Proposal for Central Valley Salinity Coalition
Salt and Nitrate Sources Work Plan and Pilot Implementation Study

April 20, 2009

in association with
April 20, 2009

Mr. Daniel Cozad, Executive Director  
Central Valley Salinity Coalition, Inc.  
360 Lakeside Ave., Redlands, CA 92373

Dear Mr. Cozad,

We greatly appreciate the opportunity to submit the enclosed proposal for Phase I of the Central Valley Salt and Nitrate Sources Work Plan and Pilot Implementation Study. A key objective of Phase I is to develop scientific underpinnings for salinity and nitrogen reduction strategies affecting Central Valley soil, groundwater and surface water. We propose to characterize salt and nutrient sources in three Pilot Areas where we have substantial experience. For Task 2 we propose to develop the salt and nutrient study and report for the selected Pilot Areas. Phase I data compilation and analyses will consider stakeholder input and a regional planning perspective, and therefore provide a template for future application to the rest of the Central Valley.

Data limitations and the complexity of hydrologic systems make quantifying Central Valley salt and nutrient loads a challenging task. Previous Central Valley studies confirm that long-term ground- and surface water quality patterns and trends represent a complex interaction of management practices and physical and chemical processes. Therefore, we have assembled a team with substantial and diverse experience and expertise in California’s Central Valley which includes HydroFocus, Inc., West Yost Associates and technical advisors.

We believe stakeholders are best served with scientifically sound salt and nutrient budgets and loads that include quantification and minimization of uncertainty. We propose to 1) prioritize data collection efforts to quantify the most important terms, 2) quantify and minimize uncertainty through focusing efforts on resolving the largest uncertainties, 3) work within a regional context to develop technical consensus and 4) develop data sets with an eye towards developing modeling tools that can aid in providing answers about the effects of management practices in the face of uncertainty. We have provided information about the team’s experience with salinity and nutrient issues in the Central Valley and elsewhere and in working with multiple stakeholder groups.

We also have several comments regarding the proposed form of contract with the Central Valley Salinity Coalition, as shown in the attachment. These requested modifications address the obligations, status, indemnification sections of the contract.
We are confident that should we be selected for this project, we will be able to reach mutually agreeable terms.

Thank you for considering our proposal. We look forward to discussing it further in the near future.

Sincerely,
HydroFocus, Inc.

West Yost Associates

Steve Deverel
President and Principal Hydrologist

Steve Macaulay
Vice-President and Principal Engineer
We have reviewed the sample standard contract forms contained in the Central Valley Salinity Coalition’s (CVSC) Request for Proposals (RFP). We are confident that should we be selected for this project, we will be able to reach mutually agreeable terms. Requested modifications are identified below by section in bold, italic text:

**Article IV Consultant Obligations**

**Subsection 4.03b** – “Obtain a policy of Professional Liability (errors and omissions) insurance appropriate to the Consultant’s profession in a minimum amount of $1,000,000.00 per claim or occurrence and in the aggregate to cover any negligent acts or omissions or willful misconduct committed by Consultant, its employees, agents and subcontractors in the performance of any services for CVSC. Architects’ and engineers’ coverage shall include contractual liability;”

**Subsection 4.04** – “As respects the operations of Consultant under this Agreement other than the performance of professional services, Consultant shall indemnify, hold harmless, and defend the CVSC and its officers, directors, and employees from and against any and all claims, liabilities, damages, losses, and costs, including but not limited to reasonable attorney's fees and other costs of defense, attributable to personal injury, bodily injury, including death, or property damage, including loss of use thereof, and arising out of or alleged to arise out of the negligence or willful misconduct of Consultant or anyone for whom Consultant is legally responsible, excepting only those claims, damages, liabilities, losses, and costs caused by CVSC's negligence or willful misconduct.

As respects the performance of professional services under this Agreement, Consultant shall indemnify and hold harmless CVSC, its officers, directors, and employees from and against liabilities, damages, losses, and costs, including but not limited to reasonable attorney's fees and other costs of defense, to the extent caused by the negligence or willful misconduct of Consultant or anyone for whom Consultant is legally responsible.”

**Article III Consultant Status**

**Subsection 8.02** – “Consultant hereby specifically represents and warrants to CVSC that the services to be rendered pursuant to this Agreement shall be performed in accordance with the standards customarily applicable to an experienced and competent professional consulting organization rendering the same or similar services. Furthermore, Consultant represents and warrants that the individual signing this Agreement on behalf of Consultant has the full authority to bind Consultant to this Agreement.”

**Article IX Audit and Ownership of Documents**

**Subsection 9.01** – “Add following to existing paragraph: “Not withstanding anything to the contrary in this section, Agency CVSC hereby agrees to indemnify, defend, and hold harmless Consultant from any claims to the extent arising out of the Agency’s or any third party’s reuse, use, or distribution of its work, completion of this project by others, or for construction of this project or any other project where Consultant is not engaged to provide engineering services.”

**Article X Miscellaneous Provisions**

**Subsection 10.05** – “Consultant shall comply with all applicable and non-conflicting local, state and federal laws, rules and regulations including those regarding nondiscrimination and the payment of prevailing wages. Consultant hereby agrees to conform to all local, State and federal laws regulating or governing the services provided und this Agreement for this 503 (c) (6) organization.”
Subsection 10.06 – “CVSC expects that Consultant will devote its full energies, interest, abilities and productive time to the performance of its duties and obligations under this Agreement, and shall not engage in any other consulting activity that would interfere with the performance of Consultant’s duties under this Agreement or create any conflicts of interest.”
TABLE OF CONTENTS

PROJECT UNDERSTANDING AND BACKGROUND................................................................. 1
  SALT AND NITROGEN SOURCES AND TRENDS............................................................... 2
  SALT AND NUTRIENT BUDGET CHALLENGES.............................................................. 3
  RECOMMENDED GENERAL APPROACH......................................................................... 7

PROJECT TEAM............................................................................................................... 8
  DESCRIPTION OF TEAM AND BACKGROUND INFORMATION....................................... 9
  DETAILED PROJECT DESCRIPTIONS............................................................................. 13
  KEY PERSONNEL......................................................................................................... 29

PROPOSED SCOPE OF WORK – PHASE I................................................................. 32
  TASK 1 – PILOT WORK PLAN DEVELOPMENT.............................................................. 32
  TASK 2 – PILOT SALT AND NUTRIENT STUDIES AND REPORT................................. 39

BUDGET AND SCHEDULE............................................................................................ 41

REFERENCES CITED...................................................................................................... 44

Front cover pictures: Top left, salts precipitated as part of solar evaporation process for on farm salinity management in the San Joaquin Valley, courtesy of Jose Faria, Department of Water Resources.
Project Understanding and Background

The Central Valley Salt and Nitrate Sources Work Plan and Pilot Implementation Study offers a valuable opportunity to progress toward reducing salt and dissolved nitrogen loads to groundwater and surface water. We believe four components are critical for the Work Plan and Pilot Implementation Study to succeed.

1) Effective data compilation and analysis, straightforward presentations and written reporting, including analysis of uncertainty.
2) Input from technical committees and recognized experts to provide the multi-disciplinary perspective critical to understanding salts and nutrients in the Central Valley.
3) Coordination with regional planning efforts, prioritize goals and objectives, and facilitate stakeholder involvement.
4) Quantitative analysis for assessment of future water quality effects of changing management practices.

The overall objective of Phase I is to develop scientific underpinnings for salinity and nitrogen reduction strategies affecting Central Valley soil, groundwater and surface water. Phase I includes two tasks: Task 1 characterizes salt and nutrient sources in three to five Pilot Areas, and Task 2 develops the salt and nutrient study and report for the selected Pilot Areas. We envision Phase I data compilation and analyses will provide a template for future application to the rest of the Central Valley. Relevant background and a summary of our recommended project approach follows.

Salt and Nitrogen Sources and Trends

In California’s Central Valley, groundwater is the key receptor at risk for salinity and dissolved nitrogen loads because of the long history and areal predominance of irrigated agriculture. Available data and analyses reveal complex interactions between physical conditions, management practices, and chemical processes all of which combine to influence constituent concentrations and transport. Understanding the scope and intensity of historical agricultural practices, combined with practical knowledge and experience with Central Valley hydrologic systems is essential for successful characterization of salt and nutrient sources and trends.

There is substantial evidence for increasing salinity and nitrates in Central Valley groundwater and surface water. For example, in the Sacramento Valley, five out of the six subareas studied by Hull (1984) showed statistically significant increases in groundwater total dissolved solids (TDS) between 1955 and 1977. The increases ranged from 0.95 to 4.75 mg/L per year. Nitrate concentrations indicated a probable association between groundwater dissolved solids and nitrate concentrations. Jurgens (2009) cited two studies documenting long-term
increases in salinity in shallow and deep groundwater in the Central Valley of about 0.8 mg/L per year. Using stable isotope data, Davison and Criss (1993) attributed high salinity and nitrate concentrations in wells located in the City of Davis area to deep percolation of irrigation water.

HydroFocus recently assessed interacting factors that affect nitrate movement to groundwater due to agricultural activities in a typical Sacramento Valley watershed (Deverel and others, 2008). Fertilization practices produce nitrate concentrations in soil water ranging from several tens to several hundred milligrams per liter. De-nitrification reduces these concentrations as soil water moves slowly through highly heterogeneous sediments dominated by fine-grained beds. Our groundwater age dating results revealed long subsurface travel times for water to migrate to supply wells and surface water features, indicating that reduced fertilization application rates, increased frequency of fertilizer application, and utilizing winter cover crops can improve groundwater quality decades in the future.

In the eastern San Joaquin Valley, Nightingale (1970) determined that mean nitrate concentrations increased during the period 1950 to 1967. Burow and others (1998) also demonstrated increasing nitrate concentrations in 65 % of 20 wells they sampled in 1986 and 1995. Dubrovsky and others (1998) reported that the analyses of several thousand ground-water samples indicates median nitrate concentrations increased significantly from the 1950's to the 1960's, and from the 1970’s to the 1980's. During the same period, the amount of nitrogen fertilizer applied in the eastern San Joaquin Valley increased 554 percent. Dubrovsky and others (1998) reported that nitrogen fertilizer is the largest source of nitrate in eastern San Joaquin Valley groundwater.

In the western San Joaquin Valley, increasing salinity in City of Mendota water supply wells and production wells located near Fresno Slough are the result of saline groundwater originating in agricultural areas. HydroFocus personnel showed that spatial variability is often substantial in western San Joaquin Valley soil and groundwater (see for example, Deverel and others, 1984; Deverel and Gallenthine, 1989 and Deverel and Millard, 1988), and Deverel and Fujii (1988) and Deverel and Fio (1991) demonstrated that soil salt dissolution and evaporative concentration of shallow groundwater are key processes affecting groundwater salinity. Furthermore, HydroFocus personnel's research showed that land and water management factors affect this temporal and spatial variability, and extensive sampling is necessary to detect and quantify these trends.

**Salt and Nutrient Budget Challenges**

Data limitations and the complexity of hydrologic systems make quantifying Central Valley salt and nutrient loads a challenging task. No “turn-key” approach can be applied to quantifying and managing salt and constituent budgets in the
Central Valley. Previous Central Valley studies confirm that long-term ground- and surface water quality patterns and trends represent a complex interaction of management practices and physical and chemical processes.

Figures 1 and 2 conceptually illustrate the components of water and salt budgets and processes affecting these components. Figure 1 shows the predominant nutrient and salt sources and processes in a typical Sacramento Valley agricultural watershed. Agricultural inputs represent the largest source of salts and nutrients to Central Valley groundwater and surface water. Salts temporarily accumulate in and on agricultural soils due to evaporative concentration of irrigation water and are eventually leached to the groundwater and can move to streams. Soil and aquifer biogeochemical processes affect salt and nutrient concentrations and loads. Discharges from municipal and industrial sources undergo similar fate and transport processes and can also contribute salts to the groundwater. Figure 2 shows the processes and fluxes associated with drained agriculture, a predominant source of salts in the western San Joaquin Valley. Groundwater and soil water flows to drain laterals and collector lines from application areas at rates varying several feet to tens of feet per year. Dissolved salts and evaporatively concentrated shallow groundwater are still being flushed through drainage systems installed decades ago. Chemical and physical processes along the flow path alter salt and nutrient concentrations.

Figure 1. Conceptual model of processes affecting salt and nutrient movement to surface and groundwater in a Central Valley watershed. (Adapted from work conducted by HydroFocus and others on the Willow Slough Watershed Study in Yolo County).
Figure 2. Typical drainage system showing water and constituent movement to buried drain laterals. Groundwater-flow model results show travel times ranging from a few to 11-years for water and constituents to move a few hundred feet (model results from 1991 Water Resources Research article “Groundwater flow and solute movement to drain laterals, western San Joaquin Valley, California 2. Quantitative hydrologic assessment” by John Fio and Steve Deverel).

Groundwater age-dating indicate long travel times (decades to centuries) for western San Joaquin Valley groundwater to move downwards through primarily fine-grained materials to production well intake screens. However, modeling results reported by Sivakumar and others (2005) showed that shorter travel times are possible due to short-circuiting past fine-grained sediment beds through the discontinuous coarse-grained strata. Moderately high salinity increases observed in production wells confirm downward salt movement to deeper aquifers has already occurred, and Dubrovsky and others (1993) showed the salinity source is groundwater originating within 100 feet of land surface.
e are substantial challenges to quantifying the salt and nutrient budget components at scales that reveal the essential cause and effect relationships for management purposes. For example, some of the largest flow and mass terms in the salt balance are not measured directly. Groundwater pumping is widely used as an irrigation supply but is rarely measured or reported. The resulting deep percolation from the crop-root zone has been measured only in a few site-specific special studies. Spills and return flows from water delivery systems and field runoff are also rarely measured, making it difficult to estimate contributions to creeks, canals, and rivers. Dissolution of soil minerals often contribute salinity to groundwater and practical estimates can be made only through geochemical modeling.

Spatial variability of salinity and nutrient concentrations will be a major source of uncertainty in determining trends and estimating salt budgets for the Central Valley Salt and Nitrate Sources Work Plan and Pilot Implementation Study. Specifically, our experience indicates Central Valley data sets are characterized by large variances and statistically significant trends in the mean or median can usually only be determined from large sample populations. Spatial variability is also a large obstacle for physical parameters like vertical hydraulic conductivity and chemical concentrations.

There are spatial mismatches among various data sources. For example, rural population, fertilizer and gypsum applications are tabulated at the county level, but the political boundaries of many Central Valley counties extend beyond the valley’s hydrologic boundaries. Surface water deliveries are commonly available at the water district or major canal scale, but water quality data from wells are point data.

Finally, spatial scales may become an issue when management areas are delineated in subsequent phases of the project. The stakeholder group will need to balance the goal for locally-tailored management practices and avoid territorial mindsets that can interfere with regional solutions.

To successfully quantify Central Valley salt and constituent budgets requires experience working on Central Valley problems with Central Valley stakeholders, familiarity with the regional perspective, and an ability to quantify and deal with uncertainty. Uncertainty plays into how best to estimate values for central tendency (means and medians) and the associated variance in the estimates of central tendency. For example, HydroFocus recently estimated the uncertainty associated with groundwater quality estimates for mass determination at the Frontier Fertilizer Site in Davis, CA. (Please see project description on page 24). Even though dozens of data points were available for a small hazardous waste site, the median could only be estimated for different water bearing zones within about 50 to 100%. We used the available data to estimate how many samples would be needed to reduce these numbers. We envision a major goal for the Phase I pilot projects is to identify reliable methods for developing salt and
nutrient balances and to estimate and minimize uncertainty. We have previous experience characterizing temporal and spatial variability in groundwater quality (e.g. Deverel and Gallantyne, 1989; Deverel, 1989; Leighton and others, 1992) at both regional and field scales. This experience provides statistical underpinnings for estimating spatial variance inherently associated with hydrogeological and water quality data, and is a tool for quantifying uncertainty.

For example, as part of the San Luis Feature Reevaluation for the USBR, HydroFocus and URS Corporation updated groundwater quality maps using geostatistical techniques (block kriging) of concentrations measured in shallow groundwater wells. Maps were produced for TDS, selenium (Se), boron (B), and molybdenum (Mo) to estimate average concentrations for 5,000- by 5,000-meter grid cells in the drainage-impaired area. The standard error from the block kriging provided a confidence limit for the resulting mean concentrations, which is a key benefit from the analytical approach. A groundwater-flow model published by the USGS represented the spatial distribution of hydraulic conductivity at similarly fine resolution (1,600 meter square cells), and hydraulic conductivity was employed to scale the mean concentrations and account for spatial differences in tile-drainage yield. Shallow groundwater concentrations were combined with predicted flow rates to develop a flow-weighted concentration for each disposal alternative considered (Please see San Luis Drain Feature Re-evaluation project description for additional details). While the spatial intensity of groundwater quality data is not always available in the Central Valley, the data that is available can lend itself to a similar approach in the pilot studies described below.

**Recommended General Approach**

We envision that future quantitative hydrologic and geochemical analysis will be necessary for development and evaluation of the effects of effective management practices. Therefore a key goal in Phase I is to develop an efficient, robust, systematic data collection approach combined with innovative analyses applied throughout the Central Valley and support regional solutions.

Initially, we recommend three pilot areas in the Sacramento and the San Joaquin valleys. Within these pilot areas, we have substantial prior knowledge on data sources, data uncertainty, hydrologic systems, and existing models to calculate salt and nutrient budgets. In addition, we have worked extensively with and developed trust with stakeholders in these areas. We propose to utilize this existing framework to mine essential missing information and calculate salt budgets – including the confidence levels for the budget terms. Specific task descriptions are detailed below (please see Proposed Scope of Work).
Project Team

Our project team has extensive experience in Central Valley water quality issues. The scientists and engineers of HydroFocus, Inc. and West Yost Associates collectively have over 150 years working on statewide and Central Valley hydrologic and water quality issues. Steve Deverel, John Fio and Gus Yates of HydroFocus, Inc. led some of the early studies of San Joaquin Valley drainage/salinity issues and have managed field investigations, developed flow and salt models and participated in long-term stakeholder planning processes to manage groundwater in the Central Valley and Coast Range regions of California. Steve Macaulay, Vice President of West Yost Associates, has managed major water supply and water quality programs for state and local agencies for more than 30 years. Our technical advisors are professors at U.C. Davis with expertise in Central Valley salt and nitrate issues and an environmental statistician with experience evaluating Central Valley water quality data. They will provide additional technical expertise and review. HydroFocus, Inc. and West Yost Associates experience includes projects with extensive stakeholder and committee input to the development of technical products. These include the development of water supply alternatives for Daly City, San Luis Drain Feature Evaluation, Davis/Woodland Water Supply Project and groundwater management plans for the Westside (San Mateo County) and Gilroy-Hollister (San Benito County) basins.
Description of Team and Background information

HydroFocus, Inc. was founded in 1998 as a California S corporation and conducts hydrologic and water-quality investigations and provides consulting services. HydroFocus employs cost-effective investigation, data collection, research, and objective analyses to help clients solve problems affecting land and water resources. Collectively, company officers have 70 years experience addressing issues and problems associated with varying land uses, water supply, water rights, groundwater pumping impacts, waste disposal, and groundwater contamination and remediation. Company officers include a Professional Geologist licensed by the State of California and Professional Hydrologists Registered with the American Institute of Hydrology. Our principals, hydrologists, hydrogeologists, and technicians:

- Develop regional groundwater management and water supply plans.
- Quantify water- and land-management effects on water quantity and quality.
- Characterize groundwater basins and analyze groundwater-flow systems.
- Construct computer models to assess water quantity and quality.
- Measure land subsidence and develop ways to stop and mitigate its effects.
- Diagnose groundwater and soil contamination.
- Evaluate wetland hydrology.
- Conduct and interpret statistical analyses of hydrologic and water quality data.
- Design and utilize data bases Geographic Information Systems (GIS).
- Collect hydrologic data and establish monitoring programs.
- Provide technical support and facilitation for litigation and dispute resolution.

West Yost Associates (WYA) is a consulting engineering firm that was formed in 1990 to provide a higher level of client service around a focused area of technical expertise; water, wastewater, and stormwater. We provide a broad depth of experience in planning, design, construction management, and program management services. WYA has six offices located throughout Northern California and Oregon: Davis, Roseville, Pleasanton and Santa Rosa, California; Eugene and Portland, Oregon. We have over 100 staff members, including certified or registered professionals in civil and mechanical engineering, geology, and hydrogeology; land surveying; water and wastewater treatment plant operations; GIS; and specialty construction inspection and construction management.

The following summarizes the depth of WYA’s expertise:

- Water, Wastewater, and Stormwater Master Planning
- Water Supply Planning and Facility Design
• Water Rights and Water Transfers
• Wastewater and Reuse/Recycling Planning and Facility Design
• Permitting and Regulatory Compliance
• Hydraulic Modeling of Water, Wastewater, and Stormwater Systems
• Integrated Water Resources Planning
• Groundwater Investigations and Basin Management Planning
• Support for Environmental Impact Analyses
• Funding Strategies
• Infrastructure Rehabilitation
• GIS/Mapping and Surveying
• Program Management

West Yost Associates’ (WYA) foundation and growth are based on the following key principles:

• Focus exclusively on water, wastewater, and stormwater engineering projects
• Promise the involvement of a firm principal to every client
• Provide senior technical staff to manage and personally perform a significant portion of each project assignment
• Create a work environment that stimulates professional development and personal fulfillment

In addition to a firm principal, who often may serve as project manager or in a key technical role, WYA offers a cadre of senior technical staff having 10 to more than 25 years of experience, who manage and personally perform a significant portion of each project assignment. WYA’s overall staffing reflects an unusually high percentage of senior personnel. Intimate involvement of senior staff in every project, coupled with WYA’s formal quality control program, is a key element in maintaining product quality and client satisfaction.

