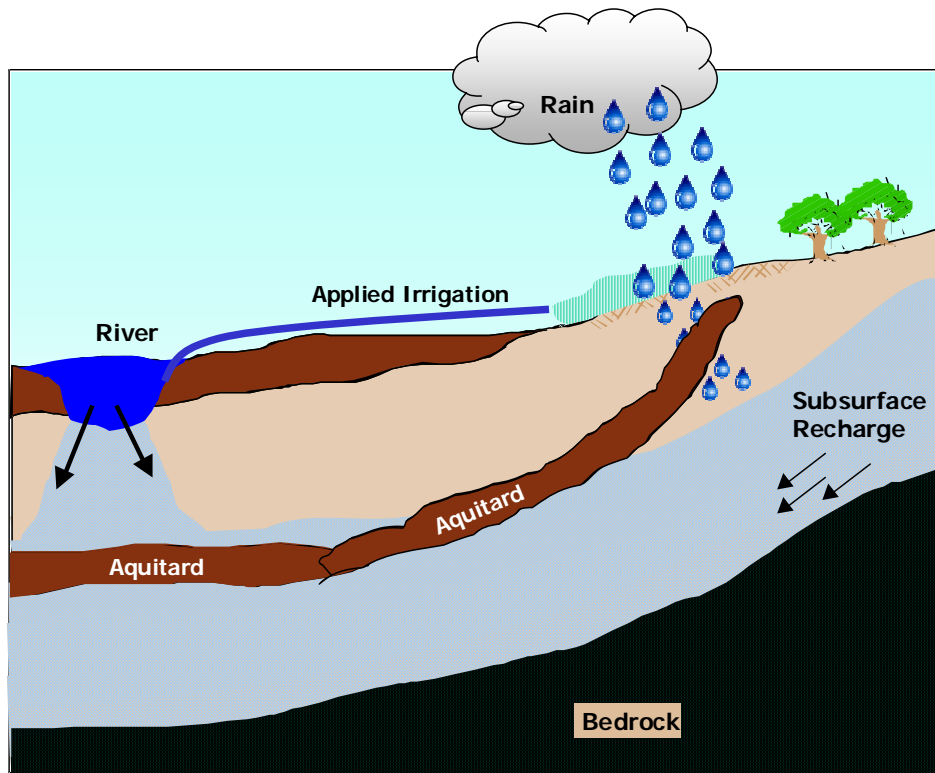
Figure A-2. Groundwater Elevation Trends for 10-Year Growth Increments



For instance, using the 2030 baseline run, the curve begins at initial conditions and quickly descends in about 15 years to approximately 220 feet below sea level and then stabilizes around this elevation for the remainder of the simulation. It is during the rapid drawdown period that the basin is said to be “out of balance” (i.e., pumping is greater than recharge). It is not until the curve flattens that natural recharge catches up with the higher rate of pumping. Higher rates of natural recharge occur predominantly through rivers that are hydraulically connected to the aquifer, such as the American and Sacramento Rivers. Recharge rates from the Cosumnes River do not increase significantly because it is not hydraulically connected over large reaches of the river bordering the Central Basin.

An illustration of a hydraulically connected river is shown in **Figure A-3** along with other sources of recharge. The slope of the groundwater surface from the river to the aquifer dictates how much recharge is occurring. The steep decline and then stabilization in **Figure A-2** is the result of river recharge going through this transition until the rate of recharge equals the rate of extraction (or pumping). Fluctuation in groundwater elevation after stabilization is the result of wet and dry year hydrology.

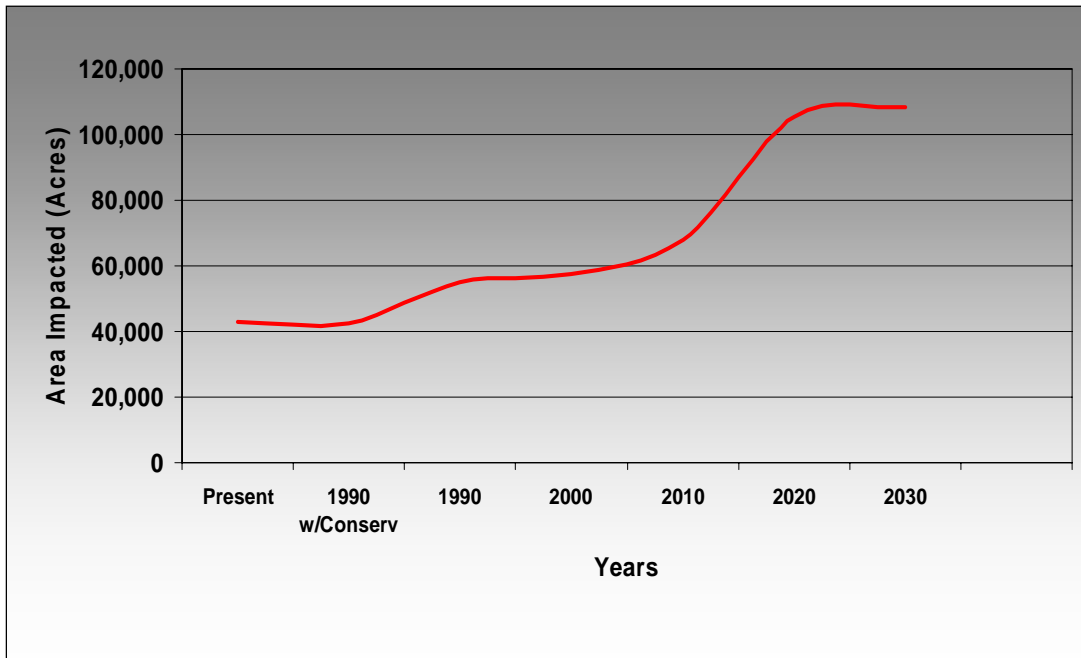
Figure A-3. Sources of Groundwater Recharge



Even though an extraction rate is sustainable, the impacts associated with it may not be acceptable to the overlying community. These impacts include water quality degradation, dewatering of wells, increased pumping costs, and ground subsidence. To address these issues, the GWNT statistically quantified these impacts for each of the baseline model runs.

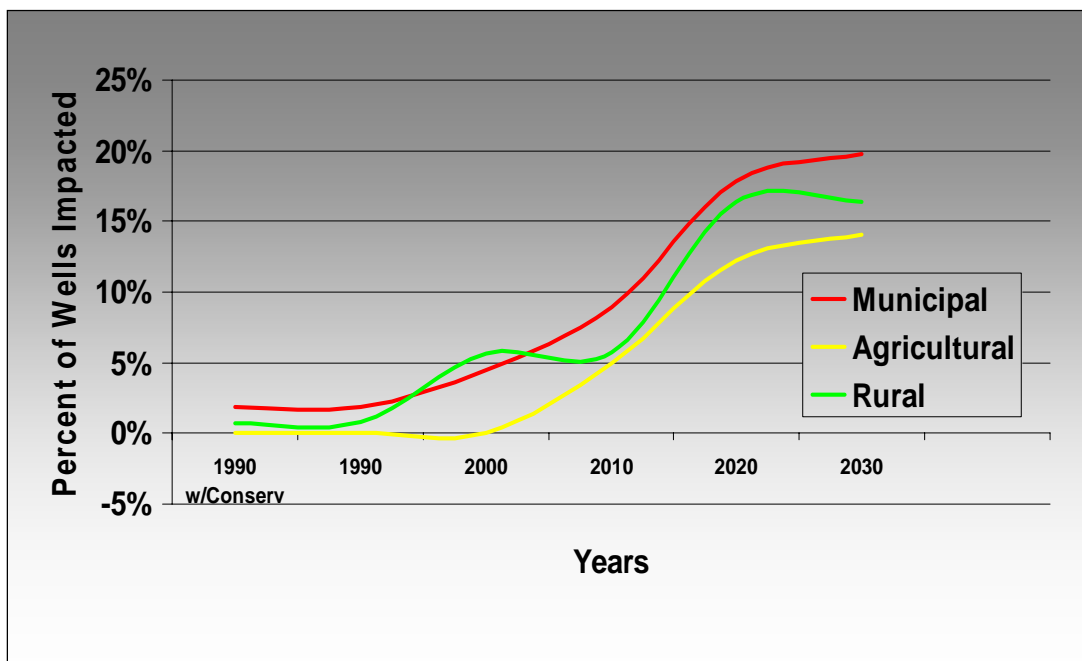
Water Quality Degradation – The amount of water quality degradation is measured by determining the land area that may currently be using water from the higher quality upper aquifer that could be impacted by lesser quality groundwater in the deeper aquifer. This occurs when groundwater levels in the upper aquifer decrease sufficiently to allow an upwelling of lower quality water from the lower aquifer. This could result in the need for private well owners to provide treatment for iron, manganese, total dissolved solids (or salinity), and possibly arsenic. **Figure A-4** shows the relationship between the baseline model runs and the amount of land area where water quality degradation “may” occur. Between 2000 and 2005 the curve remains relatively flat, after 2010 the amount of area potentially impacted increases significantly.

Figure A-4. Water Quality Degradation due to Pumping



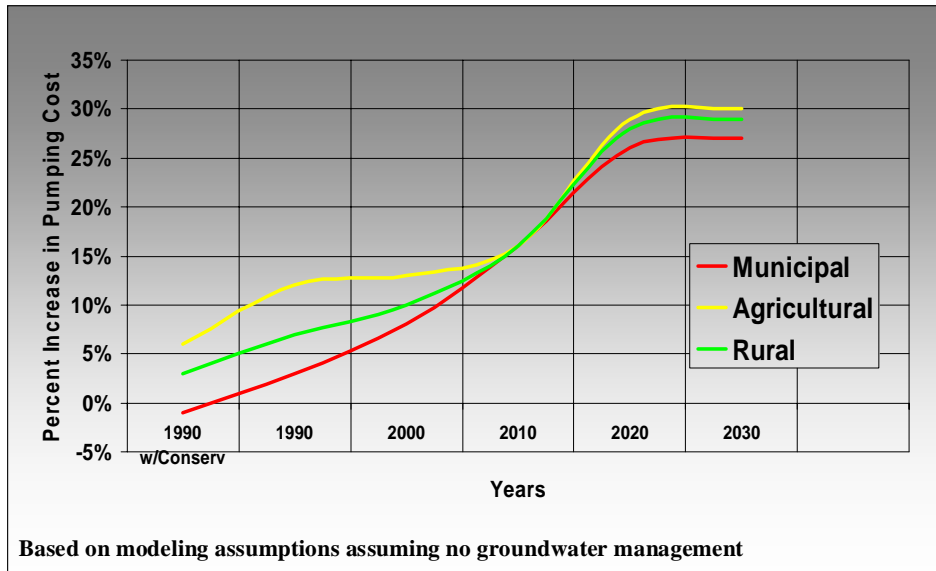
De-Watering of Wells – De-watering of a well occurs when groundwater levels drop below the depth of the well casing or screens. When this happens the well either needs to be deepened, the pump lowered, new screens constructed in the casing, or the well replaced. A sampling of wells was taken of each of the major groundwater users within 1-mile quadrants throughout the basin. For each well, the depth and location of the well was noted and then transferred to a groundwater level contour map for each baseline model run to determine if groundwater levels fell below the bottom of the well casing or screens. **Figure A-5** shows the percentage of wells impacted for each user category based on the baseline model runs. The rural and agricultural categories are of the highest interest given the sheer quantity of wells and the expense a homeowner or farmer would bear to replace a well. Similar to water quality (**Figure A-4**) impacts, it is not until after 2010 that more than five percent of the rural and agricultural wells are impacted. The slight decrease in impacted rural wells between 2000 and 2010 is an artifact of the graphing utility and should be considered as little to no change in the percentage of wells impacted.

Figure A-5. Percent of Wells De-Watered by Lowering Groundwater Elevations



Increased Cost in Pumping - As groundwater levels fall, the energy it takes to pump the water to the ground surface with sufficient pressure to meet household and irrigation needs increases. In some cases, the water level may fall to the point where the pump is unable to lift water out of the well. In this circumstance, a new pump and motor may be required. Using the same sampling of wells as was used for the proceeding analysis, an accounting of the percent increase in the cost to pump was done for each user group. The result of this analysis is displayed in **Figure A-6**. The agricultural line is relatively flat until 2010 and then it experiences a sharp increase. The other user groups steadily increase indicating a more uniform impact of lowered groundwater elevations across both municipal and rural users.

Figure A-6. Percent Increase in Pumping Cost by Lowering Groundwater Elevations



Land Subsidence - Land subsidence occurs when soils consolidate as water is removed from the soil matrix. The soil types underlying the Central Basin are not prone to subsidence. Benchmark studies over a 50+ year period indicate that the ratio of land subsidence to groundwater decline in the Central Basin is approximately 0.007 feet per foot of draw down. Based on the minimal amount of potential land subsidence, further evaluation was considered not necessary.

Appendix B

Summary of the development of Basin Management Objective #2 (Maintain specific groundwater elevations within all areas of the Central Basin consistent with the Water Forum solution).

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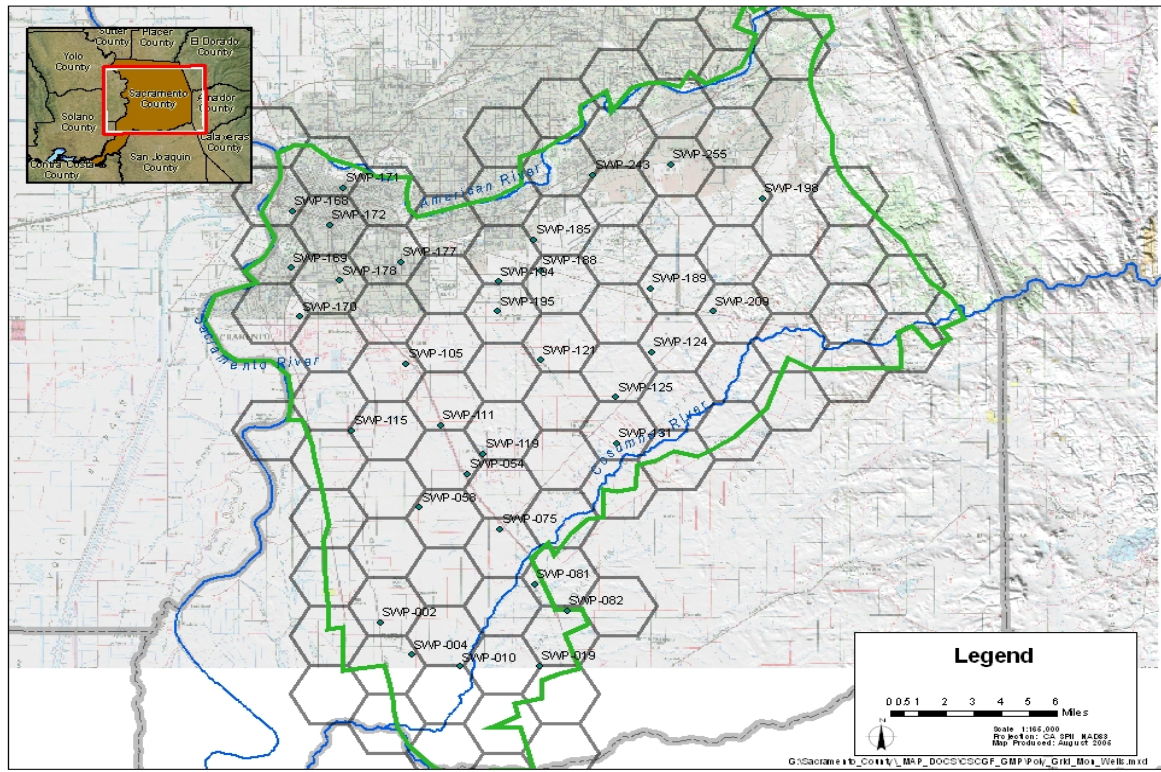
The following is a step-by-step description of how the Central Basin will develop and/or update groundwater elevation thresholds. Thresholds will be established for upper and lower groundwater elevations throughout the Central Basin. Specific thresholds are summarized in **Section 3.1.1.1** of the CSCGMP.

Step 1. Define a polygon grid over the Central Basin that can be used as surrogate areas for possible management regions. This is done first to assist in understanding the basin's behavior at a relatively high level of resolution prior to possible aggregation of the areas based on meeting the objectives above.

The polygon grid used for the Central Basin is an extension of a similar grid used in the SGA GMP. This was done intentionally to allow for combining the monitoring results for both north and south of the American River knowing that each has the same level of resolution. The polygon grid is shown in **Figure B-1**. Each polygon represents an area of 3200 acres or 5 square miles.

Step 2. Locate a State Monitoring Well to represent each grid area based on the period of measurement record and the quality of the data. The period of record should include 1977 to 2003. Gaps in data should not exceed 1 year in time with monitoring at least twice a year, spring and fall. If no well meets this criterion, the location and/or perhaps the construction of a monitoring well will be necessary in the future. The location of selected wells is shown in **Figure B-1**.

Figure B-1. Polygons and Existing Monitoring Well Assignments



Step 3. Using the Water Forum Solution dataset in the Integrated Groundwater Surface Water Model (IGSM) for 2030 conditions (Water Forum build-out), extract from the model, the hydrograph at the center of each polygon area. This is done to determine the ultimate behavior of the aquifer and then to compare the ultimate condition relative to existing groundwater elevations.

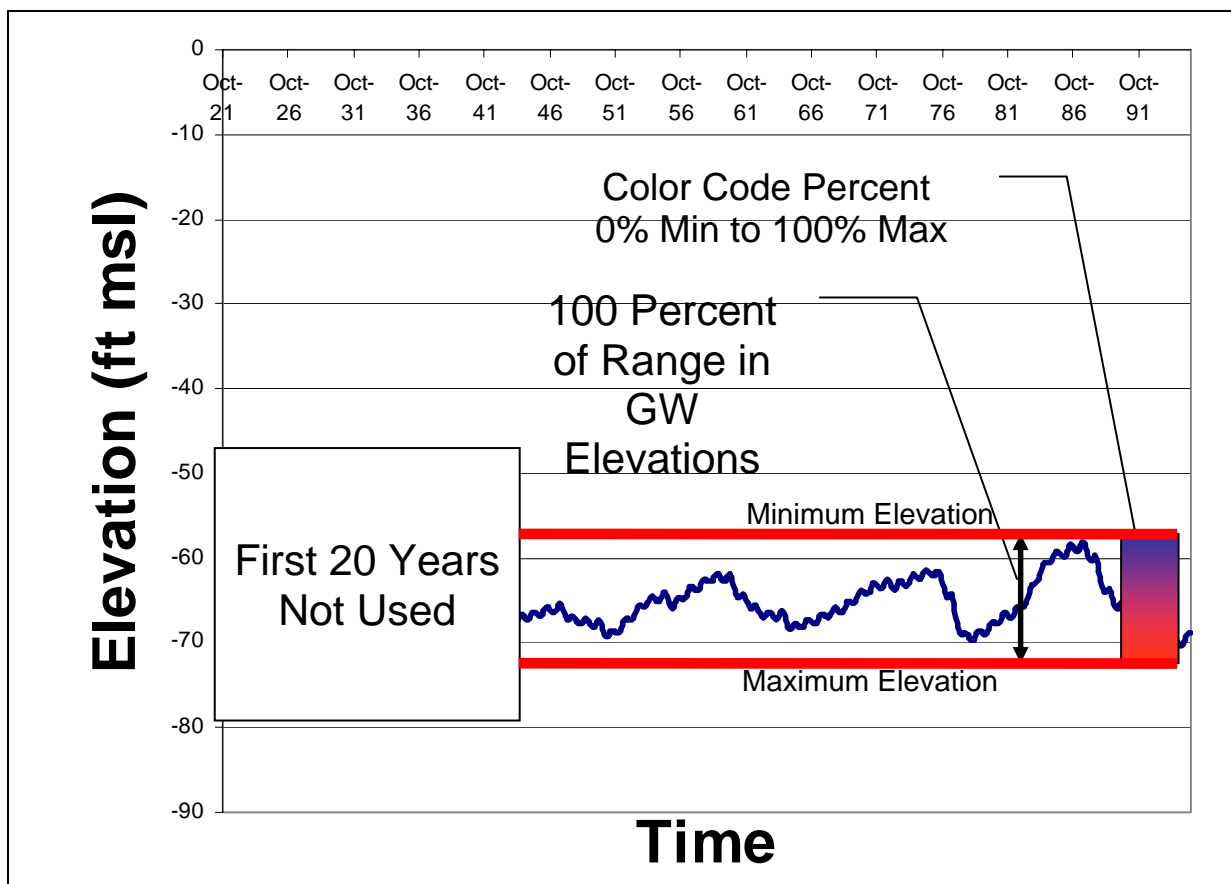
Step 4. Each of the real monitoring data hydrographs and model hydrographs will have a trace that shows groundwater elevations increasing in the wet months and decreasing in the dry months. The hydrographs also show the cumulative effect of multiple dry or wet years.

