

Steven Bond and Associates

Consulting Geologists, Groundwater and Water Quality Experts

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27 September 2010

Bill Jennings, Executive Director
California Sportfishing Protection Alliance
3536 Rainier Avenue
Stockton, CA 95204

**Subject: Monitoring Requirements for Compliance with
the Irrigated Lands Regulatory Program.**

You've asked me my opinion in the form of several questions about water quality monitoring. These questions are within the context of the irrigated lands regulatory program that deals with farmland and the water runoff from these lands into receiving waters in the State of California.

I am a professional geologist specializing in water chemistry, water quality, groundwater, and engineering geology. I hold professional licenses and certifications issued by the State of California for these practices, and operate a private consulting business providing these services. I have more than twenty-five years experience evaluating natural and contaminant water chemistry problems and issues. Eleven of those years were working for the California State Regional Water Quality Control Board on water quality issues related to the impacts and remedies of water pollution from industrial and cultural activities. My experience includes the development, preparation, and review of hundreds of water quality monitoring programs involving surface water as well as groundwater systems. A true and correct copy of my curriculum vita is attached.

You asked if it is possible to protect the beneficial uses of waters of the State without monitoring those waters. The answer is a simple no. Protection of beneficial uses of waters of the State is function of the ability to monitor those waters to determine their quality. This done to verify their conformity to water quality standards and goals as defined in the Basin Plan.

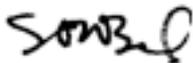
You asked if it was possible to evaluate the effectiveness of a water treatment system or of a management practice at a farm without monitoring the discharge. My answer is no. Evaluating the effectiveness of a technology or a practice requires that the change in water quality attributable to the specific practice or technology be verified. To do that a reference sample from the point of discharge and then a comparison sample taken from the same location after the technology or practice is implemented must be collected and analyzed. In actual practice, multiple samples over range of operating conditions must be collected to verify positive changes.

You also asked if it was possible to evaluate the effectiveness of a water treatment system or of a management practice at a farm from a distant downstream monitoring location. The basic answer is no. In such a case, before the samples are collected, the discharge is mixed and diluted in the receiving water with other sources of pollution from other farms. Any changes in water quality that may occur at the discharge are masked within this soup of waters and pollution and the performance of the technology or practice are essentially unknowable.

You asked if the downstream water quality of a complex watershed composed of multiple sub-watersheds, is a valid measure of the water quality in any or all of the individual sub-watersheds. My answer is no. While gross average conditions may be observed downstream, the conditions of individual upstream sub-watersheds will remain unknown. Between the downstream monitoring station and the various upstream watersheds, mixing and dilution occurs and the conditions at any upstream point are obscure to the downstream location.

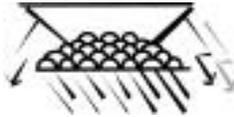
I've attached a 26 May 2003 letter from me to the Chairman of Central Valley Regional Water Quality Control Board on the subject of the Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands within the Central Valley Region. This letter also addresses many of the issues associated with water quality monitoring of irrigated lands.

Sincerely



Steve Bond PG, CEG, CHG
Principal, Steven Bond and Associates

Attachments



Steven Bond and Associates, Inc.

Consulting Geologists, Groundwater, and Water Quality Experts

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26 May 2003

Mr. Robert Schneider
Chairman, Central Valley Regional Water Quality Control Board
3443 Routier Road, Suite A
Sacramento, CA 95827-3003

Subject: Conditional Waiver of Waste Discharge Requirements for Discharges from
Irrigated Lands within the Central Valley Region, 24 April 2003

Chairman Schneider and Members of the Board.

I have reviewed the proposed Monitoring and Reporting Programs (MRP) for the Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands within the Central Valley Region which was prepared for the 24 April 2003 Regional Board hearing. I prepared this letter on 23 May 2003 but was unable to transmit because I lacked various information available only on the Regional Water Quality Control Board Web Site, which was unavailable at that time. I was informed today that the deadline for comments was extended due to technical problems with that web site. I am submitting this letter on behalf of the DeltaKeeper and Water Keepers of Northern California.

I find that the proposed MRP and associated Quality Assurance Project Plan are impressive documents with many positive elements to offer for the protection of water quality. However, in certain respects the proposed MRP is too general and provides loop holes that may result in less than adequate monitoring data.