Relevant Technical Qualifications

HydroFocus and WYA qualifications include extensive experience and background with Central Valley and Statewide water quality issues relevant to the analysis of salinity and nutrients in ground- and surface waters. Specific technical qualifications include:

1. Knowledge of relevant hydrologic and geochemical processes affecting salinity and nutrients and sources and sinks for relevant constituents in surface and groundwater water in the Central Valley.
2. Capability, experience and knowledge for assessing, processing and assimilating large amounts of regional data.
3. Statistics; capability and experience in quantitative analysis of spatial variability and multivariate and non-parametric statistical analysis.
5. Analysis of groundwater-surface water interactions

Relevant Experience

HydroFocus and West Yost experience with Central Valley water quality issues dates to the 1970s with Steve Macaulay’s involvement in the Interagency Drainage Program. HydroFocus experience began with the evaluation of western San Joaquin Valley salt and trace element issues in the early 1980’s. HydroFocus has continued to be involved in western San Joaquin Valley water quality issues as well as other areas of the Central Valley and the State. Specific relevant project descriptions follow.
Relevant example West Yost (green) and HydroFocus (blue) projects
Western San Joaquin Valley Agricultural Drainage Solutions

The primary problem in the western San Joaquin Valley is shallow groundwater and the presence of excessive soil and groundwater salinity and significant trace element concentrations. Agricultural activities have exacerbated the effects of naturally occurring salinity and trace elements (selenium, molybdenum, boron) by causing the groundwater table to rise and need for subsurface drainage. HydroFocus has extensive experience in the analysis of western San Joaquin Valley hydrologic and water quality issues dating back to the mid-1980’s.

HydroFocus helped develop and analyze alternatives for drainage-water management and led the evaluation of groundwater hydraulics and quality. A first step was to collect groundwater quality data so that results would rely on recent data. Next, HydroFocus analyzed available and newly collected data and then developed and refined U.S. Geological Survey groundwater-flow and water quality models. These included MODFLOW, PHREEQE, and unsaturated zone water budget and mass balance calculations. We relied on these models and extensive western San Joaquin Valley hydrologic experience to evaluate the effects of alternative land- and water-management practices on groundwater levels and quality. Specifically, we examined how land retirement, changing irrigation and drainage practices, development of evaporation ponds, and increased pumping would affect groundwater levels, soil and groundwater salinity levels, and dissolved concentrations of trace elements in groundwater and drain water.

HydroFocus and URS developed updated groundwater quality maps produced through geostatistical techniques (block kriging) of mean or median concentrations measured in shallow groundwater wells using data collected in the 1980s (Deverel and others, 1984). Results from the HydroFocus 2002 groundwater sampling showed no consistent changes in groundwater quality relative to 1980s results. Maps were produced for TDS, selenium (Se), boron (B), and molybdenum (Mo). Block kriging was used to estimate average concentrations for each 5,000- by 5,000-meter grid cell in the drainage-impaired area. Results from the block kriging were used to calculate mean concentrations for each subarea and for reuse areas. Estimates of the hydraulic conductivity of each 1-mile grid cell in the area covered by the USGS Belitz groundwater model were used to scale the estimated mean concentration to account for differences in drainage yield. Standard error from the block kriging was used to estimate confidence limits of the means and the scaled means for each subarea. The concentrations in shallow groundwater for the farmed and reuse areas were used with the estimated flow rates and project components (reuse and treatment) for each disposal alternative to develop a flow-weighted concentration for each disposal alternative. HydroFocus was a key player on the Consultant team which received a commendation from the U.S. Bureau of Reclamation for its outstanding performance in the successful completion and certification of the Environmental Impact Statement.

Clients: U.S. Bureau of Reclamation and URS Corporation
Schedule: 2001-2006
Project highlights:
- Key issues: high concentrations of salt and trace elements and need for western San Joaquin Valley drainage solution.
- Worked extensively with local and federal stakeholders to formulate appropriate technical questions and analysis avenues and review results.
- Team received commendation from USBR.

Project activities:
- Groundwater quality data collection and data analysis.
- Geostatistical analysis of uncertainty.
- Groundwater and soil model development.
- Analysis of long-term future impacts of continued irrigation.

Clients: U.S. Bureau of Reclamation and URS Corporation
Schedule: 2001-2006
Project highlights:
- Key issues: high concentrations of salt and trace elements and need for western San Joaquin Valley drainage solution.
- Worked extensively with local and federal stakeholders to formulate appropriate technical questions and analysis avenues and review results.
- Team received commendation from USBR.

Project activities:
- Groundwater quality data collection and data analysis.
- Geostatistical analysis of uncertainty.
- Groundwater and soil model development.
- Analysis of long-term future impacts of continued irrigation.
Soil Salinity and Groundwater Modeling for the Grasslands Drainage Area
(western San Joaquin Valley, California)

The Grasslands Drainage Area includes 97,400 acres of farmland located between the California Aqueduct on the west and San Joaquin River on the east. About 40-percent (37,950 acres) of the area is underlain by tile-drainage systems, which currently discharge drainwater to the San Joaquin River. The tile-drainage systems manage a shallow water table, which can cause water logging and salt accumulation in the root zone. HydroFocus estimated impacts to Grasslands Drainage Area groundwater and soils as part of an environmental evaluation for use of the drainage facilities to the San Joaquin River.

HydroFocus conducted the initial evaluation in 1999-2000 and the reevaluation in 2008-2009.

Soil salinity is an important consideration for irrigated agriculture and drainwater management. Irrigation water contributes salts and can dissolve and leach soil salts to the water table. Salts present in the irrigation water further increase salt loading to soil and groundwater. Impaired drainage increases soil salinity and shallow groundwater salinity due to evaporative concentration and can cause decreased crop productivity. Also, most of the Grasslands Drainage Area soils are derived from marine sediments in the Coast Ranges, and contain salts and trace elements such as boron, molybdenum, and selenium and solid phase minerals such as gypsum and calcite which influence changes in soil and groundwater salinity. HydroFocus evaluated changes in salt and selenium distributions in soil by modeling soil chemical changes under different water- and land-management scenarios. We also used groundwater flow and geochemical modeling to evaluate possible changes on groundwater levels and quality as the result of various proposed alternatives.
Delineation of Contributing Sources to Drainflows in Panoche Water District, western San Joaquin Valley, California

Clients: Department of Water Resources, Panoche Water District (conducted by HydroFocus personnel, John Fio and Dave Leighton while at US Geological Survey)


Project highlights:
- Developed water budgets for Panoche Water District
- Delineated complexity of processes affecting salt budgets for the District.
- Results published in 3 US Geological Survey reports and 1 journal article.

Project activities:
- Extensive processing and analysis of existing information.
- Development of GIS system, delineation of subareas.
- Groundwater-flow and transport model development.

On-farm drainage systems in the western San Joaquin Valley interact with the basin-wide groundwater-flow system. To reduce salt loads in drainwater, managers require information on these basin-wide interactions and sources and sinks for salts. Panoche Water District occupies about 40,000 acres of irrigated agricultural land. However, hydrologic and water management complexity complicates water and salt budget quantification. HydroFocus, Inc. personnel Dave Leighton and John Fio worked with Panoche Water District personnel (these personnel are still at the water district) to gather and process extensive water delivery, crop, drain-flow and drain-water quality data collected by the water district. Also, monitoring wells were installed and monitored. These data were incorporated into a Geographic Information System and data base. Subareas were delineated based on depth to groundwater and presence of drainage systems. Fio and Leighton developed a groundwater-flow model to identify upslope areas contributing to downslope drainflow. Isotope and groundwater chemical data and analysis were used to understand groundwater flow paths, solute sources and age.

The study revealed the complexity of and several key factors affecting the salt budget and flow to drains. The figure shows the overall salt budget for the water district and a net loss of salts from shallow groundwater system. This is the result of flushing of salts from the soil and groundwater to the drains and deep groundwater and dissolution of soil salts by applied water. The salt budget is complicated by the deep groundwater flow paths from upslope to downslope lands and drainage systems. Groundwater flow revealed that drainflows are best managed by modifying deep percolation and groundwater pumping.
Components of the water budget and control volume for Panoche Water District.
The multi-year Willow Slough Watershed Study was funded through Proposition 50 to assess how carbon, nutrients, sediments and salts, are produced and transported in agricultural landscapes. Understanding the basic processes and identifying land management strategies for reducing water-quality concerns are at the core of the study. The key elements of HydroFocus work are groundwater-stream interactions and subsurface movement of nutrients, salts and carbon from agricultural fields to surface water. The key technical challenge is the regional-scale quantification of subsurface flow and transport and stream-aquifer interactions in a highly heterogeneous subsurface environment highly perturbed by agricultural water- and land-management practices.

To address these technical challenges, HydroFocus is employing innovative modeling tools and geochemical data. To help with quantification of stream-aquifer interactions, HydroFocus used heat as a tracer and modeling heat transport. This provided an additional constraint on traditional flow and solute transport modeling. In cooperation with the US Geological Survey and UC Davis professors, HydroFocus used analysis for stable isotopes of nitrogen and carbon to interpret groundwater quality data. We have also used groundwater age dating to better understand subsurface flow and transport and for model development. The integrated and quantitative analysis of physical and chemical data from the saturated and unsaturated zones provided new insights into watershed processes and directions for improved water and land management.

Our study results demonstrated that groundwater moves slowly through primarily fine-grained materials and shallow groundwater recharged 18 to over 40 years ago. Therefore, changes in fertilizer and water management practices today will affect groundwater nitrate concentrations decades in the future. Nitrate in the unsaturated zone reflects fertilization and cropping practices; multiple fertilizer applications and winter cover cropping were associated with lower nitrate concentrations. Groundwater nitrate concentrations are lower than unsaturated-zone concentrations because of denitrification fueled by available organic carbon. Management practices such as winter cover cropping, reduced fertilization and increased frequency of fertilization application will reduce loading of nitrates to the groundwater and Willow Slough.
Example project results:

**Unsaturated-zone soil-water concentrations in corn and orchard grass fields.**

- **Corn-site1 NO3-N**
- **Corn-Site2 NO3-N**
- **Corn-Site3 NO3-N**
- **Corn-site4 NO3-N**

- **Orchard grass-Site2 NO3-N**
- **Orchard grass-Site3 NO3-N**

Unsaturated-zone chemical data shows the influence of fertilization practices and crop. Nitrogen fertilizer (applied primarily as NH4) results in nitrate concentrations in the unsaturated zone that range from less than 1 to several hundred mg/L. For a forage crop, nitrate-N concentrations in the unsaturated zone were low (less than 3 mg/L). In contrast, for corn, concentrations ranged from 5 to 40 mg/L. Fertilization rates for the two crops were similar (about 192 and 227 kg/A-year for corn and forage, respectively) but applied once at the beginning of and four times during the growing season for corn and forage, respectively. Also, orchard grass provides a winter cover crop whereas the corn field was fallow.
Ironhouse Sanitary District operates a wastewater treatment facility adjacent to the San Joaquin River and Contra Costa Canal. The District applies secondary effluent to agricultural lands, which are located at hydrogeologically complex sites.

The Contra Costa Canal conveys water for more than 500,000 people. The earthen canal passes through Ironhouse’s Mainland Facility; the bottom of the canal is constructed below the groundwater table, and consequently groundwater beneath adjacent agricultural fields irrigated with treated wastewater seeps into the canal.

The California Regional Water Quality Control Board provides regulatory oversight for Ironhouse’s disposal operation, and as part of the District’s Waste Discharge Requirements HydroFocus designed the groundwater monitoring network, prepares Quarterly Groundwater Monitoring Reports, and designed and implemented both a Beneficial Use Impact Study and Background Water Quality Study. The objective for the Beneficial Use Impact Study was to determine if irrigation with reclaimed water had degraded, or had the potential to degrade, underlying groundwater. The Background Water Quality Study utilized historical monitoring data to establish and update changes in the water quality criteria that determine whether water quality impacts have occurred.

The Beneficial Use Impact Study required quantifying the relationships between past land uses, present-day irrigation water salinity and application practices, salts naturally present in the soil, and historical and present-day groundwater quality. As part of this project, constructed monitoring wells, collected borehole samples, and extracted pore fluid for the analysis of dissolved constituents in the sediment profile. Additional sediment samples from irrigated fields, and analyses of soil and water extracts and historic water-quality data determined the effects of previous land use activities on observed groundwater quality. We employed geochemical modeling and detailed hydrologic analyses to determine the effects of soil salinity and land use on groundwater quality.

Because many dissolved constituents found in wastewater also occur naturally in the environment, we tested a number of chemical indicators to distinguish between naturally occurring constituents in groundwater and constituents introduced by land application of reclaimed water. Using these indicators, we identified monitoring wells that produce groundwater representing conditions prior to Ironhouse’s disposal operation (pre-existing groundwater), and demonstrated that constituent concentrations in pre-existing groundwater are substantially greater than indicated by upslope “background” wells.
Groundwater salinity in northern San Benito County is 800-1,100 mg/L in many areas, which limits beneficial uses for irrigation and drinking water. In 2003, Gus Yates began including basinwide salt budgets in the annual groundwater reports for San Benito County Water District. All significant sources of salt were identified and quantified using available water quality and hydrologic data. These revealed that evaporative concentration of irrigation water, importation of CVP water, gypsum application to cropland, and percolation from rivers and municipal wastewater disposal ponds were all major sources of salt (see pie diagram). Furthermore, salt inputs exceeded salt outputs by a factor of three. These findings prompted local agencies to begin managing groundwater salinity. Mr. Yates developed a salt loading and transport model to simulate the long-term effects of lowering the TDS of the municipal supply and delivering recycled water for irrigation in specified reuse areas. The modeling demonstrated that impacts on groundwater quality would remain quite localized over a 30-year analysis period and that the primary direction of salt movement would be downward.

![Water and salt fluxes, San Benito County](image-url)
Salt Inputs
73,700 tons/yr
Westside Groundwater Basin, San Mateo County

Client: City of Daly City, San Mateo County
Schedule: 1998-present
Project Components:
- Developed, updated, and calibrated basin-wide groundwater-flow model (MODFLOW).
- Designed and conduct seawater intrusion study.
- Obtained grant funding for special studies.
- Extensive technical dialog between various private and public stakeholders during model development process.
- Communicated technical information to non-technical public interest groups.

Since 1998, as Daly City’s consultant, HydroFocus personnel have contributed to managing Westside Groundwater Basin water supplies. Westside Basin aquifers provide a substantial portion of the municipal and private supply (for example, the San Francisco Public Utilities Commission, Daly City, the City of San Bruno, California Water Service Company, and various golf clubs, country clubs, and cemeteries). As demands for water increase, coordinated groundwater and surface water use is critical to maintaining a reliable water supply. As a key member of the consulting team, HydroFocus developed an AB 3030 Groundwater Management Plan for the Westside Basin. The plan addressed saline water intrusion, wellhead protection, groundwater quantity and quality monitoring, conjunctive use, and recycled water projects.

In 2002, HydroFocus successfully obtained California Department of Water Resources Public Assistance Grant funding for the City to evaluate water resources and sea water intrusion. The study included well installation, water quality analysis, groundwater geochemical modeling and groundwater-flow modeling objectives. Objectives met were (1) Improve groundwater-monitoring capabilities, especially near basin boundaries and the Pacific Ocean and San Francisco Bay; (2) Utilize new and existing wells to conduct state-of-the-art water sampling and geochemical saltwater intrusion assessment; (3) Develop and support basin-wide data storage and reporting procedures to streamline data dissemination and links with quantitative groundwater-flow models; and, (4) Thoroughly review and test existing groundwater simulation tools, incorporate newly available data, test assumptions, and preliminarily develop a management tool accepted by basin stakeholders.

Our groundwater geochemical investigation showed that sea water intrusion is not a serious factor affecting groundwater quality, and a preliminary basin-wide groundwater-flow model was completed. Since 2002, new data has provided valuable insight into geologic conditions, groundwater storage properties, surface-groundwater interactions, and water use practices. HydroFocus is incorporating this information into the model and updating the calibration. A critical aspect of our work is developing consensus between stakeholders and their technical representatives on model capabilities and limitations. This included facilitating the exchange of data between multiple parties, coordinating and responding to reviews, and listening and integrating concerns during the update and calibration process.
Groundwater Banking Assessment, Madera County

Client: Newhall Land and Farming

Schedule: 2000-2002

Project highlights:
- Quantified hydraulic relationships beneath the San Joaquin River owing to wells located on the east and west sides of the valley.

Project components:
- Develop conceptual groundwater-flow system from geologic, water level, water quality, and isotopic data.
- Design and calibrate regional groundwater-flow model (MODFLOW).
- Apply model to assess conjunctive use alternatives and potential impacts from private pumpers.
- Communicate technical information to client in an understandable way.

HydroFocus developed a groundwater-flow model to assess recharge pond operation and feasible recovery volumes for a proposed eastern San Joaquin Valley groundwater banking project. A groundwater-flow model was required to hydraulically integrate possible groundwater storage changes beneath the facility, changes in water inflow and outflow to the nearby San Joaquin River, and local and regional recharge and pumping activities.

The model integrated regional processes, spanning the eastern and western extents of the San Joaquin Valley, and localized processes at the scale of a single ranch. Model development therefore included a combination of regional and site-specific data compilation and assessment. The calibrated model was applied to assess several water-management scenarios and develop the following conclusions.

- Intentional recharge is most effective when distributed between multiple locations rather than a smaller number of centralized ponds. Distributing the recharge minimizes the potential for water-logged conditions and maximizes recovery by existing wells.

- Recovery of intentional recharge is sensitive to pumping well location and rates. Increasing annual pumping rates from existing wells increases recovery, but the relationship is not one-to-one. Increased pumpage from existing wells located adjacent to proposed ponds are the most effective at capturing the additional recharge, but most of the additional water produced originates west of the facility. In other words, incrementally greater volumes of off-site groundwater from the west supply the incremental increases in pumping rates.

- Off-site pumping from existing wells affects the fate and movement of intentional recharge beneath the facility. For example, doubling the pumping rates from existing off-site production wells lowered groundwater levels south of the proposed facility and induced greater lateral groundwater migration away from the facility. The greater lateral flow decreases intentional recharge recovery by 67 percent.
Brief Summaries of Other Relevant Project Experience

HydroFocus and West Yost Associates have consistently worked effectively on Central Valley water quality issues with regulatory agencies directly and on behalf of clients. We aim to use accurate and high quality data to develop a clear understanding of the processes affecting water quality. Some additional example projects follow.

**Davis/Woodland Water Supply Project City of Davis, City of Woodland, UC Davis, West Yost Associates (2004 – 2016)**

Davis, Woodland and UC Davis currently meet their water needs through use of local groundwater (UC Davis has limited surface water supplies from Monticello Project). That source has increasing posed challenges regarding both quality and source reliability. While there are increasing concerns about various drinking water quality constituents such as arsenic, the principal water quality driver is salinity. Source water quality is relatively high, in the range of 500 – 800 mg/l total dissolved solids. This translates into TDS concentrations well over 1,000 mg/l in wastewater treatment plant discharges. The Central Valley Regional Water Quality Control Board is requiring that such discharges meet greatly reduced salinity levels in the next few years. After many years of study and evaluation of options, the cities and UC Davis have decided to pursue surface water supplies to blend with groundwater to improve both quality and supply reliability.

West Yost Associates has worked for each of the Project partners for many years, individually beginning in the 1990s, and for the partnership for the Davis-Woodland Water Supply Project since 2004. As of April 2009, WYA has:

- completed a multi-year work plan for initial implementation activities,
- initiated a stakeholder outreach program together with Center for Collaborative Policy, CSU Sacramento,
- developed support and implementation program for creation of Joint Powers Agreement, completed preliminary design of early implementation components and is examining alternative project delivery mechanisms,
- provided support to rate studies,
- undertaken development of a project financing plan, and
- initiated work on facilities permitting, land acquisition and/or easements and rights-of-way to ensure that these “critical path” activities move forward consistent with the implementation schedule.

**Frontier Fertilizer Superfund Site, Davis, California (1995 – present).** During the 1970’s and 1980’s, a pesticide sales operation dumped large volumes of contaminants into unlined pits. The discarded pesticides caused extensive contamination of the shallow groundwater system. Nitrate is also a site contaminant. The pits and contaminant plume are now an EPA Superfund Site and EPA and its contractors are working to remediate the contamination. The
non-profit Frontier Fertilizer Superfund Oversight Group (FFSOG) attempts to ensure that the site will be effectively remediated. Since 1995, HydroFocus principal Steve Deverel has provided technical guidance to the FFSOG. HydroFocus reviews and evaluates technical work products, interpret technical information for lay audiences, and recommend changes in the scope and direction of work. The primary challenge has been to achieve meaningful and fruitful technical dialog with EPA and their consultants and influence project direction towards the optimal outcome for the neighbors. We have moved from adversarial relations to more effective interactions by objectively and concisely documenting technical shortcomings and bringing in third parity facilitators and mediators to promote technical dialog and voice concerns.

*Groundwater Flow Modeling for Turlock and Modesto Irrigation Districts (1992-2008).* Turlock Irrigation District (TID) and Modesto Irrigation Districts supply surface water for irrigation on lands within the districts. Team member Tim Durbin (West Yost Associates) developed a FEMFLOW3D groundwater flow model in the early 1990s to help the districts address various water management issues, and he has continued to refine, update and apply models in that area ever since (recently with Gus Yates of HydroFocus). Groundwater issues to which the models have been applied include soil drainage problems in the western part of TID, impacts of land use changes (primarily urbanization) on groundwater levels and quality, optimization of conjunctive use, overdraft in the adjacent Eastside and Ballico-Cortez Water Districts, and FERC relicensing of New Don Pedro Reservoir.

*City of Lathrop, California (2004 – present).* The City of Lathrop’s newly constructed wastewater facility serves a new planned community of residential and commercial developments. The facility treats wastewater to tertiary disinfected, Title 22 standards, and applies the wastewater at agronomic rates to land application areas throughout the development. HydroFocus, Inc. worked with the City, other consultants, and the California Regional Water Quality Control Board to obtain approval for disposal of treated wastewater to land. A key issue for the City was to identify land areas acceptable for treated wastewater disposal. This required that HydroFocus assess past irrigation practices, historical and planned water supplies (San Joaquin River water and treated wastewater), and variable soil types and composition. We utilized soil sample analytical results, groundwater quality data, geochemical modeling results, and hydrogeologic information to identify those areas where land disposal activities would not degrade existing groundwater quality. The analysis was critical to obtaining the Waste Discharge permit from the Regional Board. As part of Lathrop’s Waste Discharge Requirements, HydroFocus designed the approved Groundwater Monitoring and Sample and Analysis Plan, directed well installation and workplan implementation, and presently is conducting the quarterly water supply and groundwater quality monitoring and reporting.


Wastewater Treatment Plant Groundwater Investigation, City of Lodi, San Joaquin County, (1999 – Present). WYA completed a detailed groundwater study to assess existing conditions near the City of Lodi Water Pollution Control Facility, which includes a large agricultural reuse area that is irrigated with approximately 100 million gallons per year of high-salinity cannery wastewater (in addition to the City’s effluent). This effort culminated in a rigorous study that detailed a variety of natural and anthropogenic factors that affect groundwater quality in the region of the WPCF, which was complicated by the fact that the WPCF is located at the margins of the Sacramento-San Joaquin River Delta where salinity levels are naturally elevated. Through these efforts, WYA helped the City to identify the appropriate locations for “background” monitoring wells.

