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AquAeTer
optimizing resources | water, air, earth

The AquAeTerian

In This Issue:

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Hot Topics

Dr. Jim Clarke participated in a panel session on "Preserving Worldwide Nuclear Competency" at the Waste Management 07 conference in Tucson. Dr. Clarke also gave a presentation on "Education and the Nuclear Renaissance," and presented a paper entitled "Should Environmental Forensics Always Be About the Past or Can It Help Us Avoid Liability in the Future?" at the annual meeting of the American Academy of Forensic Sciences in San Antonio. He also participated as an expert witness in a Mock Daubert Hearing based on an actual case in New Mexico.

The President's Corner

Expandens Circa Terran
"Expanding Around the World"

15 years ago **AquAeTer** began as an environmental engineering company. Our services have now expanded to cover a multitude of disciplines including Energy, Engineering, Environmental, Mining, and Risk Analyses.

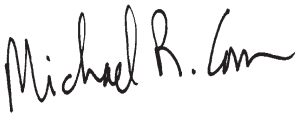
Our mining group continues to grow with new staff members who are supporting on-going projects in the U.S., Central America, and China under the direction of Sean Muller out of our Centennial, Colorado office. One of our new team members, Marc Melker, discusses his computer mapping work for determining mineral deposits for new mining ventures in this edition of The **AquAeTerian**. You can learn more about the services we offer to the mining industry at **www.aatmining.com**.

Chrisie Brown is featured in this newsletter for her continued work on acid neutralization in groundwater. Chrisie worked along with Paul Marotta and Christopher Green for the design and implementation of a remedial system that is helping our client meet the state's pH requirements. Chrisie reported her findings at the Tennessee Solid, Hazardous Waste Conference in Gatlinburg in April.

Paul Marotta has been working on environmental permits for two new greenfield sites, one in Kentucky and one in Arkansas, for new creosote wood treating facilities. Paul has successfully obtained the draft air permits for both sites and is now working on additional permits for wastewater and RCRA.

Dr. Wes Eckenfelder and Chrisie Brown recently gave a wastewater seminar on activated sludge for the Kentucky-Tennessee Water Environment Federation.

John Michael Corn and Dorie Bolze, Executive Director of the Harpeth River Watershed Agency, will be giving a paper on Dissolved Oxygen in the Harpeth River at the Tennessee Water Resource Conference at Montgomery Bell State Park in April. Congratulations to John Michael for recently obtaining his Professional Engineer license in Tennessee.



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Sodium Bicarbonate Injection for Remediation of Acidic Groundwater

At a former manufacturing Site, a slurry wall and pump-and-treat system had been installed in the early 1980's to contain and remediate groundwater contaminated with phenolics, BTEX, and high levels of acidity. Over time, a majority of the Constituents of Concern (COCs) at the Site had been reduced to below regulatory limits; however, the groundwater interior and exterior to the slurry wall remained highly acidic. After 2000, the pH in monitoring wells between the slurry wall and an adjacent river began to decrease. Therefore, the client requested a feasibility study to evaluate neutralization options to prevent acidic groundwater from reaching the river.

FEASIBILITY STUDY

AquAeTer evaluated several potential solutions to the acidity of the groundwater at the Site, including a passive neutralization barrier (limestone wall) and injection of a soluble alkali (e.g., sodium bicarbonate solution). Bench-scale and continuous column testing were performed to determine the efficacy of these neutralization processes. The alkaline materials evaluated included coarse- and fine-grained limestone, caustic soda (sodium hydroxide or NaOH), and sodium bicarbonate (NaHCO3).

Field Testing

Groundwater samples from various locations indicated very heterogeneous groundwater chemistry throughout the Site with areas of high concentrations of acidity, sulfate, aluminum, and iron. Hydrogeologic data, including boring data from well installations and slug testing, were also obtained to determine potential injection rates and groundwater flow rates in the area.

Bench-Scale Testing

Bench-scale testing was performed to determine the response of groundwater from different locations at the Site to various neutralization agents (sodium hydroxide, sodium bicarbonate, and limestone).

The titration tests revealed that the precipitate formed in the caustic (sodium hydroxide) titration was fluffier, settled less rapidly, and took up to three or four times the volume of the sodium bicarbonate precipitate. The settled precipitate from a sodium hydroxide titration and a sodium bicarbonate titration are compared in Figure 1. The yellowish layer above the dark layer in the sodium bicarbonate flask contained minimal precipitate – the bulk of the precipitate in both flasks is located in the dark region. No significant temperature increases or off-gassing were observed during the testing.