¹ The IGSM is a finite element, quasi three-dimensional, multi-layered model that integrates surface water and groundwater on a monthly time step. The IGSM was developed for use as a regional planning tool for large areas influenced by both surface water and groundwater. The tool is well-equipped to accommodate input and output of land use and water use data over large areas. Data input includes hydrogeologic parameters, land use, water demand, precipitation and other hydrologic parameters, boundary inflows, and historical water supply. For purposes of parameter definition and developing water budgets around physical and/or political boundaries, the IGSM divides Sacramento, Placer, Sutter, and San Joaquin counties into subregions. Each subregion is further divided into unique numbered elements varying from 200 to 800 acres in size. Overlying this grid is a coarse parametric grid utilized for specifying aquifer and other parameters.

For the model hydrographs, the maximum and minimum elevations are extracted from these hydrographs proceeding the first 20 years of model simulation to allow the groundwater basin to stabilize from initial conditions. The maximum and minimum values of model groundwater elevations are selected from each hydrograph. For instance, the lowest elevation may occur in the 1977 drought period and the maximum elevation may occur in the 1986 wet hydrology.

To normalize the data for the model data, the maximum and minimum elevation of each hydrograph are assumed to be equivalent to 100 percent of the operational range of the basin at that specific location within that polygon. This normalization is necessary to account for the fact that each polygon area has differing elevations due to the nature of the groundwater basin and the surface topography (i.e. the depth to groundwater in the eastern portion of the basin is less than the depth to groundwater in the southern Elk Grove portion of the basin). **Figure B-2** illustrates this process of defining the bandwidth of the model data and the percent rating using the high and low values. Five percent is added to the high elevation and subtracted from the low elevation to provide a small buffer that may show up in real-time monitoring but not in the model (e.g. monitoring wells located next to high producing wells that are running will be influenced by the localized cone of depression of the high producing wells showing a slight deviation from the actual regional groundwater elevation that is being measured).

Figure B-2. Methodology of Bandwidth based on Model Hydrograph



Importance of Bandwidth in Describing BMO Objectives

The bandwidth concept is important from the standpoint of judging whether the aquifer is within a management range; understanding that groundwater elevations fluctuate from month to month and from year to year depending on groundwater use and hydrologic conditions. The percentage indicator within the bandwidth becomes the index of performance and in setting management goals. Within the bandwidth itself, there can be various levels of warning and actions that take place based on each increasing level of warning. This concept is explained in step 6 where a framework for the BMO is defined.

Step 5. Three periods in the historical record are selected to represent a worst, best, and average case of groundwater conditions; these are 1977 (critical dry year), 1983 (very wet year), and 1979 (average year following 2 years after the 1977 drought period), respectively. The significance of 1977 is the combined behavior of increased groundwater extractions, reduced recharge from rivers and deep percolation, and cumulative effects of back to back dry years.

Underlying this information is the time element of how quickly does the groundwater elevation change in one polygon area versus another. For example, a polygon close to the river is influenced significantly by the river's recharge and will be affected almost immediately based on high or low flow river stages. In the dry years, polygons closest to the rivers experience the highest percentage of groundwater decline relative to the total bandwidth. Whereas, an area removed from the major recharge sources will not feel the full impact due to the time that it takes for river recharge to migrate to these areas. Groundwater movement is typically not more than 700 feet a year in the unconfined aquifer.

If the information described above is translated into a figure in terms of percent of the maximum and minimum or "bandwidth" values (e.g., a value from 0 to 100 percent), it becomes apparent that there are areas of similar aquifer behavior as shown in **Figure B-3** for 1977 conditions. One preferred representation of what is termed, "management zones" is shown in **Figure B-4** by the green boundary lines. The delineation of management zones takes into consideration not only the aquifer behavior but also the land use and surface water and groundwater use taking place within the basin. Additional thought in developing the zones was given based on **Figures B-5** and **Figure B-6** (described more fully below).

Aggregation of similar areas to form management zones is for purposes of monitoring and maintaining a net benefit to groundwater users over time as use of groundwater and surface water change, and land uses change over time. Aggregation is also necessary to avoid creating a management program that is cumbersome, costly, and perhaps not fully understood by the future governance body.

Figure B-3. Percentage of Groundwater Model Elevation Depth for 1977 Hydrology

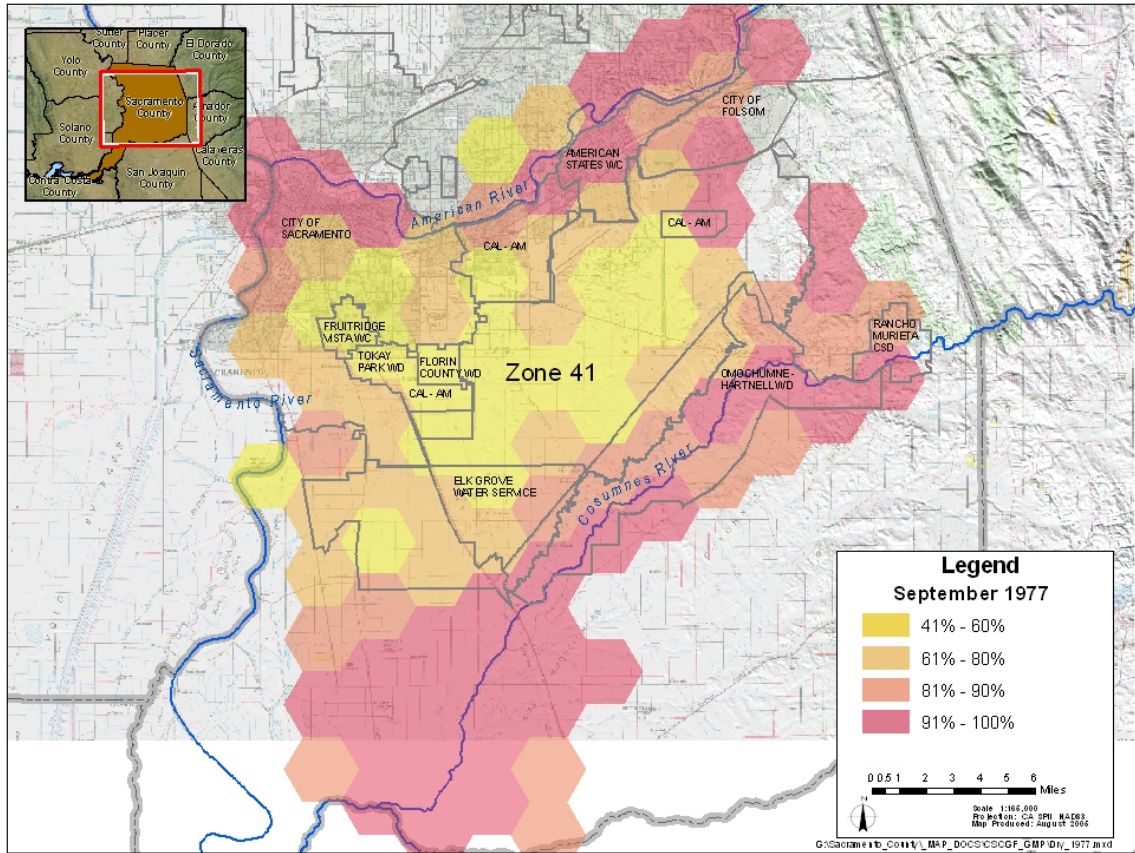
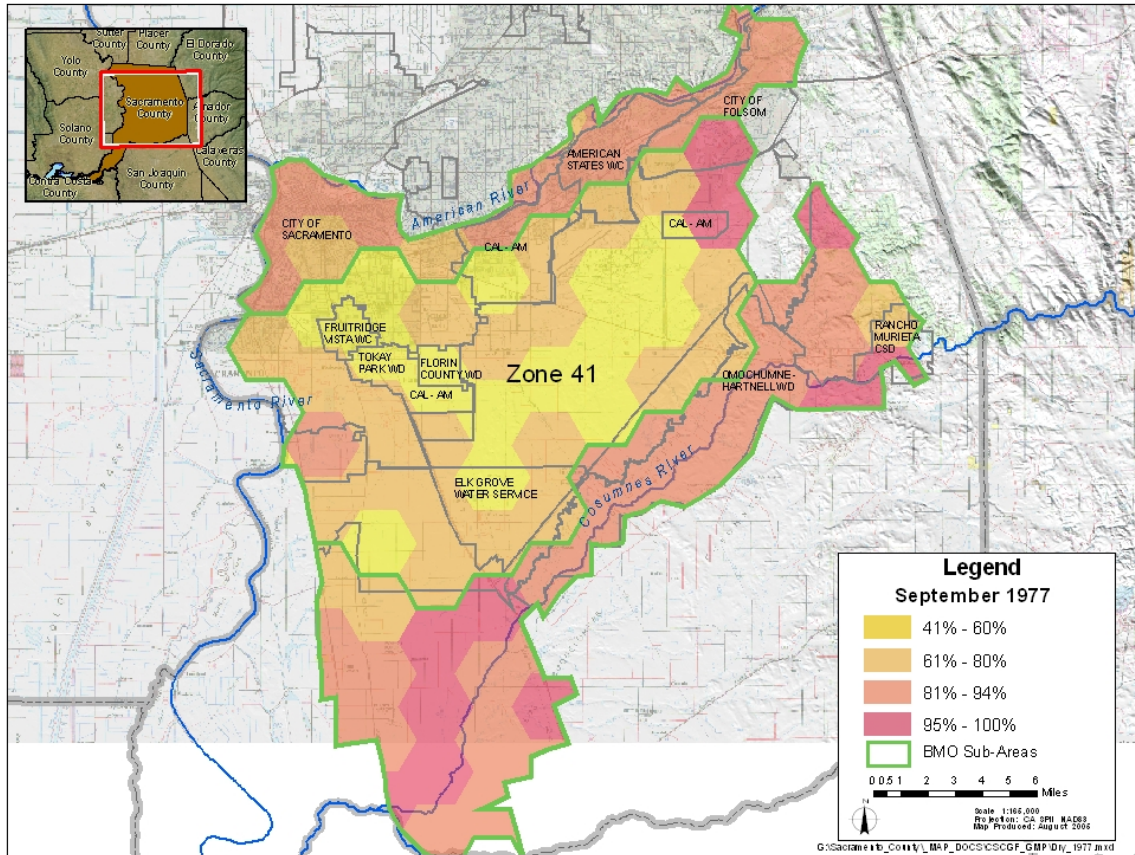


Figure B-4 suggests that within the Central Basin there be a north, central, and south management zone. The north and south zones are due to the obvious red polygons indicating areas with more sensitivity to drought conditions. The north zone is predominantly made up by the City of Sacramento, Cal-Am, and Golden State Water Company with both surface water and groundwater being used. Cal-Am is still dependent on groundwater and therefore is most affected by drought conditions.

The south zone is predominantly groundwater with agricultural and agricultural residential land uses with private wells and is deserving of being a focal point on groundwater management. Since this zone is also significantly affected by drought conditions, monitoring in this area is going to be extremely important to understand the full affect of changing conditions both in hydrology in the river recharge sources and land use changes both within the south zone and in the central zone.

Figure B-4. Groundwater Management Zone Delineation based on 1977 Hydrology



If **Figure B-4** (1977 critical year) is compared to **Figure B-5** (1983 wet year), a similar pattern of recharge is evident along the rivers except that now there is an increase in the percent of bandwidth. The darker blue in **Figure B-5** (1983 wet year) represents percentages closest to the upper elevation of bandwidth for each polygon. The same aggregation is represented in **Figure B-5** to illustrate the logical separation of management zones.

The central zone is perhaps the most interesting in terms of how it behaves. **Figure B-6** (normal year) represents 1979 average hydrologic conditions two years after the 1977 extended drought condition and just before the wet period into 1983. This figure combines the time element of how long it takes for the effect of drought conditions to fully establish itself at the cone and how long it takes to recover. The central zone maintains a residual effect of the drought by the darker yellow polygons not changing significantly from 1977 to 1979 indicating 50 percent of the bandwidth, and from 1979 to 1983 with a similar pattern near the cone of depression. This implies that the central zone takes more time to react and recover; whereas, the north and south zones react quickly to hydrologic conditions where the polygons reduce from 90 percent in 1977 to 60 to 80 percent in 1979 and 10 percent in 1983.

Figure B-5. Percentage of Model Groundwater Elevation Depths for 1983 Hydrology

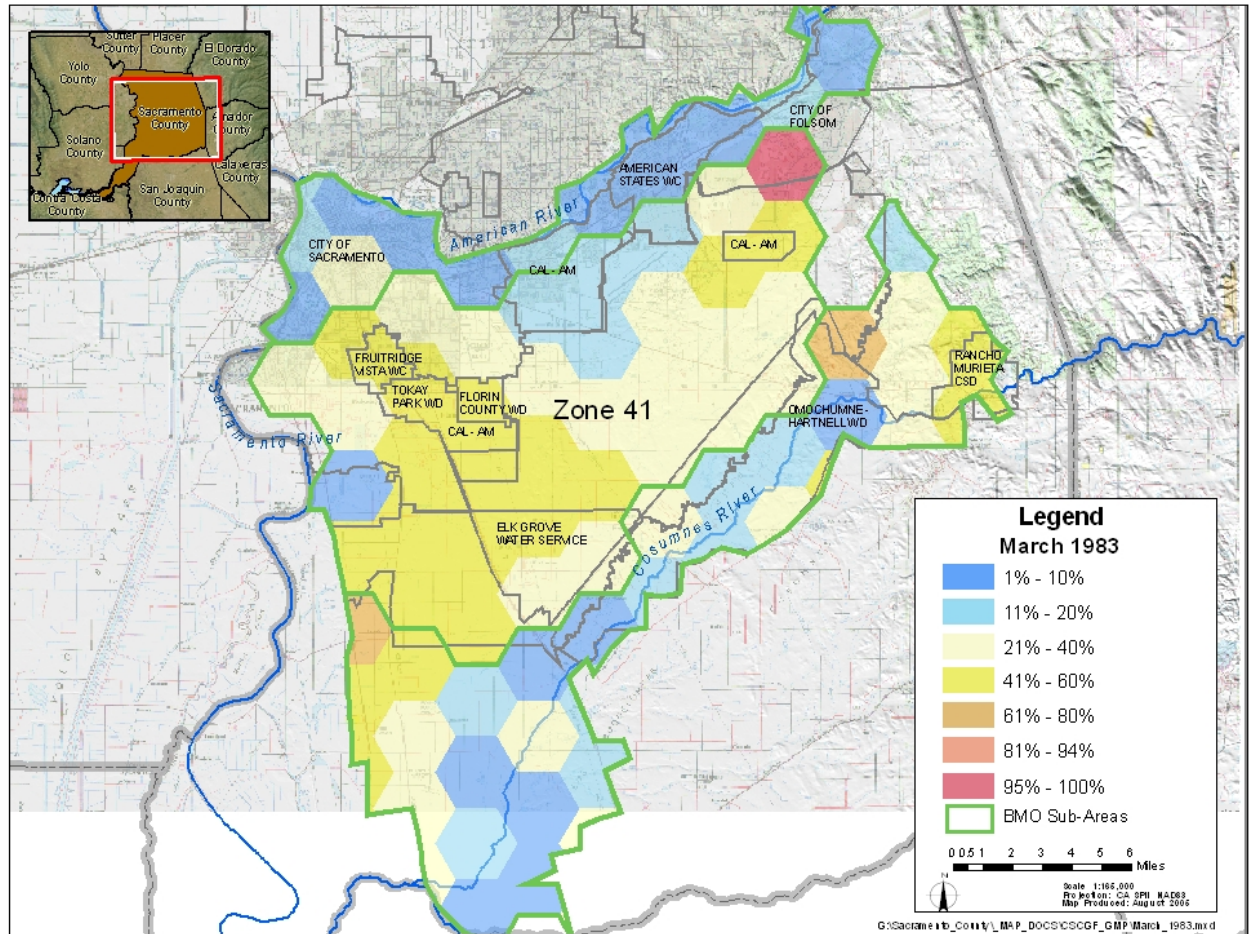
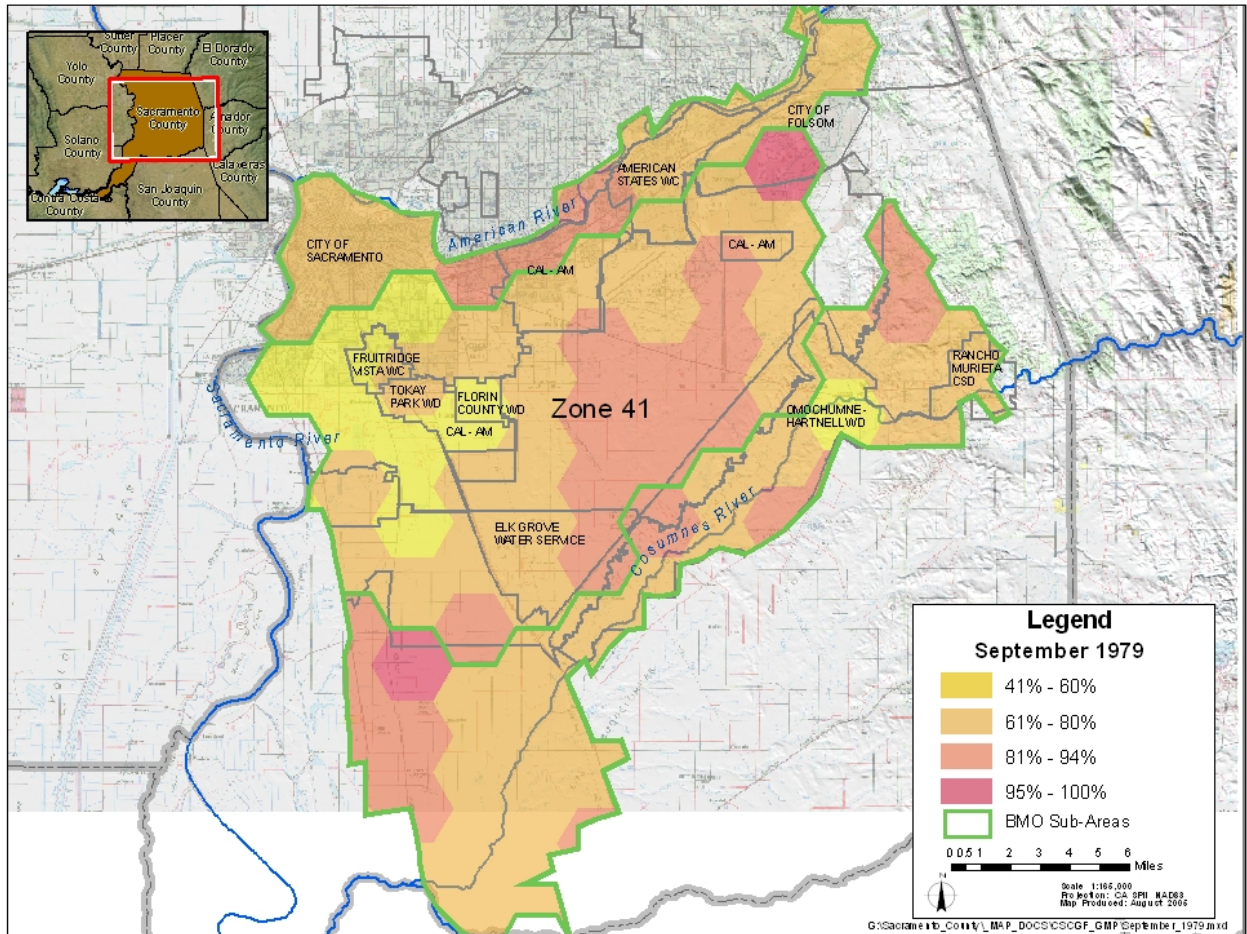


