New England Interstate Water Pollution Control Commission

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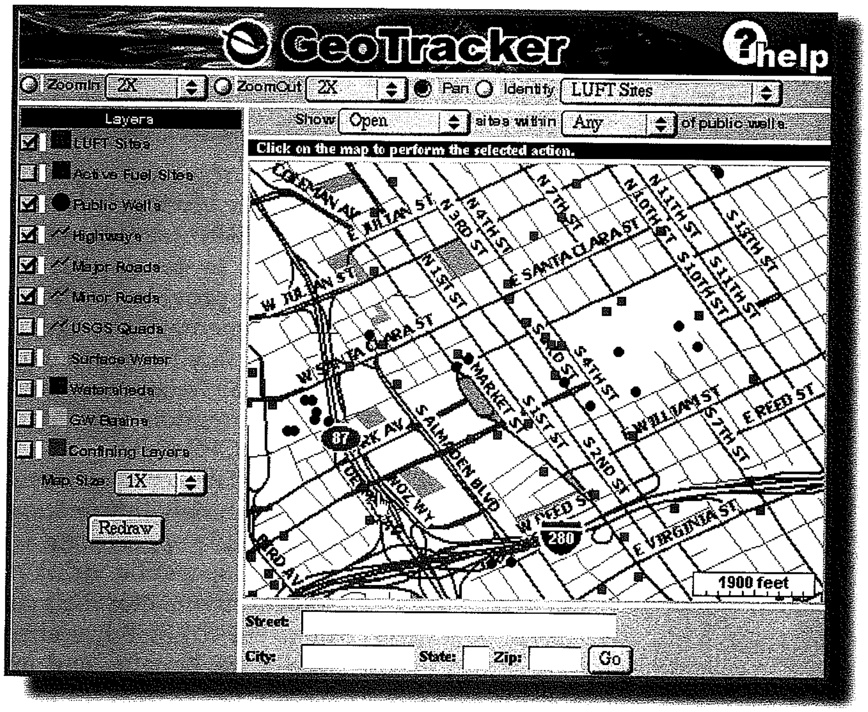
L.U.S.T.LINE

A Report On Federal & State Programs To Control Leaking Underground Storage Tanks

THE FUTURE IS COMING
TO A WEB SITE NEAR YOU

by Ann Bonner Carpenter



Regulators, can you provide prompt answers to public information questions and at the same time be off doing a site inspection? Can you easily and quickly access site-specific data from all across the regulatory landscape from one source? Can you enter site data onto your database from the field? If you can't, why not? The technology is here, it's getting more user-friendly and affordable every day, and it can make your workload a whole heck-of-a-lot more manageable.

One-stop database shopping is already up and running in some states and gearing up in others. Geographic Information Systems (GISs) are being used by regulators in many states as an important tool in the day-to-day business of environmental management and decision making. Mapping software can help them analyze data, while the Internet allows them to speed it to those who need the information and who would otherwise be calling on the phone. Don't have good location data? Well, all is not lost—there are several ways to get it, including highly accurate Global Positioning Systems (GPSs).

For regulators, the marriage of GIS, GPS, and Internet access can be a dream come true. For users, it's as easy as shopping on-line—and you don't even need a credit card.

Why Do It?

Ignorance is not bliss. GIS brings to light spatial relationships that may otherwise be unknown because information is scattered throughout various regulatory programs. Regulatory entities often lack the wherewithal to efficiently and effectively share information on gasoline releases and water supply contamination. This lack of communication can jeopardize water quality.

■ *continued on page 2*

Inside

■ The Future Is Coming...
continued from page 1

Easy access to environmental information is important for stakeholders, such as water suppliers, responsible parties, consultants, and the general public. When regulatory personnel and stakeholders can easily access the same data, the result should be less duplication of effort, better communication, and more informed decision making. And the environment is a winner, too.

When a release has been identified, UST regulators can use GIS mapping information to identify such decision-making criteria as proximity to wellhead protection areas, drinking water wells and aquifers, and other receptors. Water suppliers, land-use planners, and developers can use GIS to locate potential sources of contamination (e.g., UST facilities, dry cleaners, landfills) near drinking water sources. Realtors, developers, and bankers can use GIS to identify, among other things, potential environmental risks.

LUSTLine

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NEIWPCC was established by an Act of Congress in 1947 and remains the oldest agency in the Northeast United States concerned with coordination of the multimedia environmental activities of the states of Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont.

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California's GIS was developed in response to a legislative mandate. With the closure of several Santa Monica drinking water wells contaminated with MTBE in 1997, the state legislature passed two bills that charged the State Water Resources Control Board (SWRCB) with the task of assessing the feasibility and appropriateness of establishing a statewide environmental database and GIS mapping system, beginning by conducting pilot projects in the Santa Monica and Santa Clara Valley areas.

> ***GIS brings to light spatial relationships that may otherwise be unknown because information is scattered throughout various regulatory programs.***

In response, SWRCB and Lawrence Livermore National Laboratory (LLNL) staff members worked together to develop GeoTracker, a GIS that provides on-line access to environmental data. GeoTracker is the interface to the state data warehouse, the Geographic Environmental Information and Management System (GEIMS).

GeoTracker was developed to provide timely information to coordinate and support state agencies in protecting public drinking water sources from motor fuels contamination. The SWRCB has already realized those benefits and more from having the system up and running and on-line (http://www.geotracker.ecointeractive.com/). The entire state is now included, and the agency is planning to add active fuel sites and other data layers, such as recharge areas.

At the regional level, **EPA Region 3** is working with its states to develop a pilot system to obtain location data and map wells and regulated facilities, with the goal of GIS analysis and Internet access. Like California, Region 3 will begin with two counties. The region is also considering developing a risk-indexing tool to aid in planning.

If your UST/LUST program hasn't already done so, there are several good reasons to start planning for GIS mapping and linking up with the Internet:

■ Better Manage Site Cleanup Objectives

When you must respond quickly, there is no time for an archaeological dig in the file room. With GIS, you can view the area where an UST release has occurred and identify potential receptors. The more data available to you, the better informed your decision and the more timely your response.

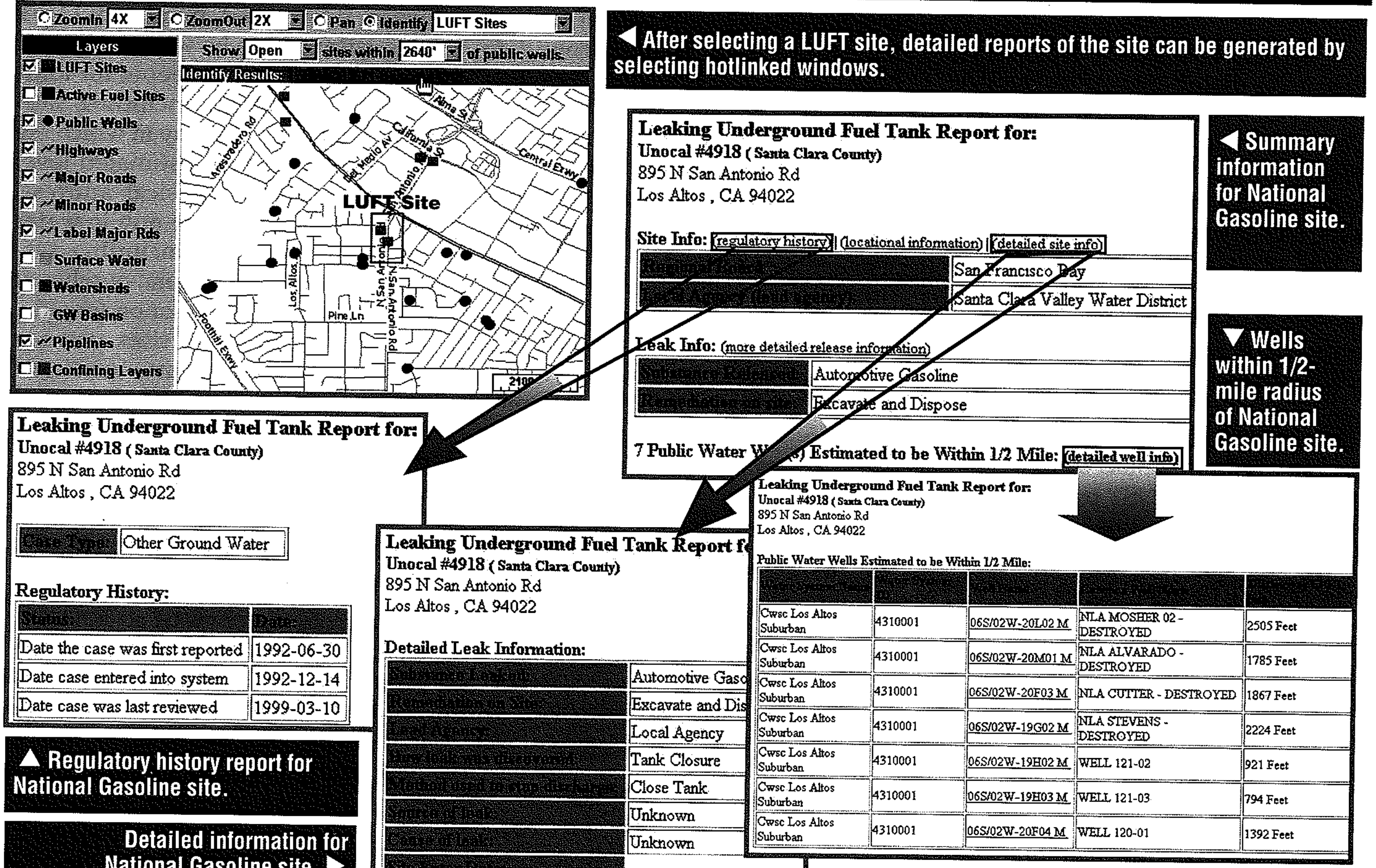
GIS can help you prioritize sites based on risk. "To help us with our risk evaluation," explains Art Shrader, with the **South Carolina** UST program, "we put all our GPS data into a common database, shook it up twice, and asked the system to tell us which of our LUST facilities were within 1,000 feet of a public water supply. We used that information to prioritize sites that had the highest potential risk so that we could begin assessments on those sites first."

Beginning in 1997, the South Carolina UST program identified 300 sites that met the high-risk criterion. Since then, about every six months, when the analysis is run again, an additional 10 to 20 sites are added to the assessment priority list.

■ Streamline Permitting, Enforcement, and Reporting

The Internet can streamline the permit renewal and compliance process by making it easy to enter, transmit, and retrieve data. For example, online UST permit forms and reporting forms are available through GeoTracker. These well-designed forms help improve the accuracy of information collected. Pull-down lists, check boxes, and select boxes give the user specific choices so that data are standardized. Error-checking software further quality-controls the values of information when it is entered on the Internet forms to assure data quality. When entering an address, for example, the system will prompt the user if the ZIP code is not consistent with the city. Now, one person can conveniently enter information and transmit it for storage and use by others. After the permit is approved, the data moves into the GEIMS database. Handwriting and in-box delays are no longer an issue. Costs are reduced and accuracy is increased.

GeoTracker can generate reports for LUFT sites and nearby drinking water wells (e.g., within 1/2 mile).



Source: http://www.geotracker.ecointeractive.com/.

■ Improve Data Accuracy

The accuracy and consistency of environmental data are particularly important in LUST site remediation, where the relationship of LUST sites and drinking water wells is always a number one question. Many states are working on the frustrating task of improving data accuracy.

California's GeoTracker features a repositioning tool in which an authorized user with a password can go in and correct a location or other site data of a regulated facility. The tool includes a short tutorial and features a list of facilities sorted by an estimated level of accuracy (in feet), beginning with the least accurate. The authorized user can change the LUST site information directly within the GEIMS database. The database automatically records the correction, the name of the person who made the change, and the method used (the tool). The estimated accuracy for this method is less than 200 feet.

When information is accessible, users will often let you know when they find an error. In **Idaho,** the public has responded to errors—although it may take time for someone to notice. A landmark gas station in Boise was "misplaced" on the map for about a year before someone noticed that that it was at the wrong intersection. California has also recognized the value of the public in finding mistakes and reporting them to the responsible party.

■ Provide Information to the Public and Other Agencies

The demand (and legal requirement) for public access to information is growing. Many states are developing data warehouses that open up access to information. Realtors, consultants, and homeowners increasingly need or want to know where storage tanks and other environmental threats are located. Sorting through mountains of paper is not practical.

Other agencies and programs have their own reasons for accessing GIS information. In **Virginia,** for example, the Department of Environmental Quality (DEQ) is required by law to supply the public with a monthly update of new petroleum releases. In **New York,** the health department has requested information such as the locations of chemical and petroleum storage tanks for studies on cancer.

