Appendix B – Performance and Monitoring Plan

Draft

Sacramento Valley IRWMP Performance and Monitoring Plan

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Contents

Contents, Continued

Acronyms and Abbreviations

BMP	Best Management Practices
Coalition	Sacramento Valley Water Quality Coalition
Department	California Department of Water Resources
EC	electrical conductivity
HY	Hydstra
ID	Irrigation District
IRWMP	Integrated Regional Water Management Plan
MOA	Memorandum of Agreement
MRPP	Monitoring and Reporting Program Plan
M.W.C.	Mutual Water Company
M.W.D.	Mutual Water District
NCWA	Northern California Water Association
Reclamation	U.S. Bureau of Reclamation
SVWMP	Sacramento Valley Water Management Program
TDS	total dissolved solids
TMDL	total maximum daily load
Water Board	Central Valley Regional Water Quality Control Board
WDL	Water Data Library
WER	Watershed Evaluation Report

APPENDIX B

Sacramento Valley IRWMP Performance and Monitoring Plan

This document describes the proposed monitoring and performance evaluation activities that will be performed in association with the implementation of the Sacramento Valley Integrated Regional Water Management Plan (IRWMP). The activities and methods identified below represent the initial steps in coordinating the collection, evaluation, and associated adaptive management of operations of those projects proposed as part of the Sacramento Valley IRWMP. It is recognized that given the size of the region, and range of available data and level of existing monitoring across the valley, the coordination of the development of additional monitoring and the dissemination of information and data will be a phased process. The Sacramento Valley IRWMP participants intend to develop a framework to guide the process and improve the coordination of activities to focus funding requests and data collection for the betterment of all regional participants.

The Northern California Water Association (NCWA), representing the Joint Exercise of Powers Agreement, is currently involved in each of these efforts and is proposed to continue as the primary conduit in helping coordinate the overall monitoring and evaluation process. This effort will be in cooperation with each of the project proponents and associated counties, California Department of Water Resources (Department), U.S. Bureau of Reclamation (Reclamation), and other interested stakeholders. The proposed monitoring program is intended to use and enhance existing monitoring efforts occurring throughout the valley at the local proponent and government, state, and federal levels.

1.1 Project Performance Evaluation

The evaluation of project performance will be determined depending on individual project characteristics and proponent and participant goals, identified benefits, and impact avoidance measures. Typically, a project-specific Performance Assessment and Evaluation Plan (PAEP) will be developed as part of each implementation agreement to articulate project goals and targets and to describe how information will be gathered and analyzed to evaluate the project's success. Each PAEP will specify monitoring approach and protocols for water quality monitoring and analysis to ensure quality assurance. The individual PAEP will also be useful in determining why a project might have exceeded or undershot expectations. Data collected by projects engaged in surface water monitoring may be entered into the California Surface Water Ambient Monitoring Program to advance regional and statewide integration of information on surface water quality.

It is anticipated that individual implementation agreements will be developed for any project involving the Department, and/or Reclamation in accordance with local county ordinances and groundwater management plans. These agreements will stipulate operation criteria including monitoring protocol and impact avoidance measures. As described below, the following parameters are recommended for evaluation/monitoring depending on the particular project and location:

- **Performance** – Water produced and groundwater level/well impacts
- **Surface Water/Groundwater Interaction** – Effects on streamflow caused by groundwater pumping
- **Habitat** – Shallow groundwater levels
- **Water Quality** – Changes in groundwater quality
- **Basin Recharge** – Recovery of water levels over winter
- **Aquifer Testing** – Verification of modeling predictions
- **Interpretation and Reporting** – Documentation of groundwater pumped, net streamflow augmentation, pumping impacts, and groundwater-basin conditions

Performance evaluation will include either measurement or mutually agreed upon estimation of decreased river diversion associated with the performance of each groundwater production project. The approach to evaluating performance will be developed in the implementation plans described above. Measurement is anticipated to vary from actual gage measurements to numerical estimates depending on the quantity of water to be produced for a given project and individual project characteristics.

System improvement projects proposed to improve water management through water district actions such as canal lining, increased water reuse, operational spill reduction, or improved access to water supplies will be evaluated in terms of performance in a similar manner to the groundwater conjunctive management projects. The determination of benefits will include the project proponent and participants and will include the measurement of water made available through the operation of the plan in terms of measured decreased diversions (at the point of diversion) and/or mutually agreed upon numerical estimates. As with the groundwater projects, the method of determining actual measured benefit will be finalized as part of the implementation agreement for each project. Anticipated water quality benefits will be evaluated through monitoring of individual projects and through the continued implementation of the Sacramento Valley Water Quality Coalition's (Coalition) monitoring program summarized below.

1.2 Groundwater Monitoring

This plan describes the proposed monitoring activities that are recommended to be performed in association with implementation of the Sacramento Valley Water Management Agreement and are proposed to be used as the template approach for any groundwater production project implemented as part of this IRWMP. Groundwater monitoring objectives are presented, along with the development of a groundwater level, stream stage, and water quality monitoring network; data collection and management activities; and, finally, data interpretation and refined impacts analysis strategies.

The groundwater monitoring network presented here is intended to supplement ongoing monitoring being conducted by Reclamation, the Department, county staff, and individual water districts. In an attempt to develop the most efficient hydrologic data collection network possible, all wells currently being monitored by the agencies listed above, as well as monitoring infrastructure planned for installation or proposed in various grant applications, are considered in this plan. The monitoring network that results from this document is intended to collectively serve the needs of monitoring project-scale impacts and monitoring the regional condition of the groundwater basin. Furthermore, this plan can act to guide installation of future wells performed by any of the stakeholders of the program, to result in a single coordinated monitoring program for the Sacramento Valley.

It should be noted that the groundwater monitoring program described herein assumes that the data collected from the well network will be used in close conjunction with groundwater modeling tools developed for the program. Monitoring would be coordinated and evaluated in conjunction with local ordinances, basin management objectives, and all other regulations. The intent of this program is to collect sufficient field data such that, combined with the use of numerical modeling tools, a reasonable assessment can be made as to the validity of any impact claims that arise during program operation. The overall approach to impacts assessment adopted by the Sacramento Valley Water Management Agreement and proposed for the IRWMP would rely on groundwater monitoring and modeling being used in conjunction with one another. A superposition model of the Sacramento Valley has been constructed using aquifer properties available in the literature. As monitoring data become available for each project location, these data will be interpreted, aquifer and streambed properties estimated, and the superposition model updated to reflect the new information. Model simulations will then be performed to refine estimates of the impacts of Sacramento Valley Water Management Agreement pumping on groundwater level and streamflows. This feedback loop will continue, as necessary, to support the needs and requirements of the program.

1.2.1 Monitoring Objectives

The primary objectives of the monitoring program are as follows:

- **Performance**
  - Water produced and groundwater level/well impacts
- **Surface Water/Groundwater Interaction**
  - Effects on streamflow caused by groundwater pumping
- **Habitat**
  - Shallow groundwater levels
- **Water Quality**
  - Changes in groundwater quality
- **Basin Recharge**
  - Recovery of water levels over winter
- **Aquifer Testing**
  - Verification of modeling predictions
- **Interpretation and Reporting**
  - Documentation of groundwater pumped, net streamflow augmentation, pumping impacts, and groundwater-basin conditions

A discussion of each of these objectives is presented below.

Performance

Performance monitoring is required to document the quantity of groundwater produced by the program, and to assess any impacts to surrounding groundwater users. It is necessary to have accurate records of the quantity of water produced to facilitate administration of the implementation agreements and the overall program. For the program to be successful, it is also necessary to estimate the impacts that groundwater production has on all surrounding groundwater users. To achieve these objectives, a suite of new and existing wells were identified that will provide sufficient information to evaluate these potential impacts. Monitoring frequency for water levels and water quality were also specified for each type of well over the course of a typical year of program operation. It should be noted that monitoring should also be conducted during any years during which the program is not executed so that changes to the hydrogeologic conditions of the basin can be evaluated. It is also critical that, to the degree possible, groundwater level and groundwater quality data begin to be collected prior to program implementation so that baseline conditions at each monitoring point can be established.

Surface Water/Groundwater Interaction

One of the potential impacts associated with implementation of the program is the effect on streamflows during, and following, the irrigation season. To quantitatively assess the degree of hydraulic connection between the surface water and groundwater systems, appropriate monitoring data must be collected. These data can be obtained from a combination of multiple-completion monitoring wells and stream stage gauging stations located in proximity to one another. River stage fluctuations will be measured during the winter months in response to storm events and compared with groundwater level fluctuations measured in the aquifers beneath the streams. These data will support calculations of the quantity of water pumped by a particular project that is either leakage directly induced from streams, or is intercepted groundwater that would have discharged to streams.

Habitat

Another potential impact associated with groundwater level declines from caused by increased groundwater pumping is impacts to riparian vegetation and wetlands species. To monitor for this type of impact, shallow groundwater monitoring wells will be installed to detect changes in water levels in the shallowest portions of the aquifer as part of the overall monitoring network. In evaluating impacts to certain wetlands species, it is important to discern both the rate of change of groundwater levels and the cumulative groundwater level change over the irrigation season. Therefore, the frequency of monitoring in these wells will be selected to support evaluations of these types.

Water Quality

Groundwater throughout the Sacramento Valley is generally of good quality except for several areas of elevated total dissolved solids (TDS) and associated constituents. A 2003 GAMA Report centered around Chico reported that eight major volatile organic compound contamination plumes exist in and around the city[1]. The central plume is known to affect drinking water wells, and is known to have migrated to the deep aquifer at concentrations of 20 parts per billion tetrachloroethylene.

Groundwater quality will be monitored as part of the Sacramento Valley Water Management Program (SVWMP) to ensure that program operation does not adversely affect groundwater flow patterns and induce migration of poorer quality groundwater into areas of currently high quality.

Basin Recharge

Using historical groundwater elevation data obtained throughout the valley, it is empirically concluded that the groundwater basin will recover to pre-pumping levels over the winter months in all but the driest climatic cycles. However, the proposed monitoring network developed will provide the necessary information to further evaluate the timing and spatial trends in water level recovery. These data will help further understanding of the principal processes that act to replenish water levels following each irrigation season.

Aquifer Testing

Because of the large extent of the Sacramento Valley groundwater basin, and the fact that a limited amount of detailed hydraulic data has been collected historically, significant uncertainty exists regarding the spatial distribution of aquifer properties across the valley. The installation of the production and monitoring infrastructure associated with the program, along with the groundwater pumping planned during the irrigation seasons, represents an opportunity to improve understanding of the aquifer properties within the Sacramento Valley Groundwater Basin. Groundwater elevation data will be collected throughout the irrigation season, and this information will document the response of the aquifer system to basinwide groundwater pumping. In addition, aquifer tests will be conducted during the winter months, to obtain information on how the aquifer system at specific locations responds to a well-defined pumping stress. The primary information obtained from aquifer tests is the transmissivity of the aquifer, the ratio of horizontal to vertical permeability, and the storage properties of the aquifer layers.

Interpretation and Reporting

As part of the proposed monitoring program, an annual report will be produced. It is recommended that a similar report be prepared for the implementation of IRWMP, or that at a minimum a similar approach be used. This report will document the data collected by the program and present all of the associated interpretation of these data. The following data analysis will be included in the report: the quantity of water produced by the program; stream augmentation over the course of the year; impacts to water levels; water quality, if any; results of subsidence monitoring; and overall basin conditions, i.e. winter recovery of water levels.

1 Lawrence Livermore National Laboratory. 2003. California GAMA Program: Groundwater Ambient Monitoring and Assessment Results for the Sacramento Valley and Volcanic Provinces of Northern California. Prepared in cooperation with the California State Water Resources Control Board. Available online at: http://www.waterboards.ca.gov/gama/gamadocs.html

1.2.2 Monitoring Network Development

The first step in the development of the monitoring network was to define what types of data need to be collected at each project location to meet the objectives described above. Using this analysis, a generic monitoring template was developed as shown on Figure B-1 (all figures are located at the end of this document). This template contains all of the monitoring elements that are expected to be required at a particular project location. The next step was to inventory the wells that are currently being monitored by water districts and government agencies across the valley, and determine which of these wells have known construction details. The monitoring template described above was then overlain on each project in the program, and locations selected that would provide the necessary information to monitor potential impacts associated with each project and allow assessment of potential third-party impact claims. Where monitoring locations coincided with wells or stage gages in the existing network, these existing wells, stage gages, and/or extensometers were included into the monitoring program. If additional monitoring was necessary in areas without existing monitoring equipment, new wells, stage gages, or extensometers were recommended. The results of this analysis are included as a series of maps attached to this document (Figures B-2 through B-9). In most cases, although a number of wells exist and are currently being monitored, inclusion of these wells into the program monitoring network will require an increase in the frequency of measurements.

The monitoring elements included in the proposed SVWMP monitoring network are summarized in Table B-1. It is clear that although many existing wells will be incorporated into the program, a significant number of new monitoring wells will be required to gather the necessary information to manage the program and to be able to address any claims of impacts by third-party groundwater users.

TABLE B-1
Summary of Sacramento Valley Water Management Plan Monitoring Network
Sacramento Valley IRWMP Performance and Monitoring Plan

Monitoring Type	Number of Locations
Existing Monitoring Wells	92
New Monitoring Wells	37
Existing Stage Gages	8
New Stage Gages	3

In addition to these proposed sites, several project proposals include additional monitoring sites. For example, the ***Lower Tuscan Aquifer Monitoring, Recharge, and Data Management Element*** proposes to include 10 stream gauging stations, 25 stream/aquifer temperature monitoring wells, 5 groundwater monitoring wells, and associated infrastructure. The project will use four active stream gauging stations within the Lower Tuscan Aquifer outcropping and will require the installation of six additional stations. Twenty-five stream/aquifer temperature monitoring wells will be installed in the reaches of five perennial streams in Butte and Tehama Counties. Six groundwater monitoring wells will be installed in the recharge zone of the Lower Tuscan Aquifer outcropping. Six groundwater monitoring wells will be installed in the aquifer recharge zone for the Lower Tuscan Aquifer. The wells will be used to monitor the response of groundwater levels in the aquifer system during performance testing procedures. The wells will be integrated into the Department-Butte

County cooperative monitoring well network. In addition to installation of equipment and infrastructure, the Tuscan Aquifer Monitoring, Data Management and Recharge Evaluation project will entail the development of a comprehensive GIS database of water and resource management information for the four counties (Butte, Tehama, Colusa, and Glenn) that overlie the Lower Tuscan Aquifer.