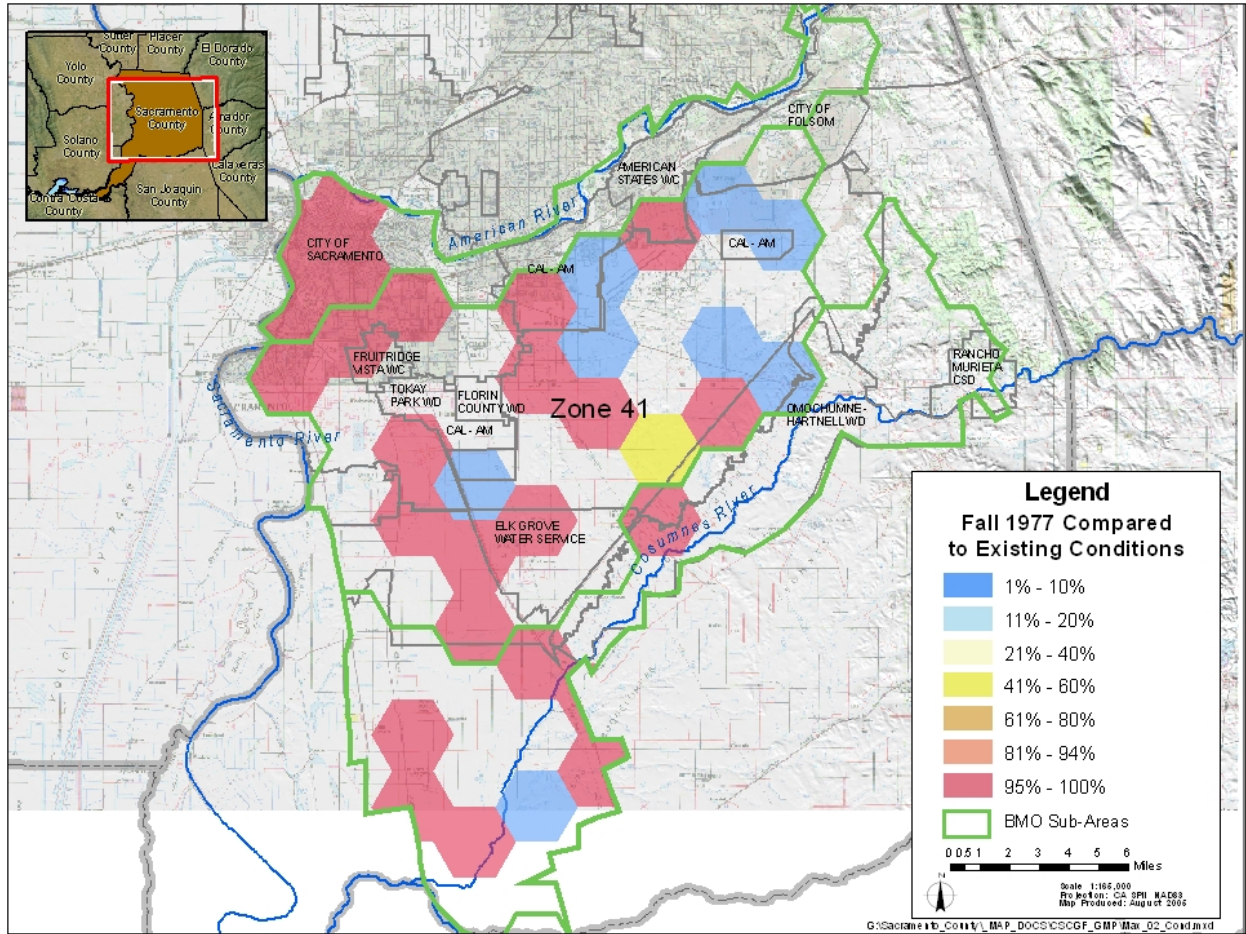
Figure B-6. Percentage of Model Groundwater Elevation Depths for 1979 Hydrology



Step 6. Ground-truthing the model data versus real data is necessary from the perspective of private well owners who currently realize a certain level of reliability in groundwater elevations and understand that during drought conditions there will be periods when groundwater elevations reach their lowest point with possible increase in energy costs and dewatering of wells. To achieve a sense of relative difference between the management objectives and current groundwater conditions, the bandwidth concept is applied to real monitoring data for the most recent measurement value as explained in Step 4 above.

Figure B-7 provides a similar graph for 1977 conditions using real data to evaluate the lowest groundwater elevation relative to today’s bandwidth and **Figure B-8** positions the 1977 real data on the model data and contours the difference. The expectation is that under the Water Forum Solution groundwater elevations do not exceed what actually occurred in 1977. If accidence does occur, **Figure B-7** provides, at a glance, the areas where accidence may occur which then provides the basin governance body to begin to understand future programs to mitigate for this event.

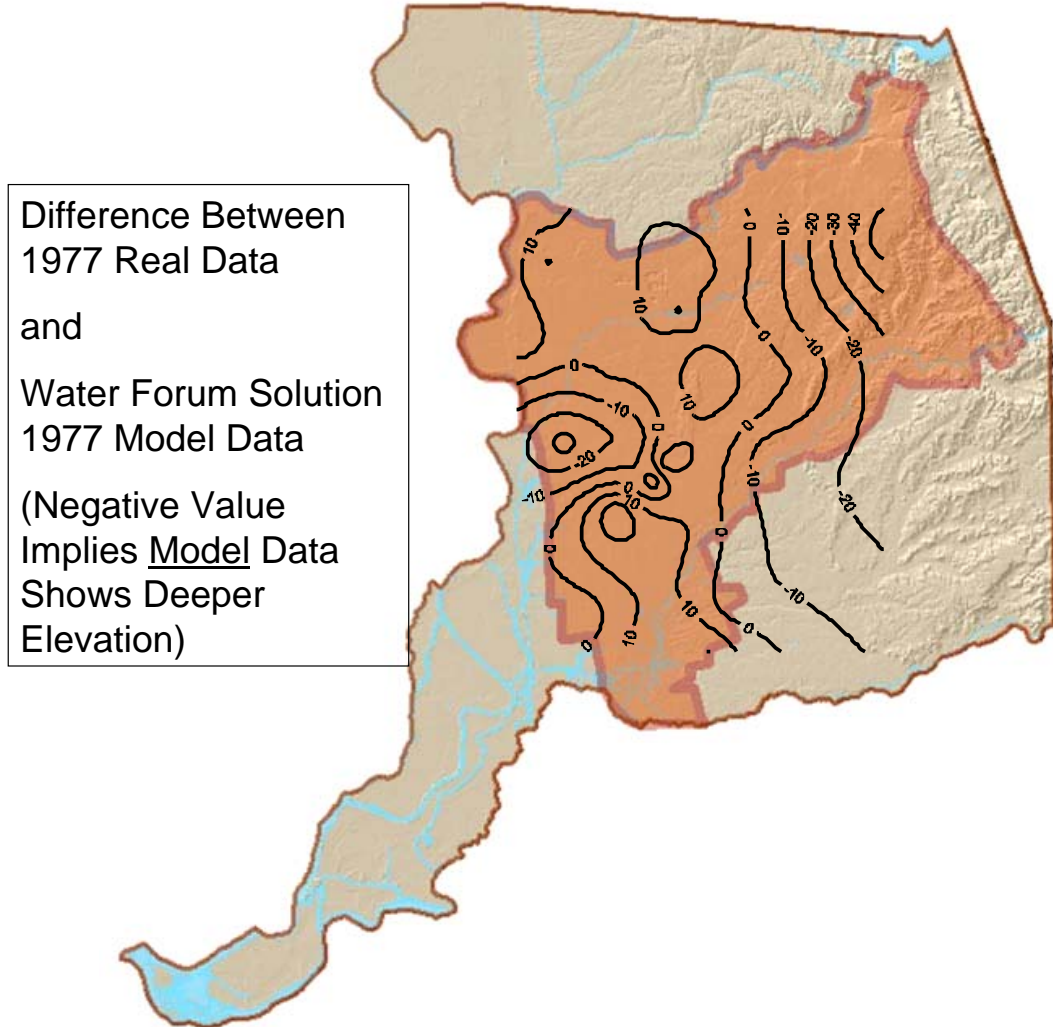
Figure B-7. Percentage of Real Groundwater Elevation Depths for 1977 Hydrology



Lastly, to look at the difference between the 1993 real data and the 1993 model data in a more absolute manner, a difference contour map is generated that indicates the probable increase or decrease that might be expected from the 2030 Water Forum Solution in the three management zones. Positive values in **Figure B-8** indicate a positive effect or higher groundwater elevation and a negative contour represents an area that may be impacted by the Water Forum Solution.

Figure B-8. Groundwater Elevation Difference Contours between Model and Real Data for 1977 Hydrology

Groundwater Elevation Contours (ft msl)



Step 7. The next step is the development of a framework for monitoring and management of groundwater elevations for each management zone. The fundamental requirements of the framework are listed as follows:

- Provides for simple implementation;
- Allows for adaptive changes based on monitored data;
- Keeps the presentation of the data in a form that can be understood by all stakeholders;
- Allows for differing stages of attention requiring specific actions;
- The details of this framework are provided in **Section 4** (Plan Implementation) of the CSCGMP.

Appendix C

Public Notices

RESOLUTION NO. WA-2590

RESOLUTION OF INTENTION TO PREPARE A GROUNDWATER MANAGEMENT PLAN FOR THE CENTRAL GROUNDWATER BASIN OF SACRAMENTO COUNTY AND ADOPT A STATEMENT OF PUBLIC PARTICIPATION

WHEREAS, the stakeholders in the Central Sacramento County Groundwater Forum (hereinafter referred to as "Groundwater Forum") desire to develop a Groundwater Management Plan (hereinafter referred to as "GMP") in accordance with Section 10753 - 10753.10 of the California State Water Code (hereinafter referred to as "Water Code") and a groundwater management governance mechanism for the Central Sacramento County Groundwater Basin (hereinafter referred to as "Central Basin"); and

WHEREAS, development of a GMP would provide for the effective management of the groundwater resource; and

WHEREAS, the State Water Code requires that before a GMP can be prepared a local public agency with statutory authority adopt a Resolution of Intention; and

WHEREAS, the Groundwater Forum lacks the statutory authority to adopt a Resolution of Intention; and

WHEREAS, the Sacramento County Water Agency (hereinafter referred to as "Agency") was formed in 1952 by a special legislative act of the State of California (the Sacramento County Water Agency Act, hereinafter referred to as "Agency Act") and is a stakeholder in the Groundwater Forum; and

WHEREAS, under the Agency Act the Agency is to provide for the protection, preservation, and enhancement, for current and future beneficial uses, the groundwater resources in Sacramento County; and

WHEREAS, under the Agency Act the Agency is empowered to develop, adopt and implement a plan for the management of groundwater resources.

NOW, THEREFORE, the Board of Directors of the Sacramento County Water Agency resolves and determines as follows:

Section 1. The foregoing recitals are true and correct and this Board so finds and determines.

Section 2. The Agency will develop the groundwater management plan for the Central Basin. Upon completion of the GMP, the groundwater management governance mechanism developed by the stakeholders of the Groundwater Forum will adopt and implement the GMP. Among other components, the Central Basin groundwater management plan shall include the following components:

- a. Basin Management Objectives;
- b. Components relating to the monitoring and management of groundwater levels, groundwater banking, groundwater quality, inelastic land surface subsidence, and changes in surface flow and surface water quality that directly affect groundwater levels or quality or are caused by groundwater pumping;
- c. Monitoring protocols to track changes in conditions related to the components in paragraph (b) and to generate information for the purpose of meeting Basin Management Objectives and establishing effective management of groundwater;
- d. A plan to involve other local agencies, water purveyors, and private well owners in the Central Basin in the development of the groundwater management plan;
- e. A map depicting the Central Basin, as defined by California Department of Water Resources Bulletin No. 118 and the Groundwater Forum, other local agencies, and water purveyors in the Central Basin; and
- f. Rules related to implementation of the groundwater management plan.

Section 3. The Groundwater Forum will provide for public involvement in the development of the groundwater management plan. The Groundwater Forum's plan for public involvement shall include the following:

- a. The formation of a Technical Review Committee and Policy Committee to guide development of the groundwater management plan;
- b. Coordination and participation from the Water Forum;
- c. Preparation of a Public Outreach Plan; and
- d. Public review and comment period and public hearings.

On a motion by Director Collin, and seconded by Director Nottoli, the foregoing resolution was passed and adopted by the Board of Directors of the Sacramento County Water Agency, State of California, this 19th day of April, 2005 with the following vote, to wit:

AYES: Directors, None
NOES: Directors, None
ABSENT: Directors, None
ABSTAIN: Directors, None

Roger Dickinson
Chair of the Board of Directors of the
Sacramento County Water Agency,
a district organized under the laws of the
State of California



ATTEST:
Clerk of the Board of Supervisors of Sacramento
County, California, and ex officio Secretary of the Board of Directors
of Sacramento County
Water Agency

2Ti April 27 & May 4, 2005

Appendix D

Trial Balloon on Well Protection Program

CENTRAL SACRAMENTO COUNTY GROUNDWATER FORUM

Trial Balloon on a Well Protection Program: Final recommendations negotiated by the CSCGF

BACKGROUND

The Water Forum Agreement sets the long-term average annual extraction of groundwater (i.e., sustainable yield) in the Central Area at 273,000 acre-feet. At the time this figure was negotiated, it was anticipated that this sustainable yield would likely lead to a further decline in the groundwater level of approximately 50 feet in the deepest part of the existing cone of depression. Such a decline would undoubtedly affect some existing domestic and agricultural wells.

The protection of domestic and agricultural irrigation wells is of fundamental importance to the Agriculture and Agricultural/Residential Groundwater Users Interest Groups. Agriculturists and “ag/res” users have no alternative source of supply and they should not be required to subsidize future development by having to pay the cost of either deepening or replacing their existing wells. In order to address this concern, we propose that the following be included as part of the “solution package” concerning groundwater management in the Central Area.

RECOMMENDATIONS

The Central Sacramento County Groundwater Forum recommends:

1. The creation of a “well protection” trust fund.
2. The purpose of this fund shall be to cover the costs of deepening or replacing any *existing* well that provides water for agricultural or domestic use that may be impacted by future development in the Central Area. (The Central Area of the groundwater basin is bounded on the north by the American River, on the east by the Sierra foothills, on the south by the southern boundary of the Omochumne-Hartnell Water District and on the west by the Sacramento River and Interstate 5.)
3. This fund should be administered by whatever entity or authority is charged with the responsibility for managing groundwater in the Central Area.
4. The trust fund should be financed through:

- A fee assessed on every new building permit issued following a specified date (e.g., 30 days after establishment of an entity/authority to manage groundwater in the Central Area) ; and
 - A fee assessed on any permit to drill a *new* well for any purpose, including agriculture, agricultural/residential, business, M & I supply, etc. However, an application to drill a remediation well required by a regulatory compliance order and all monitoring wells should be exempted from paying a fee.
5. Any property within the City of Sacramento that is served by surface water should be exempted from paying a fee on building permits to support the well protection trust fund.
 6. The amount of the fee to be assessed on both building permits (for new construction) and new well applications should be determined by the groundwater management entity/authority. The well assessment should be based upon the diameter of the well. If an individual is obtaining both a building permit and applying to drill a new well on the same property, there should be one assessment only
 7. Once an initial or interim fee has been determined and the well registration process has been completed (described in paragraph 10), the groundwater management entity/authority should undertake a nexus study including an impacts analysis and may subsequently revise the amount of the fee in light of the impacts analysis and the number of wells that have been registered.
 8. Throughout the life of the trust fund, the groundwater management entity/authority should have the power to change the amount of the assessment, based upon then current actuarial studies.
 9. Ultimate responsibility for the collection of these assessments should be vested in the groundwater management entity/authority. The authority should see that fees are collected in whatever manner it deems most efficient.
 10. In order to be eligible for coverage by the fund, existing wells must be registered by the well-owner in a manner to be determined by the groundwater management entity/authority and within a schedule or time-limit to be established by the authority. The authority shall make every reasonable attempt to inform all residents who may be eligible to participate in the well protection program of the need to register their well.
 11. Once a well has been registered, coverage by the well protection trust fund shall continue for as long as the fund is operational. Coverage of the well is not affected by a change in ownership of the property on which it is located.

12. Eligibility criteria for claims against the fund must be clearly defined and strictly related to a decline in groundwater level. Sub-standard wells, faulty motors or pumps, etc. will not be covered by the fund or eligible for consideration.
13. Any claim against the trust fund must be submitted to the entity/authority and verified by an independent source (e.g., a hydrologist, a well service company, etc.) in order to be paid by the fund.
14. The groundwater management entity/authority shall be responsible for working out the details of how the trust fund shall operate including but not limited to the amount of the fee to be assessed, how assessment fees are collected, criteria for submission of a claim, how a claim will be verified, amount to be paid for a verified claim, timeline between submission of claim and date of decision, etc.
15. At the time that the trust fund becomes operational, the groundwater management entity/authority should, on its own initiative or in conjunction with other appropriate agencies/organizations, undertake a vigorous campaign to educate all water users on the importance of conservation and recommend specific practices that can be implemented by agriculture and agricultural/residential pumpers.
16. Not earlier than five years nor later than the beginning of the eleventh year after water from the Freeport project becomes available for conjunctive use in the Central Area, the groundwater management entity/authority shall conduct a comprehensive review to determine whether there exists a continuing need to maintain a well protection trust fund. In conducting this review, the management entity/authority shall consider the following factors:
 - Groundwater levels;
 - The number of claims made against the trust fund;
 - The rate of claims filed over time: i.e., is the rate of claims increasing or decreasing;
 - Status of urbanization: i.e., is further growth/development anticipated and, if yes, how will it impact water supply.

A decision on whether or not to continue the fund shall be reserved to the governing board or authority responsible for groundwater management in the Central Area.

17. If as a result of this comprehensive review, a decision is made to terminate the well protection plan but money has accumulated in the trust fund and has not been paid out to meet prior claims, any un-disbursed money should be used for other activities consistent with the purposes of a groundwater management plan or groundwater management authority in the Central Area: e.g., conservation, habitat mitigation, enhancement of groundwater recharge, etc. (In order for this to occur, the language establishing the trust fund must be consistent with the requirements set forth in Government Code, Section 1600.)

18. All details related to the fund should be worked out and the well protection program should become operational within one year of the creation of a groundwater management entity/authority in the Central Area.

NOTE: Nothing in this proposal is intended to modify or change any provisions in the North Vineyard Protection Agreement or to relieve any party of obligations set forth in that Agreement.

Appendix E

Central Sacramento County Groundwater Management
Plan – Impact Analysis for Well Protection Program

TECHNICAL MEMORANDUM

To:	Jim McCormack, Water Forum Darrell Eck, SCWA	CC:	Eric Hong, DWR
From:	Reza Namvar Ali Taghavi	Date:	December 30, 2005
Subject:	Central Sacramento County Groundwater Management Plan – Impact Analysis for Well Protection Program		
Project Reference:	310.T01.00		

EXECUTIVE SUMMARY

The Central Basin Well Protection Program is a result of negotiations that took place as part of the Central Sacramento County Groundwater Forum. Water demands to meet the build-out level of development in future land use and water use conditions in Central Basin could potentially change groundwater levels in various parts of the Central Basin. These changes in groundwater levels may have potential impact on existing agricultural and rural domestic wells. The impacted wells may require lowering of the pump bowls, deepening of the well, or replacement of the well. The well protection program is being developed for the Central Basin to provide funding for mitigation of any wells that may be impacted by a lowering of groundwater levels. This Technical Memorandum (TM) provides an estimate of the cost of the well protection program under three future scenarios.

The number of irrigation and rural domestic wells in the Central Basin is not known. Based on the 2000 land use conditions and water demand information, it is estimated that 235 agricultural and 5,903 rural domestic wells exist in the Central Basin. Using the 2030 land use conditions, it is estimated that the irrigation wells will decrease to 194 wells, while the rural domestic wells will increase to 8,175 wells. The land use, water supply, and water demand information presented in this TM were obtained from the Hydrologic and Modeling Analysis for Zone 40 Water Supply Master Plan study (WRIME, 2004).

The water levels for the three future scenarios were obtained from the recent Hydrologic and Modeling Analysis for Zone 40 Water Supply Mater Plan (WRIME, 2004), and the modeling work performed as part of the Impact Analysis for Well Protection study. These future scenarios are:

- A – No Project (Baseline 2030),
- B – Proposed Project, and
- C – Reduced Surface Water Availability.

The “No Project” scenario represents the land and water use conditions based on the County’s General Plan build-out level of development, and the corresponding firm water supply conditions.

The “Proposed Project” scenario represents the build-out conditions with the water supplies proposed under the Zone 40 WSMP. The Zone 40 WSMP was adopted in February 2005.

The “Reduced Surface Water Availability” scenario was simulated in this study to represent a 26,700 acre-feet/year (AFY) reduction in surface water diversion at Freeport to Zone 40 and increased groundwater pumping by 26,700 AFY in the Central Basin.

The simulated water levels were compared with the well bottom depth elevation data to obtain the number of impacted wells. The impact costs of changes in groundwater level include the cost of lowering the pump bowl, deepening the wells, or replacing the impacted wells.

The following table shows the impact cost of the three future scenarios.

Scenarios	Impacted Rural Domestic Wells	Impacted Agricultural Wells	Rural Domestic Wells Impact Cost	Agricultural Wells Impact Cost	Total Impact Cost
A - No Project	164	2	\$560,000	\$20,000	\$580,000
B – Proposed Project	99	1	\$423,000	\$10,000	\$433,000
C - Reduced Surface Water Availability	252	3	\$1,097,000	\$30,000	\$1,127,000

The outline of the TM is presented below.