Idaho has created a system to respond to public information questions from realtors and environmental consultants. Matt Walo, a GIS analyst for the Idaho DEQ, has found that about 700 maps per month are accessed over the Internet, while the number of calls regarding this information has dropped to a few per month.

"Now we direct people to our Web site, and we don't ever hear from them again," says Walo. The Idaho Interactive Mapping "Quick Start" tutorial walks users through the process of how to query—how to locate and identify sites and how run proximity analyses. You can access the site at http://www2.state.id.us/deq/. Look for the GIS icon at the bottom of the page.

■ *continued on page 4*

■ The Future Is Coming...
continued from page 3

Vermont's Agency for Natural Resources distributes public data via its GIS data warehouse, the Vermont Center for Geographic Information (VCGI). Users can select an area on a state map, zoom in or out, turn available data layers on or off, and click on a well or facility symbol to find its name, address, and more specific information. The site has links to important regulatory information and notices from the water supply and waste management divisions. There's a link for water supply operators and links to contact staff.

The Vermont UST program Web site provides a listing of upgraded USTs for purveyors of fuel (required for delivery of product), a report on the Petroleum Cleanup Fund, and a grant application package for removal of farm and residential USTs. The screens are appealing and easy to use. Visit the site at http://www.anr.state.vt.us/gismaps/.

Another site to visit that is oriented toward public use is **Delaware's** Environmental Navigator. Contaminated site information includes general site discovery information, a site history summary, contaminants, proposed or final plans, site status, and deed restrictions. This site is located at http://sirb.awm.dnrec.state.de.us/.

These Web sites give new meaning to the word "accessibility," and they suggest an openness and willingness to serve the constituency.

■ Facilitate Land Use Planning, Source Water Protection, and More

With a wealth of environmental, land use, and historic information at your fingertips, there is no excuse for making uninformed land use decisions. GIS information can be a tool for evaluating risk to public health and safety and risk to ground and surface water resources. Accurate knowledge of existing and potential source locations can help determine appropriate setback distances for a multitude of competing uses, such as buildings, wells, water supplies, and parking lots.

■ Visualize and Publicize

A picture, or a map, is worth a thousand words. GIS provides you with an incomparable visual tool, in addition to its spatial analytic ability. USGS topographic maps (at various scales) are used as background to help you become oriented. Digital air photos will become available on GeoTracker to enhance site location and analysis. Want to add the dimension of time? An additional feature of GeoTracker is its ability to generate water quality graphs on-line that plot contaminant values across time, so users can visualize trends.

All of the Internet mapping sites we visited promise expansion of services in the future, and the mapping industry is busily developing new applications to expand GIS capabilities.

The Internet can streamline the permit renewal and compliance process by making it easy to enter, transmit, and retrieve data.

Test Drive a Site Today

Now that you are aware of the benefits, find out how easy it is to use interactive mapping. Take, for example, GeoTracker. (See a demo of all site features at http://www.geotracker.ecointeractive.com/gdemo/.) There are various ways to locate a site. You can use a business name, an exact or partial address, or a case ID. All sites in an area can be found by entering a particular street, city, or county. When information is really sketchy, use a wildcard (*) to let the computer do the work. Enter North*, if you don't know whether North is a street or an avenue. The computer will display all possibilities.

Once on the map screen, you can select various data layers or "themes," and use "tools" to zoom in or out, or identify a feature, such as a leaking underground fuel tank (LUFT) site or a well, selected on the map. You can also select a well and search for LUFT sites within 1,000 feet or 2,640 feet (one-half mile), or vice versa. This area is called a "buffer" and is used for proximity analyses.

To get more information about a particular well at a desired location, first use the identify function and then click on the well name. You will discover links to other screens that contain several layers of information—well description, public water system information, number of LUFT sites estimated to be within one-half mile. You can delve deeper for locational information, including latitude/longitude, the way in which the data were obtained, estimated level of error, nearest physical address, elevation of a well, or public water supply information, including system name, class of system, number of connections, and population served.

For specific LUFT sites, you can access regulatory history, locational information, more detailed site and leak information, and number of public wells estimated to be within a specified distance of the site.

Events That Have Enhanced This Information Revolution

Aside from the obvious advances in technology and software, a few key events have contributed to the availability, accuracy, and usability of GIS in the environmental field:

- The development of interactive mapping, an extension of commonly used GIS software to display GIS products over the Internet. Quality GIS software is expensive, and this system provides low-cost access to valuable geographic information. The only requirement is Internet access and a compatible browser. The user can view and query GIS data using a map interface.
- Recognizing that GPS has become "a global utility" for navigation, communication, and emergency response, the U.S. government abandoned the intentional degradation of signals (for security purposes) in May 2000. GPS users can now pinpoint locations with much greater accuracy. This ability narrows an area down from the size of a football field to that of a tennis court.
- The Internet is growing in leaps and bounds. According to the Internet Society, use of the Internet has been doubling annually since 1988. With an estimated 150 million users in 1999 worldwide, Internet usage is expected to reach 300 million by the end of the year 2000.

Getting Started

There are several ways to gather support to develop GIS and interactive mapping. In Idaho, initial work was under way when a new manager came on board and wanted the application to be up and running in a month. The focus on this effort speeded the delivery of new equipment, which made it happen soon after.

In California, the application was developed by popular demand. Stakeholders were brought together and given a sense of ownership in the development and advancement of an Internet mapping application. They found that while it may help to have a visionary at the top, not to mention the interest of the governor and a legislative mandate, the process worked from the bottom up, rather than from the top down. Members of various regulatory agencies, water districts, and the petroleum industry came together and were able to visualize the benefits to their respective organizations. Ideally, user groups should remain involved and as broad as possible. Conference calls are still held twice each month to address GeoTracker issues.

It helps to form partnerships with other state and federal agencies to identify the benefits of sharing information. Establish common "themes" and data elements. Everyone should be reading from the same script and speaking the same language.

How Far Out in Left Field Are You?

If you plan to get started on GIS, there is no time like the present to begin the process of improving location data. The first step is often to "clean" your data. For example, before you verify the location of wells, give each well a unique identification name or number. Older water systems may have a confusing array of names, or a single name applied to multiple wells. In California, a delay in issuance of state well names left many wells officially "unnamed."

The biggest barrier to performing spatial analysis is obtaining accurate locations. Starting with what you already have, plot your data and find out where each location is. If the site appears to be out in the ocean or in a different state, you know it's wrong. You can also run a sample analysis. LLNL evaluated the location of drinking water wells in California. To do this, the lab acquired highly accurate locations for over 1,000 wells and compared them with locations in the state database—26 percent of the sites were within 1,000 feet of the actual location and 40 percent were within a half a mile.

Improving locations for LUST and UST facilities can be relatively easy. Permitted facilities have addresses, but water wells generally do not. Thus different approaches are needed. Geocoding software is available that can match up street addresses with latitudes and longitudes.

It helps to form partnerships with other state and federal agencies to identify the benefits of sharing information. Everyone should be reading from the same script and speaking the same language.

In California, LLNL found that 84 percent of commercial facility addresses produced reasonably accurate latitudes and longitudes with an estimated median error of 396 feet. According to Dr. Anne Happel of LLNL, the batch approach and address matching are most cost- and time-efficient for regulated facilities. First, the addresses are standardized and verified using U.S. Postal Service software, then they are matched up to locations using commercially available geocoding services. "If it is a facility owned by a corporate entity, make sure you have the address of the facility with the tanks, and not the corporate office," cautions Happel.

When LLNL compared verified well location data for over 1,200 wells with locations in the state database, the median error was estimated to be 2,251 feet. Obviously, when a buffer or radius of 1,000 feet is used to assess vulnerability, a high level of accuracy is needed for well locations. Accurate well locations are more difficult to obtain, but with GPS technology improving, and becoming less expensive and more available, help is on the way. When data are directly downloaded from a GPS unit into the system, it allows for "single entry, multiple use." It saves time and reduces errors. Old-fashioned mapping onto assessor parcel maps and digitizing is also a possibility. California's DHS is committed to getting location information to within a 25-meter accuracy by 2003.

Security Issues

Of course, with thousands of wells and facilities and their related data, you can never guarantee 100 percent accuracy and availability. All Internet mapping sites include disclaimers concerning the accuracy of data. A disclaimer describes the purpose of the application—for example, to provide a visual display of statewide or local data from various sources. The disclaimer directs the user to the state agency staff to be sure of obtaining complete, accurate, and up-to-date information.

The disclaimer also points out particular requirements such as screen resolution that are necessary to properly view the features and indicates that the sites are dynamic and subject to change as more maps are created. Some maps or databases may be temporarily unavailable because of updating. For the applications that allow the user to input data, such as GeoTracker, passwords are issued to authorized users.

Interim Steps—Your Warm-Up Act

A number of states have plans in the works to develop or improve their GIS and Internet access. Virginia plans Internet access to its geodata, and at present has put in place an interim step. It is a "very friendly" GIS station located at each of the six regional offices and headquarters that is available to the public. The geodata contains all 15,000 petroleum release sites plus historical data.

Users can select counties, "pan" around for a specific site, zoom in or out, or identify sites within a given radius. They can also look for a specific petroleum complaint or a site name and address, and determine whether the complaint is "opened or closed." For more detailed information,

■ continued on page 10

Oxygenates

The Subsurface Fate of Ethanol

A Look at the Emerging Oxygenate Alternative to MTBE

Susan E. Powers and David Rice

In response to the widespread contamination caused by MTBE-blended reformulated gasoline (RFG), legislative initiatives in several states and at the federal level have phased out, or are trying to phase out, the use of MTBE as a gasoline oxygenate. Ethanol is currently the most likely gasoline oxygenate alternative to MTBE. This potential for increased use of ethanol has been most widely acknowledged by California. The California Executive Order requiring the phase-out of MTBE also required that an analysis of the fate, transport, and health risks associated with the use of ethanol as a gasoline oxygenate be conducted. It is clear that California and many other states now recognize the need to understand the environmental fate of gasoline oxygenates before any policy decisions are made regarding their widespread adoption.

The material included in this article begins to summarize findings of the study completed for California. The full report is available at http://www-erd.llnl.gov/ethanol/. The primary physical and biological properties of ethanol that have implications for groundwater contamination are identified in this article. Future articles will focus on the uncertainties in our understanding and research required to make sound policy decisions. (For an overview on ethanol, see LUSTLine *#32, June 1999, "With the Possible Phase-Out of MTBE, What Do We Know About Ethanol?" by Bruce Bauman.)*

Ethanol Use in Gasoline

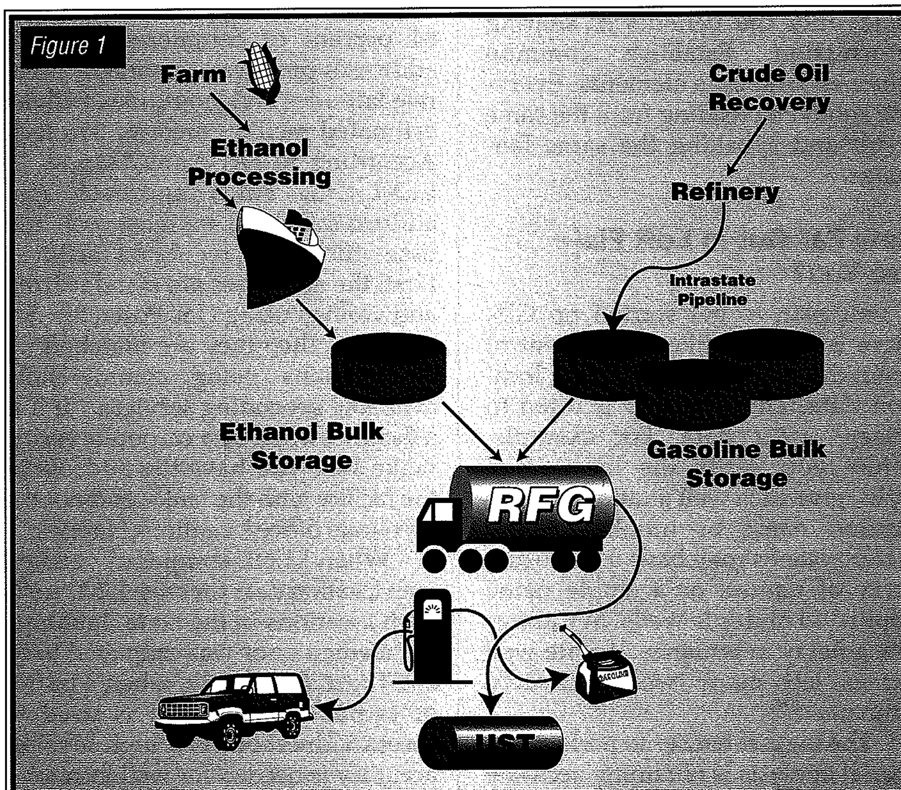
Ethanol is currently used in oxygenated gasoline, albeit not as widely as MTBE. Meeting the federal oxygen requirement would call for 8 percent (by volume) ethanol for oxyfuel and 6 percent for RFG. However, because of a 54 cents per gallon of ethanol used federal subsidy, the blending of ethanol at 10 percent with gasoline is popular. Several states provide additional subsidies for ethanol produced and used in their own states. (See sidebar on page 9.)