Figure 1. Caustic vs. Bicarbonate Precipitate

Small jar tests were also performed in the **AquAeTer** lab to evaluate the neutralization potential for two grain sizes of limestone. Because this is a surface area reaction, the efficiency of the larger limestone rock was lower than the smaller grain size limestone. Both sizes of the limestone indicated slow reaction rates and minimal pH increases.

Continuous Testing

Packed bed reactors were fabricated to simulate a limestone wall and in-situ neutralization of groundwater through alkaline injection, as shown in Figure 2. The continuous testing confirmed that limestone is a very inefficient neutralization agent for the water from the Site. Simulated injection of alkaline liquids showed that the precipitate from the sodium bicarbonate reaction moved through small pore spaces more easily than the precipitate from sodium hydroxide. Additionally, excess sodium bicarbonate in the system did not cause an unde-


Figure 2. Continuous Column Testing

FEATURE ARTICLE

sirable effluent pH, whereas, excess caustic raised the pH of the effluent above 12. Based on the results of the testing, sodium bicarbonate injection was recommended at the Site.

PILOT INJECTION

Using data from the bench-scale studies, **AquAeTer** designed a low-cost injection system for use during the pilot study. Dedicated gravity fed injection systems, which required no electricity, were placed at each injection location. The design provided the flexibility to add or remove injection locations with minimal added effort or cost.

At each injection point, a portable tote was stationed approximately one to two feet from the injection well. The top of the tote was aligned with the top of the injection well casing. A distribution line was connected to the bottom of the tote and placed into the injection well through a vented cap. The sodium bicarbonate injection was initiated by creating a siphon causing the tote to drain into the injection well. Figure 3 shows a tote being lifted to create the initial siphon. The initial siphon created a liquid column that resulted in a pressure head in the injection well that forced the bicarbonate solution into the aquifer at the maximum rate that the aquifer would sustain. The system

Figure 3. Installation of Injection System

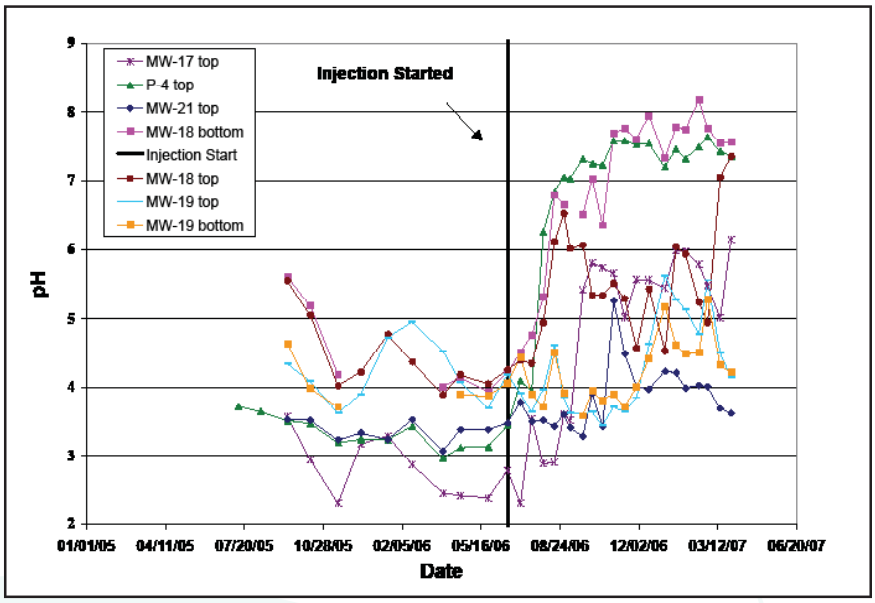

Figure 4. pH Trends in Downgradient Wells

continued to feed the injection well until the tote was emptied. The totes were refilled on a schedule which allowed for uninterrupted treatment. The injection was initiated in two wells: one in the shallow layers and one in the deeper sand layers of the aquifer. **The data indicated that the pH had increased by 3 S.U. in a nearby downgradient well within 45 days of the injection.**

Due to the success of the system, larger tanks were placed at the injection locations to facilitate a longer-term injection. Continued injection has shown an increase in pH to acceptable levels as far downgradient as 100 feet. Slug testing has revealed a slight decrease in hydraulic conductivity in the area of injection, but the conductivities remained in the expected range for silts and sands. Future plans include additional exterior injection locations, soil borings in the area of impact, and continual monitoring.