WYA has also represented the City in responding to a petition filed against the City’s discharge permit. The primary issue raised was whether the City’s land application practices should be exempt from Title 27 regulations if there is wastewater applied to the agricultural area that has elevated salinity levels. Recently, the State Water Resources Control Board issued a draft Order in response to this petition that confirmed that the City’s activities were not exempt from Title 27, in part due to the elevated salinity levels. WYA represented the City in a hearing on this matter, providing compelling documentation regarding naturally-occurring regional impacts on groundwater salinity levels. As a result, the State Water Resources Control Board did not adopt the Draft Order and is currently reconsidering the entire matter.

Wastewater Treatment Plant Groundwater Investigation, City of Galt, San Joaquin County (2002-present) WYA has completed a groundwater monitoring study for the City that demonstrates compliance with the City’s Waste Discharge Requirements for land application. The services have included evaluation of existing conditions, well siting, work plan preparation, Regional Board negotiations, well construction and monitoring, and preparation of quarterly and annual reports. As a result of these efforts, the City has demonstrated that additional controls for groundwater protection are not necessary under the State’s anti-degradation policies.

Processes Affecting Water Quality in the Sacramento-San Joaquin Delta (Department of Water Resources, 2000 – 2006). In the Sacramento-San Joaquin Delta, drainage of agricultural soils releases salt, nutrients, dissolved organic carbon, and disinfection byproduct precursors into Delta channels that provide drinking water for millions of Californians. HydroFocus, Inc. evaluated processes affecting drainage water quality under different land and water-management practices. Using groundwater-flow and transport modeling (MODFLOW and MTD3D), we evaluated options for reducing salt, dissolved organic carbon and disinfection-byproduct-precursor loads to Delta channels. Extensive field work conducted by HydroFocus included well installation and chemical and physical data collection (lithology, water quality, aquifer tests, water
levels, isotopic data). The geochemical model PHREEQE was utilized to assess water-quality changes from irrigation practices and oxidation of organic soils. A 2007 journal article summarizes some of the project results: S.J. Deverel and others, Processes Affecting Agricultural Drain-water Quality and Organic Carbon Loads in California’s Sacramento-San Joaquin Delta in San Francisco Estuary and Watershed Science. (http://repositories.cdlib.org/jmie/sfews/vol5/iss2/art2/).

Wastewater Treatment Plant Groundwater Monitoring and Reporting Program and Reuse Evaluation. WYA has recently been retained by the City of Davis to evaluate the groundwater conditions near the City’s Water Pollution Control Facility, which includes a number of clay lined ponds, and overland flow system and a wetland facility. WYA will also provide technical assistance in current negotiations with the Regional Board concerning groundwater protection needs. Of particular concern are the high salinity levels in the City’s WPCF effluent and the potential for this salinity to impact to underlying groundwater quality. However, there are also a number of regional influences on groundwater salinity. Therefore, WYA will perform groundwater monitoring studies to better understand the relationship between the potential impacts associated with the WPCF and the influence of regional conditions on underlying groundwater quality.

San Joaquin River Restoration (2006). As expert witness for Natural Resources Defense Council, HydroFocus contributed to the 2006 legal process for restoration of San Joaquin River flows by evaluating river groundwater interactions and effects of reduced deliveries on groundwater pumping. We analyzed historical data and utilized a groundwater-flow model to assess effects of changing water management practices. Our analysis resulted in a comprehensive understanding of factors affecting spatially variable groundwater influences on San Joaquin River flow and potential effects on river temperature. Also, our analysis of opposite-side expert testimony resulted in extensive upheaval to the underpinnings of their arguments.

Evaluation of Water Quality in Rice Growing Areas, Sacramento-San Joaquin Delta (2002 – 2004). HydroFocus successfully worked with UC Davis personnel the Regional Water Quality Control Board San Joaquin Ag Unit to quantify water quality impacts associated with rice growing and to develop strategies for minimizing discharges of nutrients and dissolved organic carbon. (This was a State Water Board funded grant project administered by the Regional Board.)

Development of the Environmental Impact Statement for the Regional Board Agricultural Discharge Waiver Program (2006). HydroFocus worked with Jones and Stokes and the Regional Water Quality Control Board Irrigated Lands Section to assess groundwater quality related to agricultural activities in the Sacramento Valley. HydroFocus analyzed land use, groundwater quality,
pesticide use data to develop a basin-wide assessment of current groundwater quality conditions. The final report was submitted to the Regional Board.

**Cal Water – South San Francisco District Water Supply and Facilities Master Plan (2007).** In San Mateo County, the Westside Groundwater Basin provides a significant portion of the water supplied by California Water Service Company’s South San Francisco District. As demands for water increase, coordinated groundwater and surface water use is critical to maintaining a reliable water supply. HydroFocus characterized and assessed the Westside Groundwater Basin for Cal Water’s Water Supply and Facilities Master Plan. We employed soil moisture accounting methods to describe a basin-wide water balance, and utilized a numerical ground-water flow model to project future groundwater level trends with respect to current and projected land and water use conditions (increased demand, emergency back-up water supply, conjunctive-use, and recycled water). We completed a detailed assessment of existing well water quality with respect to current and anticipated future state and federal drinking water standards, including temporal trends in increasing contaminant levels such as nitrates, iron, manganese, VOCs, TDS, and TCPA. We retrieved soil and groundwater quality information from county and state databases and integrated the information with aquifer productivity, water quality, and land use data to identify favorable locations for new wells.

**Evaluation of Groundwater Pumping for Reducing Drain-water Volumes (Western San Joaquin Valley, 2002).** Subsurface drainflow from agricultural land in the western San Joaquin Valley must decrease to reduce water quality impacts on the San Joaquin River. HydroFocus in cooperation with the US Bureau of Reclamation and Central California Irrigation District evaluating the hydraulic effects of pumping from production wells. We collected water level and drainflow data during 1 summer while two large production wells pumped about 1,000 acre feet. Using hydrologic analysis and groundwater flow modeling, we determined that pumping has an effect on shallow groundwater levels which in turn can reduce drainflow.

**Land Retirement (western San Joaquin Valley, California, 1998).** The Central Valley Project Improvement Act proposes to remove land from agricultural production to reduce irrigation drainage in the western San Joaquin Valley. Because land retirement alters the quantity and distribution of water-table recharge, managers must identify land retirement effects on the groundwater-flow system. HydroFocus, Inc. evaluated hydrologic changes due to land retirement using a groundwater-flow model. Our analysis projected future changes in groundwater storage and drainflows resulting from different retired land parcels.
Key Personnel

CV Salinity Technical and Executive Committees

Stakeholder Interface and Regional Planning
Steve Macaulay (WY)

Project Management/Leadership
Steve Deverel (HF)

Technical Advisory
Will Horwath - UCD
(Dairy, Soil Biogeochemistry, Nitrogen Issues)

Wesley Wallender - UCD
(Agricultural Irrigation, Surface/Subsurface Ecohydrology)

Yan Hopmans - UCD
(Yadose Zone Hydrology)

Steve Millard
(Environmental Statistics)

GIS/Database Management and Data Access, Mapping
Dave Leighton (HF)

Groundwater/Surface Water Hydrologic Salt and Nutrient Budget Analysis
John Flo (HF)
Gus Yates (HF)
Tim Durbin (WY)
Ken Loy (WY)
Monique de Barruel (WY)

(HF) HydroFocus, Inc. (WY) West Yost Associates
Steven Deverel, Ph.D. (Principal Hydrologist, HydroFocus, Inc.) has over 25 years of hydrologic problem-solving experience. Dr. Deverel analyzes groundwater systems, quantifies chemical and physical processes in soils, and evaluates groundwater- and surface-water quality. He is a recognized expert on hydrologic and water quality issues in the Sacramento-San Joaquin Delta and San Joaquin Valley where he has evaluated processes affecting groundwater and surface-water quality. Dr. Deverel’s professional experience includes over 10 years of hydrologic research, project leadership and organizational management at the U.S. Geological Survey, and over 13 years of experience in private consulting. His work is published in over 30 peer-reviewed journal articles and reports.

Steven Macauley, P.E. (Vice President, West Yost Associates). Mr. Macaulay has been active since the 1970s in engaging stakeholders in public planning processes. Major past efforts include his role as a member of the team at the SWRCB developing new Delta water quality standards (1976-1978), member of DWR’s team supporting designation of five northern California rivers as additions to the National Wild and Scenic Rivers System (1980-1981), Manager of DWR’s Kern Water Bank planning program (1987-1990), Manager of the State’s Drought Emergency Water Bank (1991 and 1992), member of the Public Advisory Committee for the 1998 and 2005 Updates to the California Water Plan (and initially a PAC member for the 2009 Plan), member of the CALFED Bay-Delta Public Advisory Committee (2005-2007), and member of the Delta Planning Commission (2001 – 2003). In addition, he worked closely with the Water Education Foundation as a panel moderator and speaker for several regional stakeholder workshops for the Delta Vision process (2007 and 2008). While Mr. Macaulay has been an advocate for various policy and project proposals over the years, his reputation within the broad water resources stakeholder community is very positive – particularly in the context of respecting policy positions of others and strong support for underlying, sound science.

Mr. Macaulay’s regional planning experience covers many of the projects described above, as further described in his resume. In addition, he worked directly as part of the consultant team in developing the 2007 Yolo County Integrated Regional Water Management Plan, and along with team member Monique de Barruel continues to work for the Water Resources Association of Yolo County and several of their member agencies (City of Davis, City of Woodland, RD 2035, Yolo County Flood Control & Water Conservation District) in support of their local and regional water resources planning and implementation efforts.

Tim Durbin, Managing Engineer, West Yost Associates, has over 40 years of engineering experience and directs projects relating to groundwater and surface-water hydrology. Areas of expertise include design of multidisciplinary investigations, design of large-scale programs for the collection and interpretation
of hydrologic data, and application of mathematical modeling to the analysis of problems in groundwater and surface-water hydrology.

**John Fio, MS (Principal Hydrologist, HydroFocus, Inc.)** has over 25 years of problem-solving experience. Mr. Fio analyzes groundwater systems, quantifies chemical transport in the subsurface, and evaluates groundwater surface-water interactions. He is a recognized expert on hydrologic and water quality issues in the San Francisco Bay Area and the San Joaquin Valley, California. Mr. Fio’s professional experience includes almost ten years of research and project leadership with the U.S. Geological Survey, and over eleven years of experience in private consulting. His work is published in 16 peer-reviewed journal articles and reports.

**Ken Loy (Principal Hydrogeologist, West Yost Associates)** is a certified hydrogeologist and engineering geologist with 19 years of experience in engineering consulting with emphasis on hydrogeologic and water quality characterization, data analysis, and modeling. Ken has characterized hydrogeologic conditions, assessed land and water use practices, conducted statistical analysis of groundwater quality data, and applied numerical groundwater flow and transport models in groundwater impacts analyses. He has conducted land subsidence evaluations, designed wells, and provided design services during construction of wells.

**Eugene (Gus) Yates (Senior Hydrologist, HydroFocus, Inc.)** has been a professional hydrologist in California for over 25 years. His role in water resources management projects commonly bridges the technical and policy realms. He specializes in rapidly identifying the key water-related issues for a project and addressing them with appropriate quantitative tools that make the best use of available data. He ties his technical work back into management plans and regulatory compliance documents. He has extensive experience in analysis and management of groundwater basins and related surface water and habitat systems throughout central and northern California. Mr. Yates is registered with the State of California as a professional geologist and certified hydrogeologist.

**David Leighton (Hydrologist, HydroFocus, Inc.)** has over 22 years of hydrologic experience. Mr. Leighton specializes in the development and application of Geographic Information Systems (GIS) in hydrologic investigations. He collects and manages hydrologic data, analyzes groundwater systems, and develops and implements numerical models. Past projects include numerical simulation of drainage-water management alternatives, conjunctive use operations, and VOC and PCBs transport.

**Monique de Barruel, P.E., Associate Engineer, (West Yost Associates)** has 5 years of experience in civil/environmental engineering. She obtained a Master’s Degree in environmental engineering with a focus in water quality and water
resources management. Her areas of expertise include natural wastewater
treatment systems, stream restoration, wetland systems, hydrology, and water
quality. Ms. de Barruel’s project experience consists of a conjunctive use pilot
program in Yolo County, water meter implementation program in the City of
Woodland, an infiltration and inflow study for the City of Vacaville, water quality
monitoring for the California Department of General Services, grant application
preparation, water transfers, as well as groundwater monitoring reporting for the
City of Galt, Flag City, and Reclamation District 2035.

Proposed Scope of Work – Phase I

Task 1 – Pilot Work Plan Development
We propose three areas for Pilot Work Plan Development. The pilot areas
represent key hydrologic settings in the Central Valley: eastern San Joaquin
Valley (Turlock/Modesto area), western San Joaquin Valley (Panoche Water
District/Grasslands Drainage Area), and the Sacramento Valley (Davis/Woodland
area). Table 1 summarizes the criteria we considered to select the three pilot
areas.
<table>
<thead>
<tr>
<th>Possible Pilot area</th>
<th>Water Quality and Hydrologic Data availability</th>
<th>How representative is the pilot area?</th>
<th>Possible limitations and willingness to cooperate</th>
<th>Team experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panoche Water District or Grasslands Drainage Area1</td>
<td>Large amount of historic hydrologic and water quality data available because of intensive study during San Joaquin Valley Drainage Program. Recent data monitoring due to regulatory concerns and permitted discharge. Groundwater flow models available.</td>
<td>Western San Joaquin agricultural watershed. No significant non-agricultural influence. Agricultural drainage is a key issue. Grasslands Drainage Area influences San Joaquin River water quality.</td>
<td>Previous work with Grasslands and Panoche Water District representatives indicate general openness to share data for most water districts in the area.</td>
<td>HydroFocus: Grasslands Bypass projects, San Luis Feature Re-evaluation, USGS studies conducted by John Fio and Dave Leighton.</td>
</tr>
<tr>
<td>Yolo County (Davis, Woodland area).</td>
<td>Large amount of hydrologic and water quality data available because of intensive State funded Willow Slough study. Groundwater flow model developed by Yolo County. Local water agency maintains groundwater quality data base. Part of southern Sacramento Valley GAMA study of.</td>
<td>Representative agricultural watershed in Sacramento Valley and includes significant urban areas. Documented groundwater nitrate concerns. Significant groundwater surface water interactions.</td>
<td>Some landowners hesitate to divulge data. Positive working relationships with key agencies and stakeholders.</td>
<td>HydroFoucs: Willow Slough Watershed study and Willow Slough Watershed Plan. City of Davis and City of Woodland are West Yost clients.</td>
</tr>
<tr>
<td>Turlock/Modesto</td>
<td>Large amounts of data available. Groundwater flow models available. Hilmar, Gama and USGS study areas.</td>
<td>Representative eastside San Joaquin Valley agricultural area. Urban wastewater land disposal area. Hilmar study location.</td>
<td>Data access and presentation may be an issue.</td>
<td>HydroFocus (Gus Yates) and West Yost (Tim Durbin) experience with Turlock Irrigation District and Modesto Irrigation District groundwater-flow and solute transport model development and applications.</td>
</tr>
</tbody>
</table>

1 Panoche Water District is part of the larger Grasslands Drainage Area. The Grasslands Drainage Area includes diverse land and water use practices. We initially recommend focusing on Panoche Water District because subareas of the district have already been defined, and there is substantial data and hydrologic understanding.
Subtask 1.1 Pilot Area selection and delineation.

The initial Pilot Areas are necessarily limited to three because it provides a starting point for rapid and effective data collection, compilation, and analysis which would not be possible without our extensive past experience in these areas. In consultation with CV-SALTS, we will review, revise and refine our list of recommended Pilot Areas (Table 1). We anticipate additional Pilot Areas can be added early in the process as initial results provide feedback and an opportunity to modify and improve the analytical approach while including alternative areas representing different criteria. We have budgeted for three pilot areas. If additional areas are identified, additional funds will be required. Our estimated budget for Phase I is $215,092.

Once the Pilot Areas are confirmed, we shall employ ArcGIS mapping and spatial analysis software to delineate boundaries. Pilot Area boundaries shall be based on watershed boundaries or, when necessary, political boundaries in order to best represent hydrologic conditions and the ultimate goal of developing constituent budgets. Each pilot area shall then be subdivided to represent key hydrologic characteristics or management opportunities. For example, Fio and Leighton (1991) utilized groundwater and land use data to delineate three hydrogeologically distinct subareas within Panoche Water District. Other factors to consider may include agricultural land and water use (e.g. cropping patterns and irrigated versus non-irrigated practices), soil type, and irrigation water supply (surface water, groundwater, dryland). The subareas would be finalized in consultation with CV-SALTS.

Subtask 1.2 Identify significant Pilot Area salt and nutrient sources.

Both chemical and flow data are needed to effectively define salt and nutrient sources. Based on our experience, we developed the following preliminary summary of significant salt and nutrient sources and available data for the Central Valley (Table 2). We propose to expand and refine Table 2 after additional follow-up investigation and data-mining efforts.

For each Pilot Area, we shall analyze and condense the Table 2 information into a concise, prioritized description of significant salt and nutrient sources. The relative magnitudes of the different components will guide efforts toward additional data mining efforts and improving the reliability of salt balance calculations.
Table 2. Preliminary list of salt sources, sources of flow data and available data.

<table>
<thead>
<tr>
<th>Salt Sources</th>
<th>Possible Flow Data Sources</th>
<th>Available Salt Load and Water Quality Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep percolation through agricultural soils</td>
<td>• Simulated soil moisture budgets</td>
<td>See specific components below.</td>
</tr>
<tr>
<td></td>
<td>• Measured tile drain discharges</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Collection and measurement of deep percolation (rare).</td>
<td></td>
</tr>
<tr>
<td>Natural soil minerals</td>
<td>N/A</td>
<td>• Soil surveys</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Predevelopment rainfall and leaching potential.</td>
</tr>
<tr>
<td>Irrigation</td>
<td>• Surface water: project or district operations records</td>
<td>• Site-specific soil mineral dissolution studies (e.g. Deverel and Fio 1991).</td>
</tr>
<tr>
<td></td>
<td>• Groundwater: simulated crop water demand minus surface water applications. (Few groundwater pumping records are available for the Central Valley).</td>
<td></td>
</tr>
<tr>
<td>Fertilizers</td>
<td>N/A</td>
<td>• Surface water quality from project or district records.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• GW quality based on USGS,DWR, CDPH, and GAMA databases.</td>
</tr>
<tr>
<td>Soil amendments</td>
<td>N/A</td>
<td>• CDFA statewide nitrate contamination sensitivity map.</td>
</tr>
<tr>
<td>Deep percolation through urban soils</td>
<td>• Simulated soil moisture budgets calibrated to seasonal curve separation of municipal water use.</td>
<td>• CDFA “tonnage reports”</td>
</tr>
<tr>
<td>Urban natural soil minerals</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Urban Irrigation</td>
<td>Seasonal curve separation of municipal water use</td>
<td>Municipal water purveyor records</td>
</tr>
<tr>
<td>Urban Fertilizers</td>
<td>N/A</td>
<td>• CDFA tonnage reports</td>
</tr>
<tr>
<td>Urban stormwater infiltration</td>
<td>Impervious area x annual rainfall, minus runoff to streams (mostly ungaged, but sometimes pumped)</td>
<td>• EPA and other studies of stormwater WQ.</td>
</tr>
<tr>
<td>Natural groundwater minerals</td>
<td>Seawater intrusion: doesn’t occur in Central Valley</td>
<td>Subsidence &amp; clay compaction: Upwelling of deep saline water as per east side San Joaquin Valley data</td>
</tr>
<tr>
<td>River and stream percolation</td>
<td>• Sometimes cannot calculate flow losses between gages because of too many ungaged irrigation return flow ditches (e.g. Merced and Tuolumne Rivers next to TID)</td>
<td>• USGS NWIS surface water quality database</td>
</tr>
<tr>
<td></td>
<td>• USGS studies of SJ River gains/losses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Models or local studies</td>
<td></td>
</tr>
<tr>
<td>Canal seepage</td>
<td>Project or district operations records</td>
<td>Project or district operations records</td>
</tr>
<tr>
<td>Groundwater inflow</td>
<td>Existing GW flow models</td>
<td>GW quality data for wells near inflow boundary</td>
</tr>
<tr>
<td>WWTP percolation ponds</td>
<td>RWQCB waste discharge records</td>
<td>RWQCB waste discharge records</td>
</tr>
<tr>
<td>Agricultural</td>
<td>Ditto (feedlots)</td>
<td>Ditto (feedlots)</td>
</tr>
<tr>
<td>Municipal</td>
<td>Ditto</td>
<td>Ditto</td>
</tr>
<tr>
<td>Industrial</td>
<td>Ditto</td>
<td>Ditto</td>
</tr>
<tr>
<td>Domestic septic systems</td>
<td>County unincorporated area population</td>
<td>Standard loading factors (textbook)</td>
</tr>
</tbody>
</table>
Subtask 1.3 Develop and document data accuracy evaluation methods.
Before collecting additional flow and quality data, we will develop and document methods for assessing the accuracy of various data sources. Primary sources of water quality data uncertainty include 1) analytical, 2) field data collection, 3) spatial and temporal variability. For load calculations, flow data are necessary but often introduce substantial uncertainty due to field measurement or estimation methods. Based on our knowledge of possible sources of uncertainty and with input from data providers and stakeholders, we will develop and document screening and quality assurance and control methods for future utilization of the data and for extending the procedures throughout the Central Valley. The Wildermuth Santa Ana Evaluation will provide good guidance for evaluating data quality.

Subtask 1.4 List available data sources and types and assess data quality.
Table 2 begins the task of listing data sources, which we will expand as part of Subtask 1.4. In the pilot area context, data expansion will focus on local data sources. For example, in Panoche Water District, drainflow and drainwater quality monitoring data are available. Similarly in Yolo County, Yolo Flood Control and Water Conservation District (a West Yost client and cooperator in the Willow Slough Watershed Study) maintains a database of groundwater quality data. Data are also available through the GAMA program. Using the methodologies documented in subtask 1.3, we shall augment our table to provide an assessment of data quality.