In Nebraska, 21 percent of all motor fuel sold contains 10 percent ethanol. At present, 60 percent of gasoline sold in Illinois, and 90 percent of gasoline sold in the Chicago area, contains 10 percent ethanol. Throughout the country, U.S. consumers use more than 56 million cubic meters (15 billion gallons) of ethanol-blended gasoline each year.

The ethanol used for fuel is made primarily from grains or other renewable agricultural and forestry feedstocks. One advantage of ethanol is that it can be made from liquid or solid waste, such as wood by-products, or agricultural waste, such as rice straw. The ethanol used for fuel is a high-octane, water-free alcohol produced from the fermentation of sugar or converted starch.

Unlike most gasoline hydrocarbons, ethanol loves water. These two fluids are completely miscible. This property has important implications, both for the manner in which we use ethanol-blended RFG and its environmental impacts. For example, it is difficult to distribute ethanol-blended RFG because of the propensity for water to absorb into the gasoline. Gasoline distribution terminals receive gasoline and ethanol separately; the two are then mixed as they are pumped into the tanker truck for delivery to a gasoline station (Figure 1). With current ethanol production capabilities, most of the ethanol used would be produced in

Figure 1

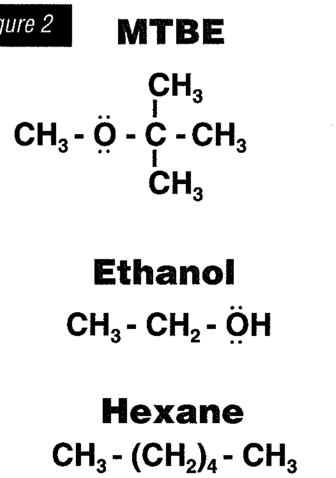


The life cycle of ethanol-RFG has some components that are significantly different than other gasoline formulations.

the Midwest and shipped by rail or marine cargo and then by rail or truck delivery to a final destination terminal.

Given the nature of the ethanol life cycle, the most likely spill scenarios associated with the use of ethanol as a primary fuel oxygenate would involve leaks of ethanol-blended RFG from tanker accidents or USTs or spills of neat ethanol at distribution terminals.

Figure 2



Molecular structure of gasoline oxygenates and hexane, a representative component of gasoline. The electrons (¨) on the oxygen atoms make the MTBE and ethanol molecules polar and, therefore, much more water-loving (hydrophilic) than hexane or other gasoline hydrocarbons.

Potential Impacts of Ethanol on Groundwater Quality

Many of the chemical properties and, therefore, the environmental transport properties of ethanol are similar to those of MTBE. The chemical structures of these two molecules can help us understand their environmental fate (Figure 2). The oxygen atom in both MTBE and ethanol makes these molecules more polar than other petroleum hydrocarbons. This polarity is the reason that they "love" water, a property described by the term "hydrophilic." Thus both MTBE and ethanol have a relatively high solubility in water and high mobility in the subsurface relative to more hydrophobic (water-hating) gasoline constituents such as hexane.

The key difference in the environmental fate of these two oxygenates is caused by the tert-butyl group on the MTBE molecule. This branched structure makes biodegradation of MTBE very difficult. Thus, while the ethanol molecule can be degraded and naturally attenuated in the subsurface, the MTBE molecule is not effectively attenuated, allowing it to travel significant distances from a spill site. The net effect of these properties results in very different environmental impacts associated with these two gasoline oxygenates:

- MTBE deleteriously affects groundwater quality for extended periods.
- Ethanol is not expected to be a significant groundwater contaminant for extended periods.

Although we do not expect ethanol to contaminate groundwater as much as MTBE, it is possible that its presence in gasoline and groundwater near a spill site will affect groundwater concentrations of other constituents from the gasoline—for example, benzene, a known carcinogen.

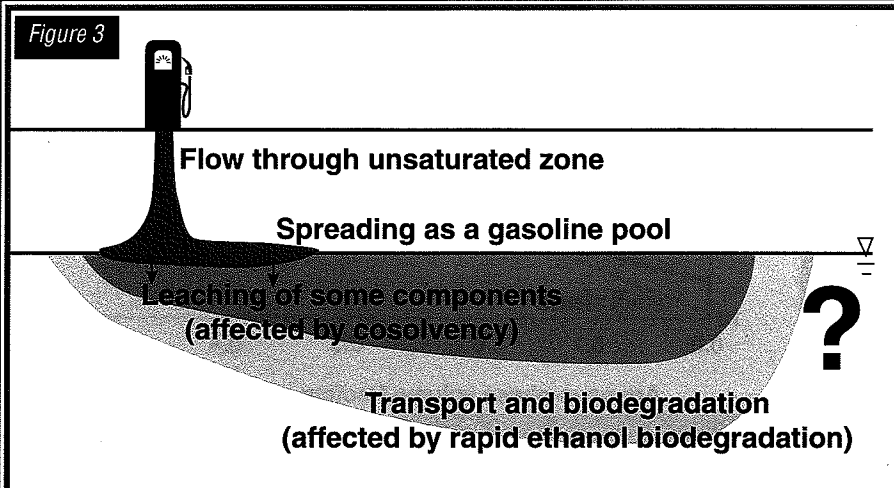
When considering the ultimate risk of any contaminant in the subsurface, we are most interested in potential groundwater concentrations at some receptor point downgradient of a spill site (Figure 3). Numerous processes can affect these concentrations following the spill of a petroleum product. The presence of a hydrophilic compound in the gasoline adds additional processes we have not had to consider previously. Research conducted so far has identified the following important issues:

- Sufficient amounts of ethanol can decrease the interfacial tension of the gasoline, potentially inducing greater lateral spreading of the gasoline within the capillary fringe.
- The presence of ethanol in water can create a cosolvent effect, increasing concentrations of other contaminants.
- All of the oxygen (and other electron acceptors, such as nitrate, iron, and sulfate) and nutrients needed for the biodegradation of benzene can be consumed as ethanol is biodegraded.

Insufficient work has been completed to date to allow us to understand the net effect of the first issue. Both of the other two processes may result in an increase in the concentration of hydrophobic compounds, such as benzene, and an increase in the distance these compounds would travel from a spill site before attenuating processes reduce their concentrations. Note that there are no known field studies of the behavior of ethanol and BTEX (benzene, toluene, ethyl benzene and xylene) from an UST release. Efforts are under way to identify sites where ethanol-blended gasolines have been used and presumably been released from an UST.

■ *continued on page 8*

Figure 3



Predicting groundwater quality and health risks at a downgradient receptor location requires that the net effects of several fate and transport processes be understood. Ethanol in gasoline can potentially increase concentrations of constituents dissolving from the gasoline source and decrease rates of BTEX biodegradation.

■ **Ethanol** *from page 7*

Cosolvency Issues

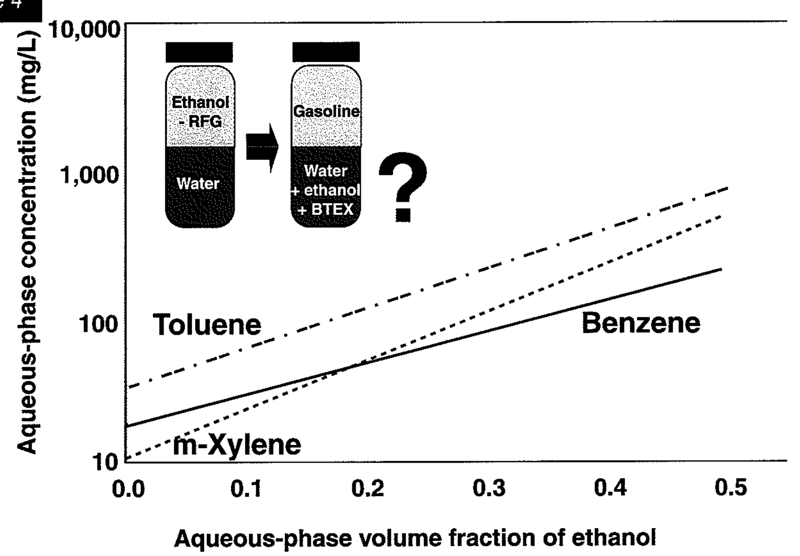
When mixed with water in the laboratory, ethanol quickly and completely transfers from ethanol-blended RFG into the aqueous phase. Depending on the volume fraction of ethanol in the gasoline and the relative volumes of gasoline and water that are mixed, it is possible that the resulting aqueous-phase concentrations of ethanol will be high enough to increase aqueous-phase concentrations of other hydrophobic compounds such as benzene.

The addition of ethanol to gasoline affects these concentrations by the "cosolvent effect." Cosolvency describes the reduction of the polarity of the aqueous phase when high concentrations of organic compounds, such as alcohols, are present. Essentially, the ethanol molecules add organic material to the aqueous phase, making it more attractive to other organic molecules.

Figure 4 illustrates the approximate logarithmic increase in BTEX concentrations with increasing ethanol concentrations. It has been predicted that the volume fraction of the dissolved ethanol in groundwater systems will be less than or equal to 15 percent (i.e., 150,000 mg/L). At these relatively low ethanol volume fractions, BTEX concentrations in the aqueous phase near a gasoline spill are predicted to increase by approximately 20 to 50 percent.

The smallest percentage increase (smallest slope) was observed for benzene, the least hydrophobic of the BTEX compounds. Therefore, it is unlikely that cosolvent-related increases in BTEX concentrations will be significant at the field scale following spills of ethanol-blended RFG. Spills of neat ethanol at a bulk terminal, however, could result in very high ethanol concentrations in a localized area. This problem could cause a much more significant—possibly an order of magnitude—increase in BTEX concentrations if the soil was previously contaminated with a petroleum product. Field studies are in progress that should help clarify our understanding of cosolubility issues.

Figure 4



The presence of ethanol can increase concentrations of BTEX species in an aqueous phase equilibrated with ethanol-blended RFG. This drawing of vials illustrates experiments conducted to determine the cosolvency effect. RFG with a range of ethanol concentrations is mixed in a small vial with water. Following mixing to equilibrate, the aqueous-phase concentrations of ethanol and BTEX are analyzed. Results plotted illustrate that contaminant concentrations increase in a generally logarithmic relation with increasing volume fraction of ethanol in the aqueous phase (data from Heermann and Powers, 1999).

Biodegradation Issues

Ethanol can be degraded either aerobically (in the presence of oxygen) or anaerobically (in the absence of oxygen) at faster rates than can other gasoline constituents (e.g., benzene, MTBE). In laboratory studies with microorganisms from a petroleum spill site, ethanol had a half-life of approximately two to three days under aerobic conditions. The half-life was approximately twice as long under anaerobic conditions. Less favorable conditions in an aquifer would likely result in longer half-lives in situ. Nevertheless, it is expected that ethanol will undergo relatively rapid biodegradation in the subsurface. In contrast, MTBE is expected to biodegrade at an appreciably slower rate under most conditions. (Note: MTBE degradation is addressed with caution in light of recent studies that suggest MTBE may not be as recalcitrant as believed. Stay tuned.)

Quantifying BTEX biodegradation rates is necessary for predicting the net transport of gasoline constituents from a spill site and, therefore, for predicting potential risks to groundwater resources. These biodegradation rates are integrally linked to the biodegradation of ethanol. Ethanol represents a carbon and energy source that is likely to stimulate the growth of a variety of microbial populations. This effect is great in terms of getting rid of the ethanol in the subsurface, but it comes at a cost: Nutrients and oxygen that are consumed in the biodegradation of ethanol are no longer available to biodegrade BTEX.

This fact is particularly important for benzene, a known carcinogen. When degraded in situ by indigenous microorganisms, the half-life for benzene is considered to be greater than 200 days under anaerobic conditions, compared with its half-life of only 2 days in an aerobic aquifer. These degradation rates have not been confirmed in the presence of ethanol. The consumption of oxygen during the biodegradation of ethanol allows benzene to travel farther with the groundwater than it would from the spill of a nonoxygenated gasoline.