Chrisie B. Brown, P.E.

Chrisie has been with **AquAeTer** for four years and has been working with this groundwater remediation project, and other projects including soil remediation, air sampling, litigation support and wastewater engineering.

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Marc Melker, B.S., M.S. Geology, has been with **AquAeTer** since September of 2006. He is a Senior Geologist with experience in brownfields and greenfields mineral exploration, regional geological modeling, mining geology, stability monitoring, mining operations, data quality assurance and quality control, ore control and production reconciliation, Light Detection and Ranging (LiDAR) survey technology, GPS, ground penetrating radar (GPR), field data acquisition, and mapping. Marc's geological background is primarily in gold mining and exploration geology, but he has also co-authored papers on numerous topics including: the regional geologic setting of the Rocky Mountains, the structural setting and kinematic bias of precious metals deposits, the paleomagnetic geology of the Cripple Creek gold district in Colorado and the Bingham Canyon porphyry copper deposit in Utah, and geological applications of high resolution X-ray computed tomography(CT). In his free time, Marc enjoys being outdoors attached to a pair of skis, a bicycle, or hiking boots. He can also be found sometimes behind the wheel of his 1968 Ford Bronco, or treasure hunting with a rock hammer out in the middle of nowhere.

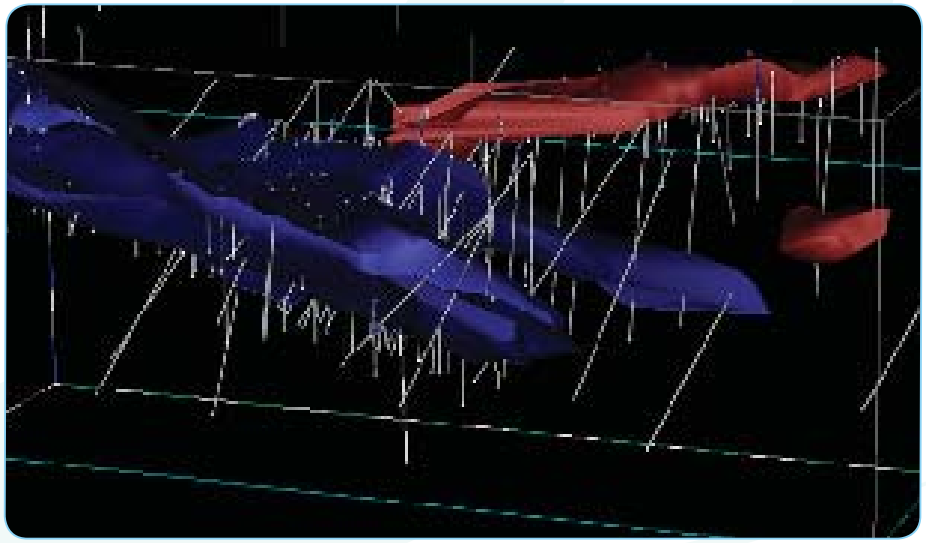
Resource Modeling for Gold Deposits

Since Marc joined **AquAeTer's** mining team in 2006, we've had no problem keeping him busy with projects in the mining services area of our business. Marc's most recent work involves resource modeling of a gold deposit in a Tertiary orogenic belt in Central America.

Mineral Reference Collection

This project began with evaluation of the drillhole data for quality. This was accomplished by adding standards of known value; taking duplicate samples to assess repeatability; and taking blank samples for comparison of background values to the sample stream. These quality control data and the sample data were then evaluated through exploratory data analysis (EDA). During this phase, all aspects of data quality were examined, including detailed comparisons of the quality control data gained from the standards, blanks, and duplicates. These qualified data are the basis of building a model of mineralization and ultimately issuing a National Instrument (NI) 43-101 compliant resource estimate. NI 43-101 was developed by the Canadian government to codify and regulate the reporting of mineral resources and avoid misinformation in the public investment arena.

Due to the dominant structural control in the gold deposit, several mineralization solids of different grades needed to be constructed to constrain higher grades and to reduce upgrading of lower grade materials. This deposit also contained significant resource inventories in a near surface saprolitic material that required special consideration to capture the full distribution of gold. Continuing work in this complex gold and copper property will require constant quality assurance and quality control and the addition of new discoveries to the growing mineralization model.



Drillholes and mineralized solids models (in blue and red) of gold mineralization at an advanced project in Central America.