It is acknowledged that this monitoring network will likely take a number of years to be fully implemented, and therefore, opportunities exist to integrate this program with the overall regional effort of managing groundwater resources in the Sacramento Valley. The monitoring network presented here is primarily designed to measure impacts to groundwater levels and streamflows associated with particular projects, but the information collected through the program will also provide critical input to regional water resource managers that are managing irrigation season drawdown and winter recovery on a countywide or districtwide scale. Therefore, as future applications for grant funding are received by the Department, this plan could represent a tool to identify monitoring infrastructure that will benefit both project-specific and regional monitoring needs. This approach would help maximize the benefits obtained from any future expenditure of funds to support groundwater monitoring throughout the valley.

1.2.3 Data Collection and Management

The monitoring program discussed above will include the collection of a significant quantity of data including groundwater levels, groundwater quality, groundwater pumping, stream stages, and other environmental data requiring a substantial management and coordination effort to ensure data quality and availability. This data will be managed and distributed using the existing Department Water Data Library (WDL). A generalized work plan to develop protocols for collection, management, exchange, and dissemination of the data is presented below. Specific details of how WDL can support the SVWMP are listed, organized according to data parameter, along with recommendations for enhancements to WDL to achieve additional required functionality.

Work Plan

The work plan would be developed as follows:

1. Develop monitoring plan
    a. Identify data components (groundwater levels, quality, pumping, and subsidence)
    b. Identify data collection locations and frequency
2. Develop data analysis and reporting requirements
    a. Identify data analyses to be conducted
    b. Develop specifications for reports from WDL needed to conduct analyses
3. Develop conceptual data management and exchange strategy
    a. Specify how data components will be managed by WDL
    b. Identify data management and exchange deficiencies
    c. Upgrade WDL to meet deficiencies

4. Meet with data providers and users
    a. Canvass existing data management methods and systems
    b. Identify specifications for data flow – into WDL from collectors' systems and from WDL to analysis tools
    c. Develop methods for exchanging data
5. Develop quality assurance plan
    a. Develop field manual specifying standard data collection methods
6. Train data providers
    a. Teach field collection techniques and standards
    b. Teach data reporting requirements and standards
7. Implement monitoring program
    a. Collect and exchange data
    b. Report and analyze data
    c. Modify data collection, management, and reports as required

Data Elements

Groundwater Levels. Groundwater levels directly reflect water storage in the aquifer system and provide the basis for analysis of flow patterns, stream/aquifer interaction, and impacts to third parties. The Department, along with local and federal cooperators, currently operates a network of wells that are manually measured on a semiannual or monthly basis. The data from these programs are currently stored, managed, and disseminated in the groundwater module of WDL. Over the last 70 years, over 200,000 measurements have been made in some 2,300 wells in the Sacramento Valley.

The Department also collects groundwater levels using automatic data recorders at more than 100 sites in the Sacramento Valley. The data are usually recorded on an hourly or bihourly basis, resulting in very large data sets. At present, the Department is the only agency collecting such data in the Sacramento Valley. WDL was recently expanded to manage this large quantity of continuous data, using the Hydstra (HY) module of WDL.

Implementing the IRWMP will increase both manual and automatic groundwater level data collection. Manual groundwater level measurements and data entry by Department staff will continue as at present, however at modified frequencies. Table B-2 summarizes the frequency of data collection required for monitoring points included in the SVWMP monitoring network, which is intended to be used as the template for the IRWMP depending on the unique characteristics of a particular project. Data providers without an in-house data management system should be provided with a Microsoft® Excel data entry template for preliminary data entry. Agencies with an in-house data management system can export their data to WDL; data export/import procedures will need to be developed for each local system.

TABLE B-2
Water Level Monitoring Frequency
Sacramento Valley IRWMP Performance and Monitoring Plan

Period	Frequency
Mid-May through June	Weekly
July	Biweekly
August	Monthly
September	Monthly
October	Monthly
November	Biweekly
December	Biweekly
January	Monthly
February	Monthly
March	Monthly
April	Monthly

Groundwater Pumping. No historical database of agricultural groundwater pumping data exists for the Sacramento Valley; thus, there is no existing mechanism for the storage, management, and dissemination of this type of data. Despite this, the HY module of WDL is capable of handling either manual or automatic (data logger) measurements of pumping at the frequencies discussed below.

Water Quality. Since 1998, data from samples analyzed at Bryte Laboratory are stored in WDL, and contains complete quality assurance/quality control data in accordance with WREM 60. Prior to 1998, Department data were stored in multiple locations. For the period 1990 through 1998, the data were stored in local data management systems or in hardcopy form. Prior to 1990, data are stored in the Department's former data management system, WDIS. These data have no quality assurance/quality control associated with it, although some of this information can be reconstituted using historical records on file at Bryte Lab.

Grab sample data can be managed within the Water Quality module of WDL; electrical conductivity (EC) data can be managed within either the Water Quality module, or within the HY module. Ideally, all grab samples should be made by Department staff or at least analyzed by Bryte Laboratory. This will allow simpler data flow into WDL. If water quality samples are analyzed by external labs, then data import routines will need to be developed to transfer the data into WDL, possibly using or based on electronic deliverable format.

Streamflow. Streamflow and/or stage height is measured by several agencies along the Sacramento River and tributaries. Data for stations managed by Division of Planning and Local Assistance Districts are stored in the HY module of WDL. The HY module also includes an import routine to obtain California Data Exchange Center data. Additional effort will be required to import data from stations that are not in the Division of Planning and Local Assistance network and not in the California Data Exchange Center.

Other Data. Data sets in addition to the ones mentioned here will probably be needed. Additional effort will be required to incorporate these data sets into WDL.

Monitoring Frequency

Water Levels. The frequency of water level measurements in all monitoring wells included in the SVWMP network is summarized in Table B-2.

Production Rate. Groundwater production rates and volumes will be recorded during the irrigation season (June through October) at the same frequency as water level measurements.

Extensometers. Data from extensometers are collected continuously, and data will be downloaded as necessary depending on the available memory of the data recording devices.

Stream/Aquifer Interaction. Stream/aquifer interaction data (groundwater levels and river stage) will be collected continuously during the winter and spring months as required to support analysis of streambed and aquifer properties.

Water Quality. Baseline water quality sampling will be conducted in each well included in the monitoring network. The baseline sampling suite will include standard minerals, minor elements, and nutrients. Ongoing water quality monitoring will be conducted annually and will include only indicator parameters (EC/TDS). If major changes are noted in EC/TDS values, the baseline sampling suite will be repeated and/or expanded as appropriate to investigate the nature and significance of the observed changes. The baseline sampling suite for all wells in the network may be repeated every 5 years to monitor long-term trends in quality.

1.2.4 Data Interpretation

This section discusses the data interpretation techniques that will be employed to obtain the aquifer and streambed properties necessary to refine estimates of groundwater level and potential streamflow impacts associated with proposed groundwater pumping.

Groundwater (Project) Pumping

Groundwater production rates and volumes over time are proposed to be collected from each groundwater production well associated with the IRWMP. These data will be analyzed and summarized by project to provide a synopsis of the quantity of groundwater produced by each project in the program for a given year.

Groundwater Levels and Pumping Impacts

Groundwater level data will be collected from hundreds of monitoring points included in the groundwater monitoring network. This information will be used to evaluate the magnitude of drawdown that occurs near the individual projects over the course of the irrigation season. Groundwater level data will be analyzed from specific depth intervals so that drawdown impacts at different depths can be identified. These data will also be analyzed to determine the rate of groundwater level recovery that occurs in the months that follow the irrigation season. These data will be correlated with precipitation data and streamflow data to further investigate the relationship between precipitation patterns and streamflow on the rate of groundwater level recovery observed each winter.

The depression of groundwater levels resulting from groundwater production near critical habitat such as riparian vegetation and wetlands will also be evaluated. The groundwater monitoring network presented herein contains shallow monitoring wells that will record changes to the water table elevation near these sensitive habitat areas. For some sensitive species, the rate of change of groundwater levels is as critical, or more critical, than the absolute change. The frequency of monitoring included in this program will allow resolution of these rates of change so that an assessment can be made as to whether they represent a substantive threat to riparian and wetlands habitat.

Surface Water/Groundwater Interaction

The use of groundwater modeling tools to interpret the data collected during assessments of surface water/groundwater interaction is especially critical because the magnitude of the streamflow impacts anticipated during groundwater pumping are smaller than can be directly measured. However, it is still important to estimate the percentage of water pumped by particular projects that is either abstracted from streams, or represents intercepted groundwater that would have discharged to streams. These estimates will be critical in the negotiation of implementation agreements between individual project proponents and the Department and Reclamation. The timing of these impacts is also critical, because what represents a significant impact to a stream during one time of year might not be significant at another time when flows are higher or critical fish species are not present.

The approach used to estimate the degree of hydraulic connection between a surface stream and the underlying aquifer will require stream stage measurements from a stage gage in conjunction with groundwater elevation data from a nearby multiple completion monitoring well. During the winter months, stream stage varies considerably (in excess of 10 to 15 feet on major streams) in response to storm events. As the stage in a stream rises, a pressure wave is propagated through the underlying aquifer and can be detected in groundwater level data collected from surrounding wells. The timing and magnitude of the pressure wave as it passes through the well, i.e., the time series of groundwater levels measured in the well, is indicative of the distribution and magnitude of aquifer transmissivity, aquifer storage coefficient, the hydraulic conductivity of the streambed, and the vertical hydraulic conductivity of the aquifer.

The stage and groundwater elevation data collected during these winter storm events will be interpreted using the MicroFEM model of the Sacramento Valley in conjunction with PEST. As in the analysis of the aquifer test data, it will be necessary to generate smaller versions of the valleywide model to perform the surface water/groundwater interaction analysis. The observed changes in river stage will be input to the groundwater model, and the aquifer and streambed properties adjusted until good agreement is achieved between the simulated and observed groundwater elevations in wells near the river. If possible, it is desirable to have an independent estimate of the aquifer transmissivity near the stream when performing this analysis. For this reason, it is preferable to construct a stage gage/monitoring well pair in proximity to a production well so that an aquifer test using the production well can be conducted in conjunction with the surface water/groundwater analysis. The results of this analysis will be a refined estimate of the spatial distribution of aquifer properties near the monitoring well(s), and an estimate of the vertical leakance (streambed permeability divided by thickness) of the riverbed. These data will then be used in a valleywide impacts assessment tool to provide improved estimates of the magnitude and timing of stream impacts resulting from groundwater pumping.

Aquifer Properties

To accurately forecast the timing and magnitude of the impacts of groundwater pumping on surrounding groundwater levels, an accurate measure of the aquifer transmissivity, storage properties, and ratio of horizontal to vertical hydraulic conductivity of the aquifer system is required. Because all of these aquifer properties vary spatially and with depth in the aquifer, it is desirable to collect information from as many locations and depths as is possible. Although the groundwater monitoring network presented herein is somewhat sparse on the scale of the entire valley, the data collected from it will provide greatly improved estimates of aquifer properties beyond what is available today.

The primary type of data that are required to estimate aquifer properties are time-variant groundwater levels that occur in response to groundwater pumping at a known rate, location, and depth. It is ideal to collect this data from a series of monitoring wells during a period of relative quiescence in the aquifer, i.e., when little surrounding groundwater pumping is occurring other than that from the instrumented well(s). However, significant information with respect to aquifer properties can still be obtained from measuring groundwater levels in the pumping wells s and during periods when groundwater pumping in surrounding areas is being conducted. It is anticipated that during the course of the SVWMP, groundwater level data will be collected during a variety of conditions, both during designed aquifer tests when background pumping is at a minimum (i.e., during non-irrigation periods) and during the course of the irrigation season while program wells are operating according to their respective implementation plans.

The overall approach to data interpretation will be to employ a series of analytical and numerical modeling tools that when given the groundwater pumping information (schedule, rate, depth, and location) can reasonably replicate the observed distribution of drawdown at various depths surrounding the pumping well. When good agreement is obtained between simulated and measured drawdown, the distribution of aquifer properties in the model are assumed to be reasonably accurate. The interpretation process will start by entering the rate. Location, depth, and timing of pumping and the resulting drawdown data will be entered into a series of analytical aquifer test analysis programs called Multi-layer Unsteady State and Multi-layer Program Unsteady State. These programs are analytical groundwater modeling codes used for analysis of unsteady flow in unconfined and leaky aquifers and multiple-aquifer systems with up to 20 layers. The programs simultaneously fit the time series drawdowns measured in multiple observation wells during the pumping and recovery phases of an aquifer test. The curve-fitting algorithms seek to minimize the difference between an observed set of time-drawdown data and an associated set of simulated data. For these analyses, each aquifer layer is assumed to be isotropic, homogeneous, and of infinite extent. The main difference between Multi-layer Unsteady State and Multi-layer Program Unsteady State is that Multi-layer Program Unsteady State allows the analysis of drawdown data collected while more than one pumping well is in operation.

Associated with the application of the analytical tools, boring logs and geophysical logs will be evaluated to develop a conceptual model of the stratigraphy at the site. To accurately interpret the aquifer test data, it is essential that the underlying interpretation of aquifer and aquitard configuration is reasonably accurate. The results obtained from the Multi-layer Unsteady State and Multi-layer Program Unsteady State modeling tools are estimates of the transmissivity and storage coefficient of each aquifer layer as well as the degree of hydraulic connection, or leakance, between the aquifer layers. Because of the limitations of the analytical computational methodology, the results are limited to a single value of transmissivity, storage coefficient, and leakance for a particular aquifer layer. In reality, these properties will vary spatially and with depth. Therefore, in most cases, it will be advantageous to employ a more complex interpretive tool to interpret the monitoring data.

The existing superposition groundwater flow model will form the basis for these more complex analyses. This tool will allow aquifer properties to vary spatially, and allow the consideration of the physical geometry of a particular site including basin boundaries and the presence of surface streams. The existing flow model was developed using MicroFEM. MicroFEM (Hemker, 1997) is an integrated numerical groundwater modeling package developed in The Netherlands. The current version of the program (3.60) has the ability to simulate up to 25 layers and 250,000 surface nodes. MicroFEM is capable of modeling saturated, single-density groundwater flow in layered systems. Horizontal flow is assumed in each layer, as is vertical flow between adjacent layers. A layered aquifer system or different aquifers within a multiple-aquifer system can be modeled in this manner.

To improve the speed and efficiency of the data analysis process, a submodel within domain of the existing MicroFEM superposition model will be developed and linked with the PEST auto-calibration software. PEST is an optimization program that runs a model numerous times, adjusting the input parameters slightly each time. While performing these iterations, the code seeks to minimize the error between a target set of calibration parameters and those computed by the current configuration of the model. This process continues until no further reduction in error is obtained by subsequent model runs. It is then assumed that an optimal set of model parameters has been obtained.