The Fate of Dissolved BTEX-Ethanol Mixtures

Although ethanol has been used in gasoline for a few decades in the Midwest, data quantifying the fate of ethanol in the subsurface and the effect of ethanol on BTEX are generally unavailable. A telephone survey of LUST regulators in these states

How Much Ethanol Is in That Gallon of RFG?

Did you know that no real formal definition exists for how much ethanol you need in gasoline to call it gasohol? It's frequently assumed to be 10 percent, but there is no legal definition. How much of an oxygenate might we expect in a gallon of gasoline? To meet the 2.0 and 2.7 weight percent oxygen requirements of reformulated gasoline (RFG) and oxygenated gasolines (oxyfuel), respectively, requires 10.8 and 14.8 volume percent MTBE. Technically, the use of ethanol in RFG requires only 5.7 percent (7.8 percent for oxyfuel), inasmuch as ethanol has a higher oxygen content than MTBE. In the real world, ethanol is almost always blended into gasoline to 10 percent volume. The reason? MONEY!

There is a federal tax break for the use of ethanol in gasoline—54 cents per gallon of ethanol used. The ethanol tax incentive has three tiers reflecting ethanol/gasoline blends at volumes of 10 percent, 7.7 percent, and 5.7 percent.

The Specifics

The 18.4 cents per gallon federal excise tax on gasoline is used to fund the Federal Highway Trust Fund, the primary source of federal dollars used for road-building projects. The ethanol tax incentive is highest when ethanol is blended at a 10 percent level. When it is blended into gasoline at that level, each gallon of gasoline receives a 5.40 cents exemption from the federal excise tax. (Each gallon of gasoline contains 0.1 gallon of ethanol, so the tax exemption is 0.1 x 54 cents, or 5.4 cents.) For ethanol blended into gasoline at 7.7 percent, each gallon of gasoline receives a 4.16 cents exemption. (In this case, each gallon of gasoline contains 0.077 gallon of ethanol, so the exemption is 0.077 x 54 cents, or 4.16 cents.) For 5.7 percent ethanol/gasoline blends, the exemption is 3.08 cents. (You do the math for this one.)

The actual economic calculus that a gasoline blender would use is fairly complex. To grossly oversimplify things, it is usually most profitable to use the 10 percent blend. It basically means that you can sell your gasoline at the pump for the same price as the nongasohol station across the street but get a 5.4 cents per gallon "rebate" from the federal government. That usually makes more "cents" than blending at 7.7 percent and getting only a 4.16 cent rebate.

A quick check of data from a recent national gasoline survey confirms this assumption. Nationally, the average ethanol concentration in alcohol-blended fuels during the summer of 1999 and the winter of 1999–2000 was about 10.1 percent, with a minimum value of 9.5 percent and a maximum of 11.0 percent.

Several states provide additional subsidies for ethanol produced and used in their own states. The take-home message here is that in the majority of cases, if a gasoline contains ethanol, be it an RFG or oxyfuel, it is probably present at about 10 percent by volume. ■

revealed that they indeed know that they have had spills of gasohol, but they cannot be tracked because databases archiving spill histories generally do not identify the type of gasoline. The lack of any regulations requiring groundwater to be tested for ethanol content also contributes to the scarcity of data. The paucity of historical data confounds efforts to understand and predict the effects of ethanol on groundwater quality.

We should learn from lessons associated with MTBE—namely, that the ubiquity of MTBE in the environment was not understood until we started to look for it. Analytical techniques for assessing ethanol concentrations are now available. It is time to start adding this analyte to routine monitoring at gasoline-impacted sites, especially in the Midwest, California, and other locations where ethanol is already in use.

At this point, no extensive modeling studies are available to predict the overall fate of ethanol and BTEX in an aquifer following a spill of ethanol-blended RFG. Various researchers have conducted modeling studies but always with limiting assumptions about the significance of cosolvency or biodegradation mechanisms. For example, many of the models assume that BTEX biodegradation does not occur in areas where ethanol is present at concentrations above some threshold value. Regardless of the assumptions employed, the conclusions drawn from the variety of modeling studies suggest that benzene is likely to travel farther from ethanol-blended RFG release sites. Predictions generally show that benzene plumes from ethanol-blended gasoline could be from 20 to 150 percent longer than those from nonoxygenated gasoline.

As states and the federal government ponder the increase in use of ethanol as an oxygenate and a biomass fuel, the potential environmental benefits and costs associated with this oxygenate must be weighed and compared with other economic and social implications. (Ideally, the politics won't overshadow the science.) Conclusions drawn based on the literature review completed for California suggest that the effects on groundwater resources associated with the use of ethanol will be less severe and more manageable than those associated with the use of MTBE. ■

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What Our Field Survey Shows

OTHER OXYGENATES

In NEIWPCC's MTBE survey, states were asked if they analyze for any of the following oxygenates: ethanol, TBA, TAME, ETBE, DIPE, or any others. The overwhelming majority of states indicated that they do not analyze for any of these substances. Of the states that do:

- Two states analyze for ethanol "most of the time" and eight states "occasionally." South Carolina and Nevada indicated that they have sites where it has been detected.
- Six states analyze for TBA most of the time, and 15 do occasionally. Six of these states have multiple sites where TBA has been detected.
- Five states analyze for TAME most of the time, and 12 do occasionally. Four indicated that they have a few to several sites where TAME has been detected.
- Four states analyze for ETBE most of the time, and 10 do occasionally. Three states have sites where ETBE has been detected; Iowa had 33.
- Six states analyze for DIPE most of the time, and 9 do occasionally. Four have multiple sites where it has been detected.
- Missouri monitors for EDB occasionally and South Carolina monitors for ETBA, TAA, and TBF occasionally.

Only five states monitor for ethanol; two others say they do sometimes. Seven states indicated that they have ethanol-contaminated LUST sites. Not surprisingly, 36 states indicated that they did not know whether they have ethanol-contaminated LUST sites. Kansas has identified 70 sites that have sold a 10 percent ethanol/gasoline mix. The state is in the process of analyzing these sites. ■

For More Information About Ethanol...

Blue Ribbon Panel on Oxygenates in Gasoline. Achieving clean air and clean water: the report of the Blue Ribbon Panel on Oxygenates in Gasoline; EPA 420-R-99-021; U.S. Government Printing Office: Washington DC, 1999 (http://www.epa.gov/otaq/consumer/fuels/oxypanel/r99021.pdf).

Corseuil, H. X., Hunt, C., dos Santos Ferreira, R., and Alvarez, P. J. J. 1998. The influence of the gasoline oxygenate ethanol on aerobic and anaerobic BTX biodegradation. Wat. Res. 32 (7), 2065.

Corseuil, H. X., and Alvarez, P. J. J. 1996. Natural bioremediation perspective for BTX contaminated groundwater in Brazil. Water Sci. & Technol. 35, 9–16.

Heermann, S. E., and Powers, S. E. 1998. Modeling the partitioning of BTEX in water-reformulated gasoline systems containing ethanol. J. Contam. Hydrol. 34(4), 315.

Hunt, C. S., Alvarez, P. J. J., dos Santos Ferreira, R., and Corseuil, H. X. 1997. Effect of ethanol on aerobic BTEX degradation. In: B. C. Alleman and A. L. Leeson (eds.), In situ and onsite bioremediation, 4 (1). Batelle Press, Columbus, OH, pp. 49–54.

Rice, D. W. (and others). Health and environmental assessment of the use of ethanol as a fuel oxygenate. Volume IV—potential ground and surface water impacts. Published by the state of California, UCRL-AR-135949, 1999 (http://www-erd.llnl.gov/ethanol/).

http://www.afdc.doe.gov/. Alternative fuels data center (USDOE). Biodiesel/ethanol general information. U.S. government fleet information. Alternative fuel vehicles.

http://www.cleanfuels.net/. Oxygenated Fuels Association.

http://www.ethanolrfa.org/. Renewable Fuels Association.

http://www.greenfuels.org/index.htm. Canadian Green Fuels Association.

http://www.ethanol-gec.org/. Governor's Ethanol Coalition.

http://www.ethanol.org/main.html. American coalition for ethanol. Information on ethanol, MTBE, publications, press releases, and more. Also links to other organizations.

■ The Future Is Coming...
continued from page 5

such as the extent of contamination or health risks, they are encouraged to check the site characterization reports, which are available to the public at specified regional offices. To protect the privacy of responsible parties, financial information related to the ability to pay for cleanup is kept separately.

New Hampshire uses a similar approach. The Site Remediation Programs for the Waste Management Division sponsor a GIS terminal at their headquarters office for the public, consultants, and other parties to identify potential and existing contamination sources and water sources. They charge small fees to print maps and reports. Reports can be saved to a disk, and a feature to save maps will be incorporated later. In the meantime, source and receptor databases with addresses are available over the Internet on a system called "Onestop" (http://www.des.state.nh.us/onestop/). That's the warm-up act until a New Hampshire Internet GIS site is on a Web site near you—soon.

It Just Makes Sense

The reason for getting your GIS program up and running on the Internet is not because everyone else doing it, but because spatial analysis can improve your agency's ability to protect the environment through better information and sharing of that information. The public can get better (graphical) answers to questions than they can over the phone, and you can spend your time doing site inspections and catching the leak before it reaches the well.

In the next issue of *LUSTLine*, we'll continue our technology theme with a story about a new integrated UST inspection system, developed by EPA Region 2 and New York, that uses GPS to enter information into the database in the field...and much more. Stay tuned. ■

Ann Carpenter is a former EPA employee who now teaches geography at a community college in Massachusetts and writes on a free-lance basis.

A LUSTLine Book Review

"Nothing But the Truth" Uses MTBE as Its Weapon of Choice

by Patricia Ellis

First came the Woburn case, followed by the book *A Civil Action*, followed by the movie starring John Travolta. Next came *Erin Brockovich,* starring Julia Roberts, based on a case involving Pacific Gas and Electric in Hinkley, California, where hexavalent chromium had been used as an antifouling agent in cooling towers at a compressor station. With MTBE playing such a major role in my life these days, I'd been trying to decide which of the major MTBE impacts or which of the many MTBE legal cases in the works would make a good book or movie. Now mystery writer John Lescroart has presented us with.....

Oh, wait—that book is fiction. Nobody *really* dumped MTBE in a reservoir as an act of eco-terrorism. So far, the impacts to water resources in real life have all been "accidental"—accidental tank leaks, accidental pipeline leaks, accidental car accidents, and other assorted accidental spills. The gasoline leaks that cost Santa Monica more than half of its water supply, the problems that caused the shut down 13 of 35 wells in South Lake Tahoe, or the spill from the Explorer pipeline that took out one of Dallas's water supply reservoirs for months? These incidents weren't fiction like Lescroart's book.

Nothing But the Truth is mystery writer John Lescroart's eleventh novel, including two that have made the *New York Times* best-seller list. The plot involves petroleum, MTBE, evil ethanol lobbyists, gubernatorial politics, romantic tangles (sorry, no steamy sex scenes), grand juries, and lawyers, including an ambitious prosecutor out to make a name for himself. What more could you want?

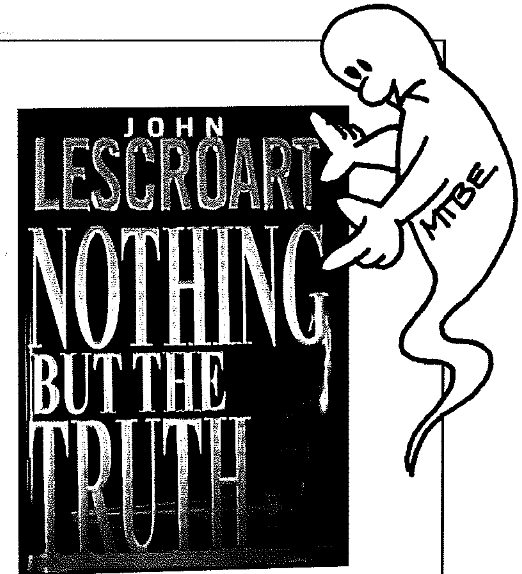
The book involves the death of Bree Beaumont, a scientist who had believed that MTBE was wonderful for improving air quality and had been a consultant for the Western States Petroleum Association and later for Calco Oil. Shortly before her death, she had changed sides in the volatile wars over the gasoline additive, after coming to believe that MTBE was a cancer-causing additive that was seeping into California's groundwater in alarming amounts.

In the story, MTBE was big business for the oil companies—they were making $3 billion per year on it. On the other hand, the ethanol industry profits were a mere $45 million in the United States just before California announced its MTBE ban. Now the ethanol market was expected to multiply exponentially. Stakes were high.

During pre-election speeches, gubernatorial candidate Kerry calls for an immediate moratorium on MTBE use. "There is no reason to tolerate even for one more moment this dangerous and insoluble toxin in our gasoline where there is an environmentally safe and effective substitute so readily available, and by this I mean ethanol."

