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Case Study: Zymax Forensics Stable Isotope Analysis used to Determine Denitrification Trends at Waste Water Treatment Facility—Barstow, CA

By Amanda Jensen

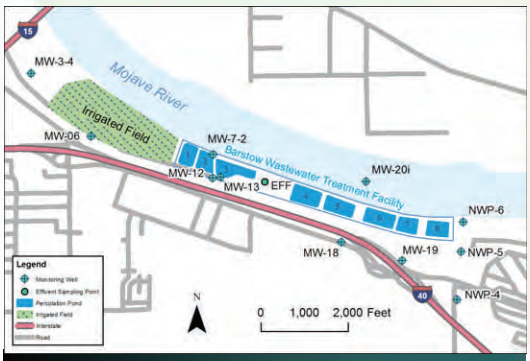
Since the early 1980's the City of Barstow, CA, has been monitoring groundwater quality in the vicinity of their Waste Water Treatment Plant (WWTP). The City's WWTP lies along the southern bank of the Mojave River, which serves as a major beneficial use drinking water aquifer for the residents of Barstow and other high desert communities. The area has been under investigation for the past three decades with Nitrate being the primary contaminant of concern.

Over the past 6 years DPRA has had an active role in investigating (on behalf of the City of Barstow) the lateral and vertical extent of nitrate (and other nitrogen bearing compounds) in groundwater due in part to current and historical discharge practices of secondary treated water from the WWTP into holding ponds and onto farmed land.

One of the primary goals associated with this project was to determine the fate of the nitrate being discharged by the WWTP. Rather than continuing to install costly monitoring wells to trace nitrate discharges down gradient, DPRA proposed to demonstrate that nitrates being discharged to the Mojave River were naturally degrading through denitrification processes. Denitrification is a bacterial initiated process in which microorganisms break apart nitrates ultimately reducing them to nitrogen gas.

Typical Denitrification Reduction:

$$NO_3^- \rightarrow NO_2^- \rightarrow NO + N_2O \rightarrow N_2\,(g)$$



Barstow California Waste Water Treatment Plant.

To help determine if denitrification processes were occurring, the City and DPRA procured the services of Zymax Forensics. Select groundwater and effluent samples were analyzed for nitrogen/oxygen stable isotopes using their signature "Denitrifier Method".

Stable isotopes of nitrates and oxygen have been widely used for identifying nitrogen sources. Many studies have shown that techniques used to determine isotopic signatures, especially δ18O and δ15N of nitrate, are very powerful tools to distinguish the major sources of nitrate in groundwater and determine if the process of denitrification is occurring.

Advantages of using Zymax's "denitrifier Method"

- Sample volumes no longer in liters or gallons; only 100mL or less.
- The [NO3-] concentrations can be as low as ~0.1 mg/L.
- Water Sulfate and saline presence in the sample is acceptable.
- No interference with other N-bearing substances.
- Accuracy is 0.2 and 0.5 permil (‰) for 15N and 18O isotopes, respectively.

To demonstrate that natural denitrification processes were occurring, DPRA collected samples of secondary treated effluent and groundwater samples from within the WWTP site and from offsite (downgradient) monitoring wells through traditional water sampling techniques. One of the biggest advantages of using Zymax's nitrate isotope analysis is the relatively small sample volume needed. Other methodologies typically require upwards of 1 gallon of sample volume. With Zymax's method, no special sample containers or preservatives are needed. One 100mL HDPE container is all that is required. The small sample volume requirement significantly reduced field sampling time and shipping costs. Another advantage of this methodology is that this analysis can be performed on samples that have nitrate concentrations as low as 0.1 mg/L (Wang, 2010).