Executive Summary presents a summary of the TM findings.

1. Introduction provides some background on declining groundwater levels in the Central Basin, brief description of the alternatives, and the purpose of the TM.

2. Available Data provides details of available data that was used in this analysis.

3. Analysis of Well Inventory provides estimates of the number of agricultural and rural domestic wells in the Central Basin.

4. Impacted Wells provides estimates of the number of impacted agricultural and rural domestic wells in the Central Basin and the associated impact cost.

5. References lists the sources of information used in this analysis.

1. INTRODUCTION

Groundwater is a vital source of water for Central Sacramento County. In 2000, approximately 250,000 AF of groundwater was pumped in the Central Basin resulting in declining groundwater levels in some parts of the Central Basin.

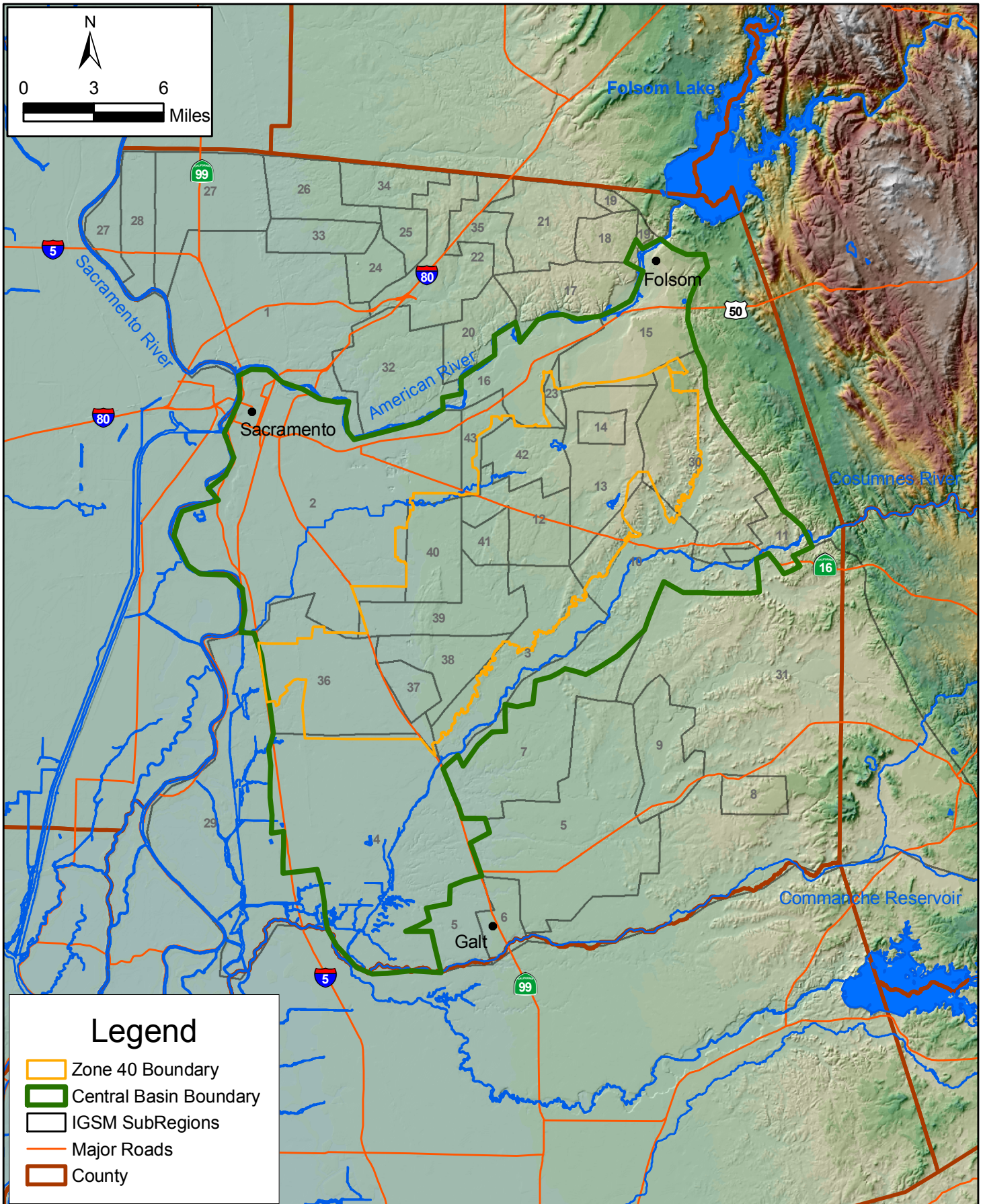
Anticipated urban water use is expected to increase the reliance on the groundwater aquifer and to lower groundwater levels. The Zone 40 Water Supply Master Plan (WSMP) project provides a conjunctive use program that consists of surface water, groundwater, and recycled water. As a result of the implementation of the WSMP groundwater levels in some parts of the Central Basin are expected to be lower than their current levels; however, higher than the future No Project conditions. Figure 1.1 shows the Zone 40 and the Central Basin.

Several water management scenarios including the Proposed Project were analyzed by WRIME (2004) using the Sacramento County Integrated Groundwater and Surface water Model (SACIGSM). A modified version of the Proposed Project scenario was also simulated as part of this study. The purpose of this scenario was to evaluate the worst-case scenario by analyzing the impact of reduced available surface water via the proposed Freeport diversion facilities, and maximum groundwater pumping in the Central Basin. The scenarios presented in this Technical Memorandum include:

- A – No Project (Baseline 2030),
- B – Proposed Project, and
- C – Reduced Surface Water Availability.

All of the simulations indicate that groundwater levels in some parts of the Central Basin will decline in the future. Declining groundwater levels may have an adverse impact on existing wells in Central Basin. Some wells may need to be deepened while some others may have to be replaced.

The Well Protection Program has been developed for the Central Basin to provide funding for deepening or replacement of impacted wells. This Technical Memorandum (TM) presents the results of an analysis of the expected impact cost to agricultural and rural domestic wells in the Central Basin.



**Central Sacramento Groundwater Basin
 Well Impact Analysis
 General Project Location**

November 2005
 Figure 1.1

2. AVAILABLE DATA

This study uses four categories of data for well impact analysis:

- Land Use Conditions,
- Water Demand,
- Well Depth, and
- Groundwater Levels.

The land use and water demand information are used to estimate the number of agricultural and rural domestic wells. The depth to groundwater at each well is compared to the depth to the bottom of the well to determine whether a well is impacted. The land use, water supply, and water demand information presented in this TM were obtained from the Hydrologic and Modeling Analysis for Zone 40 Water Supply Master Plan study (WRIME, 2004). The data sources and description of the available data is provided in the following subsections.

2.1 DATA SOURCES

The data for the well impact analysis was obtained from previous studies of Central Sacramento County, available databases, and interviews with local professionals. The data sources are presented below.

Sacramento County Groundwater Yield Analysis

A groundwater yield analysis including an evaluation of impacts and associated impact costs of increased groundwater withdrawals from the aquifer systems underlying the County of Sacramento was completed in 1997 for the SCWA (Montgomery Watson, 1997). The report consisted of two technical memorandums, TM1 Baseline Conditions and TM2 Impacts Analysis. The impacts and impact costs were based on the potential groundwater level changes for six Baseline Conditions. This study is commonly referred to as the 1997 Baseline Yield Analysis.

The 1997 Baseline Yield Analysis covers the northern, central, and southern areas of Sacramento County and investigates the impacts of lowering groundwater levels on groundwater quality, wells, land subsidence, and groundwater contamination. The replacement and additional pumping costs of the municipal, agricultural and rural domestic wells were evaluated on a reconnaissance level.

The numbers of agricultural and rural domestic wells in Central Sacramento County were estimated to be 324 and 4,955 wells, respectively. Depending on the simulated baseline condition, the number of agricultural wells impacted by additional groundwater level decline ranged from 0 to 54 wells. The number of impacted rural domestic wells ranged from 0 to 996 wells. The simulations with the highest groundwater pumping rates resulted in the highest number of impacted wells.

Distributions of agricultural and rural domestic well depth are provided in the technical memorandum of the 1997 Baseline Yield Analysis. However, the memorandum does not provide specific information about the location and depth of individual wells. The electronic files of the 1997 Baseline Yield Analysis provides well depth and location information for 964 wells in the Zone 40 area (Figure 2.1). No information was available in these electronic files for the wells outside the Zone 40 area.

DWR/USGS Well Log Database

The California Department of Water Resources (DWR), in cooperation with the United States Geological Survey (USGS), has developed a well log database for selected wells in the Central Sacramento County (DWR, 2005). This database has depth information for 92 wells in the Central Sacramento County. These wells are distributed over the entire central area (Figure 2.1).

Central Sacramento County Data Management System (DMS)

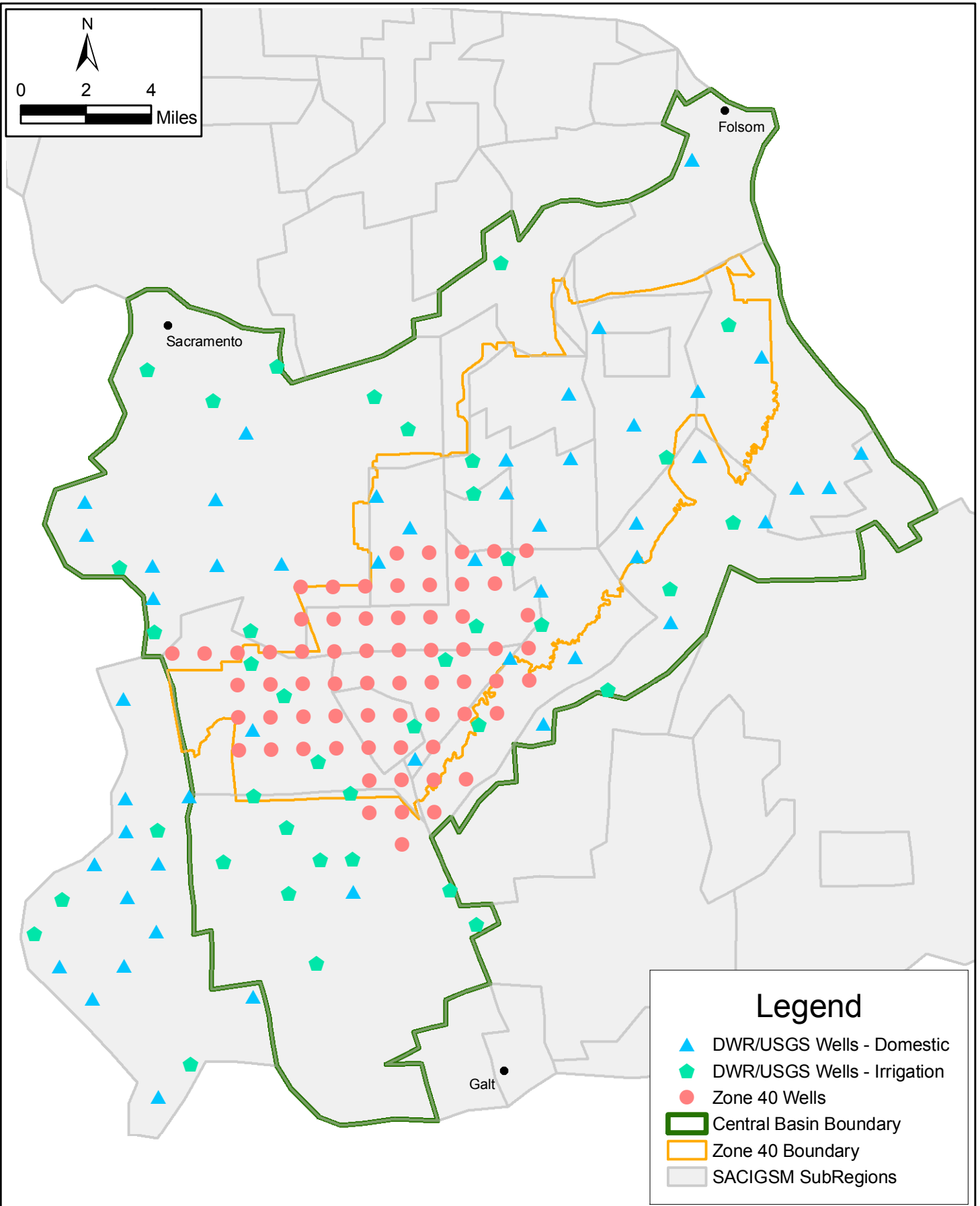
A database of 597 well logs in Central Sacramento County was obtained from MWH – Montgomery Watson Harza (MWH, 2005). However, this database contains only municipal and monitoring well information. Because this database does not provide information on irrigation and/or rural domestic wells, the database was not used in this study.

Hydrologic and Modeling Analysis for the Zone 40 Water Supply Master Plan

A hydrologic and modeling analysis was conducted for the Zone 40 WSMP (WRIME, 2004). Zone 40 was initially established in 1985 by the Sacramento County Water Agency to provide drinking water for the urbanizing unincorporated areas in the Laguna, Elk Grove, and Vineyard communities in Sacramento County.

The SACIGSM was used in the analysis of hydrologic effects of alternatives considered under the WSMP. The effects of water management alternatives were compared to two baseline conditions, 2000 and 2030 levels of development, reflecting existing conditions and ultimate buildout conditions. Table 2.1 presents the description of the alternatives. The Proposed Project represents the long-term effect of water demand and supply resulting from 2030 buildout conditions with additional surface water available and full reuse of remediated water. The Reduced Surface Water Availability scenario represents a 26,700 AFY reduction in available surface water from the FRWA diversion at Freeport and a 26,700 AFY increase in groundwater pumping in the Central Basin.

Water levels at selected irrigation and domestic wells were obtained from SACIGSM simulations for No Project, Project, and Reduced Surface Water Availability scenarios.



Legend

- ▲ DWR/USGS Wells - Domestic
- ◆ DWR/USGS Wells - Irrigation
- Zone 40 Wells
- ▭ Central Basin Boundary
- ▭ Zone 40 Boundary
- ▭ SACIGSM SubRegions



**Central Sacramento Groundwater Basin
Well Impact Analysis
Location of Sample Wells**

November 2005

Figure 2.1

Table 2.1 Descriptions of Model Scenarios

	2000 Baseline	A - No Project (2030 Baseline)	B - Proposed Project	C - Reduced Surface Water Availability
Land Use	DWR 2000 Land Use Survey (Agricultural = 53,000 acres, Urban = 86,000 acres)	Projected 2030 Land Use (Agricultural = 45,000 acres, Urban = 137,000 acres)	Projected 2030 Land Use (Agricultural = 45,000 acres, Urban = 137,000 acres)	Projected 2030 Land Use (Agricultural = 45,000 acres, Urban = 137,000 acres)
Urban Water Demand	Based on DWR 2000 Land Use and a 12% level of conservation (205,000 AFY)	Based on projected 2030 Land Use and a 25.6% level of conservation (304,000 AFY)	Based on projected 2030 Land Use and a 25.6% level of conservation (304,000 AFY)	Based on projected 2030 Land Use and a 25.6% level of conservation (304,000 AFY)
Agricultural Demand	Based on crop type and the DWR 2000 crop acreages (171,600 AFY)	Based on crop type and estimated 2030 crop acreage (144,200 AFY)	Based on crop type and estimated 2030 crop acreage (144,200 AFY)	Based on crop type and estimated 2030 crop acreage (144,200 AFY)
Surface Water Supplies	Current supplies, estimated based on CALSIM II 2000 Baseline Condition simulation (128,100 AFY)	Increased to include 'firm water' supplies including 4,400 AFY of reclaimed water (194,800 AFY)	Increased to include 'firm water' supplies including 4,400 AFY of reclaimed water (194,300 AFY)	Reduced surface water diversion at Freeport to the Zone 40 area by 26,700 AFY (167,600 AFY)
Remediated Water	No Reuse	9,400 AFY is used in Zone 40, 5,000 AFY provided to augment Cosumnes River flow enhancement	100% Reuse (6,200 AFY reinjection, 5,000 AFY Cosumnes River flow enhancement, 18,800 AFY reuse)	100% Reuse (6,200 AFY reinjection, 5,000 AFY Cosumnes River flow enhancement, 18,800 AFY reuse)
Groundwater Pumping	Current Level of pumping (248,600 AFY)	Less pumping for agricultural demand, groundwater pumping to meet unsatisfied water demand (244,000 AFY)	Less pumping for agricultural demand, groundwater pumping to meet unsatisfied water demand (235,100 AFY)	Groundwater pumping in the Central area increased by 26,700 AFY (261,800 AFY)
Additional Supply Areas	None	None	North Vineyard, Zone 40 Uniform Pumping	North Vineyard, Zone 40 Uniform Pumping

2.2 IMPACT UNIT COSTS

The exact impact cost of each well will be different, however, representative average impact costs were used in this study to calculate the total impact cost. Current average costs for replacement of agricultural and rural domestic wells are \$200,000 and \$20,000, respectively (Ken Worster, 2005). The average replacement cost of agricultural and rural domestic wells in the 1997 Baseline Yield Analysis were \$150,000 and \$10,000, respectively. Assuming an annual inflation of 6%, the 2005 estimates for these costs are approximately \$250,000 and \$15,000. The impact unit cost estimates used in this study are presented in Table 2.2.

Table 2.2 – Impact unit cost estimates.

Impact	Cost Estimate	
	Agricultural Well	Rural Domestic Well
Pump Bowl Lowering	\$10,000	\$1,000
Well Deepening	\$50,000	\$5,000
Well Replacement	\$220,000	\$20,000

2.3 WELL DEPTH DATA

Well depth information for the agricultural and rural domestic wells in the Central Basin was obtained from the 1997 Baseline Yield Analysis and the DWR/USGS well log database. Table 2.3 presents the number of wells with bottom depth information that are available from these two sources. Figure 2.1 presents the location of the wells in Table 2.3.

Table 2.3 - Number of Wells in Central Basin With Bottom Depth Information.

Source	Well Type		Total
	Agricultural	Rural Domestic	
1997 Baseline Yield Analysis	189	775	964
DWR/USGS Databse	40	52	92
Total	229	827	1056

Agricultural wells are usually deeper than rural domestic wells. The distribution of depth of agricultural wells identified in Table 2.3 is illustrated in Figure 2.2. The agricultural wells are at least 80 feet deep and mostly range from 120 feet to 360 feet in depth. Eight wells are more than 600 feet in depth.

The distribution of depth of rural domestic wells identified in Table 2.3 is illustrated in Figure 2.3. The rural domestic wells are at least 60 feet deep and mostly range from 120 feet to 320 feet in depth.

Wells in the western part of the Central Basin pump from the upper aquifer (Layer 1 of SACIGSM), while wells in the eastern part pump from the lower aquifer (Layer 2 of SACIGSM). The location of the east-west SACIGSM cross-section and the locations of the wells are shown in Figure 2.4. Layer 1 thins out from west to east and occurs at lower depths in the eastern part of the Basin. The vertical distribution of pumping is illustrated in a SACIGSM cross-section (Figure 2.5).