Subtask 1.5 Identify data gaps and propose methods to bridge them with estimated values.
In the proposed subareas, we have knowledge of additional data that may need to be developed. For example, in the Grasslands Drainage Area and Panoche Water District, additional data for groundwater use and quality will be required. As another example, for agricultural areas, the source of nitrogen loads to groundwater is mostly from fertilization; fertilizer application rates are often difficult to quantify at local scales using the existing available data. We will contact local agencies, farmers and other stakeholders in the pilot areas to obtain additional sources of available data as well as the relationships between land use, cropping patterns, and other farming practices that can influence fertilizer use and application rates.

We will propose methods to fill remaining data gaps with indirect estimates obtained by a variety of methods, including regional estimates, extrapolation from similar areas, existing models, or simulation of known physical and chemical processes such as soil moisture balances and soil chemistry. For example, existing groundwater flow models are available that can provide estimates of groundwater flow across pilot area boundaries, distributed recharge from rainfall...
and irrigation water, vertical flow within the basin, and water exchange between river and the groundwater systems. At the broadest scale, the USGS CVRASA2 model and DWR’s C2VSIM Central Valley model cover the entire Central Valley. Models are also available for many parts of the Valley. HydroFocus and West Yost members Tim Durbin and Gus Yates operate a FEMFLOW3D model of the Turlock Irrigation District area, and a USGS MODFLOW model of the Turlock-Modesto area is also available. Three USGS models have been developed for areas partially overlapping Panoche Water District and Grasslands Drainage Area, and they could potentially provide useful estimates of salt budget variables. Integrated Groundwater and Surface-water Model (IGSM) and USGS MODFLOW groundwater flow models have been developed for the Willow Slough Watershed and Yolo County.

Subtask 1.6 Demonstrate how data collection shall account for total salt load, salt balance and salt accumulation for each pilot area.

In the Central Valley, analysis of salt loads, salt balances and salt accumulation must be tempered with evaluation of the time lag for salts to move from sources to discharges. For the pilot areas we have studied, this lag time can be several years to decades. Therefore, changes in salt storage, residence lag times, and the uncertainty in constituent traveltimes must be considered. As an example, regional estimates for movement of saline groundwater to well screens in the western San Joaquin Valley vary several fold depending on assumptions about the range in aquifer permeability and the distribution of coarse- and fine-grained sediment beds.

Our initial salt load calculation approach shall first estimate input and output term independently, and the net “residual” assumed to represent the storage change. As a first accuracy check, we shall compare calculated storage changes with observed historical trends to assess whether the results are reasonable. The comparison shall consider time lag effects, spatial variability, and uncertainty.

The best measure of success may not be the salt budgets themselves, but rather how well the budget framework serves stakeholders within a regional context develop strategies to minimize salt loads to receiving waters. We believe stakeholders are best served with budgets and loads that quantify and minimize uncertainty. When we speak of uncertainty, we refer to an answer to the question; how wrong can we be in developing terms for salt and nutrient budgets? We anticipate that much of the answers will come from subsequent modeling in Phase II designed to provide probabilistic estimates of land- and water-management effects. However, substantial work can be done in Phase I to estimate uncertainty associated with available data. We therefore envision data collection efforts targeted to account for loads, calculate salt balances, and estimate salt and nutrient accumulation. This can be accomplished through 1) data collection efforts that prioritize the most important terms, 2) quantifying and minimizing data uncertainty, 3) working with stakeholders in a regional context to
develop technical consensus, and 4) developing data sets that support model
development that account for uncertainty.

Subtask 1.7 Identify critical concentration discharges.
Throughout the Central Valley—including the recommended pilot areas—
discharges to groundwater are of critical concern. Other important discharges
include subsurface drainage water discharged to the San Joaquin River and
tributaries, and groundwater discharges to surface water. We will use our
knowledge of the Central Valley and pilot areas to work with CV-SALTS and local
agency personnel to identify other critical discharges.

Subtask 1.8 Ensure the magnitude of each source is accurate when
combined into the overall salt balance.
We propose to use quality assessment tools developed in subtask 1.3 to ensure
each budget and load term is as accurate as possible and to quantify its
uncertainty.

Subtask 1.9 Identify methods to calculate historical, current and
future salt and nutrient trends.
The response of concentrations in the groundwater system to changes in
activities at the land surface occurs over time scales of decades to centuries.
Although some studies have been able to use historical water quality data to
detect statistically significant trends over time spans of 2-8 decades, these
retrospective analyses do not provide a link to current and future management
practices. For future management, modeling methods will provide the most
useful estimates of projected trends. Models can incorporate changes in inputs
(for example, fertilizer use) and incorporate spatial variability and time lags
known to affect the long-term impacts on water quality deep within the basin. We
will develop a workplan to use existing and straightforward models for estimating
salt and nutrient fluxes from the unsaturated zone and translating the results into
long-term groundwater concentration trends.

Subtask 1.10 Identify and quantify areas where nutrients, especially
nitrates, impact beneficial water uses.
Beneficial groundwater use is the large scale key water resource impairment. In
many Central Valley municipalities, nitrates impair groundwater use (Davis and
Woodland are examples of this in the proposed Yolo County subarea) and
concentrations are increasing. Salinity also impairs groundwater use and
impairment is expected to increase with time. We plan to work with CV-SALTS
using available data to identify and quantify areas where beneficial uses are
impacted. For irrigation uses, theoretical impairment may differ from what
farmers actually experience. For example, basin plan objectives might be based
on yield reduction in a salt-sensitive crop (e.g. dry beans), but farmers do not
experience impairment either because they do not grow dry beans or because
salt-related yield reduction is masked or compensated for by other environmental
and cultivation practices.
Subtask 1.11 Prepare Task 1 report
We shall compile the results of Subtasks 1.1 through 1.11 into a written work plan and circulate it to CV-SALTS members for review prior to beginning Task 2. The report will include an explanation of how our methods will provide best possible estimates of salt budgets and loads in the face of uncertainty. The Task 1 report will also provide a final list and description of the pilot areas.

Task 2 – Pilot Salt and Nutrient Studies and Report
For each approved pilot area we shall collect, review and validate constituent data in accordance with the work plan developed in Task 1. We propose that the data will be collected and entered into a Microsoft Access database. We propose to conduct the following subtasks.

Subtask 2.1 Review and validate data
Based on the methodology in the approved workplan, we propose to review and validate data and develop estimates of uncertainty for loads and budget terms.

Subtask 2.2 Develop GIS layers
We propose to use ArcGIS to store and develop maps. HydroFocus and WYA have substantial geographic information available including groundwater flow model inputs, soils data, groundwater quality data, physiographic data and land use. We shall incorporated additional data developed during subtask 2.3. To the extent applicable and where data is available we will use kriging to estimate distributions and spatial variances.

Subtask 2.3 Collect and enter data into database
At the outset we propose to use Microsoft Access as the primary data storage tool. We shall listen to the CV-SALT technical committee and our technical advisory specialists for the best way to organize data for future dissemination and fate and transport analyses. We shall solicit input for preferred models to employ and how best to organize the data. Team members have substantial modeling and data management experience using Access, US Geological Survey, State of California and proprietary data bases. HydroFocus, Inc. has the capability to make data available on its server using Sharepoint Server software. We have consulted with the Consortium of Universities for the Advancement of Hydrologic Science, Inc. Hydrologic Information System and will look to them for possible direction for storing data collected during the course of the project for broader access by the scientific community.

Subtask 2.4 Develop and evaluate salt budgets
We shall quantify fluxes and loads for nutrients and salts and develop salt and nutrient budgets based on the available data. We shall estimate uncertainty in flux, concentration and load terms and document effects of uncertainty of the
budgets and load estimates. After completing the salt and nutrient balances, we will identify data gaps that contribute the greatest amount of uncertainty to the balances. To assist CV-SALTS in its future salt and nutrient management efforts, we will outline potential data collection programs designed to fill key data gaps. In addition, we will use the budgets to identify potential opportunities for salt and nutrient management.

**Subtask 2.5 Write draft and final reports, make presentations.**

We propose to provide draft and final reports based on the agreed upon schedule and provide at least three presentations of interim and final results to committees and other stakeholders.
## Budget and Schedule

Based on our experience with the proposed subareas and consideration of the Task 1 subtasks, we developed the following tables showing our estimated costs for conducting phase I. All work will be conducted on a time and materials basis.

### Summary Budget Table (please see detailed budget and billing rates in Appendix B)

<table>
<thead>
<tr>
<th>TASKS</th>
<th>Estimated cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task 1. Pilot Area Workplan</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Subtasks:</strong></td>
<td></td>
</tr>
<tr>
<td>1.1. Pilot Area Selection and Delineation</td>
<td>$10,543</td>
</tr>
<tr>
<td>1.2. Identify salt and nutrient sources of significance</td>
<td>$6,784</td>
</tr>
<tr>
<td>1.3. Develop and document methods for evaluating data accuracy</td>
<td>$4,950</td>
</tr>
<tr>
<td>1.4. Develop a list of data sources and types of data that are currently available and evaluate the quality of the data</td>
<td>$6,545</td>
</tr>
<tr>
<td>1.5. Identify data gaps and propose methods to fill them with estimates</td>
<td>$4,658</td>
</tr>
<tr>
<td>1.6. Demonstrate how the data collection shall account for the total salt load, salt balance and salt accumulation for each of the pilot areas</td>
<td>$4,065</td>
</tr>
<tr>
<td>1.7. Identify critical concentration discharges</td>
<td>$5,481</td>
</tr>
<tr>
<td>1.8. Ensure the magnitude of each source is accurate when combined into the overall salt balance</td>
<td>$2,736</td>
</tr>
<tr>
<td>1.9. Identify methods for calculating historic, current and future salt and nutrient trends</td>
<td>$6,566</td>
</tr>
<tr>
<td>1.10. Identify and quantify areas where nutrients, especially nitrates are impacting beneficial uses of the waters</td>
<td>$4,472</td>
</tr>
<tr>
<td>1.11. Prepare Task 1 report meetings and travel</td>
<td>$14,714</td>
</tr>
<tr>
<td>Technical Review</td>
<td>$5,000</td>
</tr>
<tr>
<td>Contingency -10%</td>
<td>$8,636</td>
</tr>
<tr>
<td><strong>TASK 1 TOTAL</strong></td>
<td><strong>$94,991</strong></td>
</tr>
<tr>
<td>Task 2. Pilot Area Studies</td>
<td>Estimated Cost</td>
</tr>
<tr>
<td>----------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td><strong>Subtasks:</strong></td>
<td></td>
</tr>
<tr>
<td>2.1. Review and validate data</td>
<td>$14,850</td>
</tr>
<tr>
<td>2.2. Develop GIS layers</td>
<td>$15,225</td>
</tr>
<tr>
<td>2.3. Collect and enter data into database</td>
<td>$13,796</td>
</tr>
<tr>
<td>2.4. Develop and evaluate salt budgets</td>
<td>$19,225</td>
</tr>
<tr>
<td>2.5. Write draft report</td>
<td>$23,970</td>
</tr>
<tr>
<td>Write final report</td>
<td>$3,540</td>
</tr>
<tr>
<td>3 Presentations</td>
<td>$5,714</td>
</tr>
<tr>
<td>Meetings</td>
<td>$4,362</td>
</tr>
<tr>
<td>Technical Review</td>
<td>$8,500</td>
</tr>
<tr>
<td>Contingency 10%</td>
<td>$10,918</td>
</tr>
<tr>
<td><strong>TASK 2 TOTAL</strong></td>
<td><strong>$120,100</strong></td>
</tr>
<tr>
<td><strong>Phase I total</strong></td>
<td><strong>$215,091</strong></td>
</tr>
</tbody>
</table>
## Proposed Schedule

<table>
<thead>
<tr>
<th>TASKS</th>
<th>May-09</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>Sept.</th>
<th>Oct</th>
<th>Nov</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Subtasks:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 Pilot area selection and delineation, delineation of subareas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2 Define salt and nutrient sources of significance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3 Develop and document methods for evaluating data accuracy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4 Develop a list of data sources and types of data that are currently available and evaluate the quality of the data</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5 Identify data gaps and propose methods to fill them with estimates</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.6 Demonstrate how the data collection shall account for the total salt load, salt balance and salt accumulation for each of the pilot areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.7 Identify critical concentration discharges</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.8 Ensure the magnitude of each source is accurate when combined into the overall salt balance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.9 Identify methods for calculating historic, current and future salt and nutrient trends</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.10 Identify and quantify areas where nutrients, especially nitrates are impacting beneficial uses of water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.11 Prepare Task 1 report</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Technical Review</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Task 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Subtask:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 Review and validate data</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2 Develop GIS layers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3 Collect and enter data into database</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.4 Develop and evaluate salt budgets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5 Write draft report</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write final report</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Presentations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meetings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Technical Review</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
References Cited


Deverel, S.J. and Roger Fujii, 1988, Processes affecting the distribution of selenium in shallow groundwater of agricultural areas, Western San Joaquin Valley, California, Water Resources Research, 24, 516-524.


Deverel, S.J., Leighton, D.A. and Tesfay, T., 2008, Subsurface Processes Affecting Nitrate Mobility, Willow Slough Watershed, Yolo County, CA, Poster Presentation at CALFED Science Conference, Sacramento, California


Nightingale, H.I., 1970 Statistical evaluation of salinity and nitrate content and trends beneath urban and agricultural areas – Fresno, California: Ground Water v.8, no.1, p. 22-28.


Appendix A - Resumes
Monique de Barruel has 5 years of experience in civil/environmental engineering. She obtained a Master’s Degree in environmental engineering with a focus in water quality and water resources management. Her areas of expertise include natural wastewater treatment systems, stream restoration, wetland systems, hydrology, and water quality. Monique’s project experience consists of a conjunctive use pilot program in Yolo County, water meter implementation program in the City of Woodland, an infiltration and inflow study for the City of Vacaville, water quality monitoring for the California Department of General Services, grant application preparation, water transfers, as well as groundwater monitoring reporting for the City of Galt, Flag City, and Reclamation District 2035.

PROJECT EXPERIENCE

Water

San Luis Drain Disposal Option Alternatives. Assisted in investigations of alternatives for agricultural return water disposal in the San Luis Drain. Alternatives included ocean disposal, on-site ponds, and disposal to the Delta and San Francisco Bay. Investigated the potential impacts to Contra Costa County Water District’s drinking water supply. This project was completed prior to Monique’s arrival at West Yost Associates. U.S. Bureau of Reclamation, California.

Byron Ranch Assessment of Water Transfer Potential. Assisted in assessments of water available for transfer under various scenarios, met with various stakeholders, identified potential lessees, and provided reconnaissance-level evaluation of potential groundwater resources available as an alternative supply to Byron Ranch. This project also includes an investigation of the future water needs under a scenario of urban development of Byron Ranch. Contra Costa County, California.

Byron Ranch Temporary Water Transfer. Wrote petition for temporary transfer between Byron Ranch owner and Contra Costa Water District. Prepared transfer period fallowing and monitoring plan. Coordinated with State Water Resources Control Board and California Department of Fish and Game. Contra Costa County, California.

Prop 50 IRWM Implementation Grant Application. Prepared a combined Prop 50, Round 2, Step 1 grant application for the Yolo County Flood Control and Water Conservation District, RD 2035, Cache Creek Conservancy, and Lower Putah Creek Coordinating Committee. Yolo County Flood Control and Water Conservation District, RD 2035, Cache Creek Conservancy, and Lower Putah Creek Coordinating Committee.

Davis/Woodland Water Supply Project. Assisted in investigation of alternative means of supplying treated surface water to the Cities of Davis and Woodland and to the University of California Campus at Davis. Assisted in the preparation of a “Community Report” to describe the Project to the layperson. Project has involved close coordination with various project partners, environmental, and financial consultants. City of Davis, City of Woodland and University of California at Davis, California.
Yolo County Flood Control and Water Conservation District Incentive-Based Conjunctive Use Pilot Program. Project manager and engineer in creating an incentive-based conjunctive use program. The District had identified a need for this type of program as a result of irrigation water capacity needs, infrastructure constraints, and increasing drought concerns. This project included an economic rate analysis, well survey, and multiple meetings and coordination with District staff, District farmers, PG&E, and the Yolo County Farm Bureau. **Yolo County, California.**

Woodland Water Meter Implementation Plan. Project manager and engineer in creating a Water Meter Implementation Plan. The Plan includes recommendations on equipment selection, phasing, public education, and maintenance. This project included coordination with City staff from O&M, finance, planning, and engineering departments as well as coordination with other consultants for an economic rate analysis and meter sizing recommendations. In addition to this Plan, bid document preparation and engineering services during construction for the first phase of implementation were included in the scope of this project. **City of Woodland, California.**

Woodland Water Focus Study. Prepared several chapters of the Water Focus Study as a project engineer. Chapters included one on water demands, existing groundwater supply, and surface water supply. **City of Woodland, California.**

Woodland Public Relations Newsletter. Project manager in preparing several issues of the “Woodland Water News,” a public education newsletter that is included in water customer’s utility bills. Newsletter topics included water meters, aging infrastructure challenges facing Woodland, water meter Phase 1 implementation, and water system reliability improvements. **City of Woodland, California.**

**Wastewater**

Woodland Wastewater Treatment Plant Upgrade. Performed QA/QC on design specifications for the retrofit of WWTP from 8.5 to 10.5 mgd. **City of Woodland, California.**

Sanitary Sewer Infiltration and Inflow (I&I) Program. Served as staff engineer for a city-wide sanitary sewer I&I program involving sewer flow and surcharge monitoring, on-site inspection work, database management, field crew supervision, data analysis and reporting, and development/coordination of I&I control measures. **City of Vacaville, California.**

Central Valley Clean Water Association Data Compilation and Analysis. Served as a project team member in compiling and checking data from more than 20 wastewater treatment plants in California. **Central Valley Clean Water Association, California.**

Flag City Sanitary Sewer Influent Monitoring. Staff engineer for setting-up of a Flo-Dar flow measurement unit and training County staff how to download data. **San Joaquin County, California.**

Biosolids Land Application System Best Practicable Treatment Control (BPTC) Evaluation. Staff engineer for writing two technical memoranda including one on Historic Field Loadings and Revised Source Evaluation and one on Land Application System Best Practicable Treatment Control Assessment. In these technical memoranda, monthly site-specific crop nitrogen uptake rates were developed and historical field nitrogen uptake rates were revised. Potential land application system BPTCs for biosolids were also evaluated. **City of Lodi, California.**
Wastewater Reuse

Wastewater Reuse Facilities Planning. Staff engineer for wastewater reuse facilities planning for the Davis Water Pollution Control Plant. Several reuse alternatives were evaluated including both irrigation and wetland habitat reuse components. City of Davis, California.

Water Reuse Feasibility Study. Investigated the feasibility of using dewatering well water beneath the I-105 freeway for drinking. This project was completed prior to Monique’s arrival at West Yost Associates. City of Downey, California.

Permit Compliance

Regulatory Assistance. Assisted in writing the Report of Waste Discharge and filing the NPDES permit application. Department of General Services, Sacramento, California.

Regulatory Assistance. Assisted in writing the Pollution Prevention Plan, as required by the NPDES permit. Flag City, San Joaquin County, California.

Regulatory Assistance. Assisted in writing a dioxin, THM, and metals monitoring workplan which included the use of composite samplers. City of Atwater, California.

Water Quality Monitoring. Project engineer for water quality monitoring and data analysis of heating and cooling facilities, including sampling, lab coordination, reporting, and quality control. Department of General Services, Sacramento, California.

Groundwater

Groundwater Monitoring and Reporting. Project engineer for quarterly groundwater monitoring, analysis, and report writing. Flag City, San Joaquin County, California.

Groundwater Reporting. Project manager and project engineer for writing quarterly groundwater monitoring reports. City of Galt, California.

Groundwater Monitoring and Reporting. Project manager and project engineer for groundwater monitoring, analysis, and report writing. Reclamation District 2035, Woodland, California.

Drainage

Stormwater Drainage Master Plan. Project engineer for data collection, XP SWMM model development, and report writing. Reclamation District 777, Live Oak, California.
QUALIFICATIONS

Steven J. Deverel has over 24 years of hydrologic problem-solving experience in California. Dr. Deverel analyzes groundwater systems, quantifies chemical and physical processes in soils, and evaluates groundwater- and surface-water quality. He is a recognized expert on hydrologic and water quality issues in the Sacramento-San Joaquin Delta and San Joaquin Valley, California. Dr. Deverel is a registered professional hydrologist certified by the American Institute of Hydrology.

Steven Deverel:

- Conducts surface and groundwater quality assessments.
- Develops analytical tools and numerical models to evaluate water movement and solute transport.
- Quantifies chemical and physical processes in the saturated and unsaturated subsurface.
- Applies statistical techniques to analyze land and water resources.
- Evaluates land subsidence.
- Determines water sources using geochemical and age-dating techniques.

PROFESSIONAL EXPERIENCE

February, 1996 – present

Consulting Hydrologist in Private Practice and Principal Hydrologist and cofounder, HydroFocus Inc. since January, 1998, Davis, CA

Recent project activities include:

- Evaluate drainage alternatives in the western San Joaquin Valley, California. Specific tasks included soil salinity modeling to predict effects of alternatives, groundwater-flow and geochemical modeling for estimating future groundwater quality and hydraulic effects of alternatives.
- Subsidence mitigation strategy evaluation – Sacramento-San Joaquin Delta, California. Field data collection and modeling to evaluate different wetland management strategies for stopping and reversing the effects of subsidence.
• Evaluate processes affecting water quality – Sacramento-San Joaquin Delta. Field data collection and modeling to estimate organic carbon and salt loads for different wetland and agricultural water management practices.
• Evaluate subsurface flow and canal leakage, Nevada Irrigation District, Grass Valley California. Used water isotopes and modeling to determine effects, rates and nature of leakage.
• Assess pesticide transport in groundwater at EPA Superfund Site – Davis, California. Serves as technical advisor to community group overseeing site activities.
• Identify causes and subsidence rate calculation – Sacramento-San Joaquin Delta, California. Includes modeling of subsidence and estimating current and future rates.
• Evaluate groundwater supply, flow and quality in relation to land and water management practices in various locations – Examples include grape growing in Sonoma County, gravel mining in Sacramento and Butte counties, golf courses in Marin County, residential development in San Mateo County, agriculture and water transfers in Yuba County, wetlands in San Luis Obispo and Santa Barbara counties.
• Quantitatively evaluate processes affecting groundwater and spring water chemistry and effects of changing groundwater management in Southern Nevada.
• Serves on standing CALFED Science Panel

1994 to 1996

Senior Hydrologist, Hydrologic Consultants, Inc.  
Davis, CA

Consulting assignments included the following:
• Evaluated sea water intrusion, nitrate contamination and flow of groundwater and nitrate movement in unsaturated zone – Salinas Valley, California.
• Analyzed water supply and quality issues– Santa Ynez Valley, California.
• Developed water resources element of city General Plan – City of Lompoc.
• Advised California Department of Water Resources on issues relating to subsidence in organic soils – Sacramento-San Joaquin Delta.
• Quantified geochemical processes and groundwater flow for gold mining operations – northern Nevada.