The current version of the Sacramento Valley model contains 152,261 surface nodes and six layers and takes several hours to simulate a pumping season. The data interpretation strategy described herein will require tens to hundreds of simulations to be performed for each analysis, especially if the PEST model is employed, making it impractical to use the superposition model in its current form. Therefore, a submodel (a model grid covering a smaller area of the valley near the project of interest) will be developed and used to interpret the data collected from that project. The final result of the data interpretation process will be a refined distribution of aquifer transmissivity, storage coefficient, and vertical hydraulic conductivity in the area of the aquifer test. These values will be incorporated into the valleywide impacts assessment tool as described in later sections of this document.

Groundwater Quality

Baseline groundwater quality sampling will be performed on wells in the SVWMP monitoring network to provide baseline information on the current groundwater quality. The baseline sampling suite will consist of standard minerals, minor elements, and nutrients. Ongoing water quality monitoring will be conducted annually and will include only field parameters (EC/TDS). If major changes are noted in EC/TDS values, the baseline sampling suite will be repeated. The baseline sampling suite for all wells in the network may be repeated every 5 years to monitor long-term trends in quality.

Overall Basin Condition (Recharge)

The installation of monitoring wells in the Sacramento Valley will provide additional information regarding how groundwater levels in the basin respond to winter recharge patterns during a variety of water-year types. The groundwater level data collected over the last several decades suggest that water levels decline during the irrigation season and recover to pre-pumping conditions the following spring in all but the driest years. However, this conclusion is based almost solely on groundwater measurements taken once in the spring and once in the fall. Groundwater elevations in monitoring wells included in the proposed monitoring network will be measured at a minimum once a month. Therefore, it will be possible to correlate groundwater level recovery with the timing of precipitation events to better understand the relationship between groundwater level recovery and the magnitude and timing of rainfall events. Hypotheses that can be investigated include the relationship between local groundwater level recovery and proximity to streams or basin margins, or the relationship between rate of groundwater level recovery and aquifer transmissivity and/or storage coefficient.

1.2.5 Integration with Impact Assessment Tool(s)

The data interpretation strategies outlined above will yield improved estimates of various hydrologic parameters at numerous locations throughout the Sacramento Valley. However, the ultimate goal of this monitoring program is to use these data to improve understanding of groundwater flow, recharge processes, and the interaction between surface streams and the underlying aquifers such that improved estimates of impacts created by groundwater pumping can be obtained. To achieve this objective, it is necessary to integrate the refined hydrogeologic information into a numerical model that can incorporate these data to yield improved impacts estimates to groundwater levels and surface water flows. This refined tool can also be used to help investigate claims of impacts by third-party groundwater users, and to manage individual project operations such as changed production rates, or the inclusion of new projects into the program.

The first step in the effort to develop refined estimates of program impacts will be to update the existing superposition model of the Sacramento Valley using the newly developed aquifer and stream properties. This model exists, has been successfully used to perform previous estimates of groundwater elevation and streamflow impacts, and is therefore a known and proven tool. This effort can be achieved at relatively low cost compared to more complex methodologies, and has been effective at addressing the needs of the program up to this point. However the superposition assumption, upon which this model is based, has certain limitations. The superposition model does not include all of the components of the water budget that exists in the valley, and therefore, cannot explicitly simulate the recovery of groundwater elevations over the winter months in response to winter rains. For the same reason, it is not possible to simulate various year types, such as multiple drought years, to investigate impacts to groundwater levels during these critical periods. If these capabilities are deemed critical to the effective management of the IRWMP, then more complex modeling platforms must be considered.

To develop a model capable of incorporating a complete water budget of the valley would require a major effort to use existing land use and cropping pattern data, and estimate water demand and deep percolation quantities from various crop types. It would also require some form of quantification of the existing 2.5 million acre-feet of annual pumping that currently occurs in the valley, including location of pumping wells, pumping schedule, and the aquifers from which the groundwater is produced.

A water budget-based model can be developed in one of two ways – use an existing saturated flow groundwater model and include surface processes as a boundary condition computed externally, or use a coupled surface water-groundwater model that includes all of the hydrologic processes that define the water budget. Both of these approaches are workable, and each has its advantages and disadvantages when working on a scale as large as the entire Sacramento Valley. It is important to note that the tool selected for this analysis must be capable of predicting impacts at the scale of resolution of an individual production well to support impacts assessment and third-party claims evaluation. Many of the surface water-groundwater models currently available would have difficulties operating at that level of detail over the entire Sacramento Valley. All of the issues above must be carefully considered prior to choosing a modeling approach for program. Although it is certainly possible to incorporate all of the data necessary for input to a comprehensive modeling tool considering the entire water budget of the valley, the resources required to construct and calibrate such a tool will be substantial.

1.3 Water Quality Monitoring and the Sacramento Valley Water Quality Coalition

The Coalition was formed in 2003, to enhance and improve water quality in the Sacramento River, while sustaining the economic viability of agriculture, functional values of managed wetlands, and sources of safe drinking water. The Coalition is composed of more than 7,500 farmers and wetlands managers encompassing more than 1 million irrigated acres and supported by more than 200 agricultural representatives, natural resource professionals, and local governments throughout the region to improve water quality for Northern California farms, cities, and the environment.

The Coalition developed and submitted its Regional Plan for Action to the State Water Resources Control Board and the Regional Water Quality Control Board for the Central Valley (Water Board) in June 2003. To effectively implement the Monitoring and Reporting Program Plan (MRPP), the Coalition and 10 subwatershed groups have signed a Memorandum of Agreement (MOA) that defines the respective roles and responsibilities of the subwatershed groups, as well as NCWA, Ducks Unlimited, and the Coalition for Urban Rural Environmental Stewardship, to implement the Regional Plan for Action. Additionally, the Coalition has signed an MOA with the California Rice Commission to coordinate the respective programs in the Sacramento River Basin. The Coalition is pursuing partnerships with municipalities and urban areas in the region that are developing stormwater management plans and facing increasingly more stringent effluent limitations.

To implement the Regional Plan for Action and to meet the Water Board's regulations, the Coalition prepared and submitted two documents on April 1, 2004, that serve as the foundation for a phased water quality management program: (1) a Watershed Evaluation Report (WER) and (2) an MRPP. The WER is a comprehensive watershed assessment prepared by local agricultural representatives, wetlands managers, and natural resource professionals. The WER provides a detailed description of the landscape in each of the 10 Coalition subwatershed areas, including cropping patters, soil quality, water quality issues, management practices, implementation, and pesticide use.

The ultimate output of the WER is a drainage prioritization table for each subwatershed area. Using Department land-use survey data, the entire 21-county region was divided into nearly 250 geographic areas. The Coalition evaluated raw acreage numbers for orchard, annual, and pasture crops (excluding short- and long-grain rice), respectively, in each drainage area and then multiplied these raw acreages by a weighting factor, with orchards receiving the greatest emphasis and pasture the least. Adding each of these weighted acreages in each subwatershed area produced an index that was used as the primary criterion for ranking a drainage area. The Coalition also evaluated diazinon, chlorpyrifos, copper, and pyrethroid use in each drainage area and used this data as the second criterion. The third criterion was the existence of impaired water bodies listed under the so-called 303(d) list. Each subwatershed group then evaluated the ranked drainages in their subwatershed, and depending on their local knowledge of the hydrology and current issues, selected monitoring sites for the initial sampling.

Following extensive review by the Water Board and considerable discussion and negotiation regarding the details of the Coalition MRPP, the Water Board issued a Conditional Approval on December 2, 2004. The Coalition has completed its Quality Assurance Project Plan, including sampling site specifics and sampling follow-up methodologies. If sampling reveals significant and persistent toxicity as defined in the MRPP, or exceedances of relevant water quality objectives, then a diagnostic approach will be used to expand monitoring activities upstream to identify the general source of toxicity or cause(s) of exceedances. If the magnitude and duration of the toxicity or water quality objective exceedance is sufficient to warrant implementation of management practices, then the Coalition will mobilize its partners at the subwatershed area level to work with growers to implement practices intended to improve water quality. The Coalition will determine the spatial distribution of crops associated with the identified constituent of concern in the affected subwatershed area. The County Agricultural Commissioners and other local partners will then organize management practices workshops with growers. If water quality problems persist, the Coalition will engage County Agricultural Commissioners in the implementation of a Mandatory Product Stewardship Program. This program, requested by the County Agricultural Commissioners and the California Department of Pesticide Regulation, engages the pesticide registrants and charges them with a more specific management practice outreach program directly associated with their product. The Coalition plans to move through this response strategy with Water Board oversight through Communications Reports and Semiannual Reports, thereby providing the Water Board information sufficient to take stricter action if necessary.

In 2004, the Coalition prioritized 10 subwatersheds, shown on Figure B-11, in the Sacramento River watershed according to potential relative impact on water quality using three main data sources: drainage mapping, land use, and pesticide use. Of the ten subwatersheds, three subwatersheds were categorized as high priority and four were categorized as medium priority. The subwatersheds were further evaluated by drainage. Of the 244 drainages within the 10 subwatersheds, 42 drainages were identified as medium or high priority.

The Coalition has identified numerous priority drainages and is involved in the monitoring of 34 sites in 2006 (see Table B-3). Figure B-12 shows the location of those sites proposed for monitoring in 2006. To ensure compliance with the Irrigated Lands Waiver Program, monitoring of priority drainages will rotate over time. Attachment 1 is the full monitoring plan for 2006, which was provided as an attachment to the Coalition's amended MRPP.

TABLE B-3
Sacramento Valley Water Quality Coalition 2006 Monitoring Locations
Sacramento Valley IRWMP Performance and Monitoring Plan

Map Index	Subwatershed	Site Name	Latitude	Longitude
1	Pit River	Pit River at Pittville	41.0454	-121.3317
2	Pit River	Fall River at Fall River Ranch Bridge	41.0351	-121.4864
3	Pit River	Pit River at Canby Bridge	41.4017	-120.931
4	Shasta/Tehama	Burch Creek at Woodson Ave Bridge	39.90528	-122.18368
5	Colusa Basin	Stony Creek on Hwy 45 near Rd 24	39.71005	-122.00404
6	Colusa Basin	Colusa Drain near Maxwell Rd	39.2756	-122.0862
7	Colusa Basin	Stone Corral Creek near Maxwell Rd	39.2751	-122.1043
8	Colusa Basin	Rough and Ready Pumping Plant (RD 108)	38.86209	-121.7927
9	Colusa Basin	Colusa Basin Drain above KL	38.8121	-121.7741
10	Colusa Basin	Butte Creek at Gridley Rd Bridge	39.3619	-121.8927
11	Placer/Nevada/S Sutter/ N Sacramento	Coon Creek at Striplin Rd	38.8661	-121.5803
12	Butte/Yuba/Sutter	Butte Slough at Pass Rd	39.1873	-121.90847
13	Butte/Yuba/Sutter	Wadsworth Canal at South Butte Rd	39.15337	-121.73435
14	Butte/Yuba/Sutter	Pine Creek at Nord Gianella Rd	39.78114	-121.98771
15	Butte/Yuba/Sutter	Sacramento Slough	38.7833	-121.6338
16	Solano/Yolo	Z Drain – Dixon RCD	38.4157	-121.6752
17	Solano/Yolo	Toe Drain at NE corner of Little Holland	38.3491	-121.645
18	Solano/Yolo	Tule Canal at I-80	38.57	-121.58
19	Upper Feather River	Spanish Creek above confluence with Greenhorn Creek	39.96777	-120.91643
20	Upper Feather River	Middle Fork Feather River at County Rd A-23	39.81892	-120.39179
21	Upper Feather River	Indian Creek downstream from Indian Valley	40.0507	-120.97406
22	Lake/Napa	McGaugh Slough at Finley Rd East	39.00417	-122.86233
23	Lake/Napa	Pope Creek upstream from Lake Berryessa	38.64637	-122.36424
24	Lake/Napa	Capell Creek upstream from Lake Berryessa	38.48252	-122.24107
25	El Dorado	North Canyon Creek	38.7604	-120.7102
26	Sacramento/Amador	Cosumnes River at Twin Cities Rd	38.29098	-121.38044
27	Sacramento/Amador	Dry Creek at Alta Mesa Rd	38.248	-121.226
28	Sacramento/Amador	Big Indian Creek at Bridge	38.5498	-120.8478
29	Solano/Yolo	Shag Slough at Liberty Island Bridge	38.30677	-121.69337
30	Shasta/Tehama	Andersen Creek at Ash Creek Rd	40.418	-122.2136
32	Solano/Yolo	Ulatis Creek at Brown Rd	38.307	-121.794
33	Butte/Yuba/Sutter	Gilsizer Slough at George Washington Rd	39.009	-121.6716
34	Shasta/Tehama	Burch Creek at Rawson Rd		

Note:

In summer 2006, the Coalition will work with the Water Board to update their Monitoring Program Plan for 2007.

The following several management plans were initiated as a result of 2005 and 2006 water quality data collection.

1.3.1 *E. coli* Monitoring Plan

This sampling plan is designed to evaluate the causes of exccedances of *E. coli* Basin Plan objectives observed in the Solano/Yolo subwatershed during monitoring for the Yolo Bypass Program and the Coalition monitoring for the Irrigated Lands Program. As a result of these exceedances, the Coalition has agreed to conduct this pilot study to investigate bacterial sources in this subwatershed. This pilot study is part of a broader management plan provided to the Water Board January 6, 2006, to address exceedances of several water quality parameters. This monitoring plan will be implemented in July 2006, pending plan and Quality Assurance Project Plan approval by the Water Board.

1.3.2 Diazinon Management Plan

The Coalition submitted its Diazinon Runoff Management Plan for Orchard Growers in the Sacramento Valley to the Water Board on January 19, 2006. The plan was approved by the Water Board in March 2006. In fulfillment of the requirements set forth in the plan, the Coalition submitted the 2006 Annual Report on June 1 summarizing the 2005-2006 monitoring objectives, location and results, outreach efforts, grower survey follow-up, and management practices effectiveness.

Results from the first year of this multi-year effort include the following:

- All sites were in compliance with load-based total maximum daily load (TMDL) objectives, and most samples were in compliance with the concentration-based TMDL objectives for diazinon. These results indicate that the combination of changes in diazinon use patterns, changes in management practices, and modifications to labeling have been successful in reducing in-stream ambient diazinon concentrations and loads to below historically observed levels that have resulted in these waters being listed as impaired.