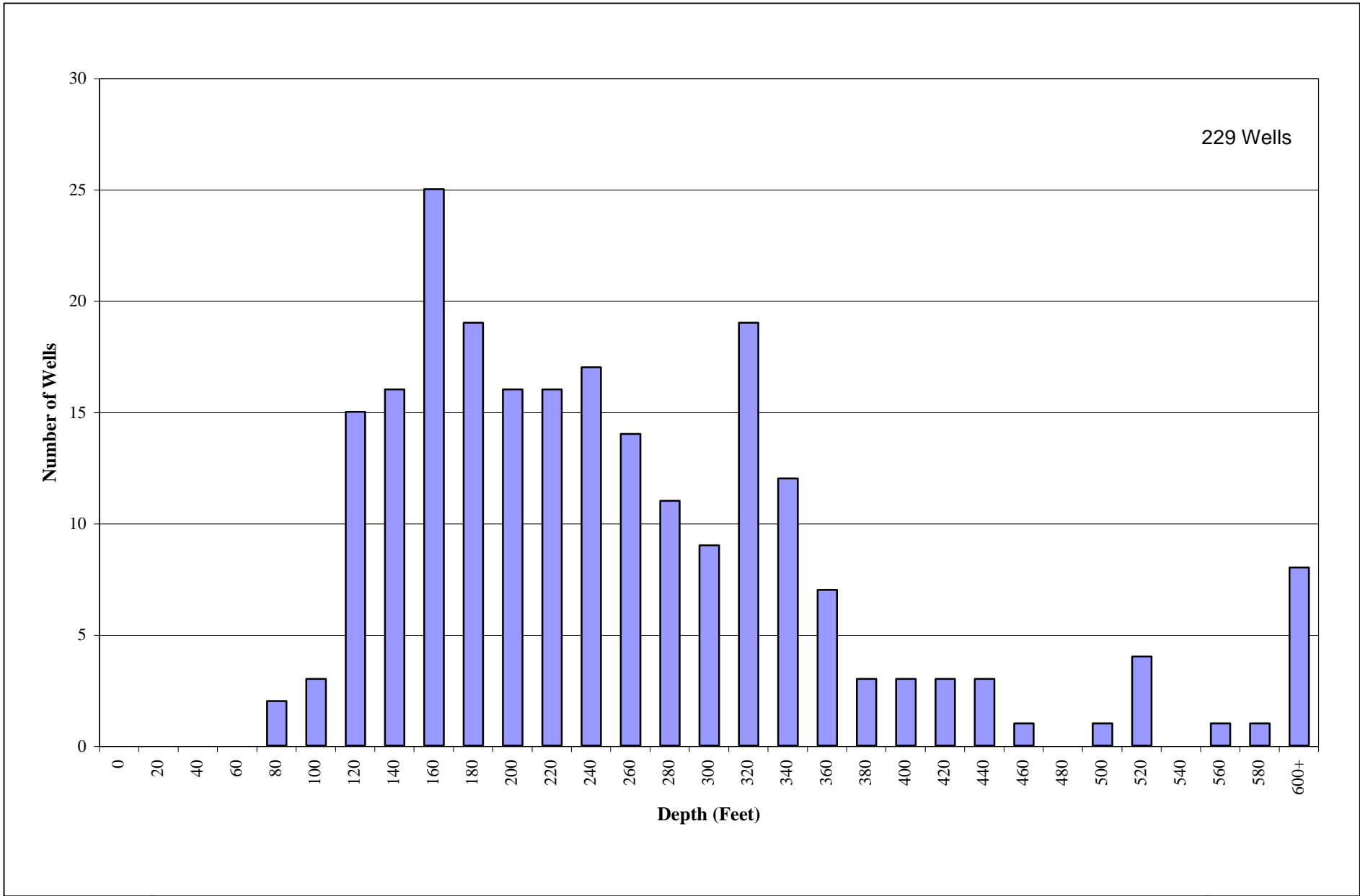
2.4 GROUNDWATER LEVELS

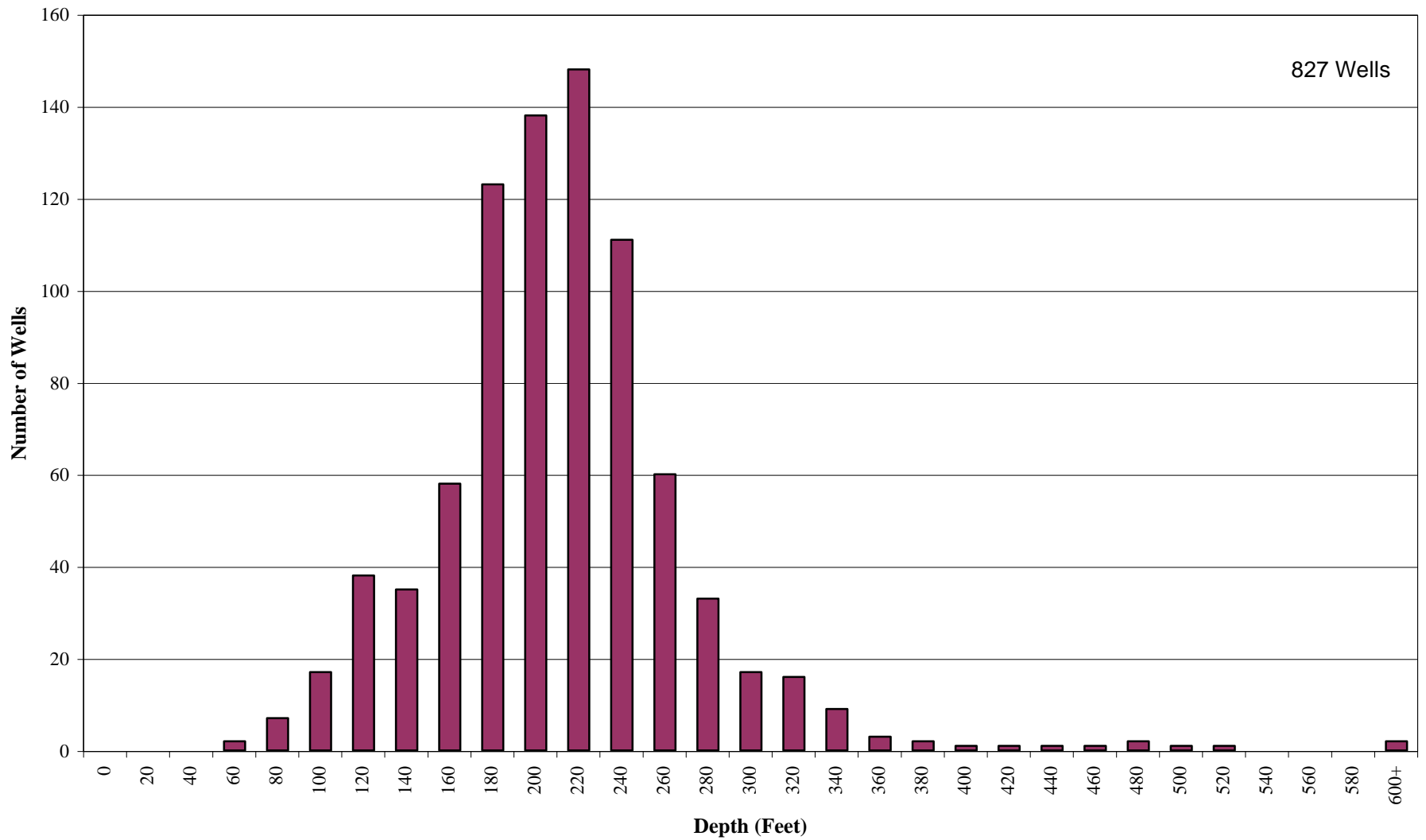
Groundwater levels at the location of the agricultural and rural domestic wells with available bottom depth data were obtained from WRIME's recent SACIGSM modeling analysis for Central Sacramento County (WRIME, 2004) and from a new SACIGSM simulation that was performed as part of this study for the Reduced Surface Water Availability scenario. Groundwater levels were compared with the well depth information to determine whether any well is impacted due to declining groundwater levels. The groundwater levels were obtained for the following scenarios:

- A – No Project (Baseline 2030),
- B – Proposed Project, and
- C - Reduced Surface Water Availability.

The Reduced Surface Water Availability scenario was developed as part of this study to obtain groundwater levels for a situation where 26,700 AFY of the planned surface water diversion at Freeport would not be available for Zone 40 and the water supply deficiency would be met by an additional 26,700 AFY of groundwater pumping in the Central Basin. This scenario represents the worst case conditions in which the groundwater pumping in the Central Basin is at maximum rate of 261,800 AFY.

Groundwater levels from layers 1 and 2 were used in this study. Layer 1 is thicker in the western half of the Central Basin and most of the wells in the western half pump from Layer 1. In contrast, Layer 1 thins out in the eastern half and most of the wells in this half pump from layer 2 (Figure 2.5).



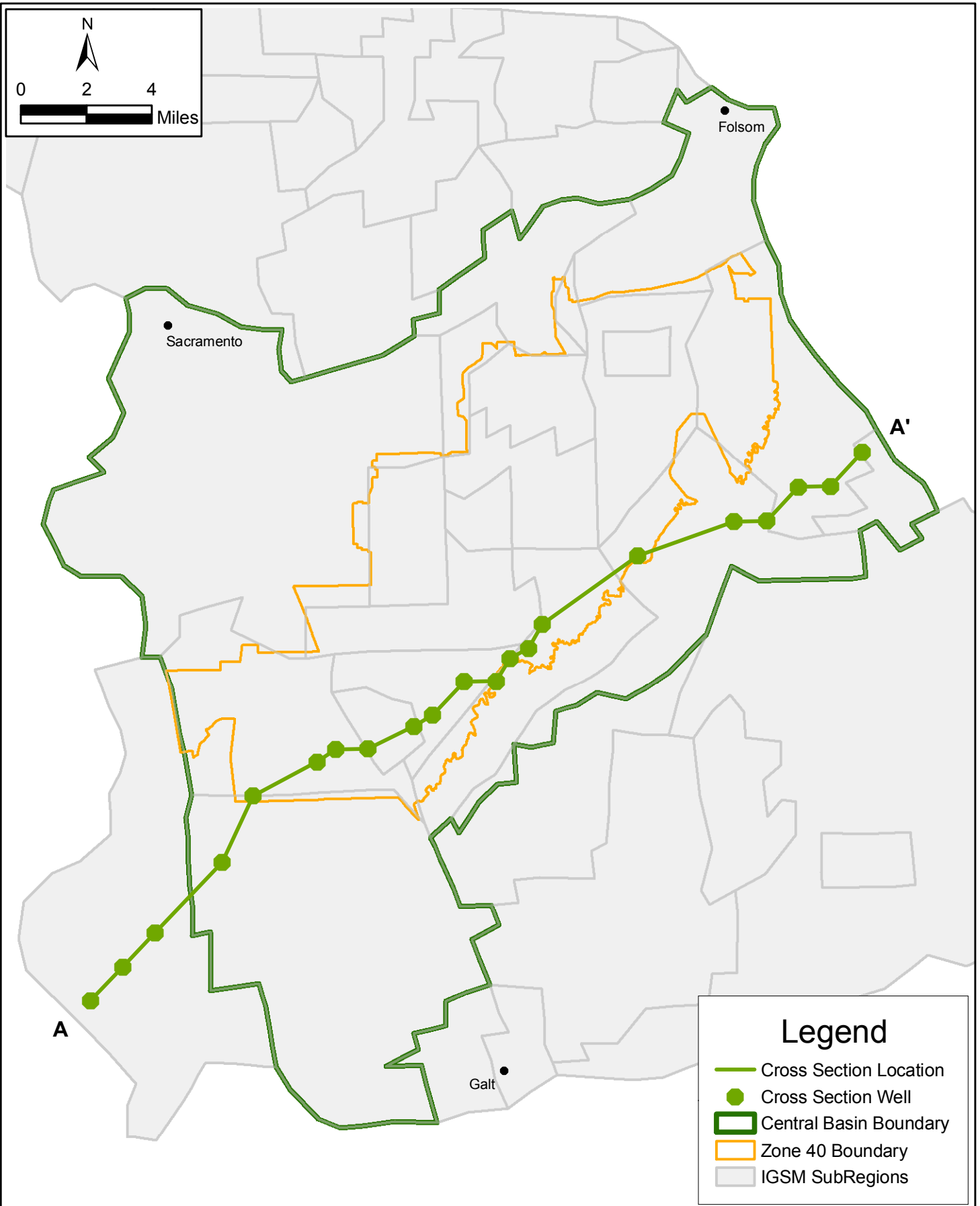


Central Sacramento Groundwater Basin Well Impact Analysis

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Rural Domestic Well Depth Distribution

FIGURE 2.3



Legend

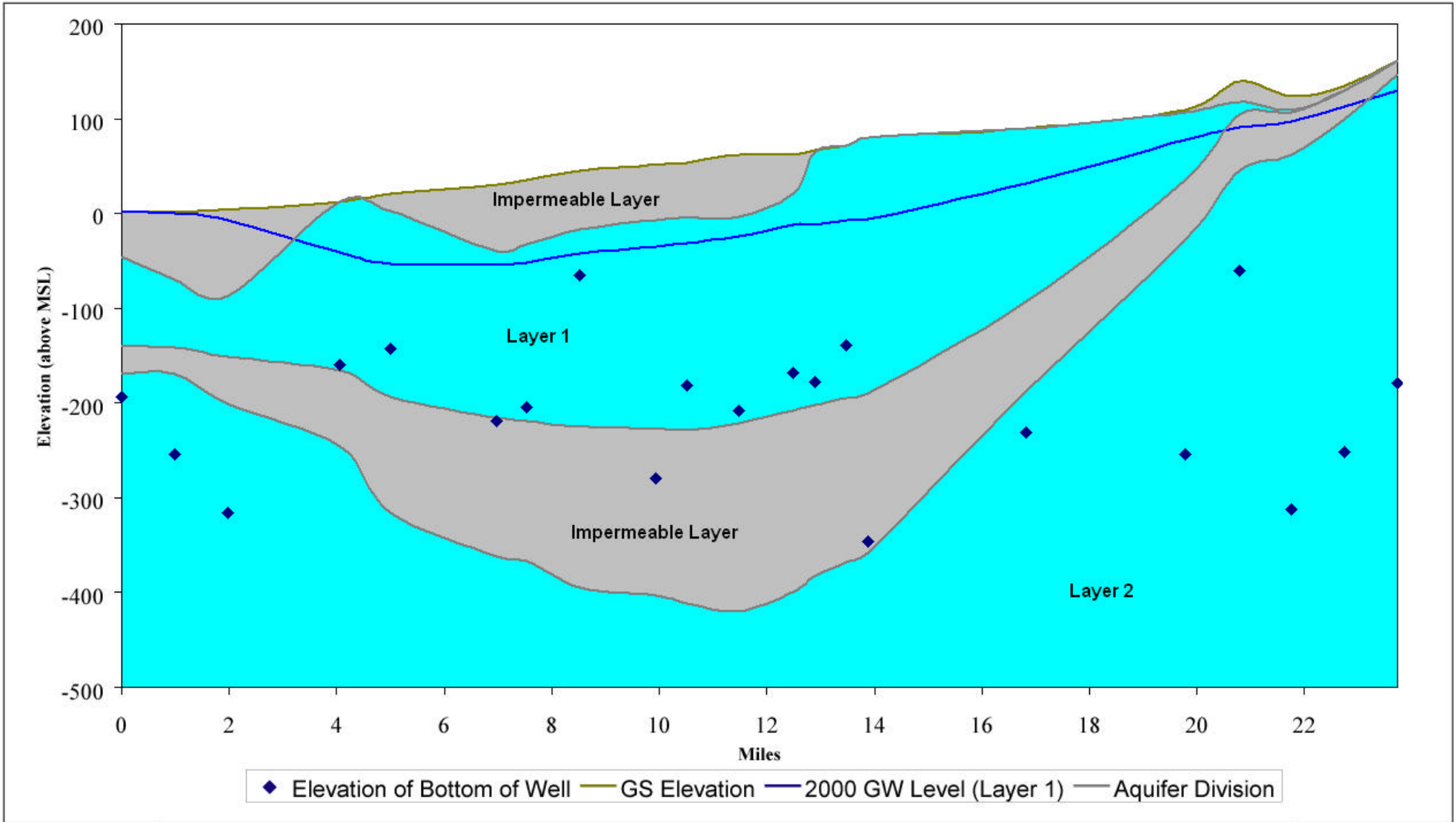
- Cross Section Location
- Cross Section Well
- Central Basin Boundary
- Zone 40 Boundary
- IGSM SubRegions



**Central Sacramento Groundwater Basin
Well Impact Analysis
Location of East-West Cross Section**

November 2005

Figure 2.4



Central Sacramento Groundwater Basin Well Impact Analysis

November 2005

Geologic Cross Section A - A'

FIGURE 2.5

The No Project scenario represent groundwater levels at buildout (2030 level of development). The level of development represents a set of land use, water use, and water supply/demand conditions. The No Project scenario represent the long-term effect of buildout of the 2030 level of development with reduced agricultural demands and increased surface water supplies (Table 2.1). The No Project scenario provides a frame of reference for comparison of hydrologic impacts of various water management alternatives. The Proposed Project and the Reduced Surface Water Availability scenarios were analyzed under the 2030 level of development.

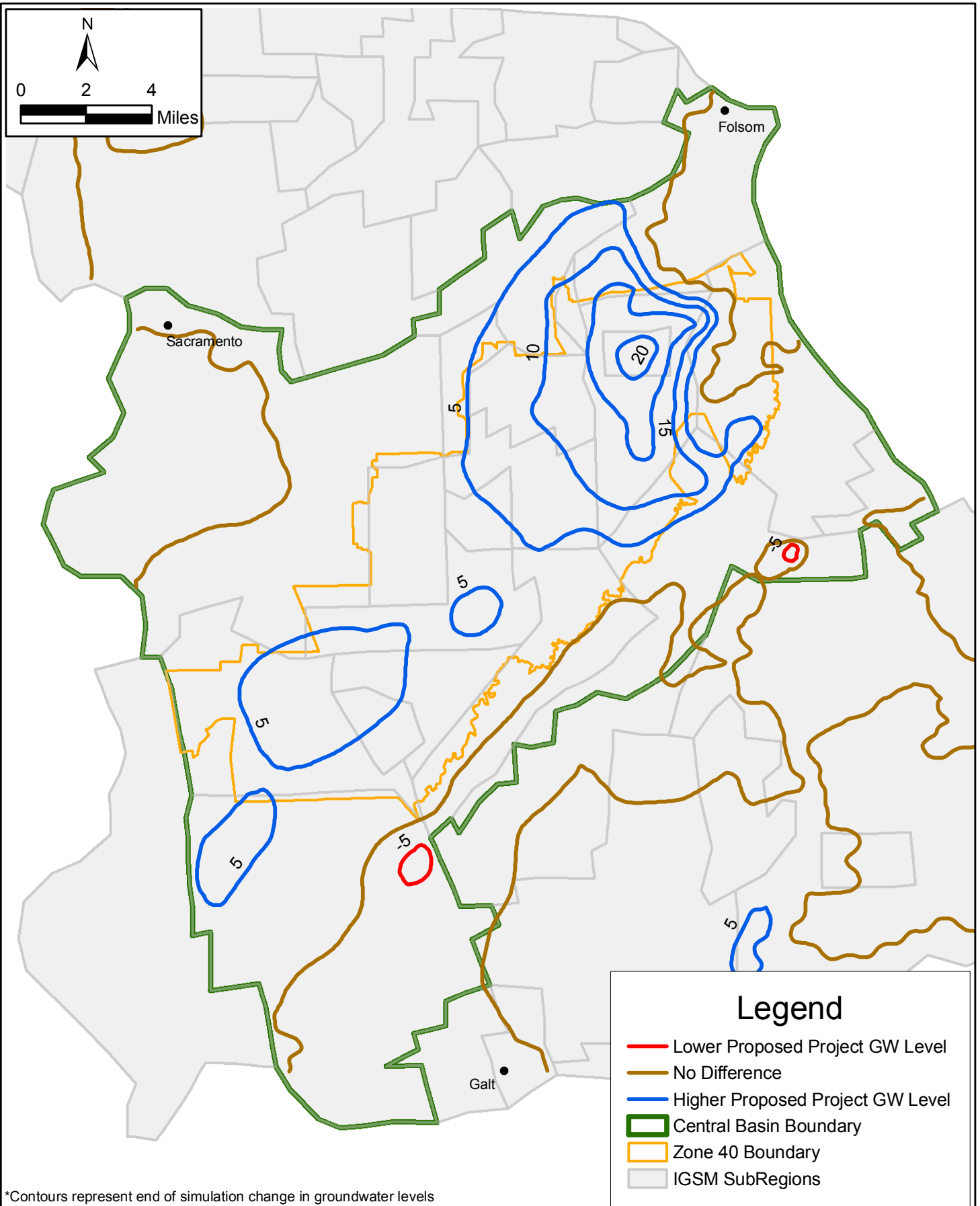
The groundwater levels of the Proposed Project scenario at the end of the simulation are compared to the groundwater levels of the No Project scenario (Figures 2.6 and 2.7). The blue contour lines represent areas with higher Proposed Project water levels than the No Project. The red contour lines indicate the Proposed Project water levels are lower than the No Project. The groundwater levels of the Reduced Surface Water Availability scenario at the end of the simulation are compared to the groundwater levels at the end of the No Project simulation (Figures 2.8 and 2.9). In the Reduced Surface Water Availability scenario water levels drop below the No Project water levels. The higher water level zone in the foothills is also limited to a smaller area. The comparison of the Reduced Surface Water Availability groundwater levels with the Proposed Project groundwater levels is presented in Figures 2.10 and 2.11. The groundwater levels of the Reduced Surface Water Availability scenario are lower than the Proposed Project water levels in all of the Central Basin. The maximum drop in water levels is observed in the western part of Zone 40 where less surface water is available for the Reduced Surface Water Availability scenario.