We need to point out at this juncture that MTBE is not "insoluble." If it were, MTBE would hardly be a groundwater issue. While it isn't completely miscible (as is ethanol), it does have a rather high solubility (45,000 ppb) compared with benzene (1,707 ppb).

Back to the story—candidate Kerry's opponent, speaking about the act of eco-terrorism, says "It's not the MTBE that has caused this terrible crisis any more than it is guns that kill people. People kill people, and people—criminals—have poisoned the San Francisco water supply. Gasoline without additives would have produced the same effect, and no one is talking about making gasoline illegal."



"Nothing But the Truth" by John Lescroart, Delacorte Press, January 2000.

Well I can't think how many times I heard during the Blue Ribbon Panel hearings, "It's not the MTBE, it's the tanks. If 'you people' would keep the tanks from leaking, the MTBE wouldn't be a problem!"

A visit to Bree's office sounded like a visit to my office—"propaganda by the armload on...every imaginable side of the additive issue. Legislative reports, news clippings, executive summaries from various thinktanks, media alerts. MTBE, ethanol, reformulated gasoline." Did this get Bree killed?

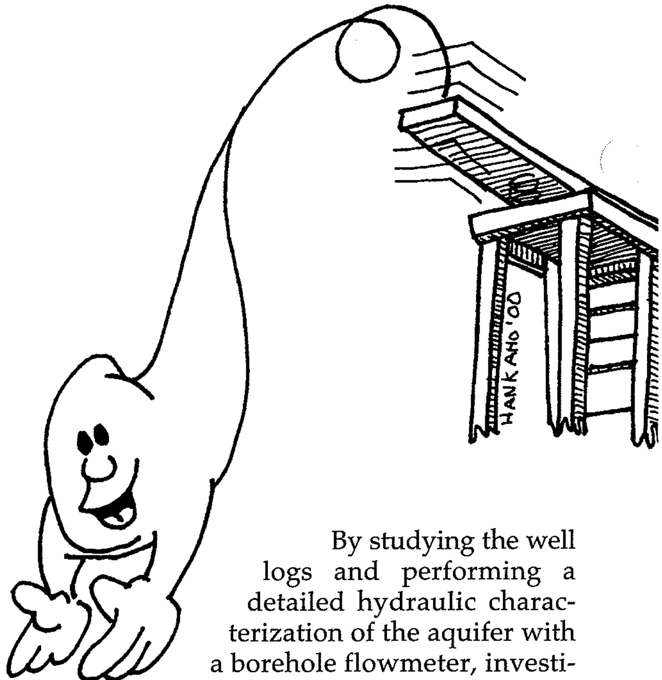
As I read the book— with the idea of writing a review of it—I was "sticky-noting" the pages where MTBE was mentioned. Lescroart had a pretty good handle on the issues and facts involving MTBE, putting the proper words into the mouths of each of his characters. Now, who can we cast as... ■

Pat Ellis is a hydrologist with the Delaware DNREC UST Branch and was a member of EPA's Blue Ribbon Panel.

Investigation and Remediation

Diving Plumes and Vertical Migration at Petroleum Hydrocarbon Release Sites

by James W. Weaver and John T. Wilson



Petroleum hydrocarbons are mostly less dense than water. So they should float or at least hang around the water table, right? Not so fast. There are some fairly common situations where we would expect a plume of petroleum hydrocarbons to move vertically into the aquifer—as a result of water table drawdown associated with pumping from water supply wells, smearing of contaminants due to water table fluctuation and site investigation activities, and movement of water through preferential flow paths in heterogeneous environments. But even in the absence of any of these circumstances, a plume may still move downward, or "dive," into an aquifer.

This diving situation occurs when groundwater recharge enters the top of a shallow water table aquifer. Once in the aquifer, this water begins to move in the direction of groundwater flow. Because the recharge water is entering the aquifer from above, it can push contaminant plumes downward. The amount that a plume "dives" depends on the amount of recharge water entering the system and the relative contribution this additional water makes to flow in the aquifer.

We expect that such diving plume scenarios may occur in the wetter parts of the country, but even in dry climates, recharge-driven diving can occur because of irrigation, leaking water or sewer pipes, or recharge from ephemeral surface water features. In either case, plume diving depends on the localized pattern of recharge, the flow rate in the aquifer, and the distribution of contaminants—as shown in the following East Patchogue, New York, example.

East Patchogue, New York

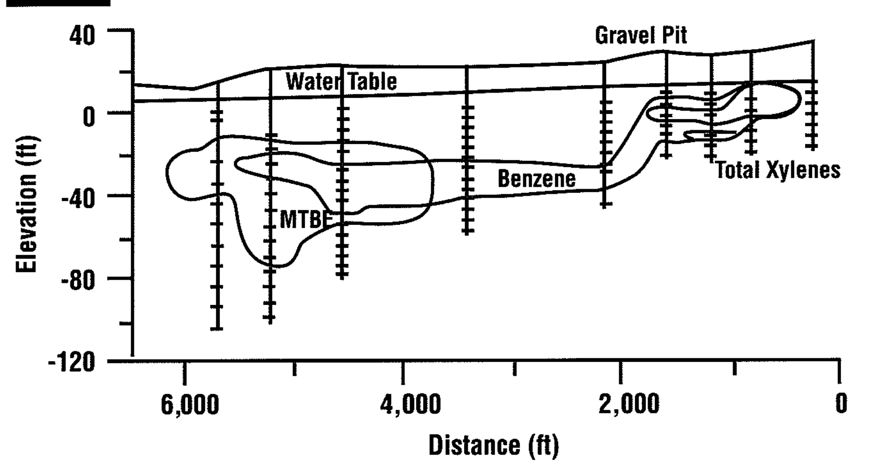
A gasoline release at an East Patchogue, New York, UST facility created large BTEX and MTBE plumes. The plumes were detected because a private water supply well, located 4,000 feet downgradient from the source, was in their path. The well screen was about 50 feet below the water table, where much of the MTBE mass was located. The site investigation started at this point and went upgradient to identify the source.

Because of the importance of the aquifer for drinking water supply, New York undertook an extensive investigation of the site, including vertical characterization of the plumes. Multilevel samplers with 6-inch screens at 5-foot intervals were used. A resulting vertical section through the plume showed that BTEX and MTBE tended to dive into the aquifer with distance from the source. (See Figure 1.) It was further noted that a significant amount of diving occurred as the BTEX plumes passed under a gravel pit.

By studying the well logs and performing a detailed hydraulic characterization of the aquifer with a borehole flowmeter, investigators ruled out vertical migration controlled by stratigraphy, because the hydraulic conductivities varied by less than a factor of 2 over the aquifer. This left recharge as the most likely explanation for the plume diving. The model described in the sidebar on page 14 was used to simulate the site and provided additional evidence that recharge was the cause of the diving.

This Patchogue example sheds light not only on how recharge pushes the plume downward, but also on what happens when water discharges from aquifers. Where water comes up at discharge points, so will the contaminants—along streams, rivers, lakes, or the ocean.

Figure 1



A vertical cross section through the MTBE, benzene, and total xylene plumes at East Patchogue, New York. The gasoline source is located at the right-hand edge of the sections, and flow is to the left. Each of the plumes dives into the aquifer with transport in the aquifer.

The ocean is the expected destination of the MTBE plume at East Patchogue, where the groundwater flow system discharges into Great South Bay, adjacent to the southern shore of Long Island. The groundwater and contaminants move upward as they approach the discharge point at the bottom of the bay.

Consequences of Missing the Dive

What about the consequences of a diving plume, or more to the point, the consequences of *missing* a diving plume? We averaged the East Patchogue data set to show how the plume would appear if sampled only from long-screened wells. The data were averaged over the top 10 feet of the aquifer to simulate 20-foot well screens—10 feet in and 10 feet out of the aquifer.

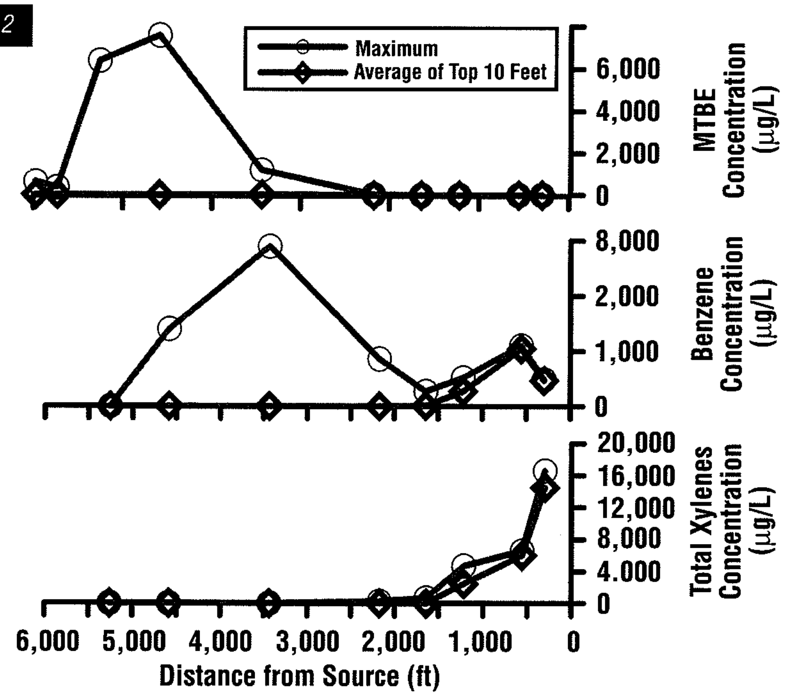
The graphs in Figure 2 show two sets of concentrations plotted along the length of the plumes. The first data set (circles) shows the maximum concentrations from the multilevel samplers. This set represents the maximum concentration measured in each sampler, regardless of depth, at each location along the plume. It is intended to be a reference to show the extent of contamination on the x-y plot.

The second concentrations (diamonds) are the values for the simulated 10-foot screens. For these, the MTBE concentrations all fall below New York State's threshold of 10 µg/L. With only these data we would have concluded that there was no MTBE plume at this site. The maximum concentrations, however, indicate a significant MTBE plume in the downgradient portion of the aquifer.

The simulated long-screened data show that the benzene plume appears to be shortened to about one-third its actual length. This effect occurs because plume diving pushes the benzene plume out of the bottom of the sampling network. Along the way, the concentrations appear to decrease, because clean and contaminated water mix in the well. This mixing results in diluted samples and lower concentrations.

Interestingly, the long-screened data also show that the total xylenes and benzene plumes appear to be the same length. Here, because of sorption, the total xylenes did not travel far enough in the aquifer to drop out of the monitoring network, and there was no apparent shortening of the plume. Nevertheless, these two contaminant distributions hint at a sampling problem. Our expectation is that there should be separation of benzene and total xylenes caused by sorption. In this case, the expected chromatographic separation has been negated by the monitoring network.

Figure 2



Consequences of sampling only the top 10-feet of the aquifer at East Patchogue. The MTBE plume disappears (top), the benzene plume is shortened by two-thirds, and the total xylenes plume appears at the same length, because it does not reach the gravel pit where diving dominates the contaminant distribution.

Rethinking Our Assumptions

Are plumes longer than we think they are? The short answer is yes! The reason we think that they are shorter is that most LUST site monitoring well networks do not adequately delineate contaminant plumes in three dimensions.

"Conventional" monitoring wells are primarily designed to monitor for the presence of free product floating on the water table. To accomplish this task, conventional wells are constructed with relatively long screens that bisect the water table. This approach is meant to allow for seasonal fluctuations in water table elevation in the hope that the screen will extend below the lowest low-water elevation and just above the highest high-water elevation.

Also, many monitoring networks consist of relatively few wells, most of which are located on the LUST site property. We've seen that such networks are not well suited for determining the true extent of a plume, nor can they provide accurate information about the vertical distribution of either contaminants or hydraulic conductivity. The lack of such data is a critical limitation for performing a quantitative risk assessment.

Groundwater samples drawn from these conventional wells represent composite samples. Because they mix waters of varying true concentrations, they are diluted and give a falsely low impression of the severity of contamination.

So how do we interpret concentrations of contaminants that are below state or federal action levels? Here, an old dictum applies: The absence of evidence is not evidence of absence.

It may be that, sometimes, low concentrations are just that. But we need assurance that the wells have been located such that they actually

■ *continued on page 14*

■ **Diving Plumes** *from page 13*

sample the plume. When we sample from the wrong place, as our Patchogue example shows, we may well think that concentrations are lower than they actually are. As a consequence, we incorrectly believe that plumes are shorter than they are actually, even to the point of apparent nonexistent.