1991 to 1994

Sacramento, CA

Assistant District Chief: Guided hydrologic research, investigations and data collection programs throughout California:
• Supervised and planned research of land- and water-management effects on subsidence and carbon fluxes – Sacramento-San Joaquin Delta.
• Facilitated interactions among diverse projects and personnel.
• Developed and maintained projects investigating processes affecting land and water resources.
• Communicated research results to the resource management community and other audiences using published reports and oral presentations.
• Established long range research and data collection activities.
• Responsible for over 100 employees and an annual budget of over $11 million.
1984 to 1991

Research Chemist, U.S. Geological Survey, Sacramento, CA

Project leader: Directed studies of processes affecting constituent mobility and transport. Evaluated transport processes in aqueous and gaseous phases. Conducted regional, subregional and local scale studies. Guided an interdisciplinary team that integrated multi-scaled data:

- Defined water and solute movement to agricultural drainage systems.
- Identified processes affecting trace element mobility in soil and water.
- Evaluated and implement statistical methods.
- Directed hydrologic study of water quality, carbon fluxes and subsidence in organic soils – Sacramento-San Joaquin Delta:
  - Identified processes affecting subsidence.
  - Related carbon fluxes from organic soils to subsidence and global carbon balance.
  - Developed water and land management strategies for reducing subsidence.
  - Determined water management effects on drainage water quality.

1980 to 1984

Research Associate, University of California, Davis, CA

- Developed computer code to simulate solute transport and chemical reactions in soils and shallow groundwater.
- Designed and implemented water movement and chemical experiments for the laboratory and field – Sacramento-San Joaquin Delta.
- Co-authored book chapter on simulating reclamation of salt affected soils.

ACADEMIC BACKGROUND

Ph.D., June, 1983, Soil and Water Science, Department of Land, Air and Water Resources, University of California at Davis
MS, September, 1980, Soil-Plant-Water Relations, Department of Vegetable Crops, University of California at Davis
BS, December 1979, Agricultural Science and Management, University of California at Davis
BA, June, 1974, Zoology, University of California at Berkeley
Lecturer, Department of Land, Air and Water Resources and Associate in the Experiment Station, University of California at Davis, 1988-1992, Taught undergraduate course "Chemistry of the Hydrosphere"
PhD dissertation and oral-exam committee member for University of California, Davis Hydrologic Sciences graduate students., 2001 – present
PROFESSIONAL AFFILIATIONS

American Geophysical Union
American Institute of Hydrology – registered professional hydrologist
California Groundwater Resources Association
International Association of Hydrogeologists

AWARDS AND HONORS

Letter of appreciation from Assistant Secretary of the Interior, 1985

RELEVANT PUBLICATIONS, REPORTS and PRESENTATIONS

Vadose-Zone Hydrology, Biogeochemistry and Subsidence


Groundwater Geochemistry and Quality


Deverel, S.J., 1990, Distribution and mobility of selenium in irrigated areas in the western United States. American Association for the Advancement of Science, annual meeting, Davis California (invited presentation).

Deverel, S.J. and R.B. Bell, 1988, Carbon mass transfer and isotopic evolution in irrigated, semi-arid agricultural areas, EOS, 69:1194,.


Deverel, S.J. and Roger Fujii, 1988, Processes affecting the distribution of selenium in shallow groundwater of agricultural areas, Western San Joaquin Valley, California, Water Resources Research, 24, 516-524.


Statistics


Ground Water Hydrology


Tim Durbin has over 40 years of engineering experience and directs projects relating to groundwater and surface-water hydrology. Areas of expertise include design of multidisciplinary investigations, design of large-scale programs for the collection and interpretation of hydrologic data, and application of mathematical modeling to the analysis of problems in groundwater and surface-water hydrology.

**Project Experience**

**Antelope Valley Groundwater Basin, California.** The Antelope Valley groundwater basin is being adjudicated to address the overdraft within the basin. Developed criteria for defining the geographic extent of the groundwater. Developed estimate of natural recharge within adjudicated area. Work was done in support of litigation related to the adjudication. *City of Los Angeles, California.*

**Seaside Groundwater Basin, California.** The Seaside groundwater basin was adjudicated to balance the threat of seawater intrusion against the need for groundwater production to supply water to communities overlying the basin and within the Monterey Peninsula area. Developed a groundwater model to assess the relation between groundwater production and seawater intrusion. Work was done in support of litigation related to the adjudication. *California American Water, Monterey, California.*

**Carbonate Aquifer System, Eastern Nevada.** Analyzed the water-related impacts of groundwater development within the regional Carbonate Aquifer System that underlies central and eastern Nevada. The Southern Nevada Water Authority, which delivers water to Las Vegas and neighboring communities, is considering a project to import of groundwater from the Carbonate Aquifer. The analysis is focused on the possible impacts of the project on springs and phreatophytes. The work includes developing a groundwater model of the Carbonate Aquifer System. The model extends over an area covering 20,000 square miles. The work was done in support of hearings before the Nevada State Engineer on water-right applications by the Authority. The work was done also in support of the environmental compliance for the project. *Southern Nevada Water Authority, Las Vegas, Nevada.*

**North Platte River, Wyoming and Nebraska.** Analyzed the impacts of water-resource development and reservoir operations on water supply, streamflows, regional economics, and wildlife resources within the North Platte River Basin, Nebraska and Wyoming. Designed and directed a multi-disciplinary investigation involving agricultural engineers, groundwater hydrologists, surface-water hydrologists, agricultural economists, and environmental scientists in six different consulting firms. Work was done in support of litigation before the U.S. Supreme Court between the states of Nebraska and Wyoming. *Attorney General, Lincoln, Nebraska.*

**Santa Monica Groundwater Basin, California.** Analyzed the occurrence of MTBE in the Santa Monica groundwater basin, California. MTBE contamination from multiple sites has resulted in abandonment of public-supply wells. An analysis of the sources and fate of MTBE within the Santa Monica groundwater basin is being conducted. Work was done within the context of State and Federal regulatory proceedings and litigation. *ConocoPhillips, Houston, Texas.*


Special Master, California. Assigned as Special Master in a technical dispute between City of San Bernardino, California and the Regional Water Quality Control Board. The issue is the cause of a wastewater discharge to the Santa Ana River. The work was being done within the context of a State regulatory proceeding. Regional Water Quality Control Board, Santa Ana, California.


Directed projects related to groundwater and surface-water hydrology. Directed a staff of about 30 engineers, hydrologists, biologists, and geologists. Examples of such projects include:

Flooding, Arizona. Analyzed the causes of flooding near Phoenix, Arizona. Residential and commercial areas were flooded during a summer storm. The analysis involved assessing the effect of irrigation ditches and other facilities on the depth of flooding. The work was done in support of litigation.

Pipeline Break, California. Analyzed the impact of floodflows on the failure of a stream pipeline crossing within Thousand Oaks, California. A large sewer line failed owing to channel erosion during an extreme flood event. The recurrence interval of the erosion event was analyzed. The work was done within the context of a State regulatory proceeding.


Directed projects related to groundwater and surface-water hydrology. Directed a staff of about 30 hydrologists, geologists, and engineers. Examples of such projects include:

Lake Tahoe, California and Nevada. Analyzed the impacts of urban development on the water quality of Lake Tahoe, California. Work involved the analysis of sediment and nutrient transport in streams tributary to the lake and nutrient cycling within the lake. Work was done for litigation.

Streamflow Temperature, California. Analyzed streamflow temperature within the Owens River, Owens Valley, California. Work was done to evaluate the hydrologic feasibility of reestablishing a fishery within the Owens River.

Groundwater Salinity, California. Analyzed the source and management of surface-water and groundwater salinity within the Lompoc groundwater basin. Work involved developing groundwater and surface-water models of the Santa Ynez River basin, including salinity models. Work was done in support of litigation.

Agricultural Drainage, California. Analyzed the causes and management of drainage water discharges from the Firebaugh and Central California Water District to natural watercourses and the San Joaquin River. Work was done in support of litigation.

FERC Re-licensing, California. Developed a model for the optimal use of groundwater and surface water within the Turlock and Modesto Irrigation Districts for the benefit of water supply and environmental resources. Work was done in support of the FERC re-licensing of New Don Pedro Reservoir.

Seawater Intrusion, California. Analyzed seawater intrusion in the Salinas Valley. Analyzed the impacts of groundwater pumping on seawater intrusion. Analyzed the impacts of reservoir operations on streamflow recharge and seawater intrusion. Work was done in support of litigation.

Petroleum Contamination, California. Analyzed the source of soil and groundwater contamination by petroleum hydrocarbons at Santa Barbara, California. Work was done in support of litigation. Analyzed the source of soil and groundwater contamination by petroleum hydrocarbons at Oxnard, California. Work was done in support of litigation.

San Bernardino Groundwater Basin, California. Analyzed the occurrence of high groundwater levels in the San Bernardino Valley, California using surface-water and...
West Yost Associates


groundwater models. High groundwater levels resulted from excess artificial recharge and other factors. Work was done in support of litigation.

Arkansas River, Colorado and Kansas. Analyzed the effects of groundwater pumping and other factors in the depletion of streamflow in the Arkansas River at the Colorado-Kansas state line using surface-water, groundwater, and institutional models. Work was done in support of litigation in the U.S. Supreme Court between the states of Kansas and Colorado.

Geothermal Development, California. Analyzed the effects of geothermal development on thermal-spring discharges in the Mammoth Lakes area, California using groundwater and heat-transport models. Work was done in support of litigation.


Directed and conducted investigations of numerous aspects of groundwater hydrology. Examples of such projects include:

Love Canal, New York. Analyzed the migration of groundwater contaminants at the Love Canal hazardous waste site in Niagara Falls, New York using a groundwater model. The Love Canal site is a Superfund site. Work was done in support of litigation.

Groundwater Contamination, New Jersey. Analyzed the migration of groundwater contaminants at the Lone Pine landfill near Freehold, New Jersey. The Lone Pine landfill is a Superfund site. Work was done as part of a remedial investigation.

Modeling Code. Developed a computer program for the simulation of soil-water movement within and near a land-disposal facility. Work was done for the U.S. Environmental Protection Agency in support of the preparation regulations relating to the design of cover, liner, and leak-detection systems for land-disposal facilities.

Sediment Transport, California. Analyzed the impacts of urban development on flooding and sediment transport for streams in Orange County, California. Work supported the permitting of a large residential and commercial development project.

Williamson and Schmid, Hydrotec Division, Davis, California. Manager of Davis office (July 1984 – October 1985)

Directed and conducted investigations for evaluation of groundwater resources, management of regional groundwater systems, and evaluation of hazardous waste sites. Studies involved identification of essential hydrologic issues, collection of hydrologic data, and application of quantitative methods to evaluate alternatives and to select an optimal solution. Examples of such projects include:

Groundwater Contamination, California. Developed a three-dimensional groundwater model of a physical barrier at a hazardous waste landfill in order to evaluate performance of the existing barrier and proposed modifications. Work was done for regulatory compliance.

Isotope Geochemistry, California. Analyzed a hazardous waste site using isotope geochemistry and groundwater models as investigative tools. Work was done for regulatory compliance.

Groundwater Salinity, Nevada. Analyzed the utilization of fresh water body overlying saline water using surface geophysical techniques and a density-dependent groundwater flow model.


Managed California District (350 persons in 14 offices) with annual budget of $25 million (in 1995 dollars) for hydrologic investigations. Responsible for developing plans for hydrologic investigations and ensuring plans were implemented. Provided organizational and technical input to development of large scale, multi-agency investigations. Examples of such projects include:

Agricultural Drainage, California. Investigation of water quality related to
agricultural drainage from the west side of San Joaquin Valley, California.

San Francisco Bay, California. Investigation of hydrodynamics of San Francisco Bay and Sacramento-San Joaquin, California Delta hydrologic systems.

Groundwater Exports, California. Investigation of the effects of exporting water from Owens Valley groundwater basin, California, including both hydrologic and biological impacts.

Central Valley Groundwater, California. Assessment of the groundwater resources of the Central Valley, California. Work was part of the Central Valley Regional Aquifer System Analysis (RASA).

Modeling Code. Development of numerical finite element codes (now used within the U.S. Geological Survey) for simulation of two- and three-dimensional groundwater flow and solute transport.


Managed Nevada District (80 persons in three offices) with annual budget of $10 million (in 1995 dollars) for hydrologic investigations. Projects included:

Truckee River, Nevada. Design and organization of Truckee-Carson River Quality Assessment and Great Basin Regional Aquifer System Analysis (RASA).


Served as Project Chief for numerous groundwater projects involving hydrogeologic and geophysical investigations and groundwater modeling. Conducted research in development of finite-element models for simulation of groundwater flow and mass transport. Applied results of research to solution of management problems and provided assistance to hydrologists within USGS and other public agencies in use of these models.


**Books**


JOHN L. FIO

QUALIFICATIONS

John L. Fio has almost 25 years of problem-solving experience. Mr. Fio analyzes groundwater systems, quantifies chemical transport in the subsurface, and evaluates groundwater surface-water interactions. He is a recognized expert on hydrologic and water quality issues in the San Francisco Bay Area and the San Joaquin Valley, California.

John Fio:

- Develops and employs numerical models for site, water district, and basin-wide investigations.
- Calculates extraction effects on groundwater levels, stream flow, and lake levels.
- Establishes water quality monitoring programs.
- Designs water management plans.
- Evaluates groundwater quality effects of wastewater and recycled water disposal to land.
- Develops and implements Geographic Information System (GIS) databases.
- Determines water sources using chemical and age-dating techniques.

PROFESSIONAL EXPERIENCE

January, 1998 – present

Principal Hydrologist, HydroFocus, Inc. Davis, CA

- Water supply master plan, California Water Service Company, South San Francisco, California. Assessed water supply and quality benefits of alternative water supply projects in the Westside Groundwater Basin.
- Data and modeling analysis of regional drainage conditions – San Joaquin Valley, California.
- Groundwater-flow, solute-transport, and water-quality impacts from wastewater disposal to land: sanitary districts and municipalities located in San Joaquin and Contra Costa Counties, California.
- Groundwater extraction to control and remediate solvent plume – San Mateo County. Use of groundwater-flow model and field data collection and analysis to quantify contaminant movement and remediation.
- Groundwater recharge and subsurface storage, Merced County, California. Developed and implemented regional groundwater-flow model to assess groundwater recharge and pumping projects.
• Depletion of subsurface flow to the North Platte River, Wyoming and Nebraska. Data analysis and modeling of stream aquifer interactions in support of interstate water rights conflict.
• Hydrologic and geochemical impacts of groundwater pumping and surface water injection—Sacramento County.

1995 to 1997

Senior Project Hydrologist, Hydrologic Consultants, Inc. Sacramento, CA

Project experience in the evaluation of groundwater flow, water quality, and solute transport. Consulting assignments included the following:

• Developed relationships to describe geologic controls and load-flow relationships for Santa Ynez River drainage system. The Santa Ynez River is a significant source of water recharging the Lompoc Groundwater Basin, and the relationships were part of a network of interacting reservoir operations, surface-water, and groundwater-flow and transport models.
• Evaluation of groundwater-flow paths beneath South San Francisco Bay. The groundwater-flow system was quantified using a groundwater-flow model to assess system response to pumping centers located east and west of the Bay.
• Coordination with the California Regional Water Quality Control Board on the remediation of a VOC plume in Mountain View, California.
• Assess the response of groundwater levels, streamflow, and spring discharge to groundwater pumpage in the Mammoth Basin, California.
• Quantifying stream flow depletions owing to increased consumption and groundwater pumping.

1990 to 1995

Research Grade Hydraulic Engineer, U.S. Geological Survey Sacramento, CA

• Conducted regional and geohydrologic and groundwater quality investigations in the western San Joaquin Valley, California.
• Directed the development of a regional Geographic Information System database for the South San Francisco and Peninsula Area, California.
• Supervised data collection and development of databases, data analyses, and report writing.
• Constructed groundwater flow models for parts of the western San Joaquin Valley and South San Francisco Bay areas, California.
• Interacted with private and public cooperators and funding agencies.
1987 to 1990

Civil Engineer, U.S. Geological Survey                Sacramento, CA

- Conducted field-scale investigations of on-farm drainage systems.
- Developed groundwater-flow model of tile drainage system. Assessed flow paths and salt transport in shallow flow-system. Quantified regional groundwater-flow paths intercepted by on-farm drainage systems.
- Integrated particle-tracking models with groundwater-flow model results to assess advective transport of salts and selenium.

1985 to 1987

Hydrologist, U.S. Geological Survey                     Sacramento, CA

- Designed and conducted sorption experiments and incorporated results into a solute transport model.
- Assessed the distribution of salts and selenium in unsaturated and saturated soil profiles.
- Developed analytical method to estimate organic selenium concentrations in soil extracts.

1983 to 1984

Research Assistant, University of California           Davis, CA

- Conducted an assessment of methods used to analyze for selenium in soil extracts, aqueous samples, and animal tissues.
- Implemented experiments to assess arsenic volatilization from soils.
- Conducted laboratory analyses to estimate the buffering capacity of soils in response to acidic deposition.

ACADEMIC BACKGROUND

Master of Science, 1987, Civil Engineering, University of California at Davis
Bachelor of Science, 1984, Soil and Water Science, University of California at Davis

PROFESSIONAL AFFILIATIONS

American Society of Civil Engineers
Association of Groundwater Scientists and Engineers
California Groundwater Resources Association
AWARDS AND HONORS

Citation for Outstanding Performance, University of California, Davis (1981)
Edward Kraft Scholarship Prize, University of California, Davis (1981)

RELEVANT PUBLICATIONS

Hydrogeology of the San Francisco Bay Area

Metzger, L.F. and Fio, John L., 1997, Ground-water development and the effects on
ground-water levels and water quality in the Town of Atherton, San Mateo County,
California, U.S. Geological Survey Water-Resources Investigations Report 97-4033,
31p.

Development of the ground-water system, and general hydrologic and water-quality
conditions in 1990, south San Francisco Bay and Peninsula area, California: U.S.

Leighton, D.A., Fio, John L., and Metzger, L.F., 1995, Database of well and areal data,
South San Francisco Bay and Peninsula area, California: U.S. Geological Survey Water-
Resources Investigation Report 94-4151, 47 p.

Geochemistry and Salt Migration

1313-1320.

laterals, western San Joaquin Valley, California. 1: Geochemical Assessment, Water
Resources Research, v. 27, no. 9, 2233-2246 p.

Fio, John L., and Fujii, R., 1990, Selenium speciation methods and application to soil
saturation extracts from San Joaquin Valley, California: Soil Science Society of America

Fujii, R, and Fio, John L., 1988, Partitioning and speciation of soluble and adsorbed
selenium in soils: Agronomy Abstracts, Amer. Soc. Agron. Annual meetings, Anaheim,
California, p. 196-97.
Numerical Modeling – Groundwater flow and contaminant transport

**Fio, John L.**, 1997, Geohydrologic effects on drainwater quality: Journal of Irrigation and Drainage Engineering, ASCE 123(3).


**Fio, John L.**, and Deverel, S.J., 1988, Ground-water flow to subsurface agricultural drains in the western San Joaquin Valley, California: Transactions of the American Geophysical Union, v. 69, no. 44.

**Monitoring**


JAN W. HOPMANS
Professor Vadose Zone Hydrology Telephone: (530) 752-3060
Hydrology Program, Dept. LAWR Fax: (530) 752-5262
University of California, Davis, CA 95616 Email: jwhopmans@ucdavis.edu

(i) Research interests: Vadose Zone Hydrology; soil physics; flow and transport modeling; microtomography; scaling techniques; plant root-soil water interactions; parameter optimization; soil hydraulic properties; climate change impacts, irrigation water management; soil moisture monitoring, sensors, and analysis.

(ii) Professional Preparation

<table>
<thead>
<tr>
<th>Year</th>
<th>Degree</th>
<th>Institution</th>
<th>Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005-2007</td>
<td>Chair Department LAWR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001-2005</td>
<td>Vice Chair Hydrology/LAWR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1994-1996</td>
<td>Director Hydrologic Science, Dept. LAWR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985-1988</td>
<td>Wageningen Agricultural University, Post Doctoral Appointment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(iii) Appointments

1988-present Assistant, Associate and Full Professor, Department Land, Air and Water Resources
2005-present Chair Department LAWR
2001-2005 Vice Chair Hydrology/LAWR
1994-1996 Director Hydrologic Science, Dept. LAWR
1985-1988 Wageningen Agricultural University, Post Doctoral Appointment

(iv) Awards: Fellow Soil Science Society of America, 2001; Fellow American Geophysical Union, 2005; Don and Betty Kirkham Soil Physics Award, 2003;

(v) Relevant Publications


(vi) Selected other recent publications


(vii) Synergistic Activities

1. Active in the organization of broad and interdisciplinary sessions at national/international professional meetings, such as American Geophysical Union, Soil Science Society of America and European Geophysical Society; E.g. Past, present and future of soil physics at 2000 SSSA Meeting, Landscape processes 2004 SSSA, Soilbiophysics 2005 SSSA & Perspective in Soil Hydrology at 2003 EGS Meeting, Nice; Kirkham Conference 2008, Davis, CA; Climate change and hydrology, AGU 2008.


3. Emphasize the need to focus on science at interfaces, thereby enhancing multi-disciplinary research such as at root-soil and land surface-atmosphere interfaces, and in vadose zone hydrology interfacing ground water, the unsaturated zone and the atmosphere using the physical, chemical and biological sciences;
4. Bring into my laboratory at UC Davis undergraduate, graduate students and post doctoral scientists from all continents of the world, conducting research on a broad variety of areas;

5. Make available all notes for soil physics course on the web, so it has become a self-instructive course or can be used as lecture material for others;

6. As Chair of Department of Land, Air and Water Resources, to streamline and help redevelop undergraduate curricula in Department, and promote interdisciplinary and integrated teaching and research in the Department and UCD campus.