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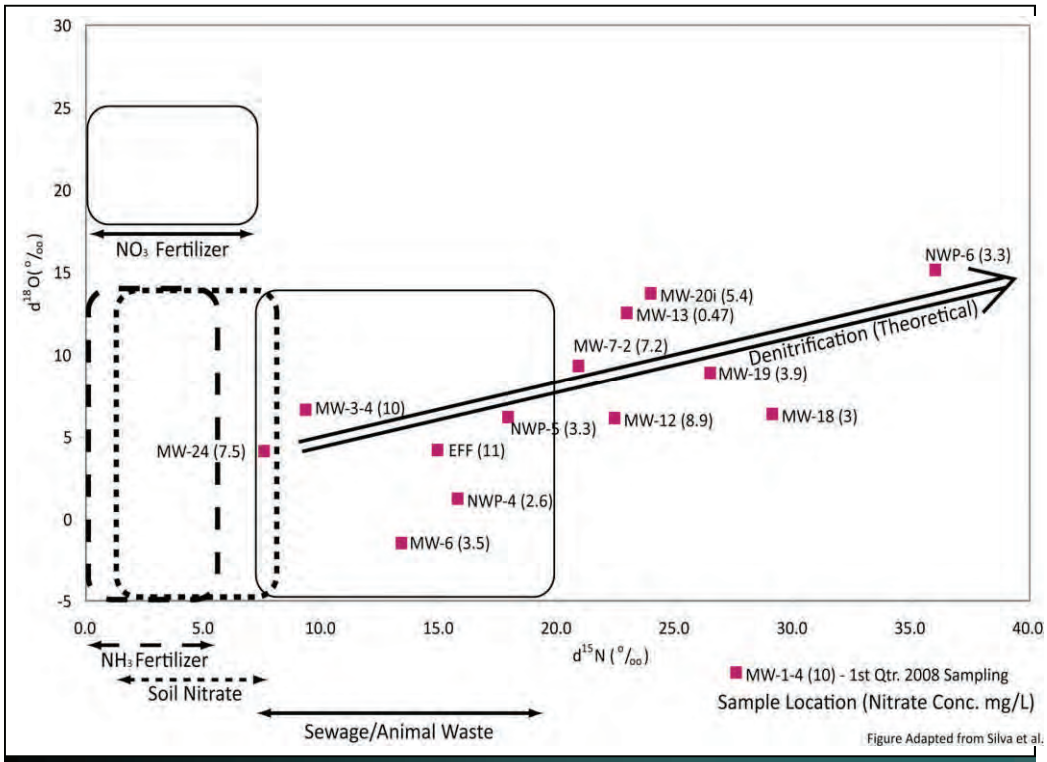
Results from samples taken from in and around the (WWTP) were plotted on a diagram adapted from Silva (Silva et al, 2002). The plot shows sample data plotted against an idealized linear trend line representative of denitrification. The observed data generally plots along the idealized denitrification trend line which in part corresponds with monitoring wells and their lateral/downgradient position from the WWTP.



Barstow California WWTP Nitrogen/Oxygen isotope samples plotted along a denitrification trend line.

Through the use of Zymax Forensics' unique stable isotope service, DPRA and the City of Barstow were able to clearly demonstrate that denitrification processes were and are occurring offsite and downgradient of the WWTP. As a result of this study, potentially hundreds of thousands of dollars in cost savings were realized by not having to construct additional monitoring wells and sampling them for many years to come.

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Ms. Jensen received her B.A . in Environmental Science and Earth Studies from University of California Santa Cruz in 2006. Since 2007 she has served as an Environmental Scientist/Research Assistant at DPRA Inc. providing support to staff scientists, geologists, project managers, and expert witnesses. Support includes quality assurance and control of data and documents, document research, analysis, and interpretation, production of technical reports and participation in Investigative Environmental Forensics.

Project Pitfalls (Part 1): Avoiding the Perils of Database Mismanagement

By Robert Falero

With any project, large or small, problems arise that threaten the budget, accuracy and timeliness of the final product. It is essential that these problems be avoided to ensure that the overall quality of the project and relationship with the client is maintained at the highest level.

Over the past 20 years, DPRA has been involved in numerous large and small scale environmental litigation, assessment and remediation projects. During this time we have identified numerous pitfalls that plague project success. For most environmental litigation projects, the three most significant pitfalls are database mismanagement, document mismanagement and finally, poor quality graphics.

Part I of this three part series focuses on how databases are mismanaged, why it's important to manage them correctly, and how DPRA can play an instrumental role in ensuring accuracy and consistency in database creation and design.