- The recently finalized National Water Criteria for diazinon and the proposed Basin Plan objective for the San Joaquin River have significant implications for the TMDL for diazinon for the Sacramento and Feather Rivers. These objectives may be used to modify the targets of the TMDL or potentially to re-evaluate the need to list the Sacramento and Feather Rivers as 303(d)-listed impaired water bodies. The affected water bodies already appear to comply with potential TMDL targets that would be based on these new criteria. At a minimum, future compliance should be more easily achieved. This issue is currently being considered by Water Board staff responsible for implementation of the TMDL.

- Landowners and crop advisors have indicated a strong interest in learning more about Best Management Practices (BMP) for diazinon. Over 700 landowners and crop advisors have attended nine outreach presentations given in the fall and winter of 2005, prior to the dormant season spraying initiated in December 2005 and January 2006. The outreach presentations focused on the diazinon label changes and the finalized diazinon TMDL. Information on available BMP options to best protect surface waters from the potential impacts of dormant season runoff from diazinon alternatives, specifically pyrethroid insecticides, was also included during the presentations.

- Of the 335 surveys mailed in 2005, 211 surveys were completed and returned to the Coalition by August 26, 2005. The survey results were submitted as part of the Diazinon Management Plan in January 2006. The Coalition worked with County Agricultural Commissioners to identify the 124 non-respondents and to determine the reason for their failure to respond or fully complete a survey. As a result of the follow up, 11 additional surveys were completed by growers, with the remaining not being submitted for various reasons including the grower no longer farmed, the grower did not respond to attempts to contact them, or the grower refused to complete the survey.
- Other management practices are currently being evaluated in the Sacramento Valley for their effectiveness in reducing or eliminating runoff of dormant orchard sprays. The BMP evaluations are being performed through grant funding provided by the State Water Resources Control Board.

1.3.3 Yolo County Technical Report

The Water Board requested a technical report for boron, conductivity, dissolved oxygen, *E. coli* and fecal coliform bacteria, and Selenastrum toxicity that were observed to exceed numeric or narrative Basin Plan limits at several monitoring sites in Yolo County. The sites identified were monitored as part of the City of Woodland's Yolo Bypass Program in late 2003 and 2004, which included sites on Cache Creek, Putah Creek, Ridge Cut, and Willow Slough.

A technical report was submitted on January 27, 2006, calling for an evaluation of existing/ future management practice effectiveness in achieving water quality objectives and a detailed approach to be taken in identifying the causes of toxicity and water quality exceedances within the subwatershed. Implementation will begin in summer 2006.

Figures

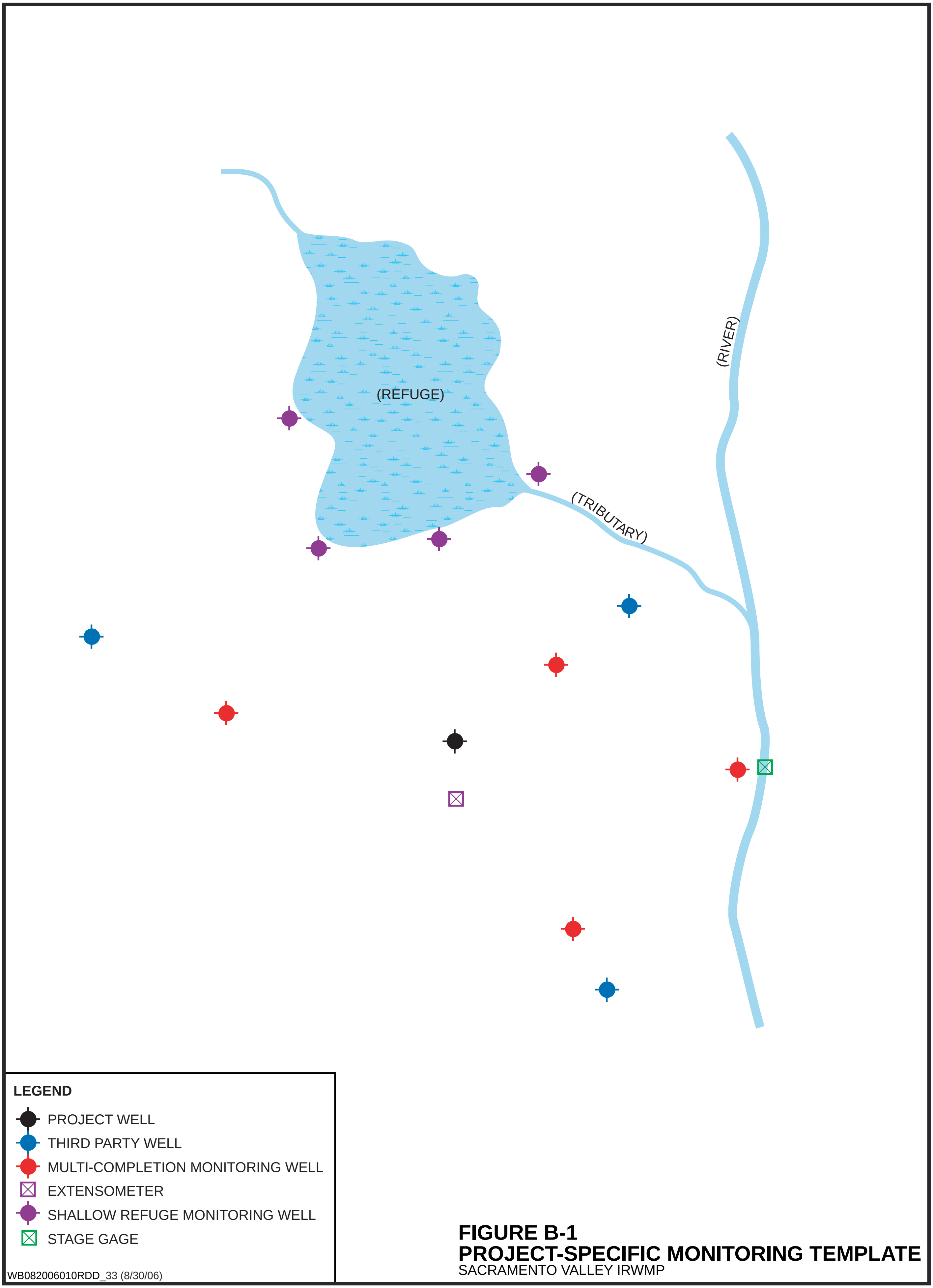

FIGURE B-1
PROJECT-SPECIFIC MONITORING TEMPLATE
SACRAMENTO VALLEY IRWMP

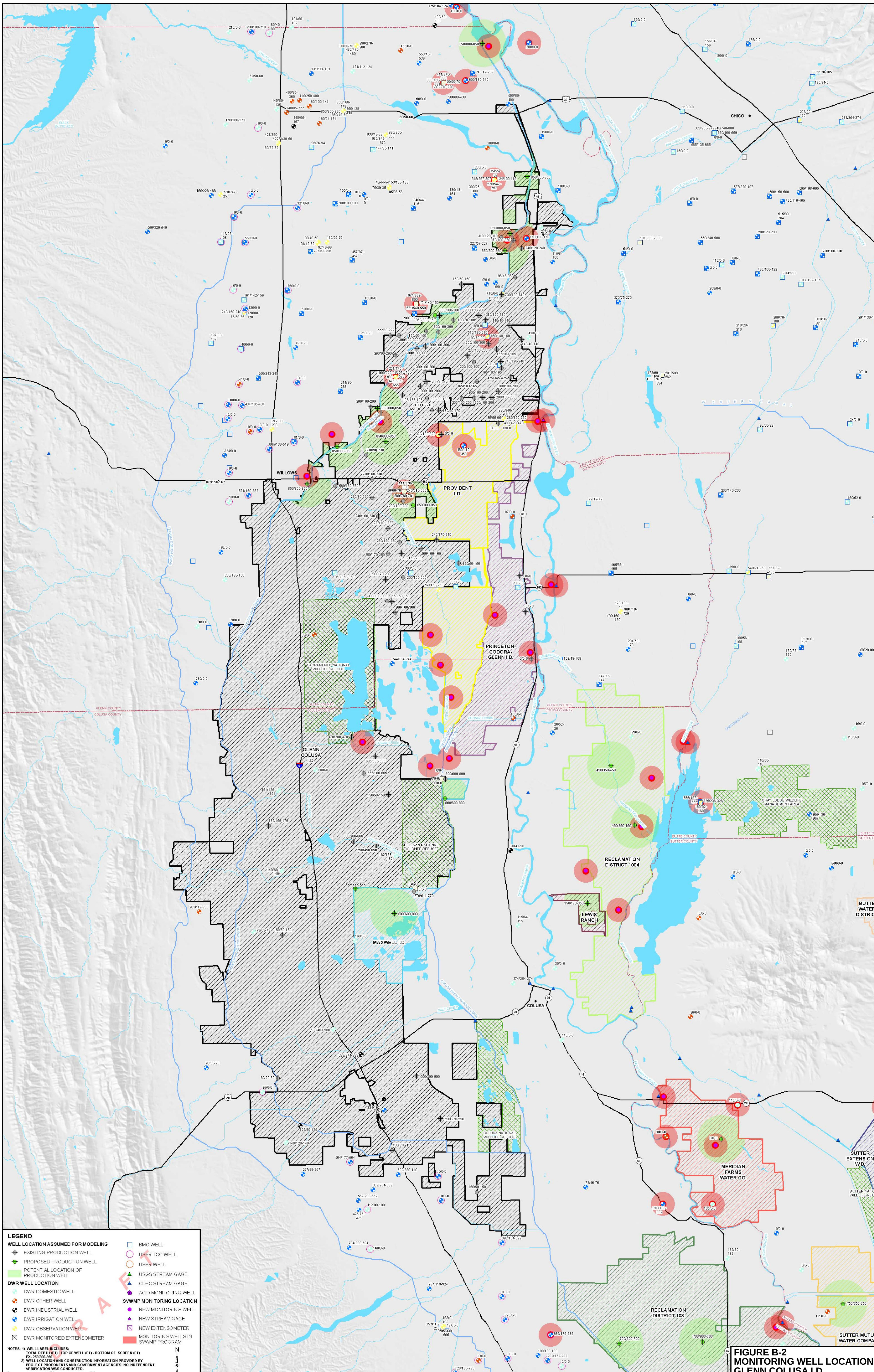

FIGURE B-2
MONITORING WELL LOCATIONS
GLENN COLUSA I.D.
SACRAMENTO VALLEY IRWMP

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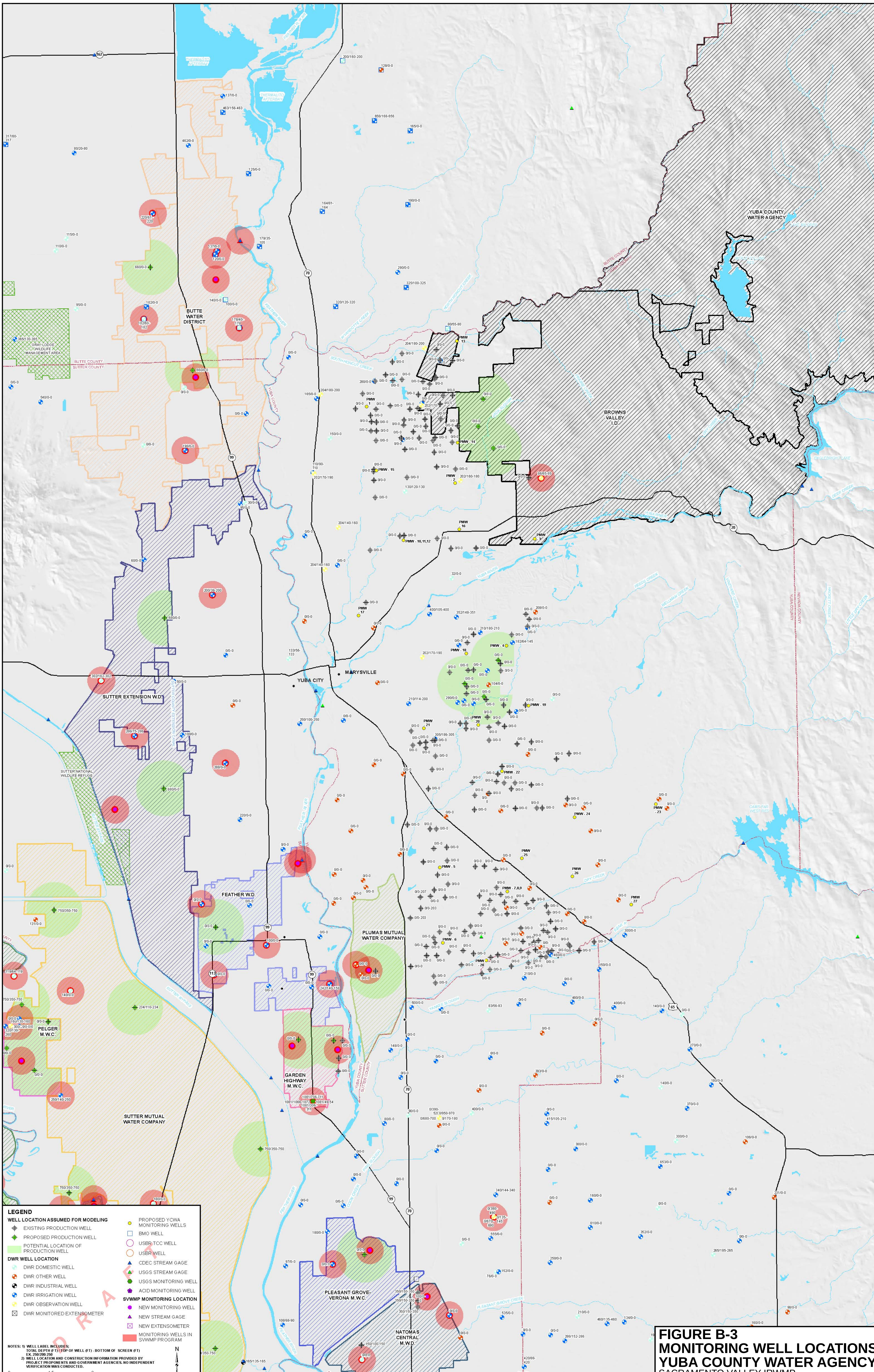