2.5 LAND USE CONDITIONS

The land use maps of the 2000 and projected 2030 conditions representing land use trends within the Sacramento County are presented in Figures 2.12 and 2.13 (WRIME, 2004). The land use data includes both the general land use and crop acreage to identify water use. The general land use conditions is divided into five classes of

- Agricultural land consisting of areas greater than 5 acres and used for agriculture;
- Agricultural-Residential consisting of 2- to 5-acre parcels zoned for agricultural and residential use;
- Urban consisting of municipal, commercial or industrial development;
- Native Vegetation/Undeveloped areas; and
- Riparian Vegetation consisting of areas along waterways.

The estimated acreage of general land use for the 2000 Baseline and 2030 Baseline are summarized in Table 2.4. The increase in urban and agriculture-residential acreages resulted from the conversion of agricultural land and the development of undeveloped land. The three

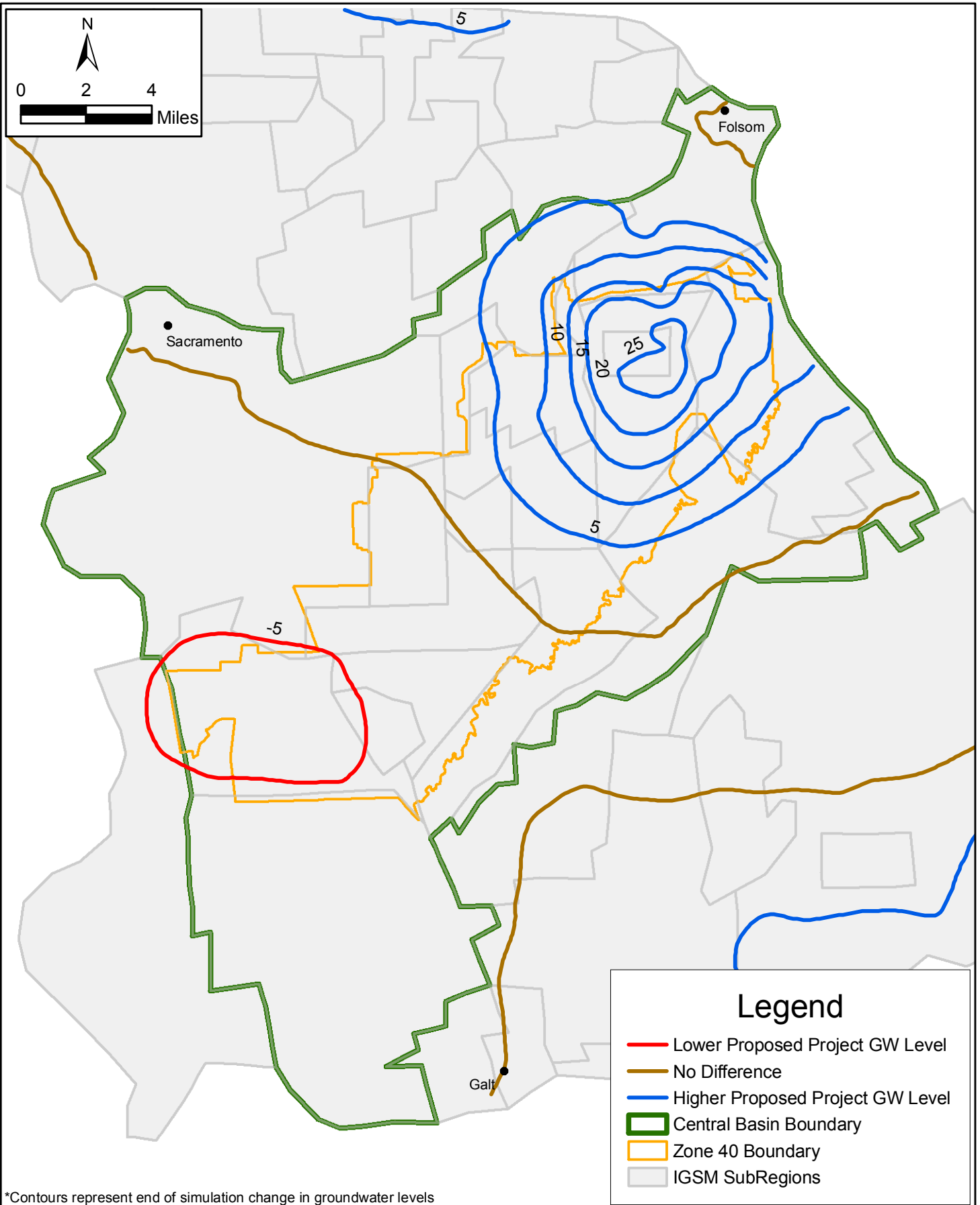


*Contours represent end of simulation change in groundwater levels



**Central Sacramento Groundwater Basin
 Well Impact Analysis
 Comparison of Proposed Project
 and No Project GW Levels - Layer 1**

November 2005
 Figure 2.6



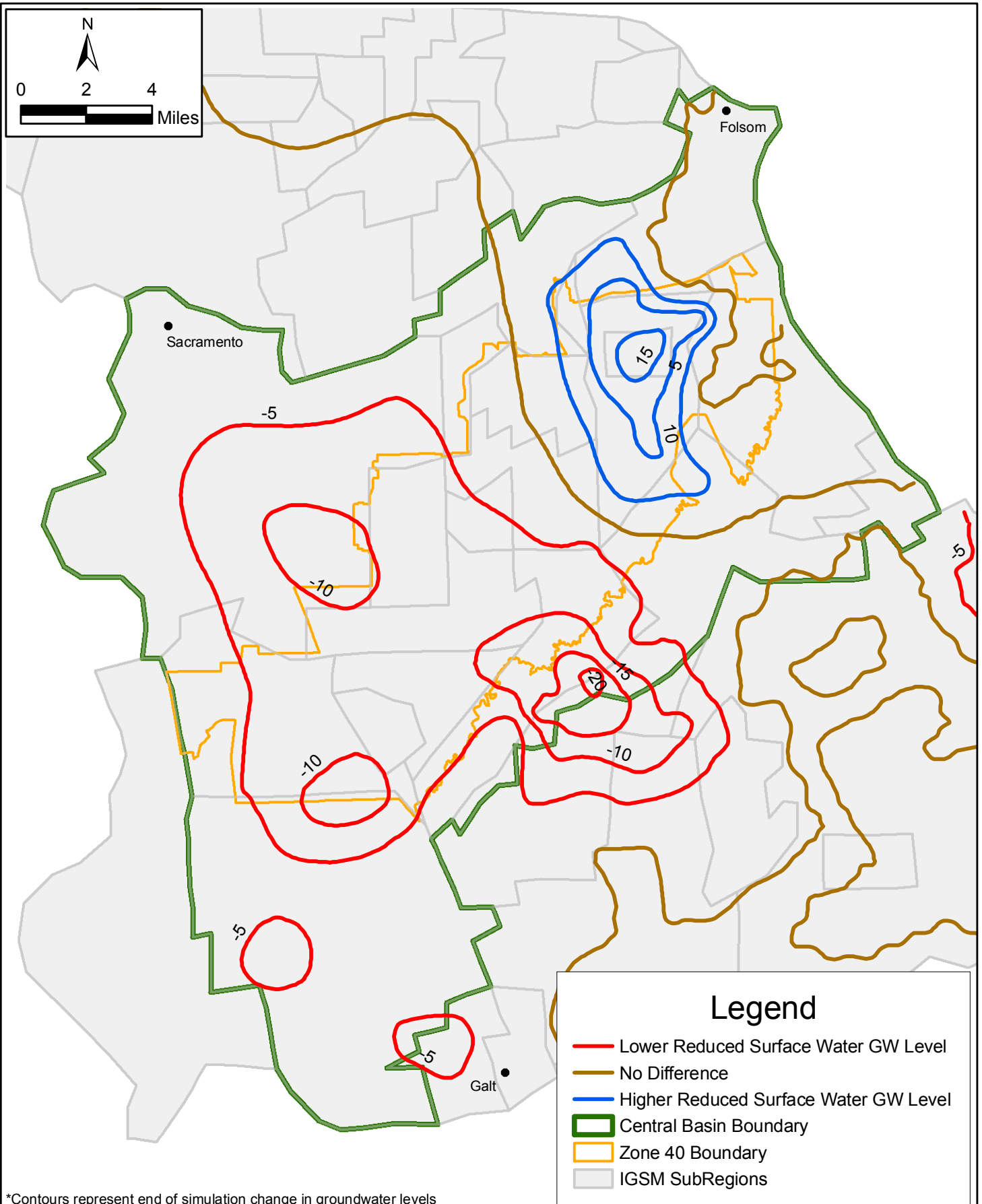
*Contours represent end of simulation change in groundwater levels



**Central Sacramento Groundwater Basin
Well Impact Analysis
Comparison of Proposed Project
and No Project GW Levels - Layer 2**

November 2005

Figure 2.7



*Contours represent end of simulation change in groundwater levels

Legend

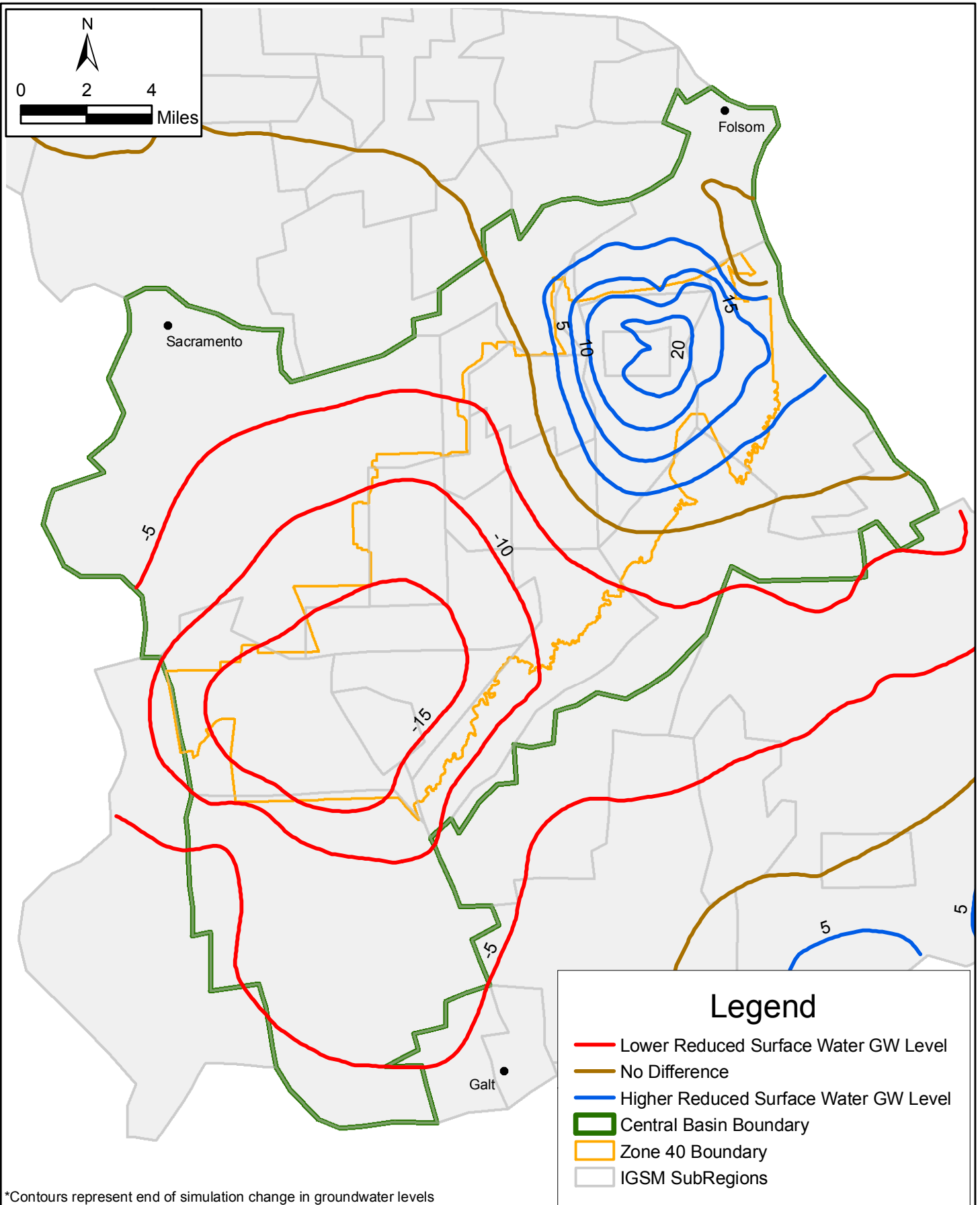
- Lower Reduced Surface Water GW Level
- No Difference
- Higher Reduced Surface Water GW Level
- Central Basin Boundary
- Zone 40 Boundary
- IGSM SubRegions



**Central Sacramento Groundwater Basin
Well Impact Analysis
Comparison of Reduced Surface Water
Availability and No Project GW Levels
Layer 1**

November 2005

Figure 2.8

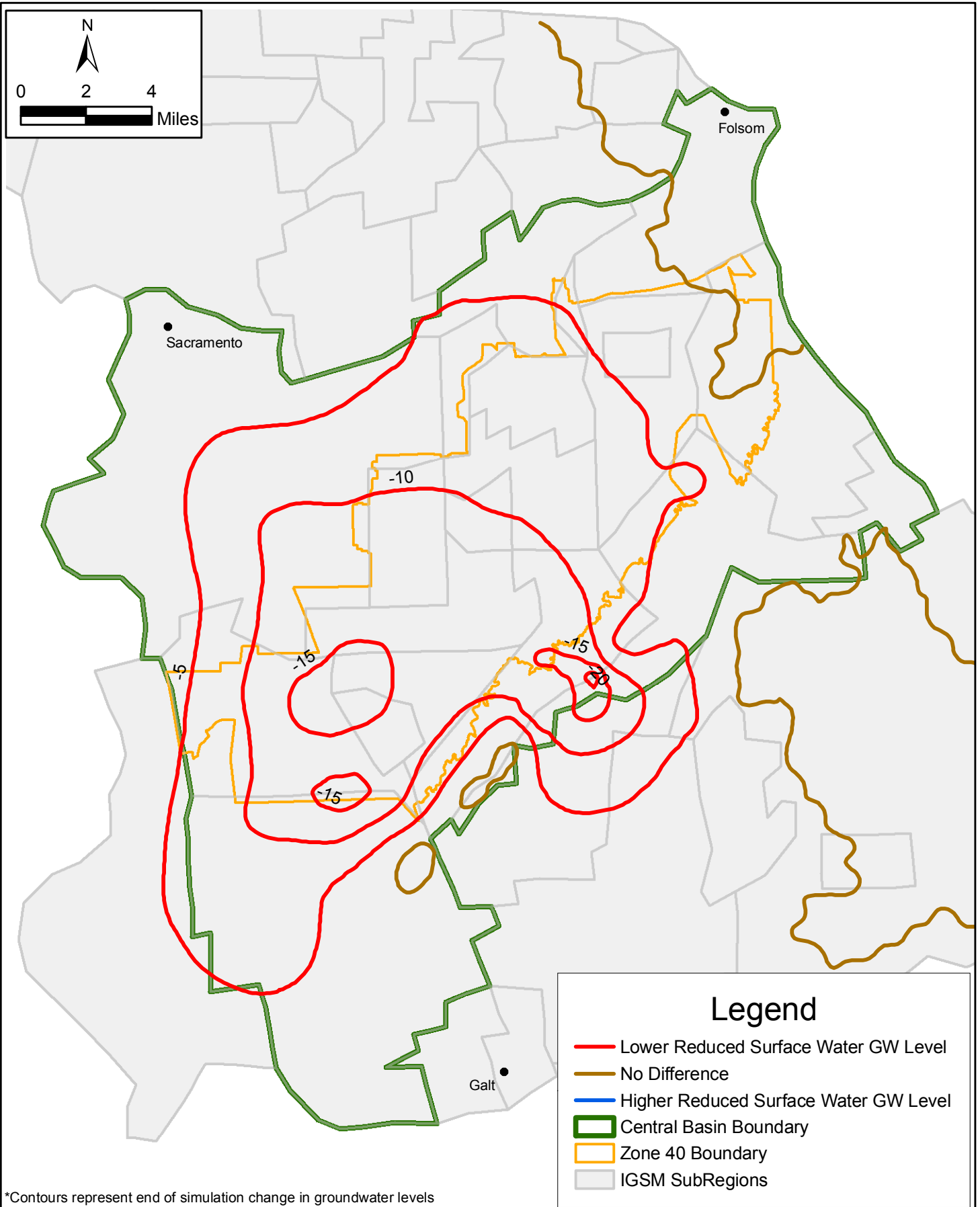


*Contours represent end of simulation change in groundwater levels



Central Sacramento Groundwater Basin
Well Impact Analysis
Comparison of Reduced Surface Water
Availability and No Project GW Levels
Layer 2