Database Mismanagement

Data has always been the single most important component of any environmental litigation project. The collection of data and the creation of a database should begin at the inception of a project, when the first sample is analyzed. How this database is created and managed during the early stages can have far reaching implications throughout the life cycle of the project. Database mismanagement is all too often the most common pitfall of an environmental litigation case, typically manifesting itself through database decentralization. Environmental litigation cases typically employ multiple expert witnesses, most often with unique database configuration requests. It may seem ideal to have each expert in control of their own database, but through DPRA's 20 plus years of experience, this approach leads to lack of sufficient quality control/quality assurance, lack of consistency between experts and most importantly runaway project costs.

QA/QC

Since databases are only as good as they are accurate, it is vitally important to have rigorous quality assurance and quality control procedures in place from the onset of database creation. Experts and their support staff vary in experience and subsequently in their abilities to create and manage databases. This can lead to inaccurate and/or incomplete databases, creating the potential for experts using the "same" data to produce conflicting opinions, essentially pitting expert against expert on the same side of a case, jeopardizing the case as a whole.

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Consistency

Throughout the process of database development, at times a "judgment call" needs to be made that can affect the foundation of the database itself.

From our experience, the data records that most commonly require judgment calls are those that are reported as either non -detect or duplicates on laboratory data sheets. All laboratory equipment has a lower limit to which a particular chemical can be accurately detected. This limit is known as a detection limit (DL). When samples are analyzed, and a particular chemical is detected lower than the DL, the result is referred to as a non-detected (ND). For reporting purposes on laboratory data sheets, NDs can be displayed in a variety of ways: ND, 0, the detection limit itself with a less-than symbol (<0.35). Results can also be redefined as an approximated numerical value of the chemical that was detected with a qualifier (0.35J).

Duplicate data records are created when duplicate samples are taken in the field to ensure the accuracy of laboratory procedures. Quite often these duplicate sample results are not identical. The question then becomes, how should these data be handled in the database? Should only the highest result be entered, the lowest, what about averaging the results?

It is easy to see how something as simple as a "judgment call" on the value given to a ND in a database or how duplicate data records are handled can greatly decrease consistency when it is compounded over many experts. Allowing multiple experts to make these judgment calls individually, breeds database inconsistency. This can lead to skewed results and conflicting opinions, both of which are potential case breakers.

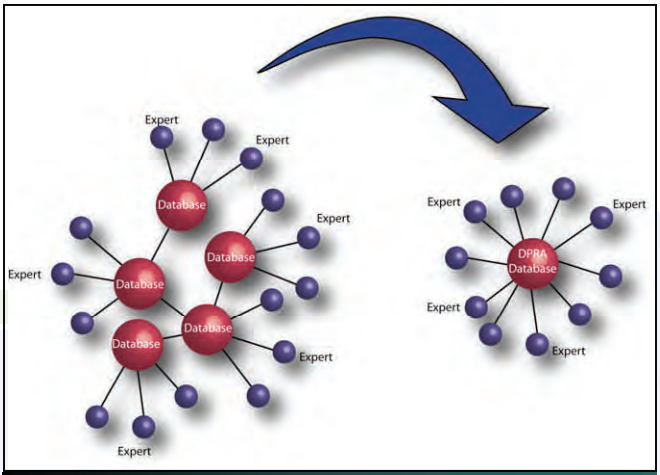
Cost Control

Cost is always the focus of every project no matter how big or how small. Whether your title is case manager, project manager, lead counsel or junior counsel, controlling costs is very often your number one priority. There are many ways that costs can get out of control when creating a database. One of the easiest ways of letting costs get out of hand is by allowing database decentralization.

In most litigation cases, cost is associated with scale. As a dataset grows larger the corresponding database grows larger and the costs increase. When the task of creating a database is multiplied by the number of experts on the case, then it stands to reason that the cost is also multiplied by the number of experts. At the litigation rates of experts in today's market it's no surprise that costs can quickly get out of hand, in many cases due to duplicative efforts.

The DPRA Solution

Armed with an understanding of how databases can be mismanaged, making sure they are managed correctly becomes a much simpler solution. DPRA has experienced and learned from the pitfalls discussed above, and from that comes expertise in centralized database design and creation. As the sole source of data inflow and outflow, DPRA can implement its case-proven proprietary QA/QC methodologies,



DPRA's database management practices eliminate database decentralization and create a more consistent, accurate and cost effective solution to clients needs.

ensure consistency between experts with proper control on subjective data, and most importantly keep costs down by eliminating the possibility of duplicate work. Avoiding the pitfalls of database mismanagement is critical and DPRA has assisted many clients doing so.