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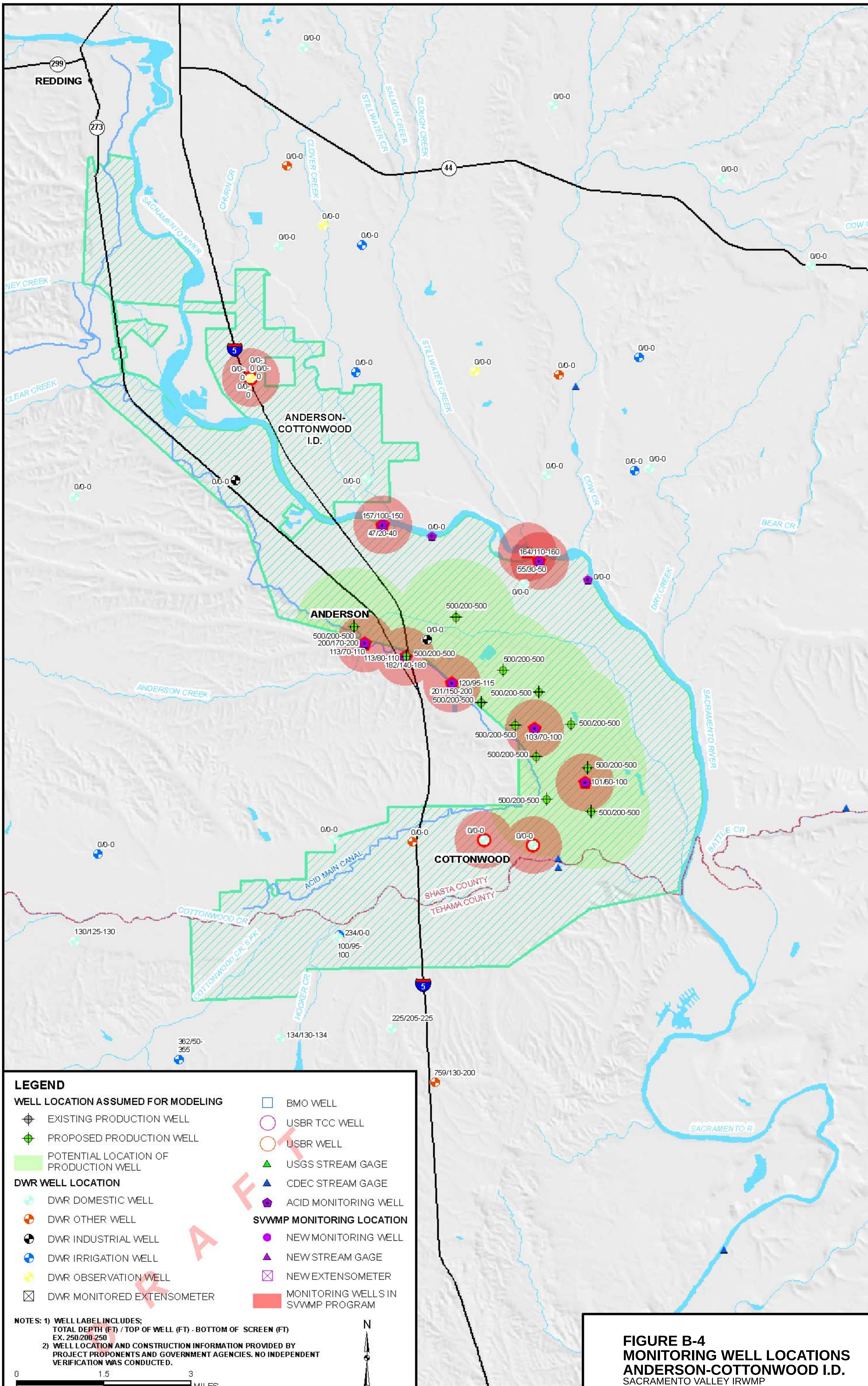

FIGURE B-4
MONITORING WELL LOCATIONS
ANDERSON-COTTONWOOD I.D.
SACRAMENTO VALLEY IRWMP

WB082006010RDD_40 (8/28/06)

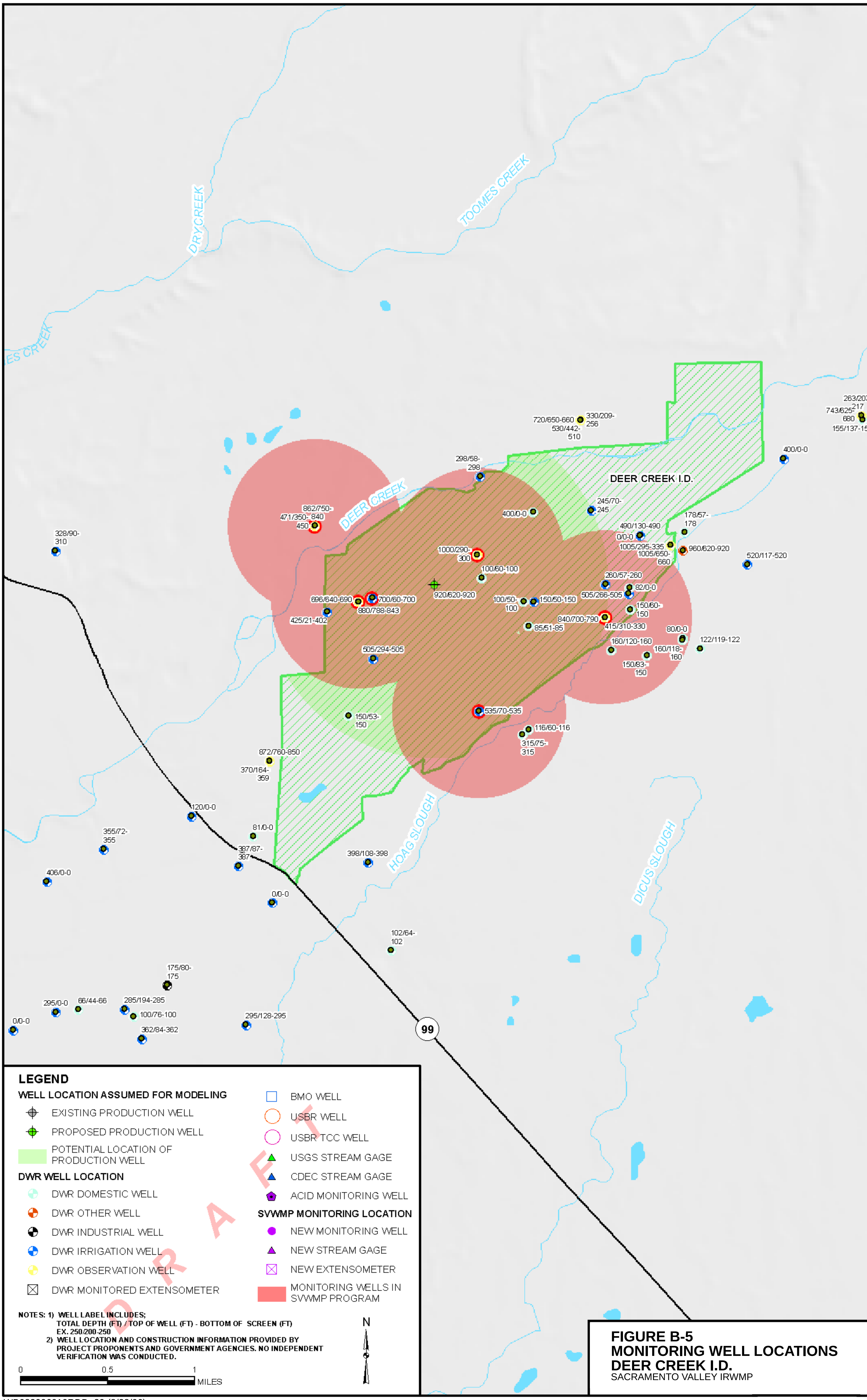

FIGURE B-5
MONITORING WELL LOCATIONS
DEER CREEK I.D.
SACRAMENTO VALLEY IRWMP

WB082006010RDD_39 (8/28/06)

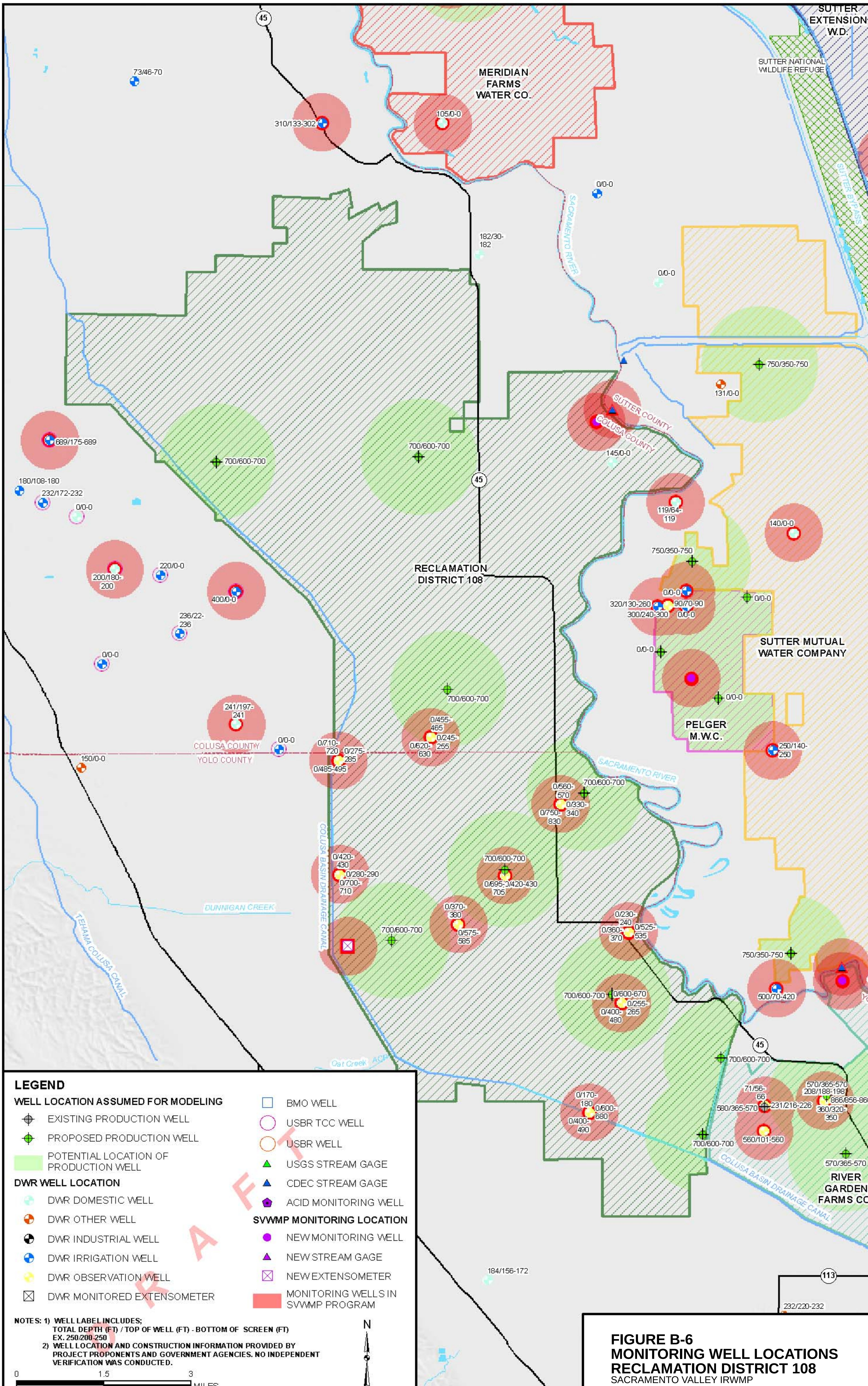

FIGURE B-6
MONITORING WELL LOCATIONS
RECLAMATION DISTRICT 108
SACRAMENTO VALLEY IRWMP

WB082006010RDD_38 (8/28/06)

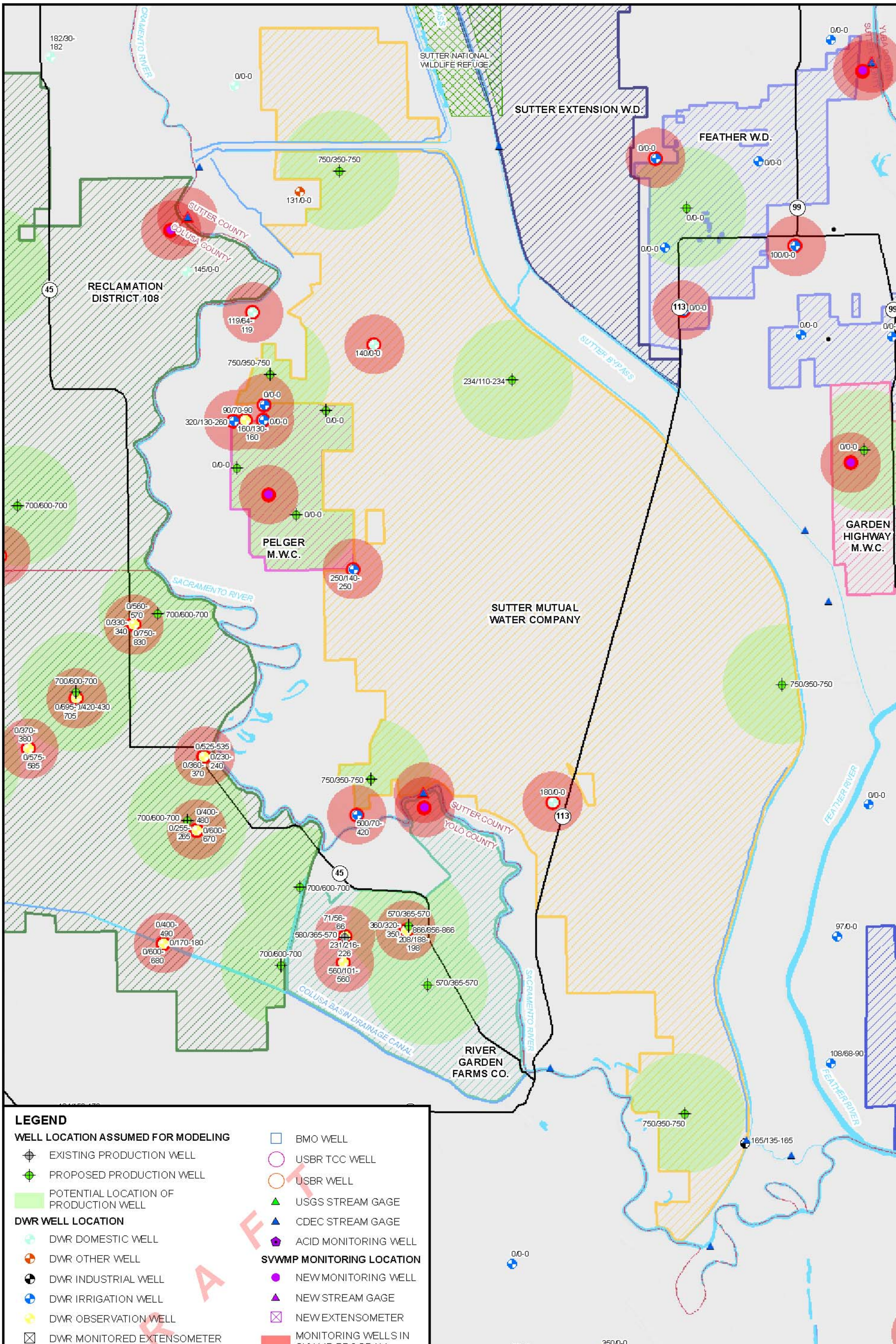

FIGURE B-7
MONITORING WELL LOCATIONS RIVER GARDEN FARMS CO., PELGER M.W.C AND SUTTER MUTUAL WATER COMPANY
SACRAMENTO VALLEY IRWMP

