Lowering the Cost of our Environmental Liabilities: Implementing the Triad Approach

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Introduction – Over the past two decades, during the growth and maturation of the environmental assessment and remediation industry, many new tools and approaches were developed for assessing the subsurface and for returning it to pre-industrial conditions. Our knowledge and ability to affect the occurrence and migration of chemicals in subsurface soils and waters has increased dramatically. However, we still are not very successful at finding subsurface sources or devising cost effective ways to clean up the chemicals that we have introduced.

The primary cause of this is the heterogeneous nature of the subsurface. Since most investigations are limited by the budget that we are able or willing to spend on assessment, we are left in the mode of under-investigating and over-generalizing subsurface conditions. This invariably leads to a poor understanding of where the chemicals reside and poorly designed and focused remediation systems.

Many of our failures do not come to light quickly. Our regulatory system is designed to remediate just the areas that impact a limited number of monitoring points. As a result, weeks, months or years later we discover that we missed the main occurrence and face much greater health and cost risks on sites that we thought we had mitigated. Since the major costs of the entire process from assessment through remediation to monitoring (and then reassessment, etc.) lies in the remediation and monitoring stages, anything we can do to ensure we have accurately characterized the site will save costs on these more expensive follow-on stages.

Over the past two years, we have found a better approach for creating more accurate and more complete Conceptual Site Models. By incorporating high density data collection technologies with rapid processing and communication tools, significantly better decisions and the resulting site models are being obtained that significantly reduce remediation and monitoring costs. Project savings of 30 to 50 percent have been achieved. This approach therefore promises to have a very positive impact on costs, project success and risk management. However, the introduction and acceptance of new technologies typically takes 5 to 10 years. Can we afford to wait that long? Or do the cost and health benefits of a better approach demand that we find ways to accelerate the use of these emerging methods for lowering our costs and improving our clean up efforts?

Background – The standard site assessment process today involves:

- Limited planning
- collecting a limited number of samples from a site
- analyzing these samples at a lab
- creating a very generic conceptual site model
- data review by a variety of interested parties
- collecting more data to answer questions raised by the model
- planning the need and design for a remediation effort that will cover the uncertainties inherent in the general site model
- installation and monitoring of a limited number of wells
- limited evaluation of system over time

This process normally requires several iterations involving multiple visits to the site over months or years.

The weakness of this approach is the challenge of trying to develop an accurate site model of a large volume of the subsurface with a limited number of samples. Most sites are highly heterogeneous by nature. To reduce the significant uncertainty of most site models in a statistically valid way would require thousands of data points. We cannot hope to understand the nuances of a site with the normal process of collecting only a few dozen samples. As a result, many of our site assessments are not valid or reliable from either a technical or legal perspective (Tindall, 2001).

Because we are not collecting enough data from a site, we don't know what volume or region of the site is represented by the samples that we do collect. Just understanding the considerable geological variability of a site is difficult enough, then one must understand the hydrologic variations and the location and migration paths of each chemical species. Add onto that the occurrence and nature of the myriad number of chemical altering microbial species that occur in various pockets throughout the site. No wonder we rarely get a good handle on what is going on in the subsurface.

With all of these variables it is difficult to know where to sample and how many samples are needed. In addition, our ability to collect a good sample and analyze it ex-situ is also challenging. How do you get a good sample of water out of a clay? What does a water sample from a 10 ft screen actually tell you about the geologic variations across that 10 ft interval? How do you get a good VOC sample from a coarse grained unit in the vadose zone? What are you analyzing when this sample finally gets back to a lab?

Based on all of this uncertainty, it should be clear to all of us, that before we try to attempt a remedial design for a site, we need much better conceptual site models than we are typically working with today.

Key Technologies for developing Better Conceptual Site Models – Instead of selecting a few samples from a site for a "quantitative, certified lab analysis based on EPA Methods", it is better to collect much more data, even if it is of lower quality, using field measurements, in order to more fully understand the site (Crumbling,2002). In fact, for any of the lab data to be meaningful, it needs to be tied into a detailed site model. It needs to be representative of a clearly defined unit, so the first step is to use a very large number of field measurements to develop an accurate Conceptual Site Model. Laboratory data are in fact only rarely needed, if at all, for developing accurate site models.