I am a professional geologist specializing in water chemistry, water quality, groundwater, and engineering geology. I hold professional licenses and certifications issued by the State of California for these practices, and operate a private consulting business providing these services. I have eighteen years experience evaluating natural and contaminant water chemistry problems and issues. Eleven of those years were working for the California State Regional Water Quality Control Board on water quality issues related to the impacts and remedies of water pollution from industrial and cultural activities. My experience includes the development, preparation, and review of hundreds of water quality monitoring programs involving surface water as

well as groundwater systems. A true and correct copy of my curriculum vita is attached.

The decades of growth and development of the Central Valley and its agricultural industry has coincided with the decline of the quality of the Central Valley waterways. Although this decline is a matter of record, discharges and runoff from irrigated agriculture and other agricultural operations have contributed to this decline in ways that are often difficult to quantify. They are not easily quantified because critical monitoring programs were not in place to require the collection of essential data.

Water Quality Monitoring Fundamentals

Monitoring is the central supporting element of water quality protection and conservation. All actions to protect and safeguard our water resources rely on what the monitoring informs us about the conditions of the water bodies. Monitoring programs are like the physical senses; they are the faculties which we perceive the conditions of the water bodies. Without monitoring, we are blind to all but the grossest conditions in our rivers, streams, and lakes. Further, a poor or inadequate monitoring program provides us with questionable information and ambiguous clues to guide us in making intelligent decisions regarding water quality control.

A valid monitoring program usually begins as a well-reasoned plan. It will include an assessment of water flow onto and off of an area of possible or potential pollution, and contaminants. It will include an assessment of all the potential sources of pollution and contamination and identify the elements and constituents associated with the sources. The elements can include individual constituents as well as possible adverse effects of combinations of individual constituents and or conditions. These effects will be measured as toxicity. The well-reasoned plan will address the representativeness of sample collection by the method and timing of sample collection and measurement.

A well-reasoned water-quality monitoring plan is based on a thorough understanding of flow paths and physical and chemical quality of the water moving through a watershed. This will include an understanding of the variability of the flow and quality of the water over time, and at different locations within the watershed. This understanding of the watershed becomes the standard by which subsequent monitoring data can be measured or judged. Definition of existing conditions within a

watershed will require, at a minimum, the monitoring of a full annual cycle of climatic changes. However, multiple years of data are needed to address variations in the annual cycles.

A good understanding of a watershed (existing-conditions) is highly desirable; it is usually essential. Lacking good understanding of the existing-conditions, the only option left is to measure the quantity and quality of water before (background) it enters the critical area of the watershed (project area), and then conduct identical monitoring of water as it passes from the project area. In this latter case, the background water quality becomes the standard, or benchmark which the down-river water quality can be measured and judged.

Monitoring Point Locations

Valid monitoring data can only be collected from logical points of monitoring placed within the flow path of the discharges from the potential sources of pollution (the agricultural lands) into the receiving waters; the waters of the State.

Monitoring Parameters

A reasonable water-quality monitoring program will track physical and chemical constituents of interest (constituents of concern) specific to the discharge from a source and, will define the mass of contaminants discharging from the source. The constituents of concern will include each constituent reasonably expected to come from the agricultural operation. Constituents of concern will also have the potential to impair the beneficial uses of the receiving waters, or they will be indicators or surrogates of such pollutants.

Sample Collection Timing

Sample collection must coincide with the most likely period of time that discharge of pollutants would occur. In many cases pesticide and fertilizer application occurs only at certain times of the year and these times vary depending on the crop. Consequently a valid plan will address these variables.

Monitoring Cost Estimates

A wide range of alternative technologies exist to assist the responsible parties in efficient and cost conscious data collection. When attempting to assign a dollar cost to monitoring project, it is not reasonable to assume that the most labor intensive sampling and analytical techniques should be used.

Monitoring Station versus Watershed Area

The proposed MRP is excessively lenient where it indicates that 20 square kilometers (5000 acres) of watershed will be a maximum area allotted per monitoring point. This language will tend to encourage dischargers to design monitoring plans around this figure and in doing so will undermine the quality of monitoring data.

For example, a monitoring plan with a large watershed and few monitoring points will inevitably have a number of small tributary water bodies located between a single monitoring point and a potential source of pollution. These small tributaries will alter the character and quality of the water and the sampled water will not be representative of the water quality impairment immediately down stream of a particular discharge. Such a program will deliver misleading and incomplete information with respect to receiving-water water quality conditions. This will result in contradictory or ambiguous conclusions with respect to the performance of any mitigation measures, or lack thereof, at the project area.