November 2005
 Figure 2.9

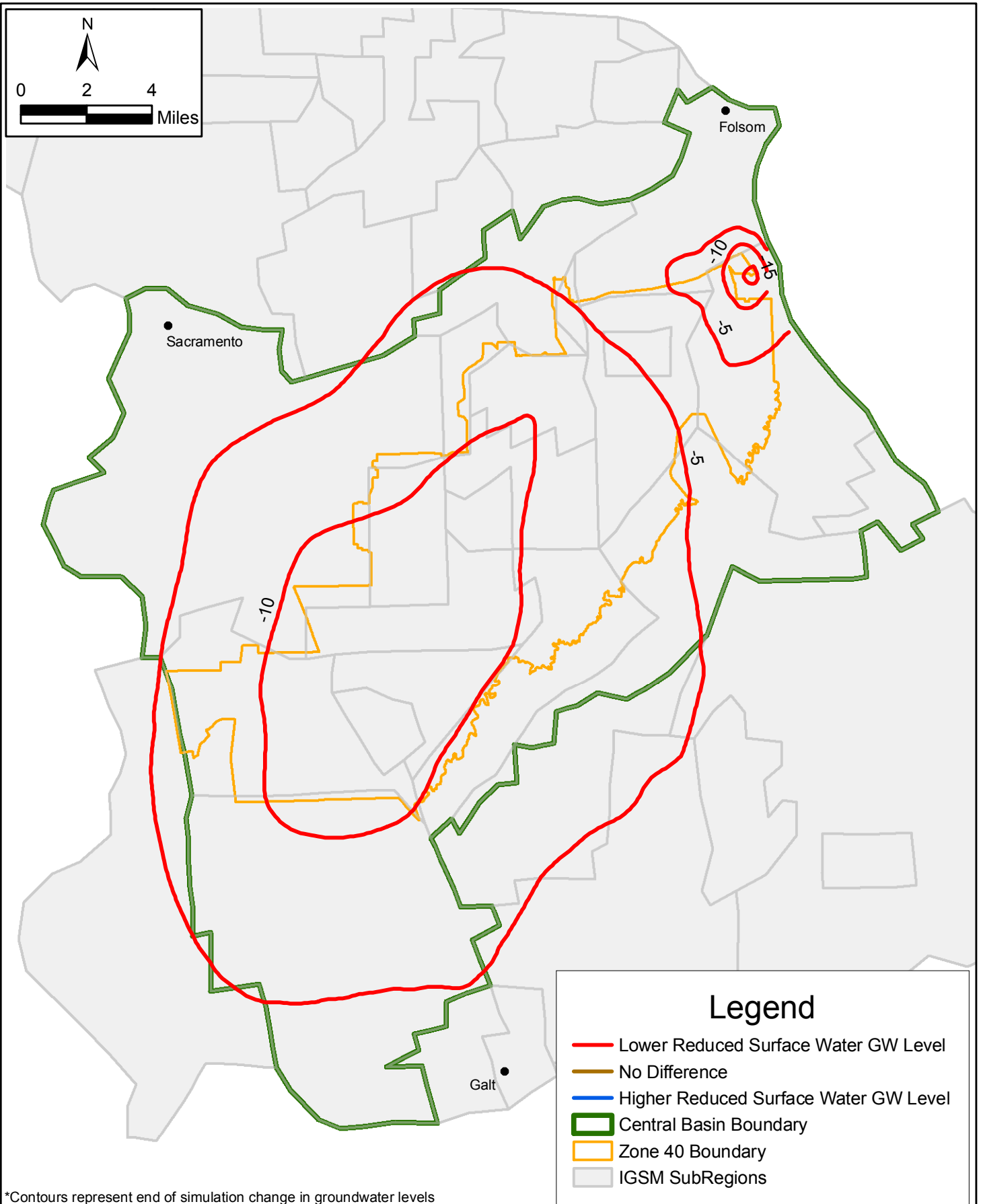


*Contours represent end of simulation change in groundwater levels

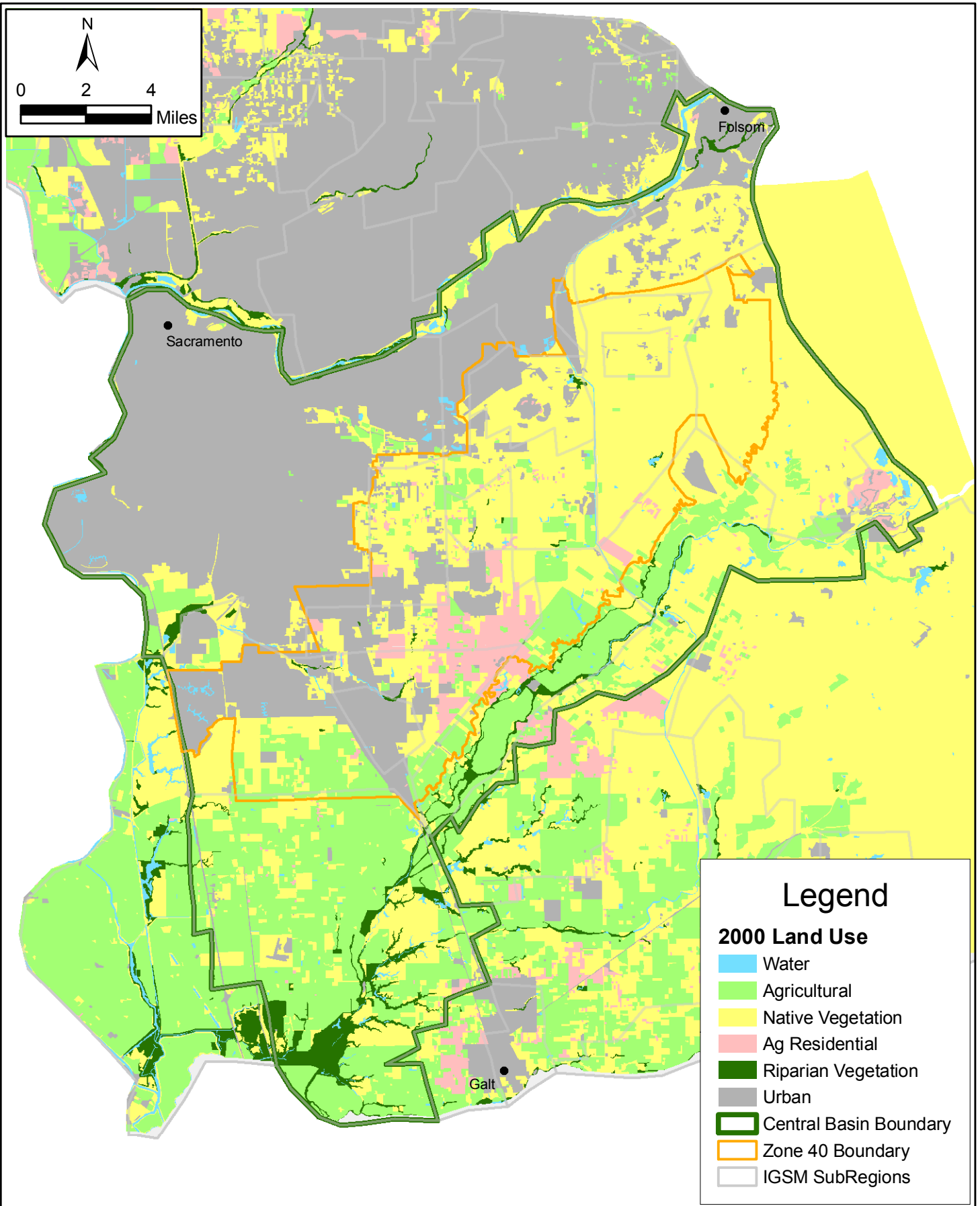


Central Sacramento Groundwater Basin
Well Impact Analysis
Comparison of Reduced Surface Water
Availability and Proposed Project
GW Levels - Layer 1

November 2005
 Figure 2.10



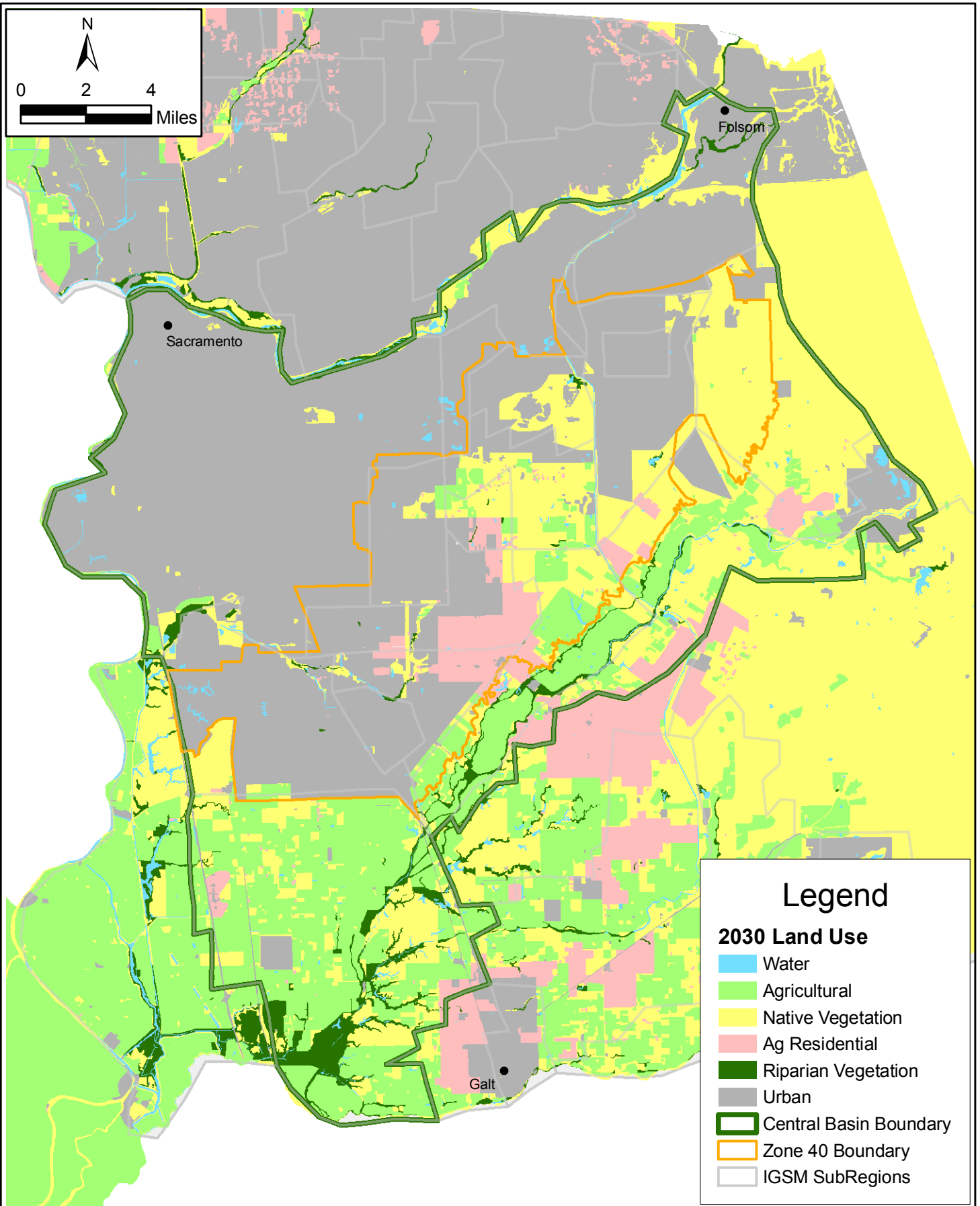
*Contours represent end of simulation change in groundwater levels



**Central Sacramento Groundwater Basin
Well Impact Analysis
Year 2000 General Land Use**

November 2005

Figure 2.12



**Central Sacramento Groundwater Basin
Well Impact Analysis
Year 2030 General Land Use**

November 2005

Figure 2.13

SACIGSM simulations (No Project, Proposed Project, and Reduced Surface Water Availability) are based on the estimated 2030 Baseline land use.

Table 2.4 Estimated Acreage of Land Use for the Central Basin (WRIME, 2004)

Class	Land Use, acres	
	2000	2030
Agriculture	51,126	39,492
Urban	80,387	132,263
Agriculture-Residential	7,572	10,486
Riparian Vegetation	6,409	6,363
Undeveloped/Native Vegetation	101,692	58,582
Total	247,186	247,186

2.6 WATER USE

Water use estimates are based on the land use data briefly described in the previous section (WRIME, 2004). Water use is divided into two categories of urban and agricultural uses. The water demands for each model subregion for 2000 and 2030 Baseline conditions are presented in Table 2.5. The 2000 Baseline urban water demand includes a 12 percent level of conservation, however, a 25.6 percent level of conservation is included in the 2030 Baseline urban water demand. The average annual agricultural demand in Zone 40 reduces from 28,400 AFY for the 2000 Baseline to 5,000 AFY for the 2030 Baseline.

2.7 WATER SUPPLY AVAILABILITY

The SACIGSM model scenarios are based on water supply availability from the following four sources:

- Surface Water Supplies;
- Recycled Water;
- Groundwater Supplies and;
- Groundwater Remediation and Reuse Options.

The surface water and groundwater supplies and remediation water reuse for each model subregion for No Project, Proposed Project, and Reduced Surface Water Availability scenarios are presented in Table 2.6. Groundwater pumping in Proposed Project is reduced by 9,400 AFY. The reduction in groundwater pumping is compensated by an additional 9,400 AFY of remediation water reuse. The surface water supply is reduced by 26,700 AFY for the Reduced Surface Water Availability simulation. The surface water reduction is accounted for by reducing the Freeport diversion by 26,700 AFY. Groundwater pumping is increased by 26,700 AFY to compensate for the surface water reduction.

Table 2.5 - 2000 and 2030 Baselines Water Demand (WRIME, 2004)

Subregion		2000 Baseline					2030 Baseline				
		Ag Acreage	Urban Acreage	AG Demand	Urban Demand	Total Water Demand	Ag Acreage	Urban Acreage	AG Demand	Urban Demand	Total Water Demand
Number	Name	(A)	(A)	(AF)	(AF)	(AF)	(A)	(AF)	(AF)	(AF)	(AF)
Central Area											
2	South Sacramento	1,440	46,525	3,912	116,296	120,208	386	50234	972	116006	116,978
3	Omochumne-Hartnell North	8,461	260	24,917	855	25,772	8388	137	24675	375	25,050
4	Southwest	27,132	1,048	84,623	1,201	85,824	26347	2284	82646	2181	84,827
10	Omochumne-Hartnell	6,132	720	20,260	1,215	21,475	6300	1277	21215	1796	23,011
11	Rancho Murieta	274	1,007	1,382	2,781	4,163	216	2178	1085	5011	6,096
12	Sunrise "A" - SCWA	1,341	721	5,715	927	6,642	1158	2482	4766	2659	7,425
15	City of Folsom	2	5,312	10	20,159	20,169	0	11697	0	32904	32,904
16	Arden Cordova	202	6,600	380	14,331	14,711	173	6929	303	12534	12,837
30	Foothills North	618	669	1,981	529	2,510	935	1825	3610	1202	4,812
37	EGWS	0	2,307	0	2,710	2,710	0	2590	0	2552	2,552
43	Rosemont - Cal Am	9	2,752	34	6,198	6,232	0	2990	0	5610	5,610
Total Central Area		45,611	67,921	143,214	167,202	310,416	43,903	84,623	139,272	182,830	322,102
Zone 40											
13	Sunrise Douglas - SCWA	96	230	145	115	259	713	8512	3012	17429	20,441
14	Security Park - Cal Am	1	86	5	381	384	11	1737	54	1455	1,509
23	Sunrise - SCWA	0	525	0	2,059	2,058	0	912	0	2059	2,059
36	Laguna/Franklin - SCWA	3,323	7,655	10,265	14,422	24,687	50	14228	154	35752	35,906
38	SCWA/EGWS Retail	1,558	1,760	7,209	6,185	13,394	53	5884	242	14308	14,550
39	Vineyard - SCWA	1,603	3,389	7,425	7,646	15,071	322	7533	1479	21988	23,467
40	N. Vineyard in POU - SCWA	540	1,978	1,644	4,444	6,088	0	5600	0	9929	9,929
41	N. Vineyard Out POU - SCWA	516	82	1,620	261	1,880	0	2351	0	7038	7,038
42	Mather	21	2,181	105	2,303	2,410	0	5755	0	11168	11,168
Total Zone 40		7,658	17,886	28,418	37,816	66,233	1,149	52,512	4,941	121,126	126,067
Grand Total		53,269	85,807	171,632	205,018	376,649	45,052	137,135	144,213	303,956	448,169

Table 2.6. Water Supplies for No Project, Proposed Project, and Reduced Surface Water Availability Scenarios

(RR=Remediation Reuse, GS=Groundwater, SW=Surface Water)

Subregion		A - No Project				B - Proposed Project				C - Reduced Surface Water Availability			
		GW	SW	RR	Total	GW	SW	RR	Total	GW	SW	RR	Total
Number	Name	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)
Central Area													
2	South Sacramento	28,590	88,388		116,978	28,590	88,388		116,978	32,070	88,388		120,458
3	Omochumne-Hartnell North	20,710	4,340		25,050	20,703	4,347		25,050	23,211	4,347		27,558
4	Southwest	84,827	0		84,827	84,827	0		84,827	95,075	0		95,075
10	Omochumne-Hartnell	16,441	6,570		23,011	16,441	6,570		23,011	18,433	6,570		25,003
11	Rancho Murieta	181	5,915		6,096	181	5,915		6,096	205	5,915		6,120
12	Sunrise "A" – SCWA	7,434	-9		7,425	7,503	-78		7,425	8,403	-78		8,325
15	City of Folsom	0	32,904		32,904	0	32,904		32,904	0	32,904		32,904
16	Arden Cordova	7,637	5,200		12,837	7,637	5,200		12,837	8,561	5,200		13,761
30	Foothills North	4,812	0		4,812	4,812	0		4,812	5,388	0		5,388
37	EGWS	2,552	0		2,552	2,552	0		2,552	2,864	0		2,864
43	Rosemont – Cal Am	5,610	0		5,610	5,610	0		5,610	6,282	0		6,282
Total Central Area		178,794	143,308	0	322,102	178,856	143,246	0	322,102	200,492	143,246	0	343,738
Zone 40													
13	Sunrise Douglas – SCWA	12,418	6,486	1,537	20,441	3,012	14,356	3,073	20,441	3,012	9,961	3,073	16,046
14	Security Park – Cal Am	839	542	128	1,509	54	1,198	257	1,509	54	831	257	1,142
23	Sunrise – SCWA	1,109	768	182	2,059	0	1,696	363	2,059	0	1,177	363	1,540
36	Laguna/Franklin – SCWA	17,831	15,314	2,761	35,906	18,504	11,880	5,522	35,906	20,292	3,984	5,522	29,798
38	SCWA/EGWS Retail	8,161	5,128	1,261	14,550	8,301	3,726	2,523	14,550	9,117	118	2,523	11,758
39	Vineyard – SCWA	13,647	7,882	1,938	23,467	13,447	6,144	3,876	23,467	14,827	601	3,876	19,304
40	N. Vineyard in POU - SCWA	733	9,141	55	9,929	2,033	7,785	111	9,929	2,093	7,785	111	9,989
41	N. Vineyard Out POU – SCWA	4,233	2,252	553	7,038	4,222	1,710	1,106	7,038	4,654	129	1,106	5,889
42	Mather	6,181	4,002	985	11,168	6,631	2,568	1,969	11,168	7,243	-248	1,969	8,964
Total Zone 40		65,152	51,515	9,400	126,067	56,204	51,063	18,800	126,067	61,292	24,339	18,800	104,431
Grand Total		243,946	194,823	9,400	448,169	235,060	194,309	18,800	448,169	261,784	167,585	18,800	448,169

3. ANALYSIS OF WELL INVENTORY

The exact number of agricultural and rural domestic wells in the Central Sacramento County is not known. In order to determine the potential impacts of lowering groundwater levels on these wells an analysis was performed to estimate the total number of wells in each model subregion. The following subsections present the methodology and the results of this analysis.

3.1. AGRICULTURAL WELLS

Agricultural wells are those wells that are primarily utilized for crop and pasture irrigation. The number of agricultural wells in the Central Sacramento County was estimated based on land use, water demand, and average well capacity.

The average well capacity of agricultural wells for Central Sacramento County is approximately 971 gallons per minute (MW, 1997). Agricultural wells are assumed to pump at the average capacity rate for 6 months each year and produce 772 AFY of water.

Agricultural water demand in each subregion is dependent on the acreage of land used for agricultural purposes and the estimated agricultural water duty. WRIME (2004) provided estimates of agricultural water demands of the subregions in Central Sacramento County for 2000 Baseline and 2030 Baseline conditions (Table 3.1).

The number of agricultural wells in each subregion is obtained by dividing the agricultural water demand by 772 AFY per well. The estimated number of agricultural wells in Central Sacramento County is presented in Table 3.1. Majority of the agricultural wells are in Omochumne-Hartnell North (Subregion 3), Southwest (Subregion 4), and Omochumne-Hartnell (Subregion 10) subregions along the Cosumnes River. The estimated total number of agricultural wells in Central Sacramento County with 2000 Baseline conditions is 235 wells and reduces to 194 wells with 2030 Baseline conditions.

3.2. RURAL DOMESTIC WELLS

Rural domestic wells are those wells that produce water for utilization at agricultural residential areas. The number of rural domestic wells in Central Sacramento County was estimated based on agricultural residential land use and average well capacity.

Rural domestic wells are assumed to pump, on the average, enough water for residential use and irrigation of 1.25 acres of land (MW, 1997). WRIME (2004) provided estimates of agricultural residential land use in the subregions in Central Sacramento County for 2000 Baseline and 2030 Baseline conditions (Table 3.2).

Table 3.1 – Estimated Number of agricultural wells in Central Sacramento County

Subregion		2000 Ag Water Demand	2030 Ag Water Demand	2000 Agricultural Wells	2030 Agricultural Wells
Number	Name	(AF)	(AF)	(well)	(wells)
Central Area					
2	South Sacramento	3,912	972	6	2
3	Omochumne-Hartnell North	24,917	24,675	33	32
4	Southwest	84,623	82,646	110	108
10	Omochumne-Hartnell	20,260	21,215	27	28
11	Rancho Murieta	1,382	1,085	2	2
12	Sunrise “A” – SCWA	5,715	4,766	8	7
15	City of Folsom	10	0	1	0
16	Arden Cordova	380	303	1	1
30	Foothills North	1,981	3,610	3	5
37	EGWS	0	0	0	0
43	Rosemont – Cal Am	34	0	1	0
Zone 40					
13	Sunrise Douglas – SCWA	145	3,012	1	4
14	Security Park – Cal Am	5	54	1	1
23	Sunrise – SCWA	0	0	0	0
36	Laguna/Franklin – SCWA	10,265	154	14	1
38	SCWA/EGWS Retail	7,209	242	10	1
39	Vineyard – SCWA	7,425	1,479	10	2
40	N. Vineyard in POU - SCWA	1,644	0	3	0
41	N. Vineyard Out POU – SCWA	1,620	0	3	0
42	Mather	105	0	1	0
	Total	171,632	144,213	235	194

Table 3.2 – Estimated number of rural domestic wells in Central Sacramento County

Subregion		2000 Ag Residential Land Use	2030 Ag Residential + General Plan Ag Residential Land Use	2000 Rural Domestic Wells	2030 Rural Domestic Wells
Number	Name	(Acres)	(AF)	(wells)	(wells)
Central Area					
2	South Sacramento	9	1	8	1
3	Omochumne-Hartnell North	897	1,240	718	992
4	Southwest	195	868	156	695
10	Omochumne-Hartnell	804	2,367	644	1,894
11	Rancho Murieta	580	0	464	0
12	Sunrise “A” – SCWA	74	69	60	56
15	City of Folsom	21	4	17	4
16	Arden Cordova	0	0	0	0
30	Foothills North	143	1,018	115	815
37	EGWS	0	0	0	0
43	Rosemont – Cal Am	0	0	0	0
Zone 40					
13	Sunrise Douglas – SCWA	9	0	8	0
14	Security Park – Cal Am	2	1	2	1
23	Sunrise – SCWA	0	0	0	0
36	Laguna/Franklin – SCWA	50	12	40	10
38	SCWA/EGWS Retail	1,953	1,720	1,563	1,376
39	Vineyard – SCWA	2,225	2,400	1,780	1,920
40	N. Vineyard in POU – SCWA	301	8	241	7
41	N. Vineyard Out POU – SCWA	87	511	70	409
42	Mather	28	0	23	0
Total		7,378	10,219	5,909	8,180

The number of rural domestic wells in each subregion is obtained by dividing the agricultural residential land use by the area covered by each well (1.25 acres). The estimated number of rural domestic wells in Central Sacramento County is presented in Table 3.2. The majority of the rural domestic wells are in Omochumne-Hartnell North (Subregion 3), Southwest (Subregion 4), and Omochumne-Hartnell (Subregion 10), Rancho Murrieta (Subregion 11), SCWA/EGWS Retail (Subregion 38), Vineyard-SCWA (Subregion 39) subregions along Cosumnes River and in the middle of Zone 40. The estimated total number of rural domestic wells in Central Sacramento County with 2000 Baseline conditions is 5,909 wells and increases to 8,180 wells with 2030 Baseline conditions. This is due to increased acreage of agricultural residential land use in the 2030 Baseline conditions.