With the prevalence of biodegradation of BTEX (and some emerging news concerning MTBE biodegradation), we may be too quick to attribute short plumes to natural attenuation, rather than to the true cause—a sampling error.

An Approach to Assessing Plume Diving

Is there a universal prescription for a practical assessment of plume diving and vertical migration? We're afraid not. The site assessment process involves putting together the pieces of the puzzle to delineate the extent of contamination. One part of that puzzle is a determination of the vertical contaminant distribution. Because of the potentially detrimental consequences of missing a diving plume, the site investigation should be designed to ensure that a diving plume doesn't extend out of the range of the bottom of the monitoring network. Site-specific factors, such as geology, hydrology, land use, and site geochemistry, provide the evidence for plume diving. The following factors should be evaluated in planning a site investigation:

■ Geology and the Sampling Network

What land form contains the plume? Is it a flood plain, delta, or coastal plain? Do drilling logs indicate that there are discrete zones that yield plentiful water and other zones that do not?

Core logs give information needed to define the stratigraphy, including the geologic units, their consistency, and their orientation. Has a cone penetrometer or borehole flowmeter test been performed? Have the monitoring wells been tested to determine hydraulic conductivity? Have they been tested to determine whether they are screened in intervals known to yield water? What are the properties of the aquifer with regard to depth, thickness, and hydraulic conductivity? Does the well network characterize the aquifer in two or three dimensions?

Clearly, vertical delineation of a contaminant plume requires three-dimensional characterization, which may include the use of permanently installed multilevel wells or temporary push points. Because of the expense of installing and sampling from multilevel wells, temporary push points can be used to reduce the cost of vertical delineation.

Using this push technique, locations can be sampled without installing permanent wells when the vertical location of the plume is not known. Permanent monitoring wells can be installed after the plume has been located. Determining the horizontal extent of contamination may not necessarily be a simple task. Push technologies can be of great benefit here as well.

Answers to the questions posed above help define the stratigraphy, which serves as the geologic control on the contaminant distribution. In many flood plains, for example, the surface material is primarily heavy silts and clays that have been deposited during historical flood events. Beneath these surface silts and clays are sand and gravel deposits associated with previous meanders of the river. The water table is frequently in the surface silt and clay. So the materials with a capacity to carry groundwater (sand and gravel) and transport a plume occur at the bottom of the sequence of deposited sediment.

The Elizabeth City, North Carolina, "Old Fuel Farm Site" illustrates the effects of recharge, stratigraphy, and sampling. It is described in a report, *Natural Attenuation of MTBE in the Subsurface Under Methanogenic Conditions,* available from EPA at http://www.epa.gov/ada/pubs/reports.html.

■ Hydrology and Land Use

From a topographic map, what do elevations of areas such streams and lakes indicate about the groundwater flow system? How much annual rainfall occurs? What recharge estimates have been developed for the area or are commonly used? What are the land use patterns?

The OnSite Plume Diving Calculator

Calibrated numerical groundwater flow models, such as MODFLOW, can be used to show how much recharge-driven diving might occur in an aquifer. Inasmuch as these models are not applied at most LUST sites, we'd like to suggest that you try some simpler alternatives.

From our experience at the East Patchogue site, a simple simulation model was developed to estimate the prospects for recharge-driven plume diving. The model is a part of EPA's on-line tools for site assessment called OnSite. Use of the tools requires only a standard browser and Internet access. The tools are available at http://www.epa.gov/athens/software/training/WebCourse/part-two/onsite.

The plume diving model allows an aquifer to be split into segments, each with its own hydraulic conductivity, recharge rate, and length. The upgradient and downgradient heads are specified in the aquifer, as is a starting point that represents the source and a well location. Given these specified aquifer parameters, an estimate is given for how deep the top of the plume goes below the water table at the specified well location.

The software has been used on several Long Island sites and found to match the observed plumes. The model, however, is based on a simple one-dimensional conceptualization, and it won't be appropriate for all sites. It does, however, give an idea of the prospects for recharge-driven plume diving.

As the site investigation moves away from the source, the model can be used to predict plume diving. Sampling of the aquifer can then show if the predictions were correct. More to the point, sampling can show if the plume is diving, and the model results give a guide for determining the vertical extent of contamination. ■

For example, the flow system at East Patchogue is determined by the regional flow on Long Island, where water generally flows from the center of the island in the north to the Great South Bay in the south. An average of 44 inches of rain falls each year, and the United States Geological Survey (USGS) estimates that the average recharge is about half of the rainfall.

The UST facility property is paved and adjacent to a highway. Downgradient, the land uses include light commercial, playing fields, a gravel pit, and medium-density residential areas. Each of these land uses influences the pattern of recharge, from very low recharge where the surface is paved to very high recharge in the gravel pit.

From this information, we could have suspected that the contaminants were likely to travel toward the bay. If the plumes moved away from the service station property and out from under the paved area, there would be a good chance for diving behavior, particularly if the plumes reached the gravel pit—as indeed they did.

At other sites, unlined drainage ditches, leaking water mains and sewer pipes, irrigation, and the flow pattern in the aquifer can determine the vertical distribution of contaminants.

Thus, where recharge is likely to be the plume diving instigator, the amount of water that infiltrates the area above the plume, and the amount that this recharge contributes to flow in the aquifer, determines where and how much diving will take place.

■ Geochemistry

Simple geochemical tests can be used to spot a plume that is diving because of clean water recharge. In general, uncontaminated recharge water at the top of an aquifer will have oxygen concentrations that exceed 1 mg/L, iron concentrations that are less than 0.5 mg/L, and methane concentrations that are less than 0.1 mg/L. Groundwater that has been contaminated with petroleum hydrocarbons will generally contain oxygen concentrations that are less than 0.5 mg/L and may contain concentrations of iron and methane that are greater than 1 mg/L. If the groundwater is sampled with a bailer, the sample is usually contaminated with atmospheric oxygen during sampling, and the rule of thumb for oxygen should not be applied.

In general, clean recharge water will have low dissolved organic carbon (DOC), usually less than 1.0 to 2.0 mg/L. The plume will usually have elevated DOC, often exceeding 10 mg/L.

Putting the Pieces Together

The stratigraphy of an area provides the first indication that plume diving should be considered. Are the contaminants contained in dipping strata? If so, off-site migration is likely to be controlled by the stratigraphy. Dipping or not, the plume direction will be dictated by the flow that water takes through the geologic structure.

The groundwater flow rate and an estimate of the petroleum release date provide clues about travel time to various downgradient locations. If the rate is low enough, the plume may never reach that gravel pit or unlined ditch that is waiting to drag it to the depths of the aquifer.

So, before taking the site investigation off-site, can an estimate of plume diving be made? In simple aquifers, the OnSite plume diving calculator can be used to estimate diving at a specific location. (See sidebar on page 14.) Subsequent sampling with a direct push probe can provide confirmation (or not) of the location of the plume, both vertical and horizontal, before a commitment to permanent monitoring wells is made.

From our work on sites with diving plumes, it's clear that the prospects for plume diving need to be factored into site investigations. This information can be used to determine whether diving is likely to occur in the downgradient plume. If diving is a possibility, then the sampling design must be such that plumes are fully characterized through the design of the monitoring network.

By the way, plume diving is not a new concept. It was evident in data collected from the first Borden Aquifer dispersion experiment conducted in the 1980s (MacKay et al., 1986, A natural gradient experiment on solute transport in a sand aquifer, Water Resources Research, 22(13) 2017–2029). It was also observed in data from the extensive USGS Cape Cod field study (LeBlanc et al., 1991, Large-scale natural gradient tracer test in sand and gravel, Cape Cod, Massachusetts, Water Resources Research 27(5), 895–910). ■

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What Our Field Survey Shows

DIVING PLUMES

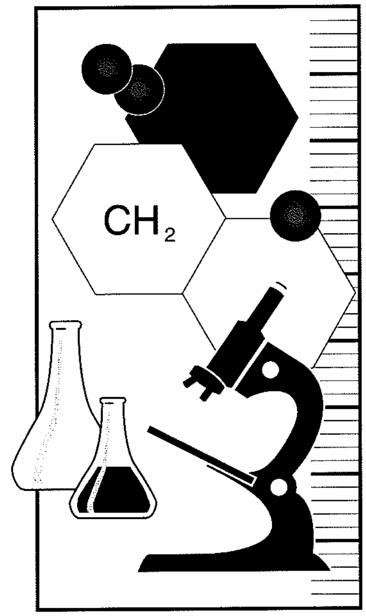
In NEIWPCC's MTBE survey, when asked if they investigate MTBE plumes differently from BTEX plumes because of the potential for diving plumes, 4 states answered "yes" and 15 answered "sometimes." When asked if they require three-dimensional characterization of MTBE plumes, 14 of the 19 states that answered "yes" to the previous question answered that they do "occasionally," 3 answered "most of the time," and 1 said "always." Delaware indicated that the answer depended on the project officer whether it was "occasionally" or "most of the time." Montana commented that if a vertical gradient is apparent, nested wells will be required to verify whether a diving plume exists.

When asked if they are taking any extra steps to make sure MTBE is not migrating beyond standard monitoring parameters, 19 states answered "yes." When asked what kinds of steps, most said that they are using multilevel wells, nested wells, deeper wells, and/or more wells located farther downgradient from the source. ■

Oxygenates

Analytical Issues for MTBE and Related Oxygenate Compounds

by Deana M. Crumbling and Barry Lesnik



Questions have been raised about which analytical methods for MTBE and related analytes are appropriate within the context of state and federal LUST programs. To help answer some of these questions, we've prepared the following overview of the current status of MTBE analysis from the perspective and experience of EPA's Office of Solid Waste (OSW) Methods Team, the group responsible for developing and maintaining the *SW-846 Methods* manual, and EPA's Technology Innovation Office (TIO).

Because MTBE is not currently a RCRA-regulated analyte, it has not been validated in any SW-846 method at this time. *Neither Method 8021 nor Method 8260 has been validated for MTBE.* As it stands, analyses of a few of the oxygenated analytes that are of more recent interest to LUST program personnel [e.g., tert-butyl alcohol (TBA) and ethanol] have already been validated and published in SW-846 methods several years ago.

"Approved Methods"

Confusion often arises in the search for an "approved method." A common misconception is that when a method is published in SW-846 it becomes an "approved method" and is, therefore, required across the board. This is not true. In fact, any reliable method may be used, whether it is published in an EPA methods manual or suggested as an alternative method. (Note: Some state UST programs require the use of "EPA-approved methods.") Any method used must be able to determine the analytes of concern in the matrix of concern at the action level of concern.

SW-846 Methods

Requirements for using specific "EPA-approved methods" in the context of waste programs are discouraged. The use of prescriptive analytical methods is counterproductive to the generation of reliable data, because samples encountered in waste programs are too varied and complex for any single method to work for all samples all the time. For this reason, the SW-846 manual uses a performance-based approach to analytical methods.

SW-846 is intended to provide general guidance, not prescriptive requirements. There are no "reference methods" in SW-846, in the context that the term is used in the Office of Water Programs. Part of the misunderstanding regarding analytical method requirements stems from the fact that EPA water programs do require "EPA-approved methods" when implementing the Safe Drinking Water Act (SDWA) and the Clean Water Act (CWA). However, meeting SDWA and CWA requirements is not usually the driver for projects within waste programs, and "EPA-approved methods" are not required.

Thus there will never be a prescriptive method for MTBE within OSW programs, even when MTBE is included as a target analyte in published SW-846 methods. However, the growing interest in oxygenates indicates that an SW-846 method that addresses MTBE would be highly valuable to the UST/LUST community.

By the time they are published, SW-846 methods have undergone thorough evaluation and peer review to (1) determine the level of method performance that can be expected under "typical" conditions, and (2) identify what interferences might compromise method performance and what to do when it happens. We believe that some of the existing SW-846 methods are appropriate for the sample preparation (Method 5031) and determination (Methods 8015 and 8260) of MTBE and other related target analytes in aqueous matrices. However, it would take a "demonstration of applicability" to prove it.

In the Meantime

Until MTBE analysis is validated in an SW-846 method, which methods could be used for MTBE and related analytes? The simple answer is that "any method that can be demonstrated to measure the constituent of concern, in the matrix of concern, at the level of concern, and at the degree of accuracy as identified as necessary to address the site decision" can be used. (See http://cluin.org/download/char/article(1).pdf, page 2.) Of course, demonstrating that a method is working as expected on a variety of real-world sample types takes time and technical expertise, and that means that the answer may not be so simple. With this caveat in mind, let's look at oxygenate analysis in relation to existing SW-846 methods.