The most promising tools presently available are the continuous chemical/physical sensors that collect thousands of data points per day, as they are pushed/hammered into the soils/waters of a site. The data they collect are digital and fully geo-referenced and therefore can be processed rapidly for onsite decision making on a daily basis. The data they collect are fully appropriate and effective for developing a Conceptual Site Model (Tillman and Sohl, 2001).

The Membrane Interface Probe – based technologies provide continuous soil conductivity measurements, from which geological models for the site can be built, as well as continuous chemical data. The probe consists of an electrical conductivity array as well as a heating block and membrane. It is heated as it is pushed into the ground, volatilizing the volatile organic compounds such as solvents and fuels (VOCs) in the soils and groundwater. The resulting vapors migrate across a membrane and then are analyzed, providing a continuous chemical log of the subsurface.

The chemical data can be obtained in a variety of forms depending on the needs of the investigation. But it is the insitu and continuous nature of this chemical data in direct juxtaposition with the physical data that provides a major step forward in understanding the nuances of subsurface contamination. It is the availability of multiple channels of chemical and physical data that allows for the much greater appreciation on where the contaminants reside and how they migrate.

By conducting a series of profiles from the surface down through the vadose zone and into the groundwater, a detailed and accurate assessment of the site can be made. Since the data are digital, they can be rapidly processed into 3D imagery and the results can be used to direct the investigation, while the field team is still in the field. A very thorough and complete assessment of a site can be achieved in this way in a single site visit. This technology allows for much better and much more complete Conceptual Site Models to be made. As a result, better remedial and monitoring decisions are probable.

Approaches for Managing Site Assessments – Just because the technology exists for obtaining better site assessments, does not mean they will be used well. The EPA has promulgated the Triad Approach for helping utilize field measurement technologies in a process that will result in the optimal use of resources. There are three key steps to this process: Systematic Planning, Use of Field Measurements and a Dynamic Work Plan.

Key to the success of the Triad Approach is the Systematic Planning Step that involves all the key players. It is this step that defines the objectives, selects the level of data quality required to meet the objectives, selects the technologies for obtaining the data and defines the decision rules for deploying the tools. On projects where the objective is to develop an accurate Conceptual Site Model for a site contaminated with VOCs, field measurement tools like the MIP- based profilers are evaluated for their ability to meet the objectives. A plan is developed for deploying the appropriate tools, monitoring their effectiveness and evaluating the resulting data.

Key to the implementation of a Dynamic Work Plan is a data and communication management system that ensures the data collected are reliable, fully processed and available to all parties on a timely basis for evaluation and decision-making. One system designed for this use is called SmartData Solutions™. This system collects all the data from the site, reviews it for its data quality and then processes it into 2D and 3D images. All the raw and processed data are posted on a project specific web page on a daily basis for review by all parties. This review and processing step is critical in order for all the experts to participate in the daily decision-making. An example of this system can be viewed at http://smartdata.columbiadata.com. Use "demo" for the password and username.

Applications and Limitations – The most effective use of these tools to date has been for volatile organic compounds. The MIP specifically is a tool that works by enhancing the volatilization of VOCs. It has been extensively deployed at sites with chlorinated solvent contamination (dry cleaners, manufacturing sites, military installations, etc.), petroleum hydrocarbons (gasoline stations, terminals, refineries and other fuel and heating oil facilities) and on landfills containing methane. Decisions as to which tool to use should be made based upon the chemicals of concern and their concentration levels. Some of the MIP-based technologies are better for source area delineation, while others can be used for chasing the down-gradient extent of plumes.

A generic limitation to the sensors that work by pushing/hammering them into the ground is that they are not deployable in bedrock or in highly resistant soils. They have been used to depths of over 150 feet in unconsolidated coastal plain or glacial areas but once they hit rock or refusal they can go no deeper. They are generally deployed on direct push rigs, CPTs or on drill rigs. They have been deployed offshore from barges and in basements of buildings in New York City.

There are other emerging tools and approaches for semi-volatiles and metals although they many not be able to obtain as much information of a site as the VOC sensors.

Cost Savings - The much greater understanding of subsurface conditions provided by continuous profiling technologies results in the potential for significantly lowering of the costs for managing our environmental liabilities. These costs can be realized in all stages of the assessment/remediation/monitoring cycle.