4. IMPACTED WELLS

Impacts associated with groundwater level decline analyzed in this study include pump bowl lowering, well deepening, and well replacement. The location of water level in relation to the pump bowl and the bottom of the well indicates the level of impact on a well. If the declining water levels remain above the pump bowl, the well would remain in operation. If the water levels drop below the pump bowl, depending on the magnitude of decline, the following impact categories or thresholds may be used:

- Threshold 1 – Lowering the pump bowl,
- Threshold 2 – Deepening the well, or
- Threshold 3 – Replacing the well.

The groundwater levels during the 26-year hydrologic sequence were analyzed at each well location, under each scenario. The lowest groundwater level over time was selected for comparison with the available well depth data. The above impact criteria were used to determine if a well is impacted by the particular scenario.

4.1. IMPACT CRITERIA

Threshold 1 – Lowering the Pump Bowl

If the groundwater level drops below the pump bowl then the pump cannot operate and the pump bowl should be lowered. However, there is a limit on how much the pump bowl could be lowered. The pump cannot operate at the bottom of the well and has to be at least 10 feet above the bottom of the well. The pump bowls are typically installed 50 feet above the bottom of the wells. Thus, the pump lowering threshold is used when the lowest groundwater level at a well location is between 50 feet above the bottom of the well to 10 feet above the bottom of the well. In this situation, it is assumed that the well remains operable and should not be deepened, however, the pump bowl needs to be lowered.

Threshold 2 – Deepening the Well

A well is expected to be deepened if the distance between the bottom of the well and the groundwater levels above the bottom of the well is less than 10 feet. By deepening the well, the pump bowl can be

lowered to a new operational depth. A well is considered a candidate for deepening if the lowest groundwater level at that well is between 10 feet above the bottom of the well and 30 feet below the bottom of the well. It is our understanding that most irrigation and domestic wells in Central Basin were drilled by cable-tool method. With cable-tool method the hole is usually drilled deeper than the casing to allow water to flow from bottom into the well. These wells could be deepened without significant technical difficulties.

Threshold 3 – Replacing the Well

If the lowest groundwater level at a well is 30 feet or more below the bottom of the well then, rather than deepening the well, it is economical to replace the well. The well replacement criterion is defined as the lowest groundwater levels to be more than 30 feet below the bottom of the well.

4.2. NUMBER OF IMPACTED WELLS

A well may be affected by multiple impacts. It may require pump bowl lowering at first, then require well deepening. If the water levels continue to drop then the well may need to be replaced. The analysis of this study assumes that only one type of impact will be applied to any well. The impact criteria will be evaluated for the lowest groundwater level at each well and the worst impact will be selected. The impact cost is based on the worst condition at each well and does not represent the sum of all possible impacts at the wells.

The wells with bottom depth elevations in each subregion of Central Sacramento County are the sample wells of each subregion (Figure 2.1 and Table 2.3). The estimated total numbers of agricultural and rural domestic wells are presented in Tables 3.1 and 3.2. These wells are the population wells of each subregion. The impact criteria are applied to the wells with bottom depth elevations (sample wells) of each subregion. The ratio of the impacted sample wells of each subregion to the total sample wells of that subregion is the subregion's impact ratio. The total number of impacted wells of any subregion is determined by multiplying the impact ratio of the subregion by the number of population wells of the subregion. The following equations were used to estimate the number of impacted wells:

$$\text{Impact Ratio (IR)}_i = (\text{Impacted Sample Wells})_i / (\text{Total Sample Wells})_i, \text{ and}$$
$$\text{Impacted Wells}_i = \text{IR}_i * (\text{Total Population Wells})_i,$$

where

i = subregion index.

The numbers of impacted agricultural and rural domestic wells for each threshold are presented in Table 4.1. For subregions with sample wells less than 10% of the population wells, the average impact ratio of the subregion and the neighboring subregions is used. The impact analysis was performed for agricultural and rural domestic wells independently. The locations of the impacted sample wells for

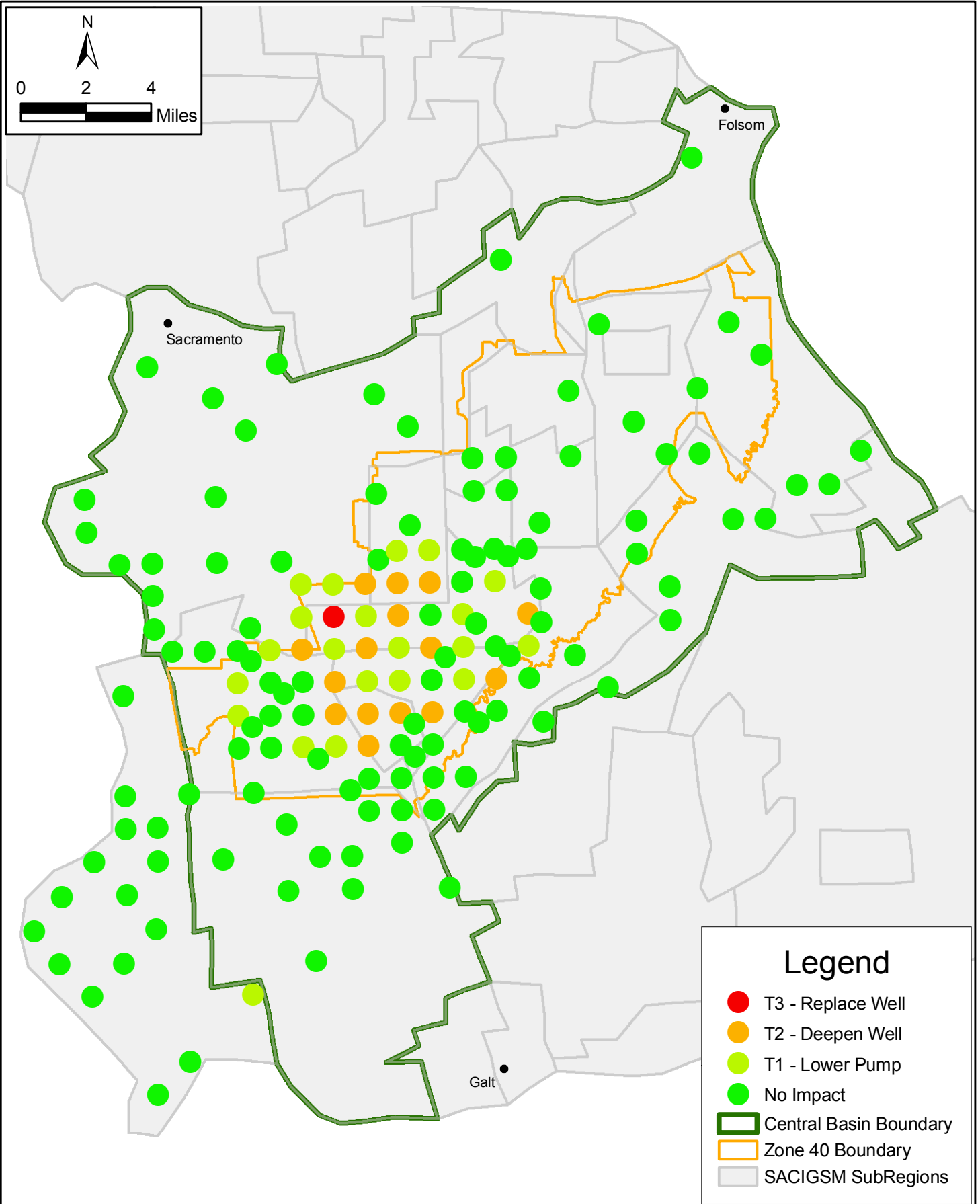
the three future scenarios are presented in Figures 4.1 to 4.3. Majority of the impacted sample wells occur in the southern parts of Zone 40.

Table 4.1 – Number of Impacted Wells

Impact Criteria	Agricultural Wells			Rural Domestic Wells		
	A-No Project	B-Proposed Project	C-Reduced Surface Water Availability	A-No Project	B-Proposed Project	C-Reduced Surface Water Availability
Lower Pump Bowl	2	1	3	95	48	142
Deepen Well	0	0	0	61	43	83
Replace Well	0	0	0	8	8	27
Total	2	1	3	164	99	252

4.3. IMPACT COST

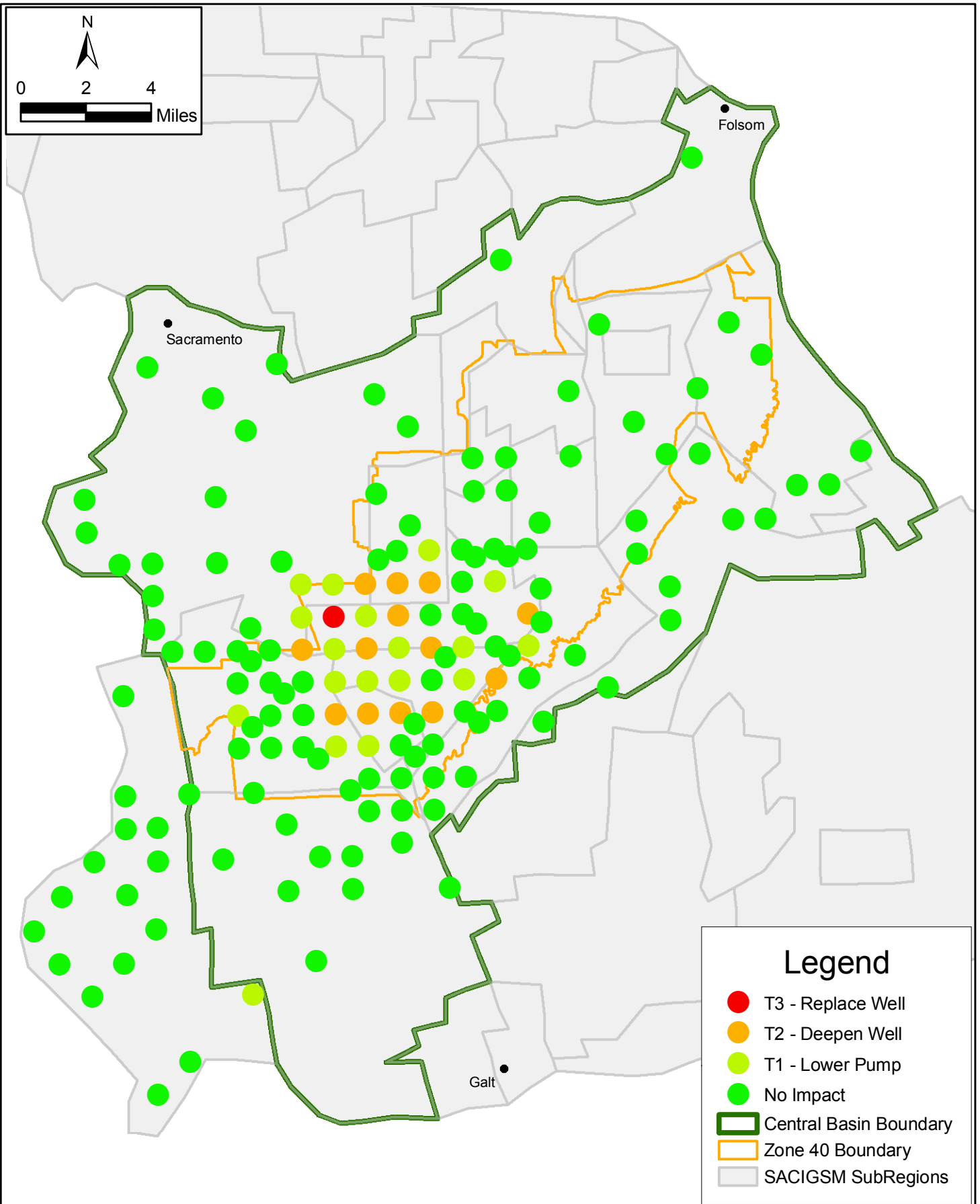
The Well Protection Plan of Central Sacramento County covers the pump lowering, well deepening, and well replacement impact costs. The unit costs of the well deepening and well replacement are presented in Table 2.2. These unit costs are multiplied by the number of impacted wells from Table 4.1 to obtain the impact cost for the Central Sacramento County (Table 4.2). The Reduced Surface Water Availability scenario has the highest impact costs while the Proposed Project scenario result in the lowest impact cost. The reduced available surface water and increased groundwater pumping of the Reduced Surface Water Availability scenario result in \$20,000 increase in impact cost of the agricultural wells and \$674,000 increase in impact cost of the rural domestic wells.



**Central Sacramento Groundwater Basin
 Well Impact Analysis**
**Location of Impacted Sample Wells
 Under No Project Scenario**

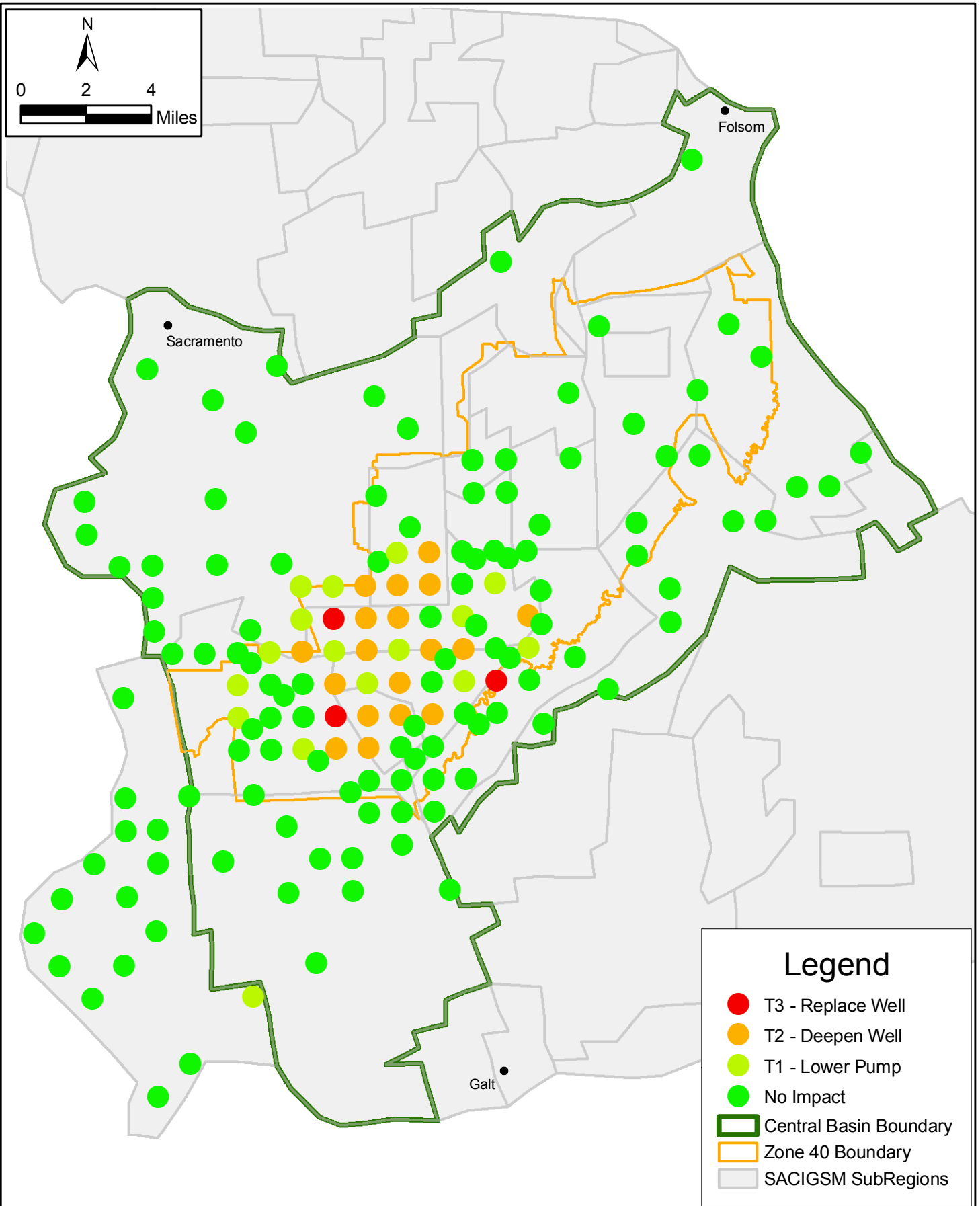
November 2005

Figure 4.1



**Central Sacramento Groundwater Basin
 Well Impact Analysis**
**Location of Impacted Sample Wells
 Under Proposed Project Scenario**

November 2005
 Figure 4.2



Central Sacramento Groundwater Basin
Well Impact Analysis
Location of Impacted Sample Wells
Under Reduced Surface Water
Availability Scenario

November 2005

Figure 4.3

TABLE 4.2 – AGRICULTURAL AND DOMESTIC RURAL WELLS IMPACT COSTS FOR THE CENTRAL SACRAMENTO COUNTY

Impact	Agricultural Wells			Rural Domestic Wells		
	A-No Project	B-Proposed Project	C-Reduced Surface Water Availability	A-No Project	B-Proposed Project	C-Reduced Surface Water Availability
Lower Pump Bowl	\$20,000	\$10,000	\$30,000	\$95,000	\$48,000	\$142,000
Deepen Well	0	0	0	\$305,000	\$215,000	\$415,000
Replace Well	0	0	0	\$160,000	\$160,000	\$540,000
Subtotal	\$20,000	\$10,000	\$30,000	\$560,000	\$423,000	\$1,097,000
Total Impact Costs for Ag and Rural Domestic Wells				A-No Project	B-Proposed Project	C-Reduced Surface Water Availability
				\$580,000	\$433,000	\$1,127,000

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Appendix F

Trial Balloon on Water Quality Collaboration Program

CENTRAL SACRAMENTO COUNTY GROUNDWATER FORUM

Trial Balloon on Groundwater Contamination; Final recommendations negotiated by the CSCGF

1. Groundwater contamination and remediation of contaminated groundwater in the Central Basin must be addressed *proactively*. Water purveyors, regulatory agencies, Responsible Parties* and the Water Forum Successor Effort should meet on a regular basis to share information and develop strategies to collaborate on drinking water supplies and cleanup activities. These collaborative strategies should be designed to minimize negative impacts on other water resources and water users. (*Responsible Parties are defined in federal legislation: 42 U.S.C. Sec. 9607 (a)).

NOTE: At such time as the management entity for the Central Sacramento County Groundwater Basin has been established, representatives of that entity should also be included in these discussions.

2. The Water Forum Successor Effort should undertake a high priority effort to persuade Sacramento County, the cities of Elk Grove, Rancho Cordova and Sacramento (as well as the cities of Citrus Heights, Folsom and Galt) to adopt policies that encourage the use of remediated water for non-potable purposes. .
3. The Central Valley Regional Water Quality Control Board requires Responsible Parties to identify all wells within 2000 feet of any known plume of contamination in the Central Basin. For those wells that the responsible lead agency* has determined are threatened by contamination, that agency should require the Responsible Parties to implement a sampling plan for the impacted well(s), including frequency of sampling, chemicals, reporting requirements, etc. (* The

lead agency is that agency which is responsible for directing the mitigation activities associated with a specific contamination release.)

4. The Sacramento County Environmental Management Department (EMD) should establish and maintain an information clearing house to assist individual well owners in addressing contamination concerns: e.g., how to get a well tested, by whom, for what, options if contamination is found, etc. This should include use of a web-page where information can be found with links to other organizations such as the Water Forum.
5. EMD should undertake a concerted effort to inform individual well owners of the importance of testing/monitoring water quality in their wells through a variety of public education tools including (but not limited to) a brochure provided to all applicants as part of the well permitting procedure.
6. EMD should collaborate with the Central Valley Regional Water Quality Control Board and other regulatory agencies to maintain up-to-date information on contamination sources in the Central Basin.
7. The Environmental Management Department, which is responsible for permitting wells, should exercise the strictest vigilance to ensure that all requirements of the well ordinance are enforced. If requirements are not met, EMD should undertake whatever rigorous enforcement actions are available and effective in the given circumstances.