Method 8015

The chemical and physical properties of the target analytes and the potential for interferences in the samples submitted for oxygenate analyses must be considered when selecting potential sample preparation and determinative methods. SW-846 Method 8015, "Nonhalogenated Organic Compounds Using GC/FID," was developed for the analysis of oxygenates and is expected to be applicable to MTBE and other related compounds. (Note: All SW-846 methods may be accessed on-line at http://www.epa.gov/SW-846/main.htm.)

Method 8015 is a determinative method [gas chromatography/flame ionization detector (GC/FID)] only. As such, it is merely part of the "analytical method" picture. A "determinative method" applies to the analytical instrumentation used to generate the analytical result. A sample preparation (or sample introduction) method is needed to get the target analytes from the sample matrix into the analytical instrumentation.

An appropriate sample preparation method must be applied to the original sample (such as water or soil) so that the analytes can be transferred from the matrix onto the GC column. If the sample preparative method is not appropriate for the analyte, transfer of the analytes from the original sample into the instrument may be incomplete or unpredictable, and the final results may be erroneous due to low recovery, no matter how good the instrumental determinative method is.

Section 1.1 of Method 8015 covers some of the sample preparative methods that have been shown to be applicable for a variety of oxygenated compounds. Note that Section 1.1 shows that the purge-and-trap technique is rarely successful for highly water-soluble oxygenates. Purge-and-trap works best for analytes that are both volatile *and relatively insoluble* in water (e.g., BTEX compounds).

MTBE, however, is more soluble in water than BTEX compounds, and this characteristic decreases its purging efficiency relative to those compounds, creating the possibility that interferences in complex sample types could render purge-and-trap analyses susceptible to imprecision and poor method sensitivity due to unpredictable sample-specific purging efficiencies. This generalization is even more true for oxygenated analytes that are more water-soluble than MTBE is.

As with *any* preparative or determinative method, evaluation of sample-specific characteristics in relation to expected method performance (to meet project-specific needs) for specific analytes is required to determine whether purge-and-trap or some other sample preparation method can consistently provide the expected data quality.

Section 1.1 of Method 8015 recommends that samples to be analyzed for highly water-soluble oxygenated organic compounds [such as tert-butyl alcohol (TBA) and ethanol] be prepared using direct injection or azeotropic distillation (Method 5031). Direct injection alone (into a GC/FID) has been shown to achieve detection limits in the range of 400–500 ppb for TBA and ethanol.

Azeotropic distillation techniques can be used to concentrate samples for these alcohol analytes. The azeotropic distillation sample preparation/concentration technique has been shown to produce detection limits in the vicinity of 10 ppb when the concentrated samples are analyzed by GC/FID. Vacuum distillation (SW-846 Method 5032) and static headspace (SW-846 Method 5021) could also be considered as potentially viable sample preparative methods. Each of these preparative methods will have its advantages and drawbacks. Additional development work for both preparative and determinative methods will be required to validate routinely applicable methods across the range of oxygenate compounds, sample types, and detection limits that are now of interest.

The selection of any analytical method must always consider the ultimate use of the data. The use of project-specific systematic planning can ensure that data collection methods are cost-effectively matched to the project's decision-making needs.

Method 8021

SW-846 Method 8021—Aromatic and Halogenated Volatiles by GC Using Photoionization (PID) and/or Electroconductivity (ElCD) Detectors—or a similar method that relies on a photoionization detector, is *not recommended* as a determinative method for MTBE and its associated oxygenates. PID is most sensitive to compounds that contain double bonds (which is why this method is a good determinative technique for BTEX compounds).

MTBE and related compounds, however, do not contain double bonds. Although the PID analysis will respond to the oxygen atom in these compounds, the response is weaker than the response for BTEX compounds and, therefore, may be subject to interference and false positives when real-world samples contain significant amounts of other contaminants such as petroleum hydrocarbons. (See pages 9 and 15 of "An Evaluation of MTBE Impacts to California Groundwater Resources," available at http://www-erd.llnl.gov/mtbe/pdf/mtbe.pdf.) The ElCD detector of Method 8021 works only for compounds containing halogen atoms, and MTBE does not possess this characteristic either.

Method 8260

GC with a mass spectrometer (MS) detector is also appropriate as a determinative method for oxygenates, as long as a sample preparative method appropriate to the sample has been used. MS offers the advantage of unambiguous identification of target compounds. It is a good idea to keep a few things in mind if a GC-MS method for MTBE and other oxygenates is discussed in terms of SW-846 Method 8260:

- Method 8260 has *not* been validated by EPA for use with MTBE.
- Method 8260 is a GC-MS *determinative* method only—the sample preparation method is separate. Purge-and-trap is not specified by Method 8260 and, in fact, is not recommended for the few alcohol analytes that have been validated in Method 8260 (e.g., ethanol and TBA). (See the Appropriate Preparation Technique table in Section 1.1 and Section 1.2.)
- Improved performance of Method 8260 for MTBE and other oxygenates can be expected if instrument operating conditions are modified to accommodate that particular analyte group (rather than trying to generalize operating conditions to accommodate the entire range of 100-plus validated analytes in the Method 8260 list).

■ *continued on page 18*

■ **Analytical Issues for MTBE**
from page 17

Field Methods

In addition to their analysis by GC-MS in the fixed laboratory, MTBE, ethyl t-butyl ether (ETBE), and TBA have been successfully analyzed in the field by using a field-portable GC/MS and heated (at 60°C) static (i.e., equilibrium) headspace. Method performance information (provided by Field-Portable Analytical, Inc.) shows detection limits in the range of 4–5 ppb when the MS is operated in full-scan mode. When operated in selective ion monitoring (SIM) mode, detection limits down to 0.2 ppb are possible with full positive identification of the analytes. As samples are analyzed in the field at the time of collection, issues regarding sample preservation are avoided.

Depending on the nature of the project, field analysis can significantly decrease costs by supporting real-time decision making according to an Expedited Site Assessment approach. (See EPA 510-B-97-001, "Expedited Site Assessment for Underground Storage Tank Sites: A Guide for Regulators," available on OUST's Web site at http://www.epa.gov/swerust1/pubs/index.htm#sam.)

The Decision-Making Factor

Above all, the selection of any analytical method must always consider the ultimate use of the data. Data for risk assessment purposes typically need lower detection/quantitation limits than when data are used to delineate a plume or to place monitoring wells. The use of project-specific systematic planning can ensure that data collection methods are cost-effectively matched to the project's decision-making needs.

The flexibility inherent in SW-846 methods permits "mixing and matching" of sample preparation and determinative methods so that the needed method sensitivity and accuracy can be achieved. As long as data are of known quality, and that quality has been matched to the decision-making needs of the project, any reliable method can be used.

Although we have discussed in general terms the various analytical method options for oxygenates that might be explored, a more specific answer to the question, "What method should be used for MTBE and/or oxygenates for this particular project?", first requires that the project manager clearly specify the intended use of the data. When this use is known, the required detection limits can be determined, the desired turnaround time for the data results can be estimated, and the most cost-effective option for generating the data (i.e., the sampling program and the analytical methods) can be deduced.

For More Information

Information about SW-846 and the selection of analytical methods can be found through the Clean-Up Information Web page of the Technology Innovation Office at http://cluin.org/char1.htm and the OSW Methods Team home page at http://www.epa.gov/SW-846/. More information about how site characterization and cleanup can be made more cost-effective can be found at http://www.clu-in.org/products/failsafe.htm. ■

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Results of NEIWPCC Survey of State Experiences with MTBE to Be Posted on Web

In August, the New England Interstate Water Pollution Control Commission (NEIWPCC) conducted a survey of all 50 state LUST programs to ascertain their experiences with monitoring for and cleaning up MTBE releases from USTs. The survey, funded by the EPA Office of Underground Storage Tanks, was undertaken to provide the states with a better picture of how each state program is currently dealing with MTBE and other oxygenates. This very comprehensive survey consists of 34 questions and numerous subquestions. NEIWPCC received responses from all 50 states.

After sending the compiled results to all states for a final review, NEIWPCC plans to post the results with an executive summary on its *LUSTLine* Web site (lustline@neiwpcc.org) on December 15, 2000. NEIWPCC will encourage states to update their information periodically and will present the information in the next issue of *LUSTLine* and at the national UST/LUST conference in Albuquerque, New Mexico, in March. You will also find issue-specific summaries in this issue of *LUSTLine* with relevant articles. Look for the "What Our Survey Shows" boxes. ■

NEW TECHNICAL BULLETINS FROM API

The American Petroleum Institute (API) has recently completed several technical bulletins that address aspects of LUST remediation. These bulletins can be downloaded from http://www.api.ehs/sgresbul.

- *Dissolution of MTBE from a Residually Trapped Gasoline Source* —September 2000, Bulletin No. 13.
- *No-Purge Sampling: An Approach for Long-Term Monitoring*—October 2000, Bulletin No. 12.
- *Strategies for Characterizing Subsurface Releases of Gasoline Containing MTBE*—August 2000, Bulletin No. 11.
- *Simulation of Transport of Methyl Tert-Butyl Ether (MTBE) to Groundwater from Small-Volume Releases of Gasoline in the Vadose Zone*—June 2000, Bulletin No. 10.
- *Non-aqueous Phase Liquid (NAPL) Mobility Limits in Soil*—June 2000, Bulletin No. 9.

Investigation and Remediation

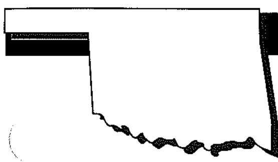
Getting Results, PFP Style

Pay for performance (PFP) is a common-sense approach to LUST site cleanup. Payments are made as contamination levels go down and cleanup goals are achieved and maintained. The price, interim payment milestones, contamination-level goals, and time limit for reaching the goals are all firmly fixed at the beginning of the cleanup and not changed thereafter. Contaminant reduction is measured carefully. "Escape clauses" are written into the contract that can release the contractor if the need arises (e.g., a faulty site characterization or a new release).

Within the PFP framework, there are significant variations on how states price their PFP cleanups. Prices may be set by award to the lowest-price bid submitted in open competition among qualified contractors or by negotiation with the contractor. Oklahoma, South Carolina, and Florida—all PFP pioneers—have been pricing their PFP cleanups using different methods. Oklahoma state staff negotiate a price with the cleanup contractor. South Carolina conducts competitive bidding and awards the cleanup to the lowest bidder. Florida has experimented with both negotiation and bidding and has also awarded "bundles" of multiple PFP cleanup sites for one total price. And predictions that lowest-bid contractors would produce shoddy work have not proved true.

The leadership of these states and the success of their PFP cleanups offer a wealth of experience that others can adapt in developing their own PFP initiatives. These states are finding that their PFP cleanups are typically less expensive and environmentally effective, conclude in the expected time, and spur innovation in cleanup technology and management by contractors.

The following three articles shed some light on the Oklahoma, South Carolina, and Florida PFP programs. PFP is a work in progress. Support for developing a state PFP program is available through OUST/EPA Regional Office representatives.



Oklahoma

After Some PFP Growing Pains

Oklahomans Realize PFP Benefits

by Richard McKay

Any state starting a performance approach to remediation will go through some growing pains. For the smoothest transition possible, those involved must accept that remediation programs will undergo a paradigm change. Leaders, technical groups, and accounting staff must think outside their traditional time-and-materials program models.

The growing pains can be intensified if the regulatory and fund groups work independently. In our experience, the ideal arrangement is to have a technical staff with both regulatory and fund authority. When one department is managing the technical and financial aspects of a case, a consistent message is projected to consultants and tank owners, and the potential for having a case slip between the cracks is reduced. If this setup is not available, a spirit of cooperation between all parties is required.

Regulators, fund groups, and consultants are all entrusted with the responsibility to protect human health, safety, and the environment and to ensure that cleanup funds are spent effectively. These purposes will be undermined if the parties involved do not consciously work together toward a common goal.

Statutory Roadblocks

Although statutes may not specifically provide or allow the authority for a state agency to enter into performance-based cleanup contracts, this omission may not necessarily be an obstacle. Recognizing that the concept of performance-based cleanup contracts made a lot of sense, the Oklahoma Petroleum Storage Tank Division (PSTD) implemented a pay-for-performance (PFP) program in 1996 on a voluntary basis. The necessary forms were created, several contracts were signed, and the remediation systems were installed and implemented.

Despite challenges to our statutory authority, the performance-based reimbursement program prevailed. There were some parties, however, who felt specific authority was needed. Thus, with the full support of the state's petroleum marketers, statutes were passed in 1998, mandating that all work be preapproved and empowering the authority to enter into preapproved purchase orders and performance contracts. The rules were revised to make the preapproval process mandatory. Now all site work must be preapproved and most site remediation is performance based.

Benefits of Pay for Performance

Oklahoma's PFP program provides benefits for the environment, for fund protection and management, and for claim processing. These benefits include the following:

- Consultants now install better-designed remediation systems. Thus our most difficult sites are being cleaned up, and all site cleanups are progressing faster.