WB082006010RDD_37 (8/28/06)

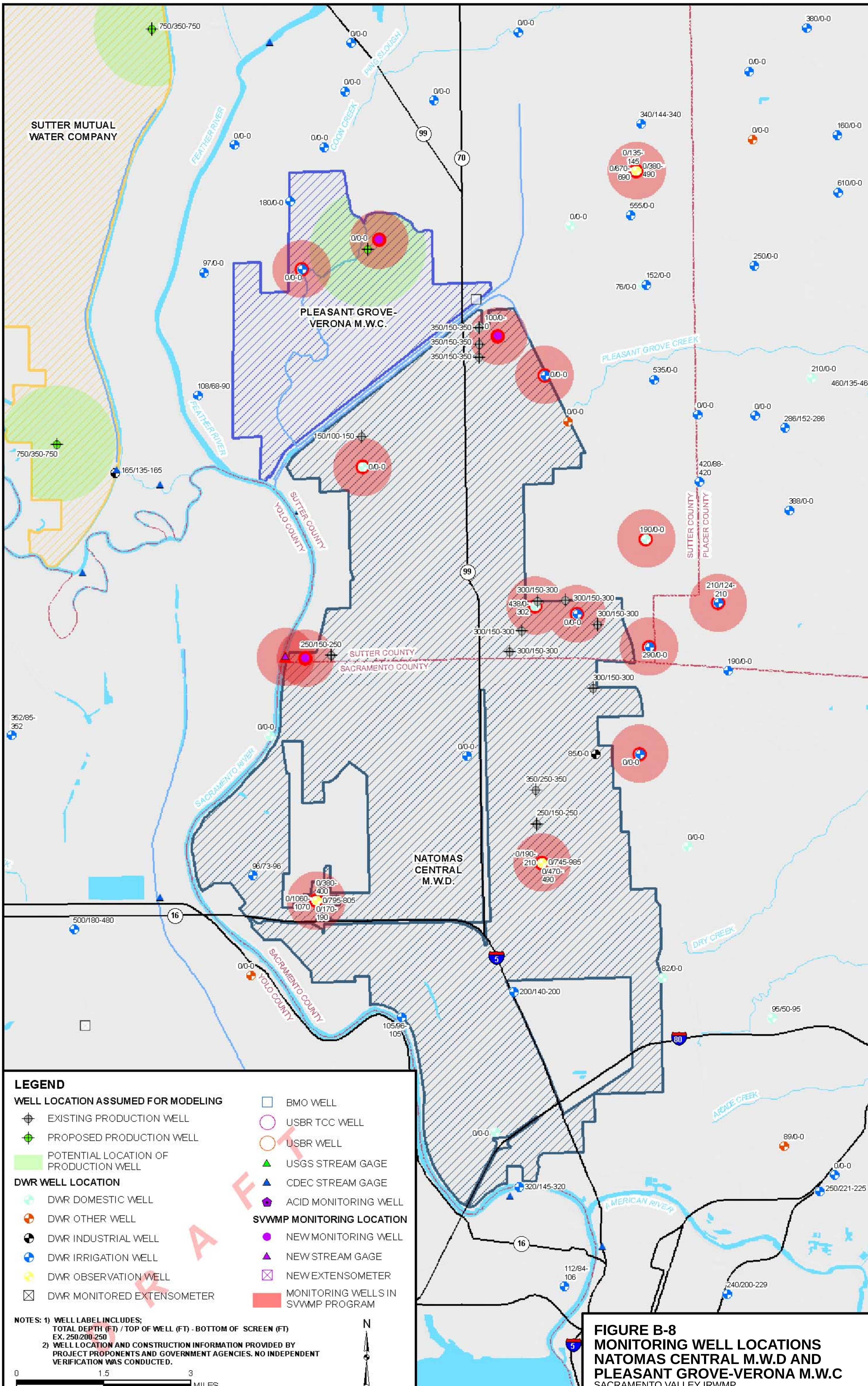

FIGURE B-8
MONITORING WELL LOCATIONS
NATOMAS CENTRAL M.W.D AND
PLEASANT GROVE-VERONA M.W.C
SACRAMENTO VALLEY IRWMP

WB082006010RDD_36 (8/28/06)

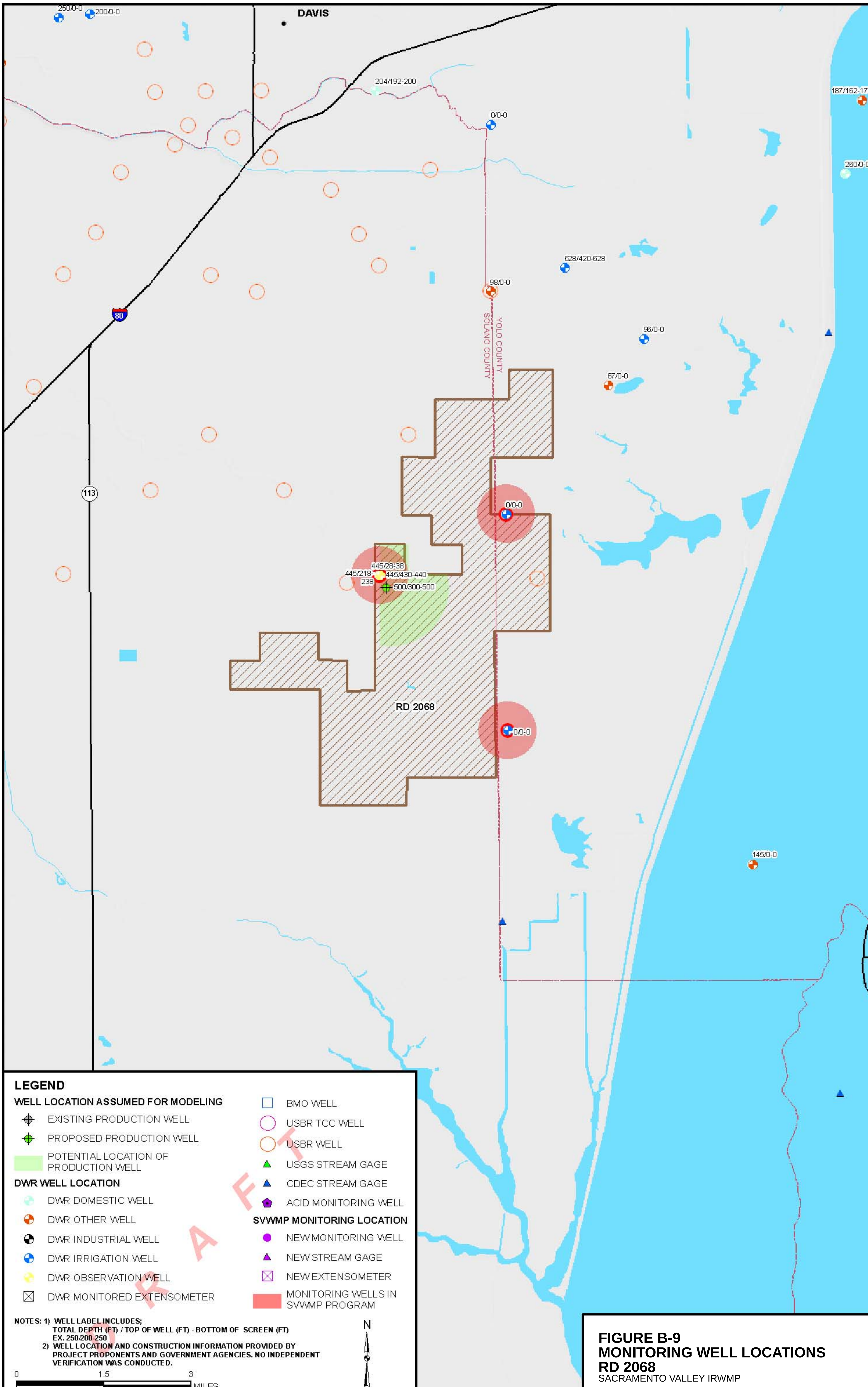

FIGURE B-9
MONITORING WELL LOCATIONS
RD 2068
SACRAMENTO VALLEY IRWMP

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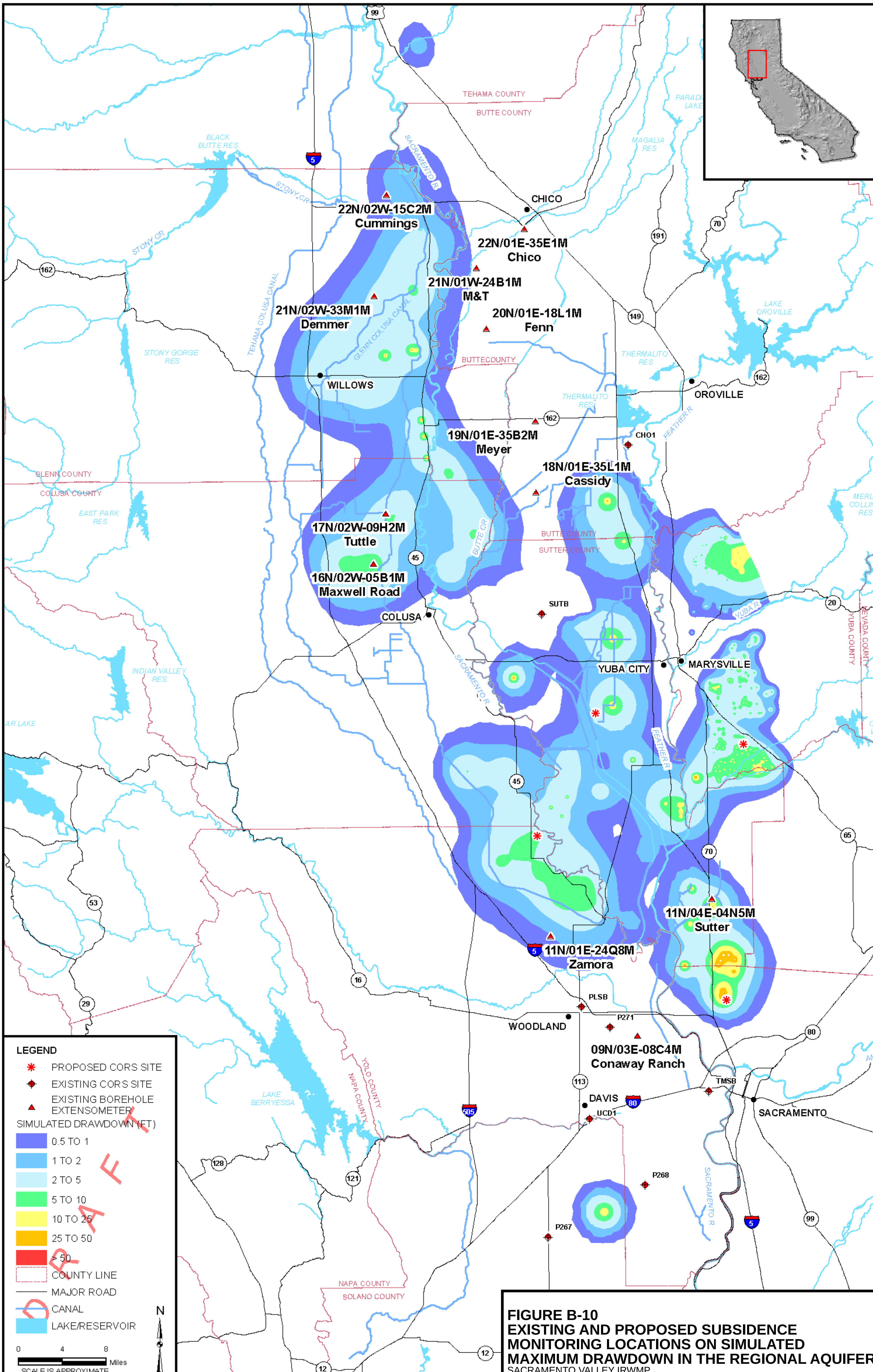
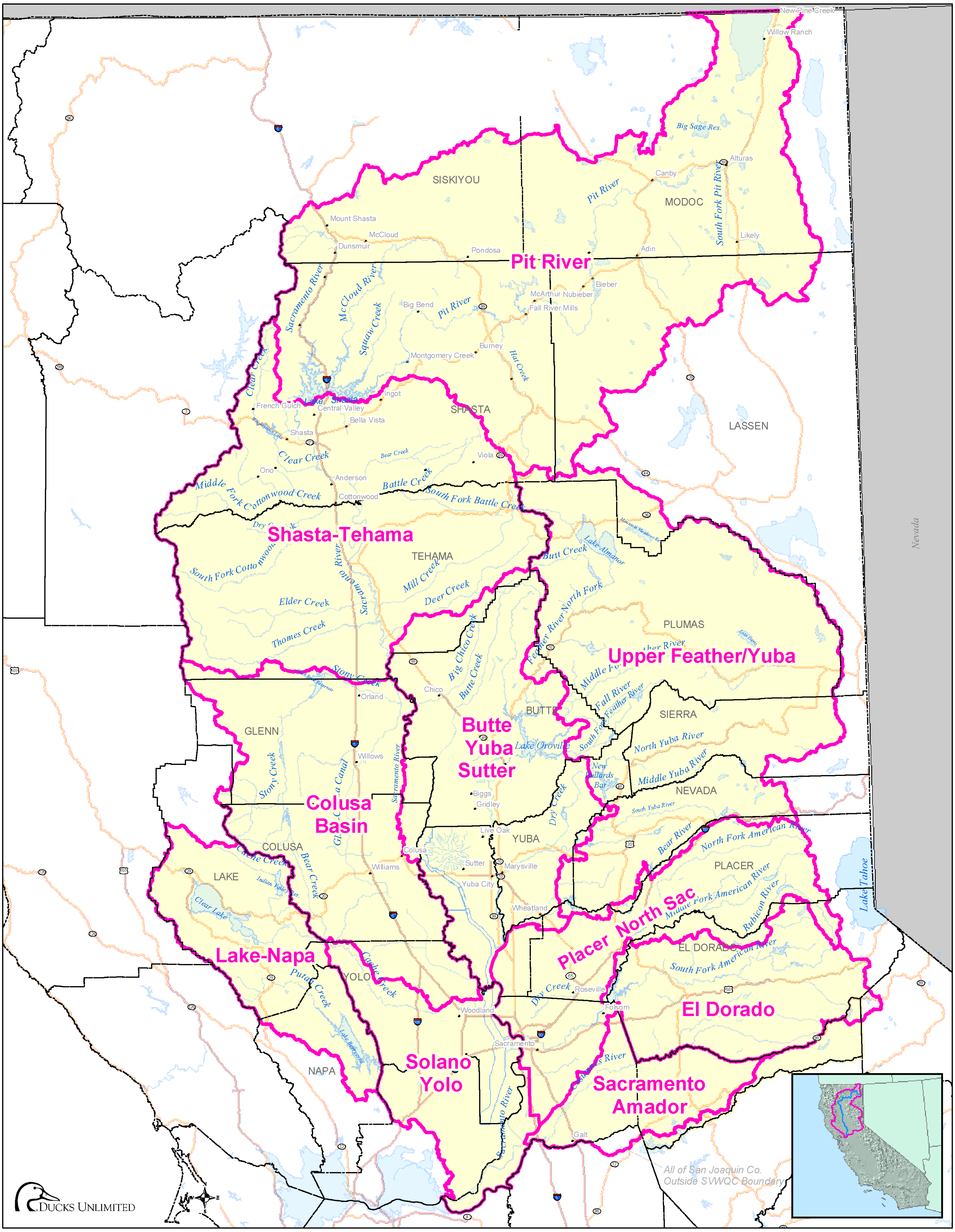