(viii) Collaborators & Other Affiliations

a. Collaborators and Co-Editors:
Keith L Bristow, CSIRO Land&Water, Australia; V. Clausnitzer, GFZ, Berlin, Germany; J.H. Dane, Auburn University, AL; G.E. Fogg, Davis; M. Gribb, Univ. of Idaho; B. Hanson, T. Harter, University of California; K. Kosugi, Kyoto University, Japan; D.R. Nielsen, University of California, Davis; P. Nkedi-Kizza, University of Florida, Gainesville; M.B. Parlange, John Hopkins University; D.E. Rolston, G. Schoups, University of California, Davis; J. Simunek, USDA Salinity Laboratory, Riverside, CA; A. Tuli, University of California, Riverside; M.Th. van Genuchten, USDA Salinity Laboratory, Riverside; C. Vaz, Embrapa, Sao Carlos, Brazil; D. Wildenschild, Oregon State University; J. Vrugt, University of Amsterdam, the Netherlands; O. Wendroth, ZALF, Muncheberg, Germany;

b. Graduate and Postdoctoral Advisors:
J.N.M. Stricker, Postdoctoral Advisor, Wageningen Agricultural University
J.H. Dane, graduate advisor, Auburn University, Auburn AL

(c. Thesis Advisors and Post-graduate-Scholar Sponsor:
G. Schoups, Stanford University, Stanford
K. Ellett, University of Melbourne, Australia
A. Tuli, University of California, Riverside
M. Tansey, US Bureau of Reclamation, Sacramento, CA
H. Shepherd, Consulting, Tahoe City, CA
V. Clausnitzer, GFZ, Berlin, Germany
F. Somma, University of Catania, Italy
D. Wildenschild, Oregon State University
C.M.P. Vaz, EMBRAPA, Sao Carlos, Brazil
P. de Vita, University of Napoli, Italy
N. Romano, University of Napoli, Italy
J. Vrugt, University of Amsterdam, the Netherlands
L. Bassoi, EMBRAPA, Brazil
D. Teruel, University of Sao Paolo, Piricicaba, Brazil
K. Kosugi, Kyoto University, Japan
M. Inoue, Tottori University, Japan
S. Shiozawa, University of Tokio, Japan
K. S. Koumanov, Fruit Growing Institute, Romania
L. Andreu, University of Seville, Spain
Y. Liu, Alabama University, Huntsville
A. Macedo, EMBRAPA, Sao Carlos Brazil
A. Mortensen, DTH Copenhagen, Denmark
Y. Mori, Shimane University, Japan
A. Reurslaag, Agric University Sweden, Uppsala, Sweden
T. Kamai, current PhD student
P. Nasta, University of Napoli, Italy
A. Saintenoy, University of Paris, France

Total nr of graduate students advised: 25
Total nr of postdoctoral scholars sponsored: 30
Department of Land, Air and Water Resources
3226 Plant & Environmental Science Building
One Shields Ave.
Davis, California 95616-8626
Telephone: (530) 754-6029 Office
FAX: (530) 752-1552 FAX
E-mail: wrhorwath@ucdavis.edu

EDUCATION
1979 BS. Forestry Environmental Impact Assessment, College of Agriculture, Department of Forestry, Southern Illinois University, Carbondale, IL.

Positions Held:
Professor of Soil Biogeochemistry, University of California, Davis, CA. 7/04 to present
Assoc. Professor of Soil Biogeochemistry, University of California, Davis, CA. 7/00 to 6/04
Assist. Professor of Soil Biogeochemistry, University of California, Davis, CA. 7/96 to 6/00
Graduate Faculty, Oregon State University, Corvallis, OR. 1/95 to present
Research Soil Microbiologist, USDA ARS, Corvallis, OR. 10/94 to 5/96
Faculty Research Associate, Oregon State University, Corvallis, OR. 11/92 to 9/94
Graduate Research Assistant, Michigan State University, E. Lansing, MI. 9/88 to 10/92
Research Specialist, Michigan State University. 11/85 to 9/88
Staff Research Associate, University of California at Berkeley, CA 4/83 to 10/85

Honors:
NSM/MARC Scholar, California State University. 2002
J. G. Boswell Endowed Chair in Soil Science. 2008-present

Publications (Selected since 2004; >100 in total)


DAVID A. LEIGHTON

QUALIFICATIONS

David A. Leighton has over 22 years of problem-solving experience. Mr. Leighton collects and manages hydrologic data, analyzes groundwater systems, and develops and implements numerical models. He specializes in the development and application of Geographic Information Systems in hydrologic investigations.

David Leighton:

- Plans and implements data collection and monitoring programs.
- Analyzes groundwater flow and quality.
- Constructs and applies numerical models for groundwater investigations.
- Integrates modeling results and field data.
- Develops and implements Geographic Information System (GIS) databases.

PROFESSIONAL EXPERIENCE

July 2001 - present

Hydrologist, HydroFocus, Inc. Davis, CA

- Numerical modeling to evaluate the effects of land retirement on groundwater levels and drainflow – Western San Joaquin Valley, California.
- Data collection and analysis of groundwater and water quality conditions related to subsidence mitigation strategies – Sacramento-San Joaquin Delta, California.
- Data collection and analysis of groundwater and surface water conditions related to agricultural reuse of treated wastewater – Ironhouse Sanitary District, Oakley, California; City of Lathrop, California.
- Use water quality characteristics to determine water sources – Nevada County, California.
- Estimate future land subsidence using a Geographic Information System – Sacramento-San Joaquin Delta, California.

1987-2001

Hydrologist, U.S. Geological Survey Sacramento, CA

- Conducted groundwater modeling investigations with emphasis on the use of Geographic Information Systems to manage model input data and display model output.
- Integrated Geographic Information Systems into projects including database creation, data analysis, and map creation.
Performed duties of Geographic Information System Coordinator for the California District of the U.S. Geological Survey which included representing the District on Geographic Information System matters, responding to requests for spatial data and information, and acting as a resource to co-workers.

Collected and compiled geohydrologic and water-quality data.

Evaluated and interpreted data using Geographic Information Systems, statistical, and other appropriate analytical methods to determine hydrologic conditions and develop an understanding of groundwater-flow systems.

Wrote technical reports describing study results and performed peer review of reports written by colleagues.

1985-1987

Hydrologic Technician, U.S. Geological Survey Sacramento, CA

Conducted geohydrologic and groundwater quality investigations – western San Joaquin Valley, California.

Directed development of a regional Geographic Information System database – South San Francisco and Peninsula Area, California.

Directed data collection, database development, data analyses, and report writing.

Constructed groundwater-flow models – western San Joaquin Valley and South San Francisco Bay areas, California.

ACADEMIC BACKGROUND

Bachelor of Science, 1982, Forest Resource Management, Humboldt State University, Arcata, California

AWARDS AND HONORS


RELEVANT PUBLICATIONS

Groundwater-Flow Modeling


Hydrogeology of the San Francisco Bay Area


Geochemistry, Salt Migration, and Water Quality


Monitoring


Ken Loy is a certified hydrogeologist and engineering geologist with 19 years of experience in engineering consulting with emphasis on hydrogeologic and water quality characterization, data analysis, and modeling. Ken has characterized hydrogeologic conditions, assessed land and water use practices, conducted statistical analysis of groundwater quality data, and applied numerical groundwater flow and transport models in groundwater impacts analyses. He has conducted land subsidence evaluations, designed wells, and provided design services during construction of wells.

PROJECT EXPERIENCE

City of Galt Wastewater Treatment Plant Groundwater Monitoring and Reporting Program. Project manager for the City’s Groundwater Monitoring and Reporting Program. The program addressed the wastewater treatment facilities and the surrounding lands, which are irrigated with plant effluent and used for biosolids disposal. Initiated the program by negotiating with the California Regional Water Quality Control Board, Central Valley Region, and developed the work plan defining well locations, analytical parameters, monitoring protocols, and schedule. No revisions to the work plan were required after the subsequent issuance of Waste Discharge Requirements. Analytical parameters included ammonia, nitrate, coliform, and metals. Established background monitoring locations that the Regional Board accepted. Plant operations resulting in year-round mounding of groundwater made placement of upgradient background wells impractical; instead, background well locations were selected based on groundwater transport and land use considerations. Evaluated the potential for impacts to neighboring supply wells; used nonparametric statistical methods to evaluate whether the monitored constituents exceeded background concentrations. City of Galt, California.

City of Lodi Wastewater Treatment Plant Groundwater Monitoring and Reporting Program. Principal hydrogeologist for evaluation of background groundwater quality and potential groundwater impacts at the City of Lodi’s White Slough Pollution Control Facility. The primary goal of this ongoing effort is to determine whether facility operations and land application of treated effluent and biosolids have impacted groundwater relative to background conditions. A major challenge of the project was to establish these background conditions. Land use in the area includes intensive agricultural and dairy operations, which have affected water quality. Ken evaluated land and water use information and existing groundwater quality in the region to develop the basis for defining background conditions. He evaluated potential sources of contamination and waste streams at the facility, site-specific hydrogeologic conditions and groundwater quality, including stable isotope data, to prioritize potential sources of groundwater contamination and identified groundwater transport pathways and seepage rates. Results of the study will be used to determine whether improved treatment and control measures are needed. City of Lodi, California.

City of Davis Wastewater Treatment Plant Groundwater Monitoring and Reporting Program and Reuse Evaluation. Project manager for assessment of background groundwater quality, comparison of site and background groundwater quality, and development of continuing investigations of background groundwater
quality. Principal hydrogeologist for the evaluation of potential wastewater reuse options, including evaluation of reuse areas and storage sites. This ongoing effort involves evaluation of regional groundwater quality to assess the effects of predevelopment environmental conditions and current land use on groundwater quality. Site data have been evaluated with respect to background conditions and water quality goals, and plans for further, more detailed spatial analysis of background groundwater quality are being developed. These plans include evaluation of baseline groundwater quality and geophysical conditions in the potential reuse areas. The work is being conducted to meet Central Valley Regional Water Quality Control Board requirements and schedules. City of Davis, California.

Flag City Wastewater Treatment Plant Groundwater Monitoring and Reporting Program. Principal Hydrogeologist responsible for quarterly and annual groundwater reporting. Prepared quarterly and annual reports using monitoring data collected by San Joaquin County. Developed and implemented the background groundwater monitoring program. Used nonparametric statistics to compare background and site groundwater data. Compared site groundwater data to published water quality goals. Negotiated with Regional Board staff to develop and implement clean closure approach for the effluent storage ponds after use of the wastewater treatment plant was discontinued in summer 2008. County of San Joaquin, San Joaquin County, California.

Wastewater Facilities Assessments for the California Department of Corrections and Rehabilitation. Principal hydrogeologist during evaluation of wastewater facilities at correctional facilities in a wide range of geologic environments. Assessed groundwater conditions, and potential groundwater quality impacts with respect to Regional Water Quality Control Board Waste Discharge Requirements. Assessed groundwater/surface water interactions with respect to recent court decisions and Regional Board permit actions. Evaluated alternative disposal options, including reuse. Prepared reports documenting findings and recommended action plans. Various sites. California Department of Corrections and Rehabilitation, Sacramento, California.

Placer County Regional University Water and Recycled Planning Studies and Modeling. Ken is the principal hydrogeologist and project manager for water and recycled water planning studies for the Regional University project in Placer County. The water supply strategy calls for initial reliance on groundwater with a gradual transition to an integrated supply of treated surface water, groundwater, and recycled water. Groundwater impacts were assessed using MODFLOW and IGSIM. A MODFLOW model was developed using the conceptual model for the regional-scale IGSIM. Drawdown for various scenarios was then modeled using MODFLOW application and superimposed on the IGSIM results to assess project impacts. KT Communities, Placer County, California.

Recycled Water Study. Evaluated the use of recycled water generated by the Sacramento Regional Wastewater Treatment Plant. Developed a projected water balance to the year 2030 for Sacramento County to assess potential changes in surface water and groundwater supply with and without the use of recycled water. Evaluated how the changes in supply might affect net surface water flows and groundwater elevations under climate conditions ranging from wet to critically dry. Evaluated the projected cost of recycled water relative to the cost of other water supplies, which included the projected costs of increasingly stringent treatment requirements. Identified and evaluated options for the best use of recycled water. Options included stabilization of groundwater elevations in high demand areas, areas critical for
West Yost & Associates ........................................................


Groundwater Municipal Well Design and Construction, Sacramento County Water Agency, Sacramento County. Principal Hydrogeologist and Project Manager for the design and design services during construction of three 1,500-foot production wells and a 1,500-foot, stainless steel, dual completion monitoring well located in Elk Grove. The wells were constructed as part of a new development but are the property of Sacramento County Water Agency (SCWA). In addition to serving the needs of the new development, the wells will also replace SCWA supply lost as a result of the implementation of the 10-mg/l federal MCL for arsenic. The effort resulted in a new 6,000-gpm potable groundwater supply in a rapidly developing area of Sacramento County. Typical production depths in the region yield groundwater with arsenic concentrations that can approach the pending 10-μg/l federal MCL. Deeper zones can contain concentrations of manganese and iron that exceed secondary MCLs and require treatment. Increasing salinity with depth places an additional constraint on groundwater production. Hydrogeologic and geochemical evaluations were performed to identify groundwater production depths that optimized water quality, while achieving production requirements. The completed wells met drinking water standards without treatment. Reynen & Bardis Communities, Sacramento, California.

ASR Well Evaluation. Evaluated the historical and projected supply and demand with and without the ASR project, developed a summary of the hydrostratigraphy, aquifer hydraulic parameters, and groundwater flow and quality characteristics obtained from published and unpublished reports and California Department of Water Resources (DWR) records. Developed a preliminary conceptual model of the groundwater basin, estimated the potential storage of the basin and evaluated the potential yield of an ASR well and its affect on storage in the groundwater aquifer near Yountville. Evaluated water quality information to assess the potential for adverse effects due to chemical reactions between recharged treated surface water, groundwater, and the aquifer. Selected possible ASR well sites, and developed a conceptual design, conceptual implementation plan and budgetary cost estimate for the ASR system. Identified potential sources of funding for construction of the ASR system and prepared a construction grant application for funding under the Groundwater Storage Program of the Safe Drinking Water, Clean Water, Watershed Protection, and Flood Protection Bond Act (Proposition 13). Town of Yountville, California.

Municipal Well Design and Hydrogeologic Consulting Services. Principal hydrogeologist supporting the City of Woodland’s (City) municipal well design efforts and efforts to expand and improve the quality of its groundwater supply. The City depends completely on groundwater, which is produced from an intermediate depth. The City sought to expand its groundwater production to meet projected water demands and improve water quality by constructing new wells in a deeper aquifer zone, which, locally, has superior water quality. Ken led the effort to evaluate hydrogeologic conditions and groundwater quality, design the wells, and provide hydrogeologic support during construction. Ken used aquifer zone sampling test resulted from multicollection monitoring wells and other subsurface information to calculate blended water quality from multiple aquifer zones, which individually exceeded water quality standards for nitrate, arsenic and manganese. He developed a well design to draw water from selected zones predicted to result in blended water maintenance of instream flows, and areas in which groundwater quality could potentially be improved. Sacramento Regional County Sanitation District, Sacramento, California.
quality that would not require treatment. The constructed well does not require treatment for public, potable supply. Ken has assisted the City in well siting prepared Drinking Water Source Assessment Reports and is preparing a groundwater management plan for the City. Ken also used analytical element modeling to assess potential groundwater impacts caused by the City’s new wells. Ken developed a working relationship with the California Department of Water Resources (DWR), Central District. DWR provides in-kind services, including geologic logging and chemical analysis at no cost to the City. City of Woodland, California.

City of Santa Rosa Municipal Well Design and Hydrogeologic Consulting Services. Principal hydrogeologist supporting the City of Santa Rosa’s efforts to identify and evaluate potential municipal well sites and to design municipal production wells meeting the City’s production and water quality requirements. Ken assisted the City in evaluating the hydrogeology of the groundwater basin, assessing municipal and private wells, selecting and evaluating potential municipal well sites, and developing a test drilling and well construction program for two of the sites, which were located in City parks. Test drilling and well construction were conducted with measures to mitigate sound and light pollution and to protect public safety. Geologic and geophysical logging was conducted in partnership with the United States Geological Survey at no additional cost to the client. Aquifer testing and chemical analysis were conducted in the test-production wells to assess yields, hydraulic parameters and groundwater quality, with respect to drinking water standards. Analytical element modeling was used to assess potential groundwater impacts to other wells in the vicinity. City of Santa Rosa, California.

Lower San Joaquin River Water Transfer Feasibility Study. Principal hydrogeologist and project manager for the analysis of water transfer alternatives for a 3,500-acre agricultural property located on the lower San Joaquin River. Efforts included evaluation of pre-1914 rights, appropriative licenses and riparian rights; evaluation of possible mechanisms by which water could be made available, including crop shifting, idling and groundwater substitution; and identification of potential buyers. Evaluated groundwater resources for the property and designed and implemented a test drilling, monitoring well construction and groundwater quality sampling program. The California Department of Water Resources, Central District provided geological and analytical services during the drilling program at no cost to the client. Recent activities include negotiations with a potential buyer and preparation of a Petition for Temporary Urgency Change, which will be submitted to the State Water Resources Control Board. Confidential Client, California.

Upper Sacramento Valley Well Construction and Aquifer Testing. Principal hydrogeologist and project manager for investigation and hydraulic testing of the Lower Tuscan Aquifer. Scope of services include providing technical support to legal challenges; developing a phased, multi-year aquifer test work plan; providing geologic expertise during drilling of three, 1500-foot test holes extending to the base of fresh water, designing five 1,500-foot production wells; overseeing construction of the production wells; and implementing the aquifer test work plan. The work is conducted in association with the California Department of Water Resources, Northern District. Stony Creek Fan Partners, California.

Hydrogeologic Consulting Services. Ken was the principal hydrogeologist and project manager on this effort to evaluate the feasibility of using groundwater as a supplement to Reclamation District 2068’s existing Delta water supply. Ken led the effort to assess the availability and quality of groundwater, the potential for impacts to stakeholders and the environment, and the costs of developing a conjunctive use
program. These efforts included obtaining and evaluating available hydrostratigraphic, geophysical and water level and quality data; drilling and logging test borings; constructing nested monitoring wells; conducting aquifer testing; performing quarterly water level monitoring and semiannual water quality sampling; establishing and performing the initial survey of a land subsidence benchmark tied to the Yolo County Subsidence Monitoring Network; performing IWFM modeling to assess the effects of full-scale groundwater production on groundwater elevations; preparing a feasibility study report; preparing a groundwater management plan; and conducting community outreach. *Reclamation District 2068, Yolo and Solano Counties, California.*

**Hydrogeologic Characterization and Modeling.** Ken was the principal hydrogeologist and project manager on a multi-year study of the Squaw Valley watershed. These efforts included analysis of annual snow pack, stream gauging, development of rating curves, groundwater level monitoring, water quality analysis and monitoring well installation using the resonant sonic method. A conceptual model of the groundwater basin was developed, and MODFLOW was used to estimate the yield of the aquifer under a range of hydrologic conditions and pumping scenarios. Tools were developed for estimating the available groundwater supply based on snowpack thickness and stream flow. *Squaw Valley Public Service District, California.*

**Groundwater Impact Analysis and Modeling.** Ken was the principal hydrogeologist and project manager during assessment of potential groundwater impacts due to a proposed gravel mine in Dry Creek, Sacramento County. Ken analyzed the geology, land use and water use of the area and developed a conceptual site model that was used to assess potential impacts to groundwater levels, groundwater quality and flow in Dry Creek. The assessment was performed using IGSM and a water balance approach. IGSM was used to assess potential impacts at a regional scale. The water balance was used to assess localized affects, including to a perched aquifer in Dry Creek stream channel deposits. *Sacramento County Department of Environmental Review and Assessment.*

**Groundwater Modeling and Conceptual Design.** Developed and implemented a program of numerical flow and transport groundwater modeling, conceptual engineering design and cost estimating to select a protective, minimum present-worth design from a range of possible groundwater treatment system configurations. The key component of the approach was evaluation of a range of extraction and injection scenarios using analytical and three-dimensional groundwater flow (MODFLOW) and transport (MT3D) modeling of a multiple aquifer system spanning the Laguna and Mehrten Formations. The models included an extensive public supply well field and predicted the effect of groundwater withdrawals on contaminant transport to the wells. *AFCEE, Sacramento, California.*

**Hydrogeologic Consulting Services for the University of California and City of Davis.** Ken was the principal hydrogeologist and project manager for aquifer testing of deep municipal wells operated by UC Davis and the City of Davis. The effort included design of the tests; procurement, installation and operation of data loggers; data collection; and aquifer test analysis. The largest test involved pumping at a rate of approximately 2,500 gallons per minute for nearly two weeks. The aquifer test data were corrected for background water level trends, fluctuations in barometric pressure due to storm events, and earth tides prior to calculation of the hydraulic properties of the aquifer. Ken also participated in the evaluation of aquifer recharge characteristics using standard water quality analyses, stable isotopes, and carbon-14 dating. Ken
worked with UC Davis/City operations staff to coordinate pumping tests with ongoing water system operations. *Cities of Davis and Woodland, California and University of California at Davis.*

**Hydrogeologic Consulting Services.** Ken was the principal hydrogeologist and project manager for the City of Petaluma’s groundwater feasibility study. This work included providing hydrogeologic support during construction of new municipal production wells, evaluation of the condition and capacity of existing wells, assessment of the hydrogeology of the groundwater basin, and aquifer testing. The City currently relies on surface water supply from the Sonoma County Water Agency to meet water demands. The reliability of this supply is currently in question; particularly in regards to expansion of the supply to meet increasing needs as the City grows. Ken led the effort to evaluate integration of groundwater into the City’s planning to meet increasing demands, either as a permanent supply or to meet peaking and/or emergency supply needs. Potential supply deficits that could be faced by the City in the future and the water quality issues associated with use of existing and proposed wells were considered in the development of alternatives for conjunctive use of surface and groundwater to meet future demands. The work also included the development of long-term objectives for the City for management of its underlying groundwater basin; development of long-term policies to protect the quality and production; and recommendations for groundwater monitoring. *City of Petaluma, California.*

**Groundwater Management Planning.** Ken was the principal hydrogeologist and project manager during evaluation of SB 1938 basin management objectives for the Solano Sub-basin. Some of the sub-basin stakeholders adopted groundwater management plans in the late 1990’s. Ken supported Solano County Water Agency’s efforts to evaluate the existing groundwater management plans and identify basin management objectives that the stakeholders held in common. The effort involved reviewing existing groundwater management plans, agreements and technical studies, and meeting with the stakeholders to develop consensus on basin management objectives. The outcome of the effort was a technical document that is available to guide preparation of individual SB 1938 groundwater management plans by sub-basin stakeholders. *Solano County Water Agency, California.*