First of all, characterization costs do decrease since the appropriate use of these tools within the context of the Triad Approach helps to more quickly assess a site without the need for multiple site visits, extensive lab analysis and months of data manipulation and review. We have been called upon to understand sites where tens and even hundreds of thousands of dollars had already been spent trying to fully understand the site. Many of these had already gone through a remediation phase that had failed.

Secondly, most remediation efforts that fail, do not achieve their objectives because the site was not well understood. In many cases, remediation is undertaken without a clear knowledge of the source, the migration paths or even whether mitigation was practicable. Having a full knowledge of where the contamination resides, will better inform you whether it is even possible to clean up a site and if it is, where to focus the effort.

Thirdly, the use of a limited number of monitoring wells to monitor the performance of a remediation system does not usually work, since they are static by nature and only monitor the pathways they intercept. Remediation, by its very nature is changing the nature and occurrence of the contamination and the entire site needs to be reassessed to see what its full impact has been. Where we have used the MIP technology to do a "before" (baseline) and "after" look, we are routinely surprised at how things have and have not changed. We find it critical to assess the impact, in order to optimize the treatment system.

Lastly, one can only know the optimal positions for long term monitoring networks by having an accurate site model. We have been on many sites where the screen intervals were not appropriate for monitoring the long-term changes on the site. The periodic data that was being collected was worthless. In some instances, the wells may have been appropriate prior to the start up of the remedial system, but became obsolete as soon as the system became operational. We only learned this by performing a second survey with continuous chemical profiling tools.

Our clients have informed us that they have lowered their assessment, remediation and monitoring costs by a third and in some cases up to one-half by deploying these tools. In an industry that spends $100,000,000 per day, this could result in a major impact on our ability to do a better job and to cleanup more sites in this country.

The Analysis of a Failed Cleanup Effort – The following chart illustrates what happens in many cases where an accurate site model is not developed at the beginning. In this case, several years have transpired and $400,000.have been wasted, without the desired results and in many cases with an exacerbated problem – plume has migrated under a housing development.

Task	Cost	Time	Result
Site Assessment	$25,000	8 weeks (<1 week in field)	Insufficient data – need to go back to field
Revisit Site	$25,000	8 weeks	Rough Site Model
Regulatory Review		8 weeks	Request for more data
Third site visit	$25,000	8 weeks	Regulatory acceptance but skeptical
Remedial Design +/- Investigation	$25,000	8 weeks	Catch-all remedial design
Implementation of system and long term monitoring network	$260,000	1 year	At some point down the road it is determined to be insufficient
Annual Monitoring Costs	$20,000/yr for two years = $40,000	2 years	Unclear what is happening, some levels go down and some go up. Regulators/bankers/or buyer demands better assessment.
Site Assessment II - Thorough reassessment of the site	$40,000	5 days	Accurate site model – regulators buy off on focused remediation and 2 years of monitoring
Targeted remediation and short term monitoring costs	$100,000	6 months	Source is reduced and short term monitoring effective in closing site.

Accelerating the Process to Cost Savings – It is clear that there are major cost savings to be achieved by incorporating high density, continuous profiling tools such as the MIP tools into more site assessments as well as into the performance monitoring of ongoing remediation systems. It is also clear that all new approaches and technologies take 5 to 10 years to get fully accepted and integrated. To date we know of only a few hundred projects where continuous profiling and the Triad Approach has been implemented as compared to the thousands of projects that occur each year. The lower cost and the greater success of using these tools should drive us all to work together to overcome the hurdles inherent in "changing the way we do business".

The EPA is working closely with ITRC, NJDEP and the COE to change the system. One industry led approach to speed up the acceptance and use of these tools is the SmartData Accelerator Program (SDAP). This Program incorporates technology developers, regulators, owners, insurance firms and the consulting community into a working group that will systematically break down the hurdles and increase the use of these technologies.

Key to this program is the development of a Service Provider Network (SPN) across the country. Each of these local firms will be trained to provide the direct sensing technologies in their region. The SPN will serve as an outlet for emerging technologies once they are tested and proven reliable by the SDAP. This will allow all participants to benefit from new technologies as they are demonstrated to be reliable, any place in the country. Anyone interested in participating in and taking full advantage of this Accelerator Program, should contact the authors.

References

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