WHITE PAPER / **GROUNDWATER REMEDIATION**

THE HIGH COST OF CROSS-INDUSTRY CULTURAL DISCONNECT

BY Mike Shultz

Past groundwater remediation strategies have proved to be costly, falling short of cleanup goals largely due to complex geological factors. Fortunately, the application of existing petroleum industry tools and best practices can lead to more effective and cost-efficient approaches for the groundwater remediation industry.

More than 126,000 sites across the U.S. require remediation for groundwater contamination, according to the National Research Council's report on Alternatives for Managing the Nation's Complex Contaminated Groundwater Sites. Of these sites, more than 1,200 are so complex that restoration is likely infeasible within the next century.

These sites represent a significant risk to human health, the environment and drinking water resources. According to that research, it will cost as much as $200 billion to clean up these sites, with taxpayers ultimately bearing most of this financial burden.

But there's hope for improvement in the future. Resolving the disconnect between two multibillion-dollar industries — groundwater remediation and petroleum — could result in a significant step forward for complex site remediation. Historically, the groundwater remediation profession, including consultants, state and federal regulators, and stakeholders, has not adequately considered that the geology upon which we live — and within which contaminated waters persist and migrate — is exceedingly complex. This oversight has severely limited the success of remediation efforts, resulting in a striking number of sites that have been unable to achieve cleanup goals.

Meanwhile, another industry focused on the very same subsurface fluid flow problem — the petroleum industry — has long recognized this geologic complexity and the risk it poses to the economic success of oil and gas production projects. Accordingly, the industry developed conceptual tools known as sequence stratigraphy and facies models to understand, predict and incorporate geologic variables into decision-making and design of extraction systems, reducing the risk of failed projects.

THE STRATIGRAPHIC FRAMEWORK

Geologists working in the petroleum industry are tasked with developing a three-dimensional conceptual understanding of the subsurface, otherwise known as a stratigraphic framework. The more accurate the understanding, the more profit potential the project has. Put simply, these stratigraphic frameworks provide the primary guide for optimizing oil and gas operations.

Unfortunately, the groundwater remediation industry has been slow to adopt a subsurface focus, impacting the industry's ability to reduce risk, achieve cleanup goals and close sites.

GEOLOGIC COMPLEXITY

The subsurface cannot be seen or understood perfectly in three dimensions. Direct information on subsurface conditions is limited to the information gathered from drilling wells. The problem often lies in predicting the conditions between wells and creating the conceptual stratigraphic framework, like predicting what a 1,000-piece jigsaw puzzle should look like with just a few pieces in hand. Yet, a prediction must be made to design a remedy. The accuracy of this prediction can determine the success or failure of any subsurface-related project. Historically, the petroleum and groundwater remediation industries have had very different approaches to creating these subsurface conceptualizations.

Aquifers — which host groundwater resources — and oil reservoirs — which host hydrocarbon resources — are primarily composed of sediments such as sand, gravel, silt and clay. Water, oil or gas flows within the pore spaces between the individual sediment grains. In the case of groundwater contamination, as clean groundwater flows through highly contaminated source zones, contamination is dissolved and carried away from the source, forming contaminant plumes. However, within source zones and groundwater plumes, contamination can exist in multiple phases (aqueous, nonaqueous liquid, solid or sorbed, and gaseous) that interact with geologic materials and each other.

Plumes require remediation to prevent or mitigate their migration to drinking water wells, springs, streams and other natural resources. Volatile groundwater contaminants can also threaten air quality within structures and dwellings located above the plumes. Groundwater remediation systems attempt to control, and ultimately remediate, contaminant plumes to keep them from expanding and endangering humans and the environment. The prevention of further migration was historically achieved through pump-and-treat methods, in which the plume was hydraulically controlled by operating pumping wells that conveyed contaminated groundwater to a central location for treatment. More recently, chemical and biological treatment methods have been implemented in situ, within the aquifer, to destroy or immobilize contaminants in place. Biological methods typically involve the injection of a food source to stimulate naturally occurring microorganisms to metabolize harmful compounds into less toxic daughter products, while chemical methods require a reagent to destroy or immobilize contaminants on contact.