**Groundwater Management Planning.** Ken was West Yost Associate’s principal hydrogeologist and project manager during preparation of a SB 1938 groundwater management plan for UC Davis and the City of Davis. UC Davis and the City rely solely on groundwater for potable supply. The groundwater management plan was prepared and adopted jointly and has been implemented by the two agencies to help manage groundwater salinity, groundwater levels and land subsidence. *University of California, Davis, and City of Davis, California.*

**Hydrogeologic Characterization/Groundwater Management Planning.** Ken was the principal hydrogeologist during evaluation of groundwater resources in Dunnigan Water District. Ken evaluated and documented hydrogeologic conditions including aquifer hydraulic properties, recharge sources and potential, historical variations in storage with hydrologic conditions, water quality, typical well construction and typical well yield. Ken also provided recommendations supporting preparation of a SB 1938 groundwater management plan, including recommended groundwater monitoring locations, stream gauging locations and recommendations for the content of the plan. *Davids Engineering, California.*
Groundwater Management Planning. Ken was the principal hydrogeologist and project manager during preparation of a SB 1938 groundwater management plan for Reclamation District 2068. The adopted plan includes DWR’s required and recommended components for SB 1938 groundwater management plans. Currently, the District does not use groundwater, and the plan is used to guide baseline data collection, including groundwater levels, groundwater quality and land subsidence potential. The groundwater management plan can also be used in the future, if the District chooses to adopt a conjunctive use program. *Reclamation District 2068, California.*

Groundwater Resource Study. Evaluated potential for development of a new nonpotable groundwater supply beneath the San Mateo Plain, southwestern San Francisco Bay region. Interviewed staff at USGS, local universities and regulatory agencies to identify and obtain site-specific subsurface information for the project site. Evaluated the potential well yield and water quality and assessed the risk of saltwater intrusion and land subsidence should the resource be developed. *Confidential client, Redwood City, California.*

Land Subsidence Study. Evaluated land subsidence caused by groundwater withdrawal in the Chino Basin, southern California. Used well construction information, geophysical logs, groundwater production and elevation records, land survey information and interferometric synthetic aperture radar (InSAR) to assess the historical magnitudes and rates of land subsidence. Performed a qualitative evaluation of the risks of further subsidence over a range of hypothetical scenarios in which groundwater production and artificial recharge were increased through the year 2020. *Confidential client, Pasadena, California.*

Land Subsidence Studies. Research assistant participating in USGS land subsidence studies using wellhead and extensometer measurements, microgravity and GPS. Participated in establishing land subsidence monitoring networks in Avra Valley, the Tucson Basin and the Picacho Basin (upper and lower Santa Cruz River basins). Research assistant for projects involving collection, processing and interpretation of geophysical data used to characterize engineering properties at proposed Superconducting Supercollider sites in Arizona. Managed the University of Arizona’s geophysical database. *University of Arizona, Tucson, Arizona.*

Groundwater Investigations. Conducted geologic, hydrogeologic and geophysical evaluations in the eastern United States and Virgin Islands. Responsibilities included development of project objectives, investigation design, data collection and interpretation, report preparation, and task management. Hydrogeologic activities included: geologic mapping and structural analysis of Valley and Ridge structures; design and implementation of bedrock drilling programs; dye trace testing in fractured bedrock and karst aquifers; groundwater flow and transport modeling; aquifer test analysis; and providing input to engineering design. Geophysical activities included location and delineation of buried structures using electromagnetic induction, magnetics and ground penetrating radar. *Various clients, Eastern United States.*

Hydrogeologic Investigations. Conducted environmental and hydrogeologic investigations on Terceira, Azores Archipelago, Portugal. Conceived and developed work plans for vanguard hydrogeological investigations at this remote volcanic island after performing extensive background research in Portuguese technical references and European Economic Community environmental regulations. *United States Air Force.*

Groundwater Flow and Transport Modeling. Project manager for the characterization and remediation of arsenic, copper, and hexavalent chromium at a former wood pressure treating facility. Evaluated the nature and extent of contamination in soil and groundwater, established background concentrations, developed remediation approaches, and managed design efforts. Conducted flow and transport modeling (MODFLOW and MT3D) to support evaluation and modification of the groundwater treatment plant. Evaluated a variety of scenarios to minimize the volume of treated water injected into the aquifer. Evaluation of the hypothetical modifications allowed the client and the Regional Board to make risk management decisions regarding the overall water balance of the site, plume capture, chemical processes applied at the treatment plant and discharge options for the treated effluent. Confidential client, Merced, California.

PCB Transport Modeling. Evaluated transport of PCBs in the vadose zone and groundwater. Performed vadose zone and groundwater flow and transport modeling to assess the potential for PCB transport from contaminated soil to groundwater production wells in the vicinity. Performed research on PCB transport properties for use in the modeling effort and presented the results to the California Department of Toxic Substances Control. Confidential client, Pico Rivera, California.

Benzene Transport Modeling. Evaluated benzene transport in the vadose zone. Developed a vadose zone model to simulate the effects of precipitation, surface runoff, evapotranspiration, infiltration to groundwater and gas phase diffusion on the transport of benzene to a deep aquifer used for water supply. Used time-dependent site-specific weather information and site- and chemical-specific transport parameters to develop the model. Confidential client, Carson, California.

Radiological Site Characterization. Designed and implemented a statistical sampling approach that was used to assess the degree and extent of reactor-generated radionuclides in the environment, including Humboldt Bay. The results of the characterization were used as part of the basis for estimating the cost of decontamination and decommissioning of the nuclear power plant. At the conclusion of the study it was possible to distinguish between areas likely to require remediation, areas that were affected by plant operations but were unlikely to require remediation, and areas in which no effects were measurable. PG&E, Eureka, California.

Remedial Investigation/Feasibility Study. Hydrogeologist for Remedial Investigation/Feasibility Study (RI/FS) of the Laboratory for Energy Related Health Research (LEHR) Superfund Site, Davis, California. Evaluated the degree and extent of nitrate, TDS, hexavalent chromium, and chloroform in the unsaturated zone and groundwater. Evaluated records of historical operations and chemical analytical results for unsaturated zone soils to assess potential sources of contamination. Evaluated hydrogeologic information, chemical analytical results for groundwater, and fate and transport processes to delineate the degree and extent of groundwater contamination. Evaluated neighboring supply wells for potential impacts. The
information developed was used to assess the effectiveness of remediation approaches, and to plan additional investigations and new groundwater remediation approaches that would be compliant with California Regional Water Quality Control Board, Central Valley Region Waste Discharge Requirements. University of California, Davis, California.

Unocal (Former PureGro) Fertilizer Facility. Project manager for the investigation and remediation of ammonia, nitrate, and organochlorine pesticides in soil and groundwater. Investigated the nature, degree, and extent of contamination and submitted compliance reports to the California Regional Water Quality Control Board, Central Valley Region. Established background concentrations in groundwater. Performed a survey of neighboring supply wells, assessed the potential for impacts, and sampled susceptible wells. Evaluated and estimated capital costs for corrective action. Walnut Grove, California.

Mountain House Wastewater Treatment Plant Pond Evaluation. Hydrogeologist for the evaluation of secondary treated effluent storage ponds. Leakage was observed shortly after the ponds were constructed. Ken evaluated as-built geotechnical data, groundwater quality data and groundwater modeling results to assess the potential future impacts of leakage; the likelihood that newly constructed ponds would meet California Regional Water Quality Control Board, Central Valley Region Waste Discharge Requirements; and potential remedial solutions. San Joaquin County, California.
Steven C. Macaulay, P.E.

Professional Registration
Professional Civil Engineer, 1975
California No. C24878

Education
M.S., Civil Engineering, California State University, Sacramento, 1972
B.S., Chemical Engineering, University of California, Davis, 1971

Professional Affiliations
American Society of Civil Engineers
American Water Works Association
Association of California Water Agencies
U.S. Committee on Irrigation and Drainage
Water Education Foundation
Yolo Basin Foundation

Publications


"Resolution of Water Resources Issues In the State of California, United

Steve Macaulay is a Vice President of WYA and has 37 years of extensive experience in a full range of activities related to water supply reliability, water conservation, water quality, water conveyance, reclamation/reuse, and surface and groundwater storage. This includes conjunctive use, water transfers, water rights, environmental issues and conflicts, and the emerging areas of climate change and integrated regional water management. Steve has a solid understanding of local and state government and the challenges of resolving water resources problems at the regional level. Steve previously served as the Department of Water Resources Chief Deputy Director, the General Manager of the State Water Contractors, and, most recently, as Executive Director of the California Urban Water Agencies under contract with WYA. He has worked on a variety of visible public processes most of his career including participation on the Public Advisory Committee for several updates to the California Water Plan, active engagement at the management level with the CALFED Bay-Delta Program, manager of DWR’s Kern Water Bank planning program, manager of the 1991 and 1992 State Emergency Drought Water Banks, and his earlier regulatory work as staff to the Central Valley Regional Water Quality Control Board and State Water Resources Control Board (the latter as staff to the 2-year effort leading to Decision 1485, the landmark Delta water quality standards adopted in 1978).

EXPERIENCE

Resources Planning for Large Ranch. Project lead for strategic resources planning for Conaway Ranch, an 18,000 acre ranch located in and adjacent to the Yolo Bypass between Davis and Woodland. Early work examined the potential of providing increased urban flood protection in the region. Support to a successful 2008 water transfer, continuing preparations for future water transfers including planning for the State’s 2009 drought water bank, environmental resources planning on the Ranch, initial planning for use of recycled water, development of a comprehensive groundwater monitoring and utilization strategy, and coordination with appropriate state and federal regulatory and planning agencies. Such coordination during 2008 included preparation of environmental documents and recommended mitigation strategies. Continued work for 2009 regarding potential water transfers, an overall farming and water plan, and comprehensive monitoring network. Conaway Preservation Group, California.

Water Transfers for Urban Water Agencies. Support to contract with several Bay Area public agencies to explore options to firm up urban water supply reliability in dry and critically dry years. Prepared material as part of a technical memorandum outlining pros and cons to various water transfer options. City of Napa and American Canyon Water District, California.

Reliable Water Supply for Proposed Development. Support to the City of Tracy on water supply reliability for the proposed Tracy Hills project. Includes evaluation of options to convey water to the City from another water user who has agreed to provide water for this proposed development. This ongoing project requires working knowledge of State Water Project conveyance policies and operational issues, as well as a detailed knowledge of water rights applicable to the water supplier. City of Tracy, California.


Manage Environmental Studies. Organize and manage environmental research studies funded by a major water user organization. Studies are principally focused on addressing endangered fish species in the Sacramento-San Joaquin Delta. State Water Contractors, California.

Water Conservation Training Program. Help to secure funding for the CA-NV AWWA Section’s initial water conservation professionals training and certification program. Secured $100,000 for initial funding for this program. In addition, WYA’s Davis office serves as AWWA’s water conservation training location for northern California. California-Nevada Section, American Water Works Association.

Water Conservation Program. Project lead for development of a more aggressive urban water conservation program. Project included providing information documenting the need for water conservation and developing a recommended Water Conservation Policy/Implementation Plan. In addition, prepared a summary and evaluation of AB 1420 outlining the new terms of eligibility for water management grants or loans made by the Department of Water Resources, State Water Resources Control Board, or the California Bay-Delta Authority to an urban water supplier relative to the implementation of water demand management measures. San Bernardino Valley Municipal Water District, California.

Davis/Woodland/UC Davis Water Supply Project. Since 2006, member of project management team for the cities of Woodland and Davis and the University of California at Davis (UC Davis) in the planning, design and implementation of a regional surface water supply project. The project will consist of a diversion intake facility on the Sacramento River, a conveyance pipeline from the intake to a new 56-mgd capacity water treatment plant, and a pipeline distribution system to the participants’ service areas. WYA continues to provide engineering, outreach and overall management assistance to the project participants through the completion of this project, expected to begin operation in 2016, including acquisition of water right permit and the full range of project implementation actions. Team lead and principal author, “Davis-Woodland Water Supply Project, Community Report” (December 2007). Cities of Davis and Woodland, and the University of California, Davis, California.

Water Supply & Facilities Master Plan for the Chico-Hamilton City District. Technical advisor and project engineer for developing and calibrating a hydraulic model for California Water Service Company’s (Cal Water) Chico-Hamilton City District, which is providing Cal Water with an opportunity to further define and prioritize areas of improvement within the water system for the next 25 years. The master plan encompasses the entire City of Chico, and WYA has been working extensively with the City’s GIS system. A significant part of the master plan involved reviewing water supply options for Cal Water and providing a detailed assessment of each of their facility (reservoir, well, and booster pump station) sites. California Water Service Company, California.

Sutter County Measure M Development. During the November 2, 2004, election the citizens of Sutter County approved Measure M by a 59-percent vote. Measure M recommended planning for commercial, industrial, and residential development in South Sutter County (within the Natomas Basin) to create new jobs in Sutter County. Served as technical advisor and project engineer for providing water supply/distribution infrastructure support for the County related to this proposed 7,500-acre development. Water supply for the development includes use of groundwater wells for the initial development phases, then a transition to a
conjunctive use of groundwater and surface water (raw water provided by the Natomas Central Mutual Water Company from the Sacramento River). Issues include surface water rights, groundwater use, potential groundwater impacts, representing the County in providing input and comments on the water supply assessment, and addressing issues that have arisen in similar developments. County of Sutter, California.

May 2003 to December 2007. Executive Director, California Urban Water Agencies. Executive Director of association of large public urban water utilities in California, with the following purposes: (1) advance the state of knowledge of progressive water management and promote application of strategies to meet urban water needs in an efficient and environmentally responsible manner; (2) pursue and promote technical investigations and policies to advance treatment technology and improve and protect drinking water quality at the source; (3) pursue and promote technical investigations and solutions to comprehensively address all factors affecting San Francisco Bay-Delta ecosystem health; and (4) advance the satisfaction of urban water needs through application of technical knowledge and collaborative participation in non-legislative forums where urban water interests are affected. Very active engagement in CALFED Bay-Delta Program, water conservation policy and technical issues, drinking water issues, etc. Appointed in April 2005 by U.S. Interior Secretary Norton to the CALFED Bay-Delta Public Advisory Committee. Co-chaired the BDPAC Water Quality Subcommittee, member of the Water Supply Subcommittee. Served as a member of the Public Advisory Committee for the 2005 update to the California Water Plan, as well as chair of the Urban Caucus of the Advisory Committee. On behalf of CUWA, developed scope of work and guided several studies to advance the implementation and understanding of urban water conservation, including a cooperative study with the California Urban Water Conservation Council in 2007 regarding greater savings from urban landscape programs. Throughout 2007 worked with Central Valley Regional Board member Karl Longley and others as part of advisory team on early framing of a proposed Central Valley salinity management study. Coordinator and principal author of CUWA publication on climate change, “Climate Change and Urban Water Resources, Investing for Reliability” (December 2007). From December 2005 through December 2007, held this position as a contract employee with West Yost Associates at a 75 percent time base, with remaining time serving other clients.

July 1999 to April 2003. Chief Deputy Director, California Department of Water Resources. Appointed by the Governor. Head of the Director’s management team in a 2,800-person state-wide agency responsible for California water resources planning and development, as well as operation and management of the California State Water Project. Principal liaison with the CALFED Bay-Delta Program, member of CALFED Management Group and Policy Group. Commissioner, Delta Protection Commission. Recipient of Director’s Special Award in February 2003 for sustained superior accomplishments as Chief Deputy Director.

Frequent participant at conferences as a speaker, moderator and panelist concerning California water issues.

Awards

Director’s Special Award in February 2003 for sustained superior accomplishments as Chief Deputy Director.


DWR Director’s Outstanding Professional Accomplishment Award, August 1989, for work as manager of Kern Water Bank program.


Frequent participant at conferences as a speaker, moderator and panelist concerning California water issues.

July 1994 to July 1999. General Manager, State Water Contractors. General Manager of a water user organization representing 27 public agencies with long term contracts for a water supply from the California State Water Project. Coordination with DWR, other state and federal agencies, elected officials, interest groups and the public. Major issues include: (1) SWP operations and maintenance; (2) SWP water supply contract administration; (3) development of solutions to financial issues; (4) development of a long-term solution to the water supply, water quality,
environmental and structural problems of the San Francisco Bay-Delta estuary; and (5) negotiation and implementation of changes in SWP water supply contracts which provide expanded water management tools to SWP water users.


March 1991 to December 1993. Principal Engineer, Executive Division, Department of Water Resources. Chief of Water Transfers Office; Manager of Governor’s 1991 and 1992 Emergency Drought Water Banks. Responsible for all activities associated with implementing the Drought Water Banks, including negotiation of 375 contracts with sellers, 30 contracts with buyers, organization and assignment of staff for all program functions, development of comprehensive monitoring program, budget preparation and fiscal management, coordination of activities within State government, coordination with U.S. Bureau of Reclamation and local government, press contacts, etc. Received commendation from DWR Director in November 1991 for work on Drought Water Bank.

June 1987 to February 1991. Supervising Engineer, Division of Planning, Department of Water Resources. Project Manager of Kern Water Bank, a large-scale ground water recharge and extraction program. Responsible for all planning activities, including contract and land purchase negotiations, technical studies, budget preparation and management, preparation of preliminary construction plans and specifications, coordination with local water districts and the State Water Contractors, land management, feasibility report preparation and environmental impact report. Developed interim ground water storage and extraction programs during 1988 and 1990. Received DWR Director’s Outstanding Professional Accomplishment Award, August 1989.

May 1984 to May 1987. Supervising Engineer, State Water Project Analysis Office, Department of Water Resources. Chief of Water Contracts Branch. Responsible for negotiating contracts and amendments concerning State Water Project facilities and water deliveries; technical studies supporting SWP operations; water/power cost studies; water delivery schedules. Concurrent responsibilities on Bay-Delta Hearings Coordination Committee and Water Transfers Committee.

May 1983 to May 1984. Senior Engineer, State Water Project Analysis Office, Department of Water Resources. Responsible for preparation of financial and economic feasibility studies of proposed SWP facilities and programs; annual financial analysis of SWP; power cost studies; support to water contract negotiations.

January 1980 to April 1983. Senior Engineer, General Staff Branch, Department of Water Resources. Staff specialist in water rights and water resources management. Manager of water rights program. Represented DWR at water rights hearings; coordinated preparation of testimony for major hearing on water availability in Sacramento and San Joaquin Rivers. Prepared special studies on State acquisition and management of the Federal Central Valley Project, and potential impacts of small hydropower project proposals. Engineer on the team that prepared Environmental Impact Statement leading to designation of 5 northern California rivers under the Federal Wild and Scenic Rivers Act.

September 1978 to December 1979. Senior Engineer, Division of Water Rights, State Water Resources Control Board. Responsible for conducting water right studies
at the direction of the Division Chief and Board members. Provided staff support to
SWRCB 1979 hearings concerning New Melones Reservoir, and to Decision 1485
litigation (Sacramento-San Joaquin Delta water quality standards).

September 1976 to August 1978. Senior Engineer, Executive Division, State
Water Resources Control Board. Member of staff reporting directly to the Board on
developing new water quality control standards for the Delta and Suisun Marsh.
Work involved preparing technical reports, extensive analysis of testimony and
exhibits, liaison with high level operations and planning staff of DWR, USBR and
DFG. Provided testimony and exhibits at hearings, and participated in developing
Decision 1485, accompanying environmental impact report and water quality control
plan. Also participated in the Interagency Drainage Program, documenting problems
and identifying potential solutions regarding high-salinity irrigation drainage water
in the San Joaquin Valley.

June 1972 to August 1976. Assistant/Associate Engineer, Central Valley Regional
Water Quality Control Board. Positions in surveillance/monitoring as part of the
State’s water pollution control program, and planning programs related to water
quality in the Sacramento-San Joaquin Delta. Prepared and enforced waste discharge
requirements for municipal wastewater treatment facilities and industrial facilities.

ADDITIONAL EXPERIENCE


Spring 2000. Lecturer, University of California, Davis, Executive Program

Spring 1989. Department of Water Resources Executive Program

Spring 1987. University of California, Davis, Executive Program

June 1983. Instructor, University of San Carlos, Guatemala City, Guatemala. Co-
instructor of course sponsored by UNESCO and Central American Committee for
Water Resources (CRRH), “Hydrologic Forecasting and Operation of Water
Resource Systems.” Students were practicing engineers from Central American
countries.

Spring 1975. Instructor, California State University, Sacramento. CE-196, “Water
Resources and Water Pollution in the 1970’s.”

Spring, 1972. Intern, California State Assembly, Environmental Quality
Committee.
Steven Paul Millard

EDUCATION

Ph.D. Biostatistics University of Washington 1985
M.S. Biostatistics University of Washington 1982
B.A. Mathematics Pomona College 1980

EXPERIENCE

1993 - Present  
**Statistical Consultant**, *Probability, Statistics & Information, Seattle, WA*. PSI provides statistical consulting, computer programming, and training services. Past projects include: drinking water contaminants analysis for USGS; book and software for environmental statistics; book on statistics in the pharmaceutical industry; expert witness for health care and environmental litigation; teaching statistics/software to EPA and pharmaceutical companies; analyses for biomedical firms; climate modeling for U.S. Army Corps of Engineers; software for automated home appraisal (sold to TransUnion).

2006 - Present  
**Biostatistician**, *Behavioral Neurosciences Group at VA Puget Sound Health Care System, ADRC-MIRECC*. Work with researchers in the areas of Alzheimer’s disease, Parkinson’s disease, schizophrenia, post-traumatic stress disorder, and other neurological disorders. Manage/mentor biostatisticians and database administrators. Assist with analyses and planning of observational and experimental studies, including: relationships between biomarkers (e.g., SNPs, CSF proteins) and disease, endophenotypes for schizophrenia, classification schemes for dementia based on Lewy body pathology, and effects of prazosin on PTSD symptoms.

November 2007 – February 2008  
**1st VP Decision Support**, *Countrywide Bank, Seattle, WA*. Worked with Seattle-based Statistics Group to develop and maintain models for acquisition and retention and perform analytics for ad hoc requests related to deposit pricing optimization. Worked closely with management and marketing personnel to develop statistically-based direct marketing response targeting models, and to identify and analyze opportunities for revenue enhancement, cost reduction, efficiency improvement, automation and business continuity.