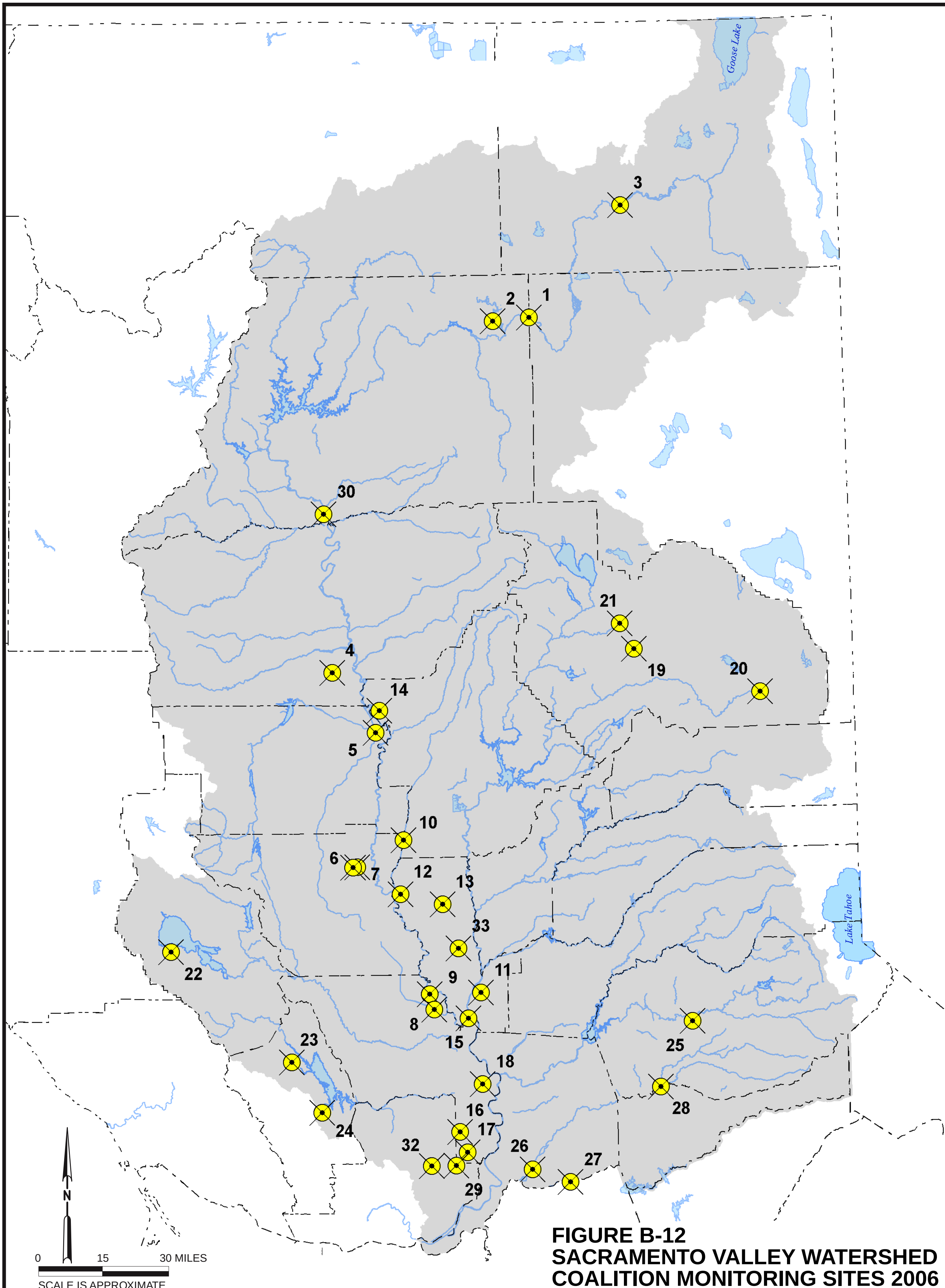
FIGURE B-10
EXISTING AND PROPOSED SUBSIDENCE MONITORING LOCATIONS ON SIMULATED MAXIMUM DRAWDOWN IN THE REGIONAL AQUIFER
SACRAMENTO VALLEY IRWMP

WB082006010RDD_34 (8/28/06)



WB082006010RDD_43 (8/28/06)

FIGURE B-11
SACRAMENTO VALLEY WATER QUALITY COALITION SUBWATERSHED MAP
SACRAMENTO VALLEY IRWMP



WB082006010RDD_02 (8/28/06)

FIGURE B-12
SACRAMENTO VALLEY WATERSHED COALITION MONITORING SITES 2006
SACRAMENTO VALLEY IRWMP

Attachment 1
Proposed Water Quality Monitoring Program for 2006: Sacramento Valley Water Quality Coalition

Proposed Water Quality Monitoring Program for 2006:

Sacramento Valley Water Quality Coalition

In January 2005, the Sacramento Valley Water Quality Coalition commenced monitoring under its Monitoring and Reporting Program Plan (MRPP) and Quality Assurance Project Plan (QAPP) submitted to the Regional Water Quality Control Board, Central Valley Region (Regional Board) on April 1, 2004 and December 22, 2004 respectively. The Regional Board issued a Conditional Approval of the Coalition's MRPP on December 2, 2004.

The following document is the Coalition monitoring plan for 2006 and is provided as an attachment to the Coalition's amended MRRP.

MONITORING IN 2005

Monitoring conducted in 2005 under the Coalition's MRPP provides the basis for the monitoring proposed for 2006. This monitoring is briefly summarized in the following sections, along with the basis for changes implemented for the 2006 storm and irrigation season monitoring.

Core Monitoring Sites

The Coalition has collected samples and performed analyses at sixteen core sites throughout the watershed (Table 1). Consistent with conditionally approved MRPP and QAPP, monitoring was generally conducted twice during the storm season (December – March), and monthly during the irrigation season (May – October).

Table 1. SVWQC core monitoring sites, 2005

Site Index	Subwatersheds	Site Location
4	Shasta/Tehama	Burch Creek at Woodson Ave Bridge
5	ColusaBasin	Stony Creek on Hwy 45 near Rd 24
8	ColusaBasin	Rough and Ready Pumping Plant (RD 108)
11	Placer/Nevada/S.Sutter/N.Sac.	Coon Creek at Striplin Road
12	Butte/Yuba/Sutter	Butte Slough at Pass Road
13	Butte/Yuba/Sutter	Wadsworth Canal at South Butte Rd
14	Butte/Yuba/Sutter	Pine Creek at Nord Gianella Road
16	Solano/Yolo	Z Drain – Dixon RCD
17	Solano/Yolo	Toe Drain at Little Holland Tract
18	Solano/Yolo	Tule Canal at I-80
19	UpperFeatherRiver	Spanish Creek above Greenhorn Cr.
20	UpperFeatherRiver	Middle Fork Feather River at County Road A-23
21	UpperFeatherRiver	Indian Creek d/s from Indian Valley
22	Lake/Napa	McGaugh Slough at Finley Road East
25	ElDorado	North Canyon Creek
26	Sacramento/Amador	Cosumnes River at Twin Cities Rd

Exceptions to the planned monitoring frequencies documented in the MRPP and QAPP were as follows:

Toe Drain @ Little Holland Tract: Poor access conditions in storm and irrigation seasons resulted in only two samples being collected at this site throughout the year. In August, the Coalition identified a new site in the same drainage area and submitted a memo to the Regional Board specifying the reason for the change. Monitoring commenced at the new location (Shag Slough at Liberty Island Bridge) in September 2005, and are proposed to continue in 2006.

Middle Fork Feather River at County Road A-23: This site was inaccessible in January 2005 due to icy conditions. This site was successfully sampled during all other planned events.

Burch Creek at Woodson Avenue Bridge: This site was sampled for two storm events and one irrigation event (January, March and May). Following the May irrigation season sample event, flow was inadequate to sample this site. The site was checked monthly for flow after May, and was found to be dry for the remainder of the irrigation season.

Pine Creek at Nord-Gianella Road: This site was sampled for two storm events and three irrigation events (January, March, May, June and July). Following the July event, flow was inadequate to sample this site. The site was checked monthly for flow after July, and was found to be dry for the remainder of the irrigation season.

Cosumnes River at Twin Cites Road: This site was sampled for two storm events and four irrigation events: January, March, May, June, July and August. Following the August event, flow was inadequate to sample this site. The site was checked monthly for flow in September and October, and was found to be dry for the remainder of the irrigation season.

Coordinated Monitoring

The Coalition also coordinated efforts with five other programs collecting samples in priority drainage areas throughout the Sacramento Valley. Samples were collected at the sites listed in Table 2 at the frequencies specified in the Coalition's Table 7A of the MRPP. The parameters analyzed were also as specified in Table 7A.

Table 2. Coordinating program monitoring sites in 2005

Subwatersheds	Site Location	Frequency	Agency
Pit River	Pit River at Pittville	Monthly, April through September	Northeastern California Water Association
	Fall River at Fall River Ranch Bridge		
	Pit River at Canby Bridge		
Lake/Napa	Pope Creek upstream from Lake Berryessa	Three events (January, March, May)	Putah Creek Watershed Group
	Capell Creek upstream from Lake Berryessa		
Colusa Basin	Colusa Drain near Maxwell Road	Monthly, May through September	Glenn County Agriculture Department
	Stone Corral Creek		
	Butte Creek at Gridley Rd Bridge		
Sacramento / Amador	Big Indian Creek at Bridge	Three events (December 2004, March and June 2005)	Plymouth Area Vineyard Erosion Control
Colusa Basin	Colusa Basin Drain above KL	No samples were collected in 2005	Sacramento River Watershed Program
Butte/Yuba/Sutter	Sacramento Slough		

RECOMMENDED MONITORING FOR 2006

Consistent with R5-2005-0833 which states that "*Based on results of the monitoring program after a minimum of one year, the Coalition Group may submit a revised MRP Plan requesting a reduction in the constituents monitored and/or sample frequency…*" the Coalition is submitting the following MRPP proposal for 2006. The proposed monitoring plan is also summarized in the attached Table 7A, which includes additional detail for parameters, sampling frequency, and implementation. The categories and criteria used for making these monitoring recommendations are discussed below.

Sites with No Observed Toxicity

For most sites that did not exhibit toxicity during 2005, the Coalition will end Phase 1 testing and initiate Phase 2 testing (i.e., pesticides, metals, nutrients, general physical parameters). These sites are listed below, with a brief discussion of exceptions:

- *Tule Canal at I-80*
- *Coon Creek at Striplin Road*
- *Wadsworth Canal at South Butte Rd*
- McGaugh Slough at Finley Road East. Although no toxicity was observed at this site in 2005, Phase 1 testing is planned to continue in 2006 to increase the number of monitored events.
- *Toe Drain at Little Holland Tract*. Due to the access problems experienced in 2005, this site was replaced during the irrigation season with Shag Slough at Liberty Island Bridge, where Phase 1 monitoring will continue in 2006.
- *Middle Fork Feather River at County Road A-23*, *Spanish Creek above Greenhorn Cr.*, and *Indian Creek d/s from Indian Valley*. Phase 1 monitoring at

these sites excluded toxicity on the basis of minimal irrigated acreage and pesticide use in these drainages. Phase 2 monitoring will be implemented in 2006, but will exclude pesticide analyses on this same basis.

Sites with Observed Toxicity

Sites with occasional toxicity observed in 2005 will be sampled as described below in 2006. Toxicity observed at these sites is summarized in Table 3. The scope of Phase 2 monitoring was determined on a case-by-case basis as described below for each site.