■ continued on page 20

■ Results, PFP Style *from page 19*

- Consultants must guarantee results, and no payments are made until incremental goals are attained.
- The flow of fund money is manageable, because remediation costs are fixed and controlled through negotiation and the use of TankRACER software. We are thus able to encumber preapproved site remediation monies in predictable amounts.
- The time it takes to pay claims is shorter, and there are minimal disputes over reimbursements and disallowances. Disputes over reasonable prices are eliminated.
- Minimal claim support documentation is required, minimal erroneous or questionable documents are received, and payment for work that is not performed is eliminated.
- Collaboration between the tank owner, the consultant, and the state has improved so that tank owners are more likely to view the agency as an advocate than as a headache.

Oklahoma's PFP program has shifted the consultants' focus from keeping cases open on a time-and-materials basis, with little incentive to close a case, to achieving results to make money. As a consequence, the rate at which groundwater benzene concentrations are reduced has changed from a small, slow decrease over several years to a large decrease within a few months.

For example, in cases where contaminant reduction milestones have been achieved, on average, the 25 percent milestone has been achieved in 6 months, 50 percent in 8 months, 75 percent in 11 months, and 100 percent in 16 months from baseline concentrations measured prior to system start-up. In each case, the consultant signed a performance contract guaranteeing results in three to five years from system start-up, and the existing remediation system was replaced by an entirely new system. None of the previous systems had been able to maintain contamination levels below site-specific cleanup levels, and most showed very little progress.

Under PFP, the consultant guarantees that the soil and groundwater readings in the remediation area will be below cleanup levels for all chemicals of concern (COCs) before the system can be turned off, and the readings must remain at or below site cleanup levels for six months before the final contract payment is made. When we convert a time-and-materials site to PFP, contamination levels typically drop suddenly, rebound somewhat, and then continue to decrease.

Changes on the Run

The PSTD has gone through several episodes of growing pains since implementing its program in 1996. Our experience with writing performance contracts has helped us close a number of loopholes. For example, system design was initially not specifically itemized as part of the final cost. One consultant contested this policy, so we changed our guidelines.

We have received many ideas for program revisions from consultants—in the spirit of cooperation—to improve the contract, rather than take advantage of an omission. By keeping an open mind throughout this process, our agency has had the opportunity to learn from its mistakes, as well as from people outside the agency, such as consultants and their attorneys.

Through our experience, we've incorporated many important defining points into our performance contract, including the following:

- Items that the contract price includes or excludes;
- The remediation system warranty area;
- Fair and reasonable payment terms;
- Which party takes responsibility for damages caused by the tank owner or his or her employee;
- The situations that will allow the contract to be renegotiated (i.e., secondary release, continuing release, or migration of a plume onto the site);
- A provision that ensures continual system operation;
- Appropriate penalties if a consultant abandons remediation activities prior to termination of the contract;
- Points at which to take baseline samples;
- Lab analyses that should be run, schedules for sampling wells, and conditions under which the consultant will be able to change labs during the course of the contract;
- Ways that reduction payments are related to BTEX concentrations and the method of calculation;
- The method for measuring free-product reduction; and
- A sampling protocol to qualify for reduction payments, reserve the agency's right to verify all sampling data, identify key monitoring wells and compliance monitoring wells, and determine a reasonable period to monitor for rebound once all wells are below cleanup levels.

The term of a PFP contract varies based on site-specific conditions, the chosen remediation technique, and the operating history of similar techniques. For example, after writing several contracts, we found that in clay-rich soils, the time it takes to achieve the final 25 percent reduction can be longer than the time it takes to attain the 75 percent reduction milestone. To compensate for this slowdown, many of these performance systems have been enhanced by localized dig and haul operations, additional remediation wells to increase well density, the introduction of nutrients to increase bioremediation, or the introduction of oxygen-releasing materials. The state also allows a PFP system to be modified from the original scope of work, provided that modifications are performed within the terms of the contract and at no additional cost.

Without the ability to make these modifications, the consultant risks leaving up to 40 percent of the performance contract on the table. Keep in mind, there are also sites where the 100 percent milestone has been achieved six months after start-up, leaving the consultant with 2 to 2 1/2 years of operation and maintenance money as pure profit. These cases create an established history from which the agency can learn what a reasonable remediation time frame should be and apply that lesson to future contracts. Although system performance varies, the consultant must ultimately achieve the final goal in a reasonable time frame and deliver a site that is ready to be monitored for closure.

Negotiating a Fixed Cleanup Price

One of the primary objectives of PFP cleanup is to achieve results at a reasonable price. Cleanup prices can be set through negotiations and/or bidding. Since the program's inception, Oklahoma has used a customized price build-up computer program, TankRACER, to determine a reasonable price. Detailed printouts from TankRACER are used as support documents for negotiating a final contract price with the consultant. Through this negotiated procedure, we have saved a total of $875,000 over the consultants' original proposals, which can then be used for characterization and restoration work on other sites. Typically, the TankRACER price varies by only 4 percent, on average, from the final contract price, and assures all parties that the final negotiated price is reasonable.

Reasonable Cleanup Goals and Price

Cleanup goals have a direct effect on the performance remediation price and are commonly based on a category system, a maximum contaminant level (MCL), or a tiered risk assessment. Oklahoma changed from a category system to a tiered approach in 1996, allowing more reasonable and achievable site-specific cleanup goals that are protective of human health and can be attained at a reasonable price. Based on this tiered approach, the consultant guarantees that soil and groundwater will be remediated to site-specific cleanup goals at a negotiated price that includes all remediation costs. Today the average performance site remediation price using air sparge and soil vapor extraction techniques is $498,000 for a 26,500 yd^3 plume or $18.80 per yd^3.

Had we utilized a risk-based program to determine reasonable cleanup levels and instituted a performance program from the inception of our tank program, we estimate we could have saved as much as $6.48 million on just 41 sites that were changed from time and materials to performance. This savings assumes that each site moved from site assessment directly into PFP remediation. These cases represent a small portion of the sites that require remediation. The economic consequences of not instituting programs to determine site-specific cleanup goals and a reasonable site remediation price could be substantial.

Since these changes were instituted, we have been able to prioritize each site, use better budget controls, and move the worst sites more quickly toward implementing corrective action. In addition, the consultants are now more inclined to develop and use remediation techniques that are faster, more efficient, and more cost-effective. ■

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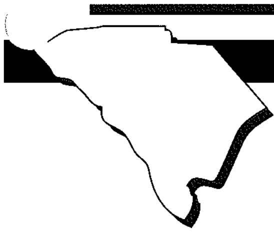


South Carolina

The Light at the End of the Invoices

PFP Bids Well in South Carolina

by Arthur Shrader

The South Carolina Bureau of UST Management implemented a pay-for-performance (PFP) remediation program for state-funded cleanups in 1997. Our program goals were to encourage cleanup contractors to be more efficient and effective, achieve cleanup goals at a reasonable price, and simplify the invoicing process. In an effort to streamline cumbersome time-and-materials procedures, we implemented PFP, using the competitive bidding process. As a result of this move, we're seeing a nice, bright light at the end of our invoices.

Here's how PFP works in South Carolina. Our department solicits bids for proposed projects in the state government biweekly publication, *South Carolina Business Opportunities*. Prior to the advertisement, department staff members prepare specification packages that contain an assortment of information necessary to assist interested contractors in preparing their bids—stated cleanup goals (based on site assessment activities and current levels of chemicals of concern in key monitoring wells), site maps, summarized technical data, and other relevant information. Contractors are also encouraged to review the entire project file located at the agency's Freedom of Information office. Inasmuch as South Carolina certifies UST rehabilitation contractors, a bid bond is not required. Any UST-certified contractor is welcome to submit a cleanup proposal.

Contractors that wish to respond to the solicitation submit a proposal that specifies a cleanup method or combination of methods, an estimated time for completion, and the total cost. UST program staff members evaluate the proposal to determine whether the proposed technology is feasible, the estimated time is protective of receptors, and the total cost is reasonable, based on the costs of similar cleanups. If more than one proposal meets all of these parameters, the contractor offering the lowest bid is selected.

When the contract is awarded, the selected contractor submits a detailed corrective action plan along with a performance bond or irrevocable letter of credit equal to the amount of the award to guarantee that the project will be completed successfully . The department approves the plan and notifies the public of the proposed corrective action before work begins.

■ *continued on page 22*

■ **PFP in South Carolina** *from page 21*

As the project progresses, the contractor is paid a percentage of the total cost as agreed cleanup milestones are achieved. Both program staff members and the cleanup contractor take duplicate water samples for analysis by separate laboratories to verify progress. When the contractor reports that cleanup goals have been reached, monitoring wells are installed at random locations selected by staff members to verify that the total affected area has been successfully rehabilitated.

Results Keep Getting Better

Since 1997, six cleanups using this process have been completed. All were completed within the schedule outlined in the proposal. Of the ongoing 180 PFP cleanups, 57 percent have reached 75 percent of the cleanup goals, 35 percent are in post-startup and are achieving goals, and 8 percent are in the corrective action plan development stage.

At their own costs, contractors routinely install additional treatment points or excavate additional soils in the main source area after implementation of the initial corrective activities to accelerate the cleanup. The use of more durable equipment (to eliminate downtime and to reuse the equipment at the next job) is also quite common.

Table 1. Examples of decreased prices over time at South Carolina PFP sites.

	1997	1998	1999	2000
Free Product & Dissolved	$275,000	$180,000	$133,216	$117,000
Free Product Only	$180,000	$100,000	$30,000	$29,500

As contractors become more familiar with the PFP process, bid amounts for cleaning up similar size groundwater plumes have been further reduced. (See Table 1.)

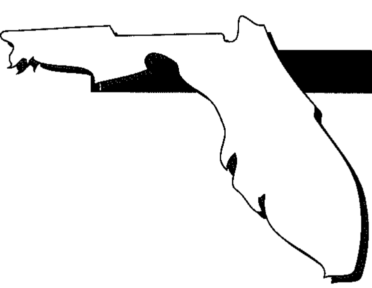
Based on available data, our cleanup costs are more directly attributable to plume size than to other factors, such as geology or levels of mass reduction. The cleanup of a larger plume requires more treatment points and a greater overall effort than a smaller plume does. MTBE plumes are more costly to clean up, because they are typically larger than BTEX plumes.

De-crazyfication

As we've eased into PFP, we've found that voluminous invoices depicting time-and-materials charges are a thing of the past. Invoices that are received from contractors that have achieved a cleanup milestone consist of a single page indicating the percentage of the bid price that is due. The quarterly monitoring report documents the amount of reduction, and the split-sample laboratory data verify progress for the selected monitoring points. The payment approval process is typically completed within two days (the invoice is approved for payment or returned until progress is documented).

PFP focuses the contractor, the regulator, and the fund administrator on environmental results. Although our PFP program is still in its infancy, we have already been witness to more timely and efficient cleanups, lower costs, and the opportunity for our staff members to spend their time more appropriately overseeing cleanup activities, not reviewing invoices that resemble novels. ■

Arthur Shrader is the Director of the Assessment and Corrective Action Division of the South Carolina Department of Health and Environmental Control, Bureau of Underground Storage Tank Management. Art can be reached at shradeaa@columb26.dhec.state.sc.us.



Florida

For a Third of the Price, Who'd Be Without It!

Competitive Bidding for Petroleum Cleanup in Florida

by Brian Dougherty

It was one of those projects you don't really want. You don't think it will work, but you need to do your best to make it work. In 1996, the Florida legislature mandated that the Department of Environmental Protection (DEP) initiate a pilot program on bidding for petroleum site cleanup services. We went along because we had to, not because we thought it was a good idea. Now, four years later, it seems like maybe bidding is a good idea. Our experiment with competitive bidding for petroleum-contaminated site cleanup services has demonstrated not only that it works, but that it gets the job done for one-third of the price of preapproved cleanup work. (That's one-third of the price, not one-third less).

To date, the department has accepted six bids for petroleum cleanup services: five for site assessment work and one for PFP cleanups. The results are easy to see. (See Table 2.) Florida has saved an estimated $815,671 (64%) by bidding the work rather than doing it under our preapproval program.

Table 2. Summary of petroleum cleanup program bids.

			Cost for Requested Services (Total for all sites)		Cost Difference Between Preapproval and Bid	
Type of Work	No. of Sites	No. of Responses	Bid Award	Preapproval Estimate	Difference Preapproval-Bid	Percent Reduction
Assessment	11	24	$ 22,500	$ 41,800	$ 19,300	46%
Assessment	10	27	$ 32,751	$ 95,000	$ 62,249	66%
Assessment	7	34	$