2000 - 2001  
**Manager of Consulting Services**, *Insightful Corporation, Seattle, WA*. Supervised statisticians and software consultants, overseeing growth of group from three to over a dozen. Insightful provides software integration and statistical support for clients in a number of fields including pharmaceutical, finance, telecommunications, manufacturing, GIS, and government. Worked on and supervised numerous projects including: web-based financial tools, monitoring quality of long-distance telephone service, and design of experiments for breeding a commercial crop.

1990 - 1993  
**Training Administrator**, *Statistical Sciences, Seattle, WA*. Started Training Department at StatSci; developed, marketed, and delivered training courses in S-PLUS. Consistently received excellent teaching evaluations.

1989 - 1990  
**Assistant Professor**, *Department of Mathematics, Saint Martin's College, Lacey, WA*. Taught calculus, discrete mathematics, differential equations, probability, and statistics.

1987 - 1988  
**Statistician**, *CH2M Hill, Bellevue, WA*. Worked with engineers, chemists, and hydrologists in the design and analysis of sampling programs at hazardous waste sites. Responsible for software development, data analysis, and report writing for the 1988 Love Canal Study.

Steven P. Millard, Ph.D.
7723 44th Avenue NE • Seattle, WA 98115-5117 • 206-715-4876
SMillard@ProbStatInfo.com • www.ProbStatInfo.com
EXPERIENCE (continued)

1986 - 1987  **Director, Biostatistical Consulting Unit,** *University of Washington, Seattle, WA.* Provided statistical advice to Health Sciences researchers; analyzed data using statistical software packages; supervised data management and data entry personnel; responsible for budget and marketing.

**Statistical Consultant,** *NeoRx Corporation, Seattle, WA.* Provided advice on design and analysis of quality control experiments for monoclonal antibody product development; analyzed QC data; developed and taught statistics short course.


PROFESSIONAL ACTIVITIES

<table>
<thead>
<tr>
<th>Member</th>
<th>American Statistical Association</th>
</tr>
</thead>
</table>

COMMUNITY ACTIVITIES

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Board Member</td>
<td>View Ridge Swim &amp; Tennis Club, 2003 – 2007.</td>
</tr>
<tr>
<td>Soccer Referee</td>
<td>Certified Level 8 soccer referee 2001-2005.</td>
</tr>
<tr>
<td>Big Brother</td>
<td>Big Brother for Big Brothers of King County, 1987-1989.</td>
</tr>
</tbody>
</table>

PERSONAL INFORMATION

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sports (swimming, spinning, running, yoga, weightlifting, x-country skiing, tennis).</td>
</tr>
</tbody>
</table>

REFERENCES

Available upon request.
PUBLICATIONS

First Author


Millard SP, and Lettenmaier DP. (1986). Optimal Design of Biological Sampling Programs Using the Analysis of Variance. Estuarine, Coastal and Shelf Science 22, 637-656.


Secondary Author


PUBLICATIONS (continued)

Secondary Author (continued)


Curriculum Vitae

WESLEY W. WALLENDER
Professor of Hydrology and Engineering
Departments of Land, Air and Water Resources (Hydrology Program) and
Biological and Agricultural Engineering
University of California, Davis, California 95616
530.752.0688 phone 530.752.05262 fax
wwwallender@ucdavis.edu email
enthusiasm.ucdavis.edu web and ftp site

EDUCATION AND REGISTRATION
Ph.D. Utah State University, Engineering, June 1982.
B.S. Utah State University, Agricultural and Irrigation Engineering, September 1981.
B.S. Oregon State University, Agricultural Engineering Technology, June 1976.
PE Professional Engineer, California, 1987.

WORK EXPERIENCE
1982-present. Assistant-82-88, Associate-88-92 and Full-Professor-92-present, University of California Davis. Research includes modeling and measurement of precipitation- and irrigation-driven watersheds from nanometer to kilometer scales. Specific subject matter interest includes water, energy and chemical transport for sustainable agroecosystems. Teach undergraduate courses in fluid mechanics, GIS and spatial analysis, and irrigation system design and graduate courses in continuum mechanics as well as surface irrigation hydraulics. Funding in excess of $10 million supporting the completion of 40 graduate student theses. More than 140 refereed journal articles and book chapters.

1992-3. Director, University of California Salinity/Drainage Research Program. Administered the development, interpretation, and dissemination of research knowledge addressing critical environmental problems on salinity, drainage, selenium, and other toxic elements in the San Joaquin Valley. Initiated a long term study on the sustainability of irrigated agroecosystems within environmental constraints.


1987-present. Registered Profession Engineering Consultant. Advise watershed entities in California. Advice and consulting to governments of France, Egypt, Oman, Mexico, Morocco, China, Brazil, and India and to the International Rice Research Institute (Philippines) and the International Water Management Institute (Sri Lanka).

PROFESSIONAL, SCIENTIFIC, HONORARY SOCIETIES AND AWARDS
American Geophysical Union, American Society of Agricultural Engineers, American Society of Civil Engineers.
Who's Who Among Students in American Universities and Colleges, Phi Kappa Phi, Sigma Xi, Alpha Zeta, Tau Beta Pi, Blue Key.
External Reviewer (4, Ph.D. Dissertation, Indian Institute of Technology.
American Society of Civil Engineers, Best Practices Paper Award, 2002.
American Society of Civil Engineers, Best Research Paper Award, 2003.
Distinguished Alumnus Award, Utah State University, College of Engineering (BIE), 2004.
American Society of Agricultural and Biological Engineers Leadership Award, 2008.
American Society of Agricultural and Biological Engineers, Fellow, 2009.
MEMBERSHIP ON COMMITTEES AND EDITORIAL BOARDS
Editor, Soil and Water Division, American Society of Agricultural and Biological Engineers, 2004-08
Associate Editor, Soil and Water Division, American Society of Agricultural and Biological Engineers, Developed and implemented procedures for an electronic journal, 1991-2004
Member, Advisory Board, International Journal of Water Resources Engineering, 1991-present
Member, Editorial Board, Irrigation Science, 1994-present
Member, Editorial Board, Brazilian Journal of Irrigation and Drainage, 2002-present
Member, Technical Advisory Committee on Forest Geology, State of California Mining and Geology Board, 2002-present
Member, Challenge Program Consortium, Global Challenge Program on Food and Water, Consultative Group on International Agricultural Research, 2001-2

MOST RECENT PUBLICATIONS
EUGENE B. (GUS) YATES

QUALIFICATIONS

Gus Yates has been a professional hydrologist in California for over 25 years. His role in water resources management projects commonly bridges the technical and policy realms. He specializes in rapidly identifying the key water-related issues for a project and addressing them with appropriate quantitative tools that make the best use of available data. He ties his technical work back into management plans and regulatory compliance documents. He has extensive experience in analysis and management of groundwater basins and related surface water and habitat systems throughout central and northern California. Mr. Yates is registered with the State of California as a professional geologist and certified hydrogeologist.

Gus Yates:

- Evaluates groundwater conditions at local and basinwide scales using modeling and statistical techniques.
- Leads stakeholder processes to develop groundwater and watershed management plans that are grounded in technical understanding of the hydrologic system.
- Routinely works on interdisciplinary teams where he provides a solid working knowledge of geology, soil science, geomorphology, climatology, land use, water use, agronomy, vegetation ecology and fisheries biology.
- Applies operations models to optimize project design and quantify environmental impacts
- Seamlessly integrates field investigations, computer models, statistics, and traditional analysis methods
- Applies training and experience in CEQA, NEPA, water-quality regulations, water rights, group facilitation, and litigation.

PROFESSIONAL EXPERIENCE

January, 1999 – present

Consulting Hydrologist in Private Practice and Senior Hydrologist, HydroFocus Inc. since April 2009

Davis and Berkeley, CA

Provides consulting services in surface water and groundwater hydrology, biohydrology, and water resources management to public agencies, private-sector clients, and nonprofit groups. Representative projects include:

- Groundwater flow and transport model, San Benito County, CA – Developed a regional groundwater flow and salinity model with MODFLOW and MT3DMS.
- Groundwater flow model, Laguna Seca subarea, Monterey County, CA – Developed and jointly calibrated a soil-moisture-recharge model and groundwater flow model to evaluate safe yield in a small, structurally complex coastal basin.
- Southeast Chico drainage study – Applied MODFLOW and HEC-RAS models to determine the cause of periodic shallow flooding in a new suburb.
- Groundwater flow model, Yuba goldfields wet-pit gravel quarry, Yuba County, CA – Developed a local-scale MODFLOW model to estimate the impacts of a proposed gravel quarry that would penetrate a regional confining layer.
- Seaside Basin update on groundwater conditions, Seaside, CA – Updated and improved prior estimates of pumping, recharge, aquifer characteristics and yield to help resolve a water-rights dispute.
- Cambria Community Services District water-supply master plan – Quantified the frequency and duration of drought-related water shortages and evaluated feasibility of water supply alternatives.
- Groundwater model update of the Turlock area, CA – Updated and recalibrated an existing finite-element groundwater flow and transport model.
- Fish habitat improvements, Yolo Bypass, CA – Applied HEC-RAS stream hydraulics model with input from landowners and biologist to design creek modifications that would improve anadromous fish passage and create localized inundation for splittail spawning and rearing.
- Integrated water resources management plan, Yolo County, CA – Provided technical expertise and local knowledge as coauthor of a countywide water management with state and local agencies.
- Groundwater management plan, Soquel Creek Water District, Santa Cruz County, CA – Served as technical advisor and coauthor for GMP update to meet SB1938 requirements and focus monitoring and management actions on emerging key issues.

1991-1999

Environmental Scientist, Jones & Stokes Associates  
Sacramento, CA

Served as hydrologist and/or project manager for CEQA/NEPA compliance and water resources management projects, including:

- Willow Slough watershed management plan, Yolo County, CA – Facilitated stakeholder process; documented groundwater, flooding and habitat conditions; and developed BMPs for agriculture.
- Groundwater management plan, northern San Benito County, CA – Served as facilitator, technical advisor and author for a multi-party planning process to identify issues and realistic solutions in a heavily-used groundwater basin.
- Subsidence impacts of groundwater pumping, Mendota, CA – Developed regression equations based on extensive USGS data to predict subsidence from groundwater transfers.
- Nitrate contamination from septic systems, Los Osos, CA – Served as expert advisor for field investigation of nitrate contamination from septic systems in a sandy coastal aquifer.
- Operations model for conjunctive use of desal plant and groundwater, Cambria, CA – Developed a probabilistic, real-time operations model to guide the conjunctive use of a desalination plant with existing water-supply wells.
- Instream flow litigation, Putah Creek, Yolo and Solano Counties, CA – Expert witness in a trial challenging the adequacy of instream flows below Monticello Dam.
1982-1990

Hydrologist, U.S. Geological Survey Sacramento, CA

- Groundwater model of Salinas Valley groundwater basin, Monterey County, CA – Developed one of the earliest models of the Salinas Valley groundwater basin and applied optimization theory to conjunctive use operations.
- Groundwater flow model, Los Osos, CA – Created a groundwater flow model to evaluate 3-D interactions of Los Osos Creek, the Pacific Ocean and groundwater flow in a layered coastal groundwater basin. Subsequently added solute transport module to estimate long-term nitrate impacts of a wastewater project.
- Groundwater flow and quality, Santa Rosa and San Simeon Creek basins, Cambria, CA – Managed a comprehensive investigation of groundwater conditions in two coastal stream valleys, and developed finite-element models to integrate data and explore management options.

ACADEMIC BACKGROUND

Master of Science, 1985, Water Science, University of California at Davis
Bachelor of Arts, 1979, Geology, Harvard University, Cambridge, MA

PROFESSIONAL AFFILIATIONS

American Institute of Hydrology – certified professional hydrogeologist
Groundwater Resources Association of California

AWARDS AND HONORS

E. Hampton Bryan Graduate Fellowship, University of California, 1983
Cum laude degree honors, Harvard University, 1979

RELEVANT PUBLICATIONS, REPORTS and PRESENTATIONS


Appendix B - Costs
<table>
<thead>
<tr>
<th>TASKS</th>
<th>Estimated Total Cost</th>
<th>West Yost Principal/Vice President</th>
<th>West Yost Engineering Manager</th>
<th>Principal Scientist/Engineer/Geologist</th>
<th>Senior Hydrologist/Scientist/Engineer</th>
<th>Hydrologist/Associate Engineer/Scientist</th>
<th>Assistant Hydrologist/Engineer/Scientist</th>
<th>Field Tech/Drafting</th>
<th>GIS</th>
<th>Travel</th>
<th>Reimbursables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1. Pilot Area Work Plan</td>
<td>$206</td>
<td>$196</td>
<td>$177</td>
<td>$159</td>
<td>$132</td>
<td>$112</td>
<td>$60</td>
<td>$60</td>
<td>$97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtasks:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1. Pilot Area Selection and Delineation</td>
<td>$10,543</td>
<td>8</td>
<td>15</td>
<td>8</td>
<td>20</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2. Identify salt and nutrient sources of significance</td>
<td>$6,784</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>10</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3. Develop and document methods for evaluating data accuracy</td>
<td>$4,990</td>
<td>10</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4. Develop a list of data sources and types of data that are currently available and evaluate the quantity of the data</td>
<td>$6,545</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5. Identify data gaps and propose methods to fill them with estimates</td>
<td>$4,658</td>
<td>5</td>
<td>10</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.6. Demonstrate how the data collection shall account for the total salt load, salt balance and salt accumulation for each of the pilot areas</td>
<td>$4,065</td>
<td>5</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.7. Identify critical concentration discharges</td>
<td>$5,481</td>
<td>5</td>
<td>12</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.8. Ensure the magnitude of each source is accurate when combined into the overall salt balance</td>
<td>$2,736</td>
<td>5</td>
<td>5</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.9. Identify methods for calculating historic, current and future salt and nutrient trends</td>
<td>$6,566</td>
<td>5</td>
<td>10</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.10. Identify and quantify areas where nutrients, especially nitrates, are impacting beneficial uses of the waters</td>
<td>$4,472</td>
<td>8</td>
<td>18</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.11. Prepare Task 1 report</td>
<td>$14,714</td>
<td>10</td>
<td>5</td>
<td>40</td>
<td>20</td>
<td>24</td>
<td>20</td>
<td>20</td>
<td>12</td>
<td>6</td>
<td>$250</td>
</tr>
<tr>
<td>Meetings and Travel</td>
<td>$9,841</td>
<td>12</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>12</td>
<td>20</td>
<td>20</td>
<td>12</td>
<td>6</td>
<td>$250</td>
</tr>
<tr>
<td>Technical Review</td>
<td>$5,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contingency 10%</td>
<td>$8,636</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task 1 total</td>
<td>$94,991</td>
<td>30</td>
<td>28</td>
<td>140</td>
<td>151</td>
<td>50</td>
<td>84</td>
<td>0</td>
<td>43</td>
<td>$469</td>
<td>$250</td>
</tr>
<tr>
<td>Task 2. Pilot Area Studies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtasks:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1. Review and validate data</td>
<td>$14,850</td>
<td>10</td>
<td>40</td>
<td>20</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2. Develop GIS layers</td>
<td>$15,225</td>
<td>5</td>
<td>10</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>45</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3. Collect and enter data into database</td>
<td>$13,796</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>50</td>
<td>50</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.4. Develop and evaluate salt budgets</td>
<td>$19,225</td>
<td>5</td>
<td>8</td>
<td>25</td>
<td>30</td>
<td>30</td>
<td>45</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5. Write draft report</td>
<td>$23,970</td>
<td>10</td>
<td>50</td>
<td>50</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>10</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>Write final report</td>
<td>$3,540</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presentations</td>
<td>$5,714</td>
<td>22</td>
<td>10</td>
<td>500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meetings</td>
<td>$4,362</td>
<td>5</td>
<td>16</td>
<td>500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical Review</td>
<td>$8,500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contingency 10%</td>
<td>$10,918</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task 2 total</td>
<td>$120,100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase I total</td>
<td>$215,091</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## 2009

### SCHEDULE OF CHARGES

#### Professional Services

<table>
<thead>
<tr>
<th>Role</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal Hydrologist</td>
<td>$176.00</td>
</tr>
<tr>
<td>Senior Hydrologist</td>
<td>$154.00</td>
</tr>
<tr>
<td>Hydrologic Modeling</td>
<td>$132.00</td>
</tr>
<tr>
<td>Hydrologist</td>
<td>$120.00</td>
</tr>
<tr>
<td>Assistant Hydrologist</td>
<td>$97.00</td>
</tr>
<tr>
<td>Field Technician</td>
<td>$81.00</td>
</tr>
<tr>
<td>GIS Services</td>
<td>$97.00</td>
</tr>
<tr>
<td>Drafting and Data Entry</td>
<td>$68.00</td>
</tr>
</tbody>
</table>

#### Travel, Per diem and Miscellaneous Expenses

<table>
<thead>
<tr>
<th>Item</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle mileage</td>
<td>$0.60</td>
</tr>
</tbody>
</table>

Ten percent (10%) will be added to direct expenses to cover administration of travel, lodging and subsistence, printing costs and photographic work, laboratory tests, miscellaneous supplies, mainframe computing, and other out-of-pocket expenses. Outside services for which a subcontract is administered (e.g. drilling or laboratory services) or other outside services such as equipment rental will be charged at cost plus ten percent (10%).

Professional or Technical Testimony is billed at 200% of the regular rates.
WEST YOST ASSOCIATES, INC.
2009 Billing Rate Schedule
(Effective January 10, 2009 through December 31, 2009)*

<table>
<thead>
<tr>
<th>Position</th>
<th>Labor Charges (dollars per hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal/Vice President</td>
<td>206</td>
</tr>
<tr>
<td>Engineering Manager</td>
<td>196</td>
</tr>
<tr>
<td>Principal Engineer/Scientist</td>
<td>179</td>
</tr>
<tr>
<td>Senior Engineer/Scientist/GIS Analyst</td>
<td>161</td>
</tr>
<tr>
<td>Associate Engineer/Scientist</td>
<td>144</td>
</tr>
<tr>
<td>GIS Analyst</td>
<td>144</td>
</tr>
<tr>
<td>Engineer II/Scientist II</td>
<td>127</td>
</tr>
<tr>
<td>Engineer I/Scientist I</td>
<td>110</td>
</tr>
<tr>
<td>Construction Manager III</td>
<td>156</td>
</tr>
<tr>
<td>Construction Manager II</td>
<td>144</td>
</tr>
<tr>
<td>Construction Manager I</td>
<td>133</td>
</tr>
<tr>
<td>Resident Inspector III</td>
<td>121</td>
</tr>
<tr>
<td>Resident Inspector II</td>
<td>112</td>
</tr>
<tr>
<td>Resident Inspector I</td>
<td>98</td>
</tr>
<tr>
<td>Sr. Designer/Sr. CAD Operator</td>
<td>104</td>
</tr>
<tr>
<td>Designer/CAD Operator</td>
<td>92</td>
</tr>
<tr>
<td>Technical Specialist II</td>
<td>90</td>
</tr>
<tr>
<td>Technical Specialist I</td>
<td>78</td>
</tr>
<tr>
<td>Engineering Aide</td>
<td>65</td>
</tr>
<tr>
<td>Administrative IV</td>
<td>92</td>
</tr>
<tr>
<td>Administrative III</td>
<td>81</td>
</tr>
<tr>
<td>Administrative II</td>
<td>69</td>
</tr>
<tr>
<td>Administrative I</td>
<td>58</td>
</tr>
</tbody>
</table>

Outside Services such as vendor reproductions, prints, shipping, and major WYA reproduction efforts, as well as Engineering Supplies, Travel, etc. will be billed at actual cost plus 15%.

Direct Costs including general computers, system charges, telephone, fax, routine in-house copies/prints, postage, miscellaneous supplies, and other incidental project expenses will be billed at 5% of WYA labor charges.

Mileage will be billed at the current Federal Rate.

Subconsultants will be billed at actual cost plus 10%.

Computers are billed at $25 per hour for specialty models and AutoCAD.

A Finance Charge of 1.5 percent per month (an Annual Rate of 18 percent) on the unpaid balance will be added to invoice amounts if not paid within 45 days from the date of the invoice.

Billing rates apply to all computers and equipment, whether owned or rented by WYA, and to all employment categories including regular full-time, part-time, limited term and contract personnel as defined in WYA’s Employee Handbook.

*This schedule will be updated annually
SURVEYING AND EQUIPMENT CHARGES

<table>
<thead>
<tr>
<th>Position</th>
<th>Labor Charges (dollars per hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS, 3-Person</td>
<td>317</td>
</tr>
<tr>
<td>GPS, 2-Person</td>
<td>271</td>
</tr>
<tr>
<td>GPS, 1-Person</td>
<td>213</td>
</tr>
<tr>
<td>Survey Crew, 2-Person</td>
<td>230</td>
</tr>
<tr>
<td>Survey Crew, 1-Person</td>
<td>173</td>
</tr>
</tbody>
</table>

EQUIPMENT CHARGES

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Billing Rate (dollars per day)</th>
<th>Billing Rate (dollars per week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO Meter</td>
<td>16</td>
<td>77</td>
</tr>
<tr>
<td>pH Meter</td>
<td>5</td>
<td>24</td>
</tr>
<tr>
<td>Automatic Sampler</td>
<td>120</td>
<td>658</td>
</tr>
<tr>
<td>Transducer/Data Logger</td>
<td>38</td>
<td>190</td>
</tr>
<tr>
<td>Hydrant Pressure Gage</td>
<td>11</td>
<td>47</td>
</tr>
<tr>
<td>Hydrant Pressure Recorder (HPR)</td>
<td>—</td>
<td>190</td>
</tr>
<tr>
<td>Hydrant Wrench</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Pitot Diffuser</td>
<td>27</td>
<td>124</td>
</tr>
<tr>
<td>Well Sounder</td>
<td>27</td>
<td>124</td>
</tr>
<tr>
<td>Ultrasonic Flow Meter</td>
<td>—</td>
<td>249</td>
</tr>
<tr>
<td>Vehicle</td>
<td>82</td>
<td>412</td>
</tr>
<tr>
<td>Velocity Meter</td>
<td>11</td>
<td>60</td>
</tr>
<tr>
<td>Water Quality Multimeter</td>
<td>163</td>
<td>891</td>
</tr>
<tr>
<td>Thickness Gage</td>
<td>—</td>
<td>66</td>
</tr>
</tbody>
</table>

*This schedule will be updated annually*