- *Burch Creek at Woodson Ave Bridge* exhibited statistically significant toxicity in three samples, including two samples in January 2005 and one sample in May 2005. Phase 1 testing will continue at this site to attempt to assess causes of the observed toxicity. Phase 2 testing will also commence at this site in January 2006. The Shasta-Tehama subwatershed group has also provided a monitoring strategy for 2006 to more completely characterize agricultural drainage in this area. The proposed strategy includes contingency samples collected at two sites upstream from the original site to identify sources of toxicity observed in 2006.
- *Pine Creek at Nord-Gianella Road* exhibited statistically significant toxicity to *Selenastrum* in one sample in January 2005. The cause was not determined and the toxicity was not repeated. Based on these results, Phase 1 toxicity testing will continue at this site for the 2006 Storm season, but will not be continued in the irrigation season. The Coalition will commence Phase 2 testing at Pine Creek beginning with the 20006 storm season. This sampling will continue analyses for organophosphorus pesticides which were identified in the January 2005 event (0.0141 ug/l diazinon and 0.227 ug/l chlorpyrifos), but determined not to be the cause of the observed *Selenastrum* toxicity.
- At the *Z Drain – Dixon RCD* site, water column toxicity has been evaluated on twelve occasions since July 2004. Three water samples exhibited statistically significant toxicity to three different test species respectively, and one sediment sample caused statistically significant toxicity. None of the samples resulted in mortality greater than or equal to 50% of the control and therefore no Toxicity Identification Evaluations (TIEs) were initiated. The Coalition will continue Phase 1 toxicity testing in 2006, and will also expand analysis of the Phase 2 analyses implemented in 2005 at this site.
- At *Stony Creek on Hwy 45 near Rd 24*, limited algae toxicity observed in one 2005 event, and therefore Phase 1 aquatic toxicity is discontinued at this site. Phase 1 sediment toxicity testing will be continued due to observed moderate toxicity in two 2005 events. Phase 2 parameters will be implemented in 2006. Due to low use of pyrethroids in this drainage, these pesticides will be excluded from the list of Phase 2 analyses in 2006.
- At *Rough and Ready Pumping Plant*, complete mortality to *Ceriodaphnia* was observed in one sample. The probable cause of the observed toxicity was determined to be the organophosphorus pesticide, dichlorvos (.087 ug/l), which is not registered for cultivated crop use in California. Because the cause of the single case of observed toxicity was determined, Phase 1 parameters (including toxicity)

are discontinued for 2006. However, there will be continued investigation of the potential source(s) of dichlorvos. Phase 2 monitoring will be implemented in 2006, including continued analysis for dichlorvos.

- At *Butte Slough at Pass Road*, complete mortality to *Ceriodaphnia* was observed in one sample (October 2005). Two additional samples caused low but statistically significant mortality to *Selenastrum* and *Hyalella*. The probable cause of the observed *Ceriodaphnia* toxicity was determined to be an organophosphorus pesticide, dichlorvos (0.542 ug/L), which is not registered for cultivated crop use in California. Because the cause of the single case of substantial observed toxicity was determined, monitoring of Phase 1 parameters (including toxicity) by the Coalition will be discontinued for 2006. However, the California Rice Commission *ILP* monitoring is continuing toxicity testing at this site, and there will be continued investigation of the potential source(s) of dichlorvos by the Coalition and subwatershed. Phase 2 monitoring will be implemented in 2006, including continued analysis for dichlorvos.
- At *North Canyon Creek*, negligible sediment toxicity (<20% effect) and no aquatic toxicity were observed in 2005. Therefore Phase 1 parameters are discontinued and Phase 2 parameters will be implemented in 2006 (including OP pesticides that were detected in 2005, but not associated with any observed toxicity).
- At *Cosumnes River at Twin Cities Rd*, negligible sediment toxicity (<20% effect) was observed in one sample and no aquatic toxicity was observed in 2005. The minimal sediment toxicity observed was associated with late season zero flow conditions not related to agricultural runoff. Therefore Phase 1 parameters are discontinued at this site and Phase 2 parameters will be implemented in 2006.
- At *Pit River at Canby Bridge*, low but statistically significant toxicity to Selenastrum was observed in one sample. Phase 1 parameters will be continued for the 2006 storm season (Dec-March) because toxicity was not monitored for storms in 2005 at this site. Phase 1 will be discontinued if no further toxicity is observed in the Storm season. Phase 2 nutrients will be added for 2006 to address 303(d) listings downstream for low DO and elevated nutrients. Organophosphate pesticides will be monitored in three events (following dormant spray application, and in July and October) to monitor potential discharges of malathion and chlorpyrifos. Bioassessment monitoring has also been added by the subwatershed monitoring agency (Northeastern California Water Association).

Table 3. Sites exhibiting toxicity in 2004-2005 initial toxicity screening tests

Site	Sample Event	Initial Toxicity Screening Test	Initial Test Result (units = percent of control)	Re-Test Result	Re-Sample Result
Burch Creek at Woodson Ave Bridge	Jan 2005	*Ceriodaphnia* survival	20%	85%	0%
	May 2005	*Selenastrum* growth	69%	n/a	n/a
Pine Creek at Nord-Gianella Road	Jan 2005	*Selenastrum* growth	46%	62%	100%
Z Drain – Dixon RCD	Aug 2004	*Selenastrum* growth	68%	n/a	n/a
	Sep 2004	Fathead survival	78%	n/a	n/a
	Jan 2005 Jun 2005	*Ceriodaphnia* survival *Hyalella* survival (replicate sample)	55% 63%, 78%	80% n/a	100% n/a
Stony Creek on Hwy 45 near Rd 24	Jun 2005	*Hyalella* survival	61%	n/a	n/a
	Sep 2005	*Hyalella* survival	74%	n/a	n/a
Rough and Ready Pumping Plant	Sep 2005	*Ceriodaphnia* survival	0%	0% (100% conc.	100%
Butte Slough at Pass Road	Aug 2005	*Selenastrum* growth	80%	n/a	(1)
	Jun 2005	*Hyalella* survival	80%	n/a	n/a
	Oct 2005	*Ceriodaphnia* survival	0%	(1)	n/a
		(replicate sample)[2]	0%		
		(replicate sample)[3]	0%	n/a	100%
North Canyon Creek	Sep 2005	*Hyalella* survival	88%	n/a	n/a
Cosumnes River at Twin Cities Rd	Sep 2005	*Hyalella* survival	84%	n/a	n/a
Pit River at Canby Bridge	Apr 2005	*Selenastrum* growth	74%	n/a	n/a

(1) Retest and re-sampling were not initiated by CRC for these samples.

(2) Collected by CRC and tested by Pacific EcoRisk.

(3) Collected by Regional Board and UC Davis staff and tested by California Department of Fish and Game ATL. Preliminary TIE results indicated non-polar organic was cause of toxicity.

Completion of Phase 1 Monitoring

Phase 1 parameters will be continued for the 2006 storm season (Dec-March) at the following sites, either because toxicity was not monitored for storms in 2005, or to provide additional sample events. Phase 1 will be discontinued if no further toxicity is observed in the 2006 storm season. No toxicity was observed in irrigation season monitoring events at these sites.

- *Colusa Basin Drain near Maxwell Road, Stone Corral Creek,* and *Butte Creek at Gridley Rd Bridge.* Phase 2 testing will also begin at these three sites in January 2006 and continue throughout the irrigation season during each event. The Glenn County Agriculture Department implemented monitoring at these sites in 2005. The Coalition will assume full responsibility for monitoring these sites in 2006.
- *Fall River at River Ranch Bridge*, and *Pit River at Pittville*. Phase 2 nutrients will be added for 2006 to address 303(d) listings downstream for low DO and elevated nutrients. Phase 2 Organophosphate pesticides will be monitored in three events (following dormant spray application, and in July and October) to monitor potential discharges of malathion and chlorpyrifos. Bioassessment monitoring has also been added by the subwatershed agency conducting monitoring (Northeastern California Water Association).

- *Pope Creek* and *Capell Creek* in the Napa/Lake subwatershed. These two sites will continue to be monitored for a drainage-specific sub-set of Phase 1 parameters, based on minimal irrigated acreage and pesticide use. Toxicity is not monitored at these sites.

New and Modified Monitoring Sites

The Coalition is proposing to add three new monitoring sites at which Phase 1 testing (water column and sediment toxicity, drinking water constituents, and general physical parameters) will commence in January 2006 and continue throughout the 2006 irrigation season:

- One new site will be monitored on *Gilsizer Slough at George Washington Road* in the Butte/Yuba/Sutter subwatershed. This site is needed to assess diazinon use and TMDL compliance in this Gilsizer Slough drainage, and complements an ongoing BMP study being conducted in this drainage.
- *Ulatis Creek at Brown Road* is a new site that will be monitored in the Solano/Yolo subwatershed. This site was added to more completely characterize agricultural drainages in this subwatershed. The site characterizes a large proportion of the irrigated acreage in Solano County.
- One site will be added on Andersen Creek in Southern Shasta County. This site is needed to more completely characterize agricultural drainages in this subwatershed. Phase 1 and Phase 2 parameters will be monitored simultaneously. Phase 2 pesticides will be limited to organophosphate pesticides, based on usage in this subwatershed. The exact location of the monitoring site will be confirmed by the Shasta Tehama Water Education Coalition (STWEC) prior to implementing monitoring in January.
- Sampling will cease at the *Big Indian Creek at Bridge* site in the Sacramento/Amador subwatershed after one additional storm event. This site will be replaced with *Dry Creek at Alta Mesa Road* (also in the Sacramento/Amador subwatershed), with analysis of Phase 1 parameters (water column and sediment toxicity, drinking water constituents and general physical parameters) beginning in January 2006. Monitoring at this site will be implemented by the Coalition.

New monitoring location are listed in Table 4. A summary of all monitoring by the Coalition and coordinating partners is provided in Table 5, with a more detailed summary in MRPP Table 7A (attached).

Table 4. New monitoring sites for 2006

Subwatersheds	Site Location	Latitude	Longitude
Butte/Yuba/Sutter	Gilsizer Slough at George Washington Road	39.0090	-121.6716
Solano/Yolo	Ulatis Creek at Brown Road	38.3070	-121.7940
Shasta/Tehama	Andersen Creek (location TBD)	NA	NA
Sacramento/Amador	Dry Creek at Alta Mesa Road	38.2480	-121.2260

Table 5. Coalition Monitoring Summary: Planned samples in 2006

Location	Physical and Chemical Parameters												Toxicity and Follow-up Testing				Implementation
	Water Column Sample Events	Sediment Sample Events	Flow	pH, conductivity, DO, temperature	Color, Turbidity, TDS, TSS, TOC	Nutrients	Trace metals	Organophosphate pesticides	Organonochlorines, triazines, pyrethroids	Glyphosate, Paraquat	Carbofuran	Pathogen Indicators: *E. Coli* bacteria	Ceriodaphnia, 96-h acute	Pimephales, 96-h acute	Selenastrum, 96-h short-term chronic	Hyalella, 10-day short-term chronic	
Butte Slough at Pass Road	8	2	8	8	8	8	8	8	8	8	6	8	ns	ns	ns	ns	SVWQC
Colusa Drain near Maxwell Road	8	2	8	8	8	8	8	8	8	8	6	8	8	8	8	2	SVWQC
Stone Corral Creek near Maxwell Road	8	2	8	8	8	8	8	8	8	8	6	8	8	8	8	2	SVWQC
Butte Creek at Gridley Rd Bridge	8	2	8	8	8	8	8	8	8	8	6	8	8	8	8	2	SVWQC
Wadsworth Canal at South Butte Rd	8	2	8	8	8	8	8	8	8	8	6	8	ns	ns	ns	ns	SVWQC
Pine Creek at Nord-Gianella Rd	8	2	8	8	8	8	8	8	8	8	6	8	ns	ns	ns	ns	SVWQC
Gilsizer Slough at George Washington Rd	8	2	8	8	8	ns	ns	8	ns	ns	ns	8	8	8	8	2	SVWQC
Z-Drain (Dixon RCD)	8	2	8	8	8	8	8	8	8	8	6	8	8	8	8	2	SVWQC
Shag Slough at Liberty Island	8	2	8	8	8	8	8	8	8	8	6	8	8	8	8	2	SVWQC
Tule Canal at NE corner of I-80	8	2	8	8	8	8	8	8	8	8	6	8	ns	ns	ns	ns	SVWQC
Ulatis Creek	8	2	8	8	8	8	8	8	8	8	6	8	8	8	8	2	SVWQC
Rough and Ready Pumping Plant	8	2	8	8	8	8	8	8	8	8	6	8	ns	ns	ns	ns	SVWQC
Stony Creek on Hwy 45 near Rd 24	8	2	8	8	8	8	8	8	8	8	6	8	ns	ns	ns	2	SVWQC
North Canyon Creek	8	2	8	8	8	8	8	8	8	ns	ns	8	ns	ns	ns	ns	SVWQC
McGaugh Slough at Finley Road East	3	2	3	3	3	3	3	3	3	ns	ns	3	3	3	3	2	SVWQC
Coon Creek at Striplin Road	8	2	8	8	8	8	8	8	8	8	6	8	ns	ns	ns	ns	SVWQC
Cosumnes River at Twin Cities Rd	8	2	8	8	8	8	8	8	8	8	ns	8	ns	ns	ns	ns	SVWQC
Big Indian Creek at Bridge	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	SVWQC
Dry Creek at Alta Mesa Road	8	2	8	8	8	ns	ns	ns	ns	ns	ns	8	8	8	8	2	SVWQC
Burch Creek at Woodson Ave Bridge	8	2	8	8	8	8	8	8	8	ns	6	8	8	8	8	2	SVWQC
Anderson Creek in Shasta County	8	2	8	8	8	8	8	8	ns	ns	6	8	8	8	8	2	SVWQC
Spanish Creek above Greenhorn Creek	7	ns	7	7	7	7	7	ns	ns	ns	ns	7	ns	ns	ns	ns	SVWQC
Indian Creek d/s from Indian Valley	7	ns	7	7	7	7	7	ns	ns	ns	ns	7	ns	ns	ns	ns	SVWQC
Middle Fork Feather River at County Rd A-23	7	ns	7	7	7	7	7	ns	ns	ns	ns	7	ns	ns	ns	ns	SVWQC
Pit River at Pittville	8	ns	8	8	8	8	ns	3	ns	ns	ns	8	2	2	2	ns	NECWA
Fall River at Fall River Ranch Bridge	8	ns	8	8	8	8	ns	3	ns	ns	ns	8	2	2	2	ns	NECWA
Pit River at Canby Bridge	8	ns	8	8	8	8	ns	3	ns	ns	ns	8	2	2	2	ns	NECWA
Pope Creek upstream from Lake Berryessa	8	ns	8	8	8	ns	ns	ns	ns	ns	ns	8	ns	ns	ns	ns	PCWG
Capell Creek upstream from Lake Berryessa	8	ns	8	8	8	ns	ns	ns	ns	ns	ns	8	ns	ns	ns	ns	PCWG
Colusa Drain above Knight's Landing	9	ns	9	9	9	9	ns	6	6	ns	6	9	9	9	9	ns	SRWP
Sacramento Slough	9	ns	9	9	9	9	ns	6	6	ns	6	9	9	9	9	ns	SRWP

Notes: Tabled values indicate number of regular samples planned for 2006. “ns” indicates parameter is not sampled. Implementation indicates whether monitoring is implemented by the Coalition (SVWQC), Northeastern California Water Association (NECWA), Putah Creek Watershed Group (PCWG), or Sacramento River Watershed Program (SRWP)