Groundwater remediation project designs have historically suffered from the same flawed assumption: The subsurface layers are continuous. In reality, the subsurface is composed of highly permeable zones or channels, responsible for most of the fluid movement. These channels are encased in less permeable silt and clay deposits, through which water moves much more slowly.

Over time, contaminants in groundwater diffuse into these less permeable silt and clay deposits, creating secondary contaminant sources throughout the plume. As time goes on, contaminant concentrations within the permeable zones become less than those trapped within the low permeability materials. This causes contaminants within these secondary source zones to back-diffuse in a slow-drip fashion into the more permeable channels, providing an ongoing source of groundwater contamination for generations to come.

By contrast, instead of assuming a layer cake subsurface, the oil and gas industry begins with the base assumption that the subsurface is highly heterogeneous and anisotropic. The term for this is "permeability heterogeneity," and it is a feared and respected factor in terms of the economic viability of oil and gas development projects. It is well known that this complexity has the potential to make or break billion-dollar developments, especially in hard-to-reach areas such as the deep ocean. To address this critical risk element, the petroleum industry has invested billions of dollars in corporate research labs and universities worldwide to develop conceptual tools such as facies models and sequence stratigraphy. These tools have proved extremely useful over several decades and have stood the test of time and financial performance, representing the current best practice for subsurface characterization.

Applying these principles and employing professionals from the petroleum industry within the groundwater remediation space is a game changer for the groundwater remediation industry. Contaminated sites where true progress toward site closeout has not been possible due to complexity and uncertainty can instead be set on a different path. For such sites, alternative management strategies may instead be developed to strike a balance between the practical realities of the subsurface and the need to protect human health and the environment. This approach will instead help responsible parties and remediation professionals avoid the selection, implementation and maintenance of expensive, ineffective remedies that are incompatible with site geologic conditions.

ECONOMIC DRIVERS

Oil companies are valued in large part by their proven reserves; that is, the oil remaining in the subsurface beneath the ground on which they hold a lease defines the overall value of the company. Contaminated groundwater, on the other hand, is a liability.

Unfortunately, many companies with groundwater liabilities opt for continued inefficient operations instead of investing in innovative strategies to accelerate cleanup and closure. While this approach may assist in predicting annual spend, it fails to capitalize on tremendous life cycle cost savings which can be achieved over decades through more sophisticated, geology-based site management strategies. Also, the remediation process outlined in the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) specifically separates the site characterization phase from remediation phases, thereby inadvertently discouraging the revision of the conceptual site model as data is collected. This further propagates an oversimplified and outdated description of the subsurface.

THE FUTURE OF GROUNDWATER REMEDIATION

The investments made over the last decades in the science of sequence stratigraphy total in the billions of dollars. There are now thousands of practitioners of sequence stratigraphy and the practice is taught as the global standard of the study of sedimentary geology. There is tremendous opportunity for innovation that can deliver substantial value.

There have been several recent examples where modern geologic concepts and characterized subsurface conditions developed by the petroleum industry have been used with great success in groundwater remediation projects. There is also a growing consensus among thought leaders in the groundwater industry that such practices provide real value and stand out in high contrast to previous practices.

These geologic tools offer a viable and cost-effective solution to groundwater remediation. Companies that can successfully leverage these tools are positioned to deliver tremendous value for remediation project stakeholders.

Expensive lessons learned from mixed success in groundwater remediation — especially the lessons learned from the challenges posed by complex geology — have potential to streamline future groundwater remediation efforts, remedying a decades-long, cross-industry disconnect to the benefit of human health, the environment and the taxpayer.

BIOGRAPHY

MIKE SHULTZ is an associate geologist at Burns & McDonnell. With more than 25 years of subsurface investigation experience in oil and gas exploration and production, environmental assessment, and groundwater remediation, his cross-industry experience and perspective allows him to provide clients with a clear, realistic view of subsurface conditions in aquifers and petroleum reservoirs.

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