For more than two decades we have successfully managed millions of chemical analysis results for samples of water, soil, air, biota and related information. Our database centralization and data standardization procedures, along with our ability to meet stringent data integrity and security provisions have proven that we have the requisite expertise to successfully manage complex and prolonged litigation projects. Our extensive database management, coupled with our records management experience provides superior litigation support services to our clients'. In the next newsletter, we will discuss document mismanagement, the second of the three significant pitfalls: database mismanagement, document mismanagement and poor quality graphics.

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Robert Falero is a Professional Geologist who has been with DPRA since 2005. He received his B.S. and M.S. in Geology from the University of California at Riverside. Since joining DPRA in August of 2005, Mr. Falero has gained extensive experience in overall project management, on-site management of large scale groundwater investigations, the preparation of various reports including remedial action plans, remedial action reports, feasibility studies, groundwater monitoring reports, health and safety plans and work plans, the construction and analysis of databases, and the design of GIS based publishable figures. In addition Mr. Falero has worked extensively with an environmental expert witness in various aspects including; critical review and analysis of legal documents, development and preparation of expert witness reports, and National Resource Damages (NRD) cost allocation analysis.

INTRODUCING THE EXPERTS: Dr. Robert Morrison and Dr. Alan Jeffery

Dr. Morrison has a B.S. in Geology, a M.S. in Environmental Studies, a M.S. in Environmental Engineering, and a Ph.D. in Soil Physics from the University of Wisconsin at Madison. Dr. Morrison has been working for over 30 years in the environmental field on issues related to soil and groundwater contamination. He specializes in the forensic review and interpretation of scientific data for the purpose of identifying the source and age of a contaminant release and manages DPRA's environmental forensic practice group. He is also an Adjunct Professor at the University of Massachusetts at Amherst, MA.

Dr. Morrison is the primary expert witness offered by DPRA. He has reviewed environmental documents for thousands of sites, worldwide, with the majority of these sites impacted with petroleum hydrocarbons and/or their derivatives/additives and chlorinated solvents. Dr. Morrison is credited for coining the term "environmental forensics", authoring the first textbooks on this subject, and with Dr. Paul Kostecki founded the society dedicated to this science (International Society of Environmental Forensics www.environmentalforensics.org).

Dr. Morrison has published articles and books on soil and groundwater contamination topics and has shared this information via lectures throughout the world. He is active in reviewing technical papers on forensics techniques and has served on the editorial boards of Ground Water, Groundwater Monitoring Review and Remediation and is currently Editor-in Chief of the Journal of Environmental Forensics. Dr. Morrison has worked as an expert witness and confidential consultant for the United States Department of Justice, the EPA and numerous law firms. Dr. Morrison has offered deposition and court testimony in over 50 cases. In his capacity as an expert witness and confidential consultant, Dr. Morrison has provided testimony in numerous cases, some with claims in the billions of dollars.

For complete resume click HERE.

Dr. Jeffrey has a B.S. in Biochemistry, an M.S. in Organic Chemistry and a Ph.D. in Oceanography. Dr. Jeffrey has over 20 years of U.S. and international experience in environmental science and geochemistry. His expertise includes managing research projects, managing geochemical and environmental analytical laboratories; initiation and management of countrywide water monitoring program; QA/QC management of analytical laboratories; and setting up and managing a small environmental consulting company.

At DPRA, Dr. Jeffrey has focused on the use of geochemical techniques to solve environmental problems, including sources of spilled hydrocarbon fuels, nitrates, and fugitive methane seeps. Dr. Jeffrey interacts with clients to determine the particular forensic issues at a site and sets up forensic analytical schemes to clarify these issues. He has prepared over 100 proprietary reports for clients that interpret analytical data, place data in the context of other site information, and answer questions such as the identity of spilled petroleum products, the similarity or difference in the products in separate plumes, and the time of release of the products.

Dr Jeffrey has served as an expert witness, has been deposed and testified at trial in litigation cases involving petroleum product spills, and is the author of fourteen publications on oceanography, petroleum geochemistry and environmental monitoring. He has conducted numerous workshops in environmental forensics, and has given numerous presentations at scientific meetings in USA, Europe and Asia.

For complete resume click HERE.