Emphasis should be placed on the requirement that each discharge point be monitored and that each sample collected be representative of the discharge water quality. The size of an area represented by a monitoring station should be a function of the number of discharges from a specific agricultural operation.

Summary

An adequate monitoring program is a valid program. It will assess the impacts to the state's waters from agricultural operations and it will require monitoring stations at the point(s) of discharge. A valid monitoring program will monitor for all constituents of concern as well as toxicity. It will assess the total mass of pollutants discharging from individual agricultural operations and it will also include a comprehensive ambient (background) monitoring program.

Sincerely



Steve Bond
Principal, Steven Bond and Associates, Inc.

Attachment

STEVEN R. BOND

Curriculum Vita

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Profile

Geologist / Engineering Geologist / Hydrogeologist / Aqueous-geochemist /

- More than twenty-five years applied experience in groundwater and engineering geology.
- Twenty years practical experience defining hydrogeologic flow systems in crystalline, fractured rock systems, and porous sedimentary aquifers.
- More than twenty years practical experience evaluating natural and contaminant water chemistry problems and issues.
- Eighteen years applying geochemical techniques to hydrogeologic situations in humid, and semiarid hydrogeologic regimes, including water supply, and contaminant fate and transport analyses.
- More than twenty years experience investigating and evaluating geologic and hydrogeologic hazards related to slope stability, seismic hazards, hazardous materials, mine wastes, and soil and groundwater contamination.
- Five years experience defining and modeling stream and river flow, flooding analyses, and sediment transport systems.
- Ten years experience evaluating industrial impacts to water quality

Professional	Registered Geologist, <i>California, USA</i>	# 5411
	Certified Engineering Geologist, <i>California, USA</i>	# 1841
Licenses	Certified Hydrogeologist, <i>California, USA</i>	# 0238

- Eleven years regulatory experience implementing California and U. S. water quality laws and regulations.

Professional Experience

January 1999 to Present

Steven Bond and Associates, Santa Cruz, CA, President, Principal Geologist

Conducted investigations and assessments of geologic hazards, threats to surface water and groundwater quality from various industrial and natural sources, and groundwater supply investigations. Performed litigation support in cases involving potential impacts of geologic hazards, groundwater supply and pollution, surface water pollution, and State water quality policy review. Examples of such activities and projects include the following:

- *Engineering Geology*: Conducted investigations of geologic hazards, foundation studies, liquefaction potential assessments, fault trace analyses, slope stability assessments and prepared the associated engineering geology investigation reports for development and industrial projects in Monterey, San Mateo, Mendocino, and Santa Cruz Counties. ◇ Conducted foundation suitability study, seismic evaluation, and fault trace study for resort development, Big Sur (Monterey Co.) ◇ Conducted analysis of debris-slide hazard potential of properties near Loma Mar (San Mateo Co.) ◇ Did technical analysis of slope stability and soil erosion potential of timber harvest operations, and evaluated surface-water monitoring practices (Humboldt Co.) for permitting dispute. ◇ Evaluated landslide activation hazard analysis of cliff side development in Brisbane (San Mateo Co.) ◇ Evaluated potential erosion hazards and drafted technical remedies from impacts of extrajudicial logging activities (Mendocino, Co.) ◇ Prepared engineering geologic reports for various residential development projects (Santa Cruz Co. , San Mateo Co.).
- *Groundwater Investigations, Modeling, and Remediation System Design*: Designed and implemented original subsurface investigation techniques, and remediation systems for a complex hydrogeologic environment of

- volcanic sediments, for Sierra Nevada Mt. community drinking water contamination (Volcano, CA). ◇ Did aquifer analysis and computer simulation (Modflow) of contaminant flow and remediation system design (groundwater extraction) for MTBE site in Turlock, CA. ◇ Did groundwater transport and pollutant fate analysis of landfill for litigation support. (Colma, CA)
- *Groundwater Supply*: Conducted groundwater use sustainability study for Sonoma Valley winery (Valley of the Moon). ◇ Did evaluation of sustainability potential and impacts from groundwater extraction in Sierra Valley (Sierra and Plumas Counties) for litigation support.
 - *Policy Review and Regional Studies*: Conducted technical review and analysis of CA State water policy (State Implementation Plan, California Toxics Rule) for litigation support. ◇ Technical consultant and committee member for San Francisco Bay Copper-Nickel TMDL impairment studies (north and south).
 - *Storm Water*: Conducted technical reviews, and did litigation support in cases of storm water pollution regarding the adequacy of monitoring programs, BMPs, and treatment technology application (Alameda, Humboldt, Placer, Sacramento, San Joaquin, San Mateo, San Francisco, Sonoma, Yuba counties) for the following types of industry: aggregate, cement, asphalt, metal fabrication, metal forging, steel casting, recycling, ship breaking, wood treatment, sawmills, CAFOs, vehicle maintenance, auto wrecking, POTW, precious and heavy metal mines, landfills, fueling facilities, and port loading facilities for ammonia, fertilizer and petroleum coke.
 - *Mining Projects*: Evaluated drinking water quality hazards posed to confined prisoners at an operating copper mine (United Nations ICTY, Bosnia-Herzegovina). ◇ Evaluated geochemical potential to produce acid and release arsenic from re-activated gold mine (Sutter Ck. CA), acid mine drainage water quality impacts. ◇ Evaluated WQ pollution potential from abandoned mercury and gold mines (Coastal Mts, central & north CA, Sierra Nev. Mts) for litigation purposes.
 - *Land Discharge Projects*: Evaluated compliance with CCR Title 23, Title 22, Chapter 15 (CA) regulations for Winery wastes (Amador County), dredging spoils disposal (Port of Stockton), Class III landfill (San Mateo Co., Shasta Co., Lake Co.). Designed monitoring programs and budgets.

March 1998 - January 1999

Fall Creek Engineering, Inc., Santa Cruz, CA, Principal Geologist

Evaluated the risk from surface and groundwater contamination to public groundwater supplies (Big Sur); performed computer simulations of flow and geochemistry of ground and surface water interaction using Modflow, Minteq. Did hydrologic studies to evaluate the flood stages, water surface profiles, and erosion potentials; constructed a computer -based hydraulic model of the river using HEC-RAS (Salinas River, Monterey Co.); prepared water quality and flood control management plans (Pajaro River). Designed and conducted soil and groundwater sampling analysis programs at various sites in Monterey and Santa Cruz Counties (leaky underground fuel tanks, wastewater disposal systems).

March 1997 - January 1998

Water For People, Denver Colorado, Consulting Hydrogeologist

Conducted a synoptic hydrogeological survey of the Bay Islands, Honduras, Central America for the Bay Island Environmental Project. Conducted a study of the islands' resources and made recommendations for a comprehensive water supply investigation of the three main islands comprised primarily of fractured metamorphic rock. Conducted local interviews, literature review and a reconnaissance level survey, field trued geology in selected areas. Evaluated island-available drilling technology, characterized water quality and supply issues for several of the island communities, prepared investigative criteria for future work, wrote report.

December 1986 - May 1998

California Regional Water Quality Control Board, Sacramento, CA. Associate Engineering Geologist

Conducted investigations of all aspects of pollutant transport in the vadose zone and groundwater and surface water. Reviewed and evaluated the geologic, hydrogeologic, geochemical, and geophysical content of professional reports. Evaluated thoroughness of surface and groundwater investigations, the completeness of remedial efforts, and validity of monitoring programs. Provided expert technical assistance to State and local agen-

cies on issues of geochemical fate and transport of pollutants, well-head protection strategies, abandoned mine investigation and remediation methods, and contaminated groundwater and soil cleanup technics. Examples of such projects include the following:

- Analysis of groundwater impacts from organic solvents and fuels in sedimentary and fractured rock terrain. Evaluated investigative methods including drilling techniques, soil, water, and vapor sampling methods, and in situ and ex-situ remedial technologies using vapor transport, groundwater capture, extraction and treatment. Did deterministic computer modeling. Technical advisor and regulator for hundreds of facilities under authority of Federal and State underground tank statutes in the counties of Alpine, Amador, El Dorado, Calaveras, Lake, Napa, Mariposa, Placer, Sierra, Solano, Stanislaus, and Tuolumne California, and in Yosemite National Park.
- Analysis of groundwater flow and pollutant transport characteristics of polluted, high density waste water (industrial acids and heavy-metals) at Davis, CA. Evaluated water quality impacts, effectiveness of groundwater extraction schemes using numerical modeling methodologies for flow, and chemical fate and transport. Co-developed in situ leaching methods of contaminated soils to accelerate cleanup rates.
- Analysis of the underlying, geochemical causes of acid mine drainage at the Penn Mine in Calaveras Co., CA. Identified and evaluated groundwater flow paths in a faulted crystalline-rock aquifer and the applicability of water quality and hazardous waste laws to the toxic discharges. Conducted a geologic and fracture mapping project and developed conceptual flow groundwater model. Evaluated acid-mine and acid-rock drainage remedial alternatives and made recommendations for their use. Developed and composed work plan for the investigation of fractured-rock hydrogeological transport, and aquatic geochemical fate of heavy metals from Penn Mine to the adjacent Camanche reservoir. Authored numerous reports and a series of successful grant proposals, prepared annual budget and obtained funding for detailed groundwater and remedial waste rock investigations.
- In companion project to the above mine waste project, developed a conceptual model for the transport mechanisms of heavy-metal laden sediment in the Camanche water-supply reservoir, developed the conceptual methodology of investigation, and managed the project. Assembled a team of limnologists from the University of California at Davis and fluid mechanical engineers specializing in sediment re-suspension from University of California at Santa Barbara. Wrote a successful Federal Clean Lakes Grant proposal, and implemented the investigation at Camanche reservoir, California.

May 1986 - September 1986

U.S. Army Corps of Engineers, Sacramento, California, Engineering Geologist.

Conducted geologic and hydrogeologic investigations preparatory to the design of Deer Creek Water Supply Reservoir, Utah. Drafted groundwater investigation plan. Conducted geologic mapping. Designed monitoring wells, supervised drilling crews and well construction, conducted aquifer pumping tests.

October 1983 - September 1984

Dames and Moore, Los Angeles, California, Sedimentary Petrologist.

Conducted sedimentological investigation of near-shore sediments in western Arabian Gulf. Characterized sediment transport systems in the Arabian Gulf area of United Arab Emirates for Abu Dabi National Oil Company.

May 1982 - April 1983

U.S. Army Corps of Engineers, Portland, Oregon, Engineering Geologist.

Conducted geologic, geophysical and hydrogeologic investigations in the Columbia Gorge near Bonneville, Oregon. Conducted geophysical borehole investigation of Bonneville New Navigation Lock. Did detailed mapping of landslides, and drill core logging. Designed passive de-watering systems, and monitoring wells. Supervised drilling crews and the construction of water supply wells and monitoring wells; conducted and interpreted aquifer pumping tests.

June 1981 - December 1981

XCO, Denver Colorado, Petroleum Field Geologist (Mud logger)

Did drill core logging, conducted field screening of chemical composition of drill cores, interpreted geologic strata, and prepared drilling reports in several depositional basins in North Dakota, Colorado, and Oklahoma.

September 1976 - September 1977

U. S. Geological Survey, Menlo Park, California. Geologic Field Assistant.

Conducted geologic mapping and did geochemical sampling for Continentally Unified Strategic Assessment Program.

**Education
&
Training**

Master of Science (ABT) in Hydrogeology, Special Studies Program, California State University, Chico, California, 1985-1986

Bachelor of Arts in Geology, Humboldt State University, California, 1979 - 1981

Annual NWWA courses in Aqueous Geochemistry, Fluid Flow through Fractured Rock, In situ Fluid Extraction Systems, Ground-Water Isotope Geochemistry. 1987-1991.

Computer Modeling. EPA CEAM: MINTEQ geochemical speciation, 1990, 1991; WASP surface water flow and transport, 1991. General Sciences Corp.: SESOIL vadose zone pollutant transport, 1994, 1996; AT 123D groundwater pollutant transport, 1994, 1996; NWWA: Visual Modflow, Flowtrans, groundwater flow and transport, 1996. WHI: Modflow 2000, MTD3, groundwater and contaminant transport, 2002.

Constructed Wetlands Workshop and Seminar Series, Humboldt State University, California, 2002.

Soil Slope Stabilization, Embankment Design, National Highway Institute, Vail, CO, 2007

40 hour OSHA Health and Safety for Hazardous Waste Operations and serial 8 hour refresher courses.

Evaluated economic potential of proposed Federal Wilderness areas and abandoned mines including the Kalmiopsis Wilderness of southwestern Oregon; an ophiolite suite and recent volcanic terrain.

Professional Associations

Association of Engineering Geologists; Groundwater Resources Association of California
Northern California MTBE and Fuel Oxygenates Committee

Non-Profit Affiliations

Valley Air Trust, Central Valley, Stockton California, Board Member 1993 - 1997

BayKeeper San Francisco Bay -Sacramento Delta, Technical Advisory Committee Member 1996 - present.

California Sportfishing Protection Alliance, Technical Advisory Committee Member 2000 - present

The Abandoned Mine Alliance, Sierra City, California, Board Member 2005 - present

Expert Testimony

- Before the United States Northern District of California Court, on issues of storm water pollutants associated with industrial ammonia and urea fertilizer production and storage operations in the case of California Sport Fishing Protection Alliance vs California Ammonia Company, September 2006.

Expert Testimony cont.

- Before the United States Northern District of California Court, on issues of surface water pollution associated with logging practices in the case of EPIC vs Pacific Lumber Company, May 2006.
- Before the United States Northern District of California Court, on issues of groundwater and storm water pollution associated with lumber milling and wood treatment operations in the case of Ecological Rights Foundation vs Sierra Pacific Industries, April, October, 2002.
- Before the United States Eastern California District Court, on issues of storm water pollution, confined animal feeding operations and industrial activities in the case of WaterKeeper of Northern CA. vs L. Vandhoef, Chancellor, University of California, Davis, June, August 2001.
- Before the CA State Water Resources Control Board hearing on the Appeal of Regional Water Quality Board's Actions regarding Pacific Lumber and the Elk Creek Timber Harvest Monitoring, July 2001.
- Before the United States Northern District of California Court, on issues of storm water pollution and ship-breaking in the case of WaterKeepers of Northern CA. et al, vs U.S. Dept. of Navy and Astoria Metals Corporation, June, August 2000.
- Before the California Superior Court on issues of groundwater pollution and crude oil in the case of Thompson Chevrolet vs Chevron Corporation et al., January, July, and November 1996.
- Before the California Superior Court on issues of acid mine drainage, water pollution, and groundwater flow through fractured crystalline rock in the case of California Sportfishing Protection Alliance vs State Water Resources Control Board, June 1994.
- Before the California Senate Natural Resource and Wildlife Committee Investigative Hearing on Conflicts of Interest in the California Environmental Regulatory System, June 1992.
- Before the California Senate Natural Resource and Wildlife Committee Investigative Hearing on Acid Mine Drainage, Water Pollution, and the California Regulatory Environment, Jan. 1992.
- Before the California State Water Resources Control Board hearing on the Appeal of Regional Water Quality Boards Actions regarding the Penn Mine, October 1991.

Public Speaking and Presentations*Presentations before the State Water Resources and Regional Water Quality Control Boards.*

- Presented testimony and briefs before the State and Regional Boards on specific cases of regulatory enforcement actions, (1990 - 2007)
- Mediator of formal discussions regarding disputed technical issues about groundwater quality between responsible parties, (1988 - 1998)

Workshop Presentations before professional societies, and local and State regulatory agencies:

- The application and interpretation of discreet groundwater sampling methods and data collection.
- The use and interpretation of computer modeling simulations for vadose transport and mineral equilibria
- The effects and determination of vertical gradients on pollutant transport in groundwater.
- Contaminated soil cleanup criteria based on California State Water Code, regulations and policies.
- Acid Mine Drainage issues: the geology, mineralogy, and chemistry, the environmental effects, remediation, policies, and politics.

Writings

Author of scores of reports for private organizations, NGO's, Federal, State and local Agencies, on the subjects of (a. organic and inorganic pollutant transport in surface and groundwaters, (b. polluted groundwater remediation, (c. the investigation and analysis of the potential transport of soil contamination (metals, fuels, solvents) through the vadose zone, (d. unsaturated zone characterization including vapor-phase transport and cleanup technologies, (e. acid mine drainage causes, fate, and mitigation, (f. the logical elements of water quality monitoring, (g. regulatory compliance of state and federal environmental laws by federal, state and private parties, (h. metal mobility and mineral equilibria, (i. net-vertical transport of groundwater pollutants, (j. general surface water and groundwater resource protection, (k. water budget accounting in mixed geologic environments with multiple density fluid interfaces, (l. groundwater supply evaluations, (m. reconciliation of threats to water resources and risks to human health, (n. engineering geology, geological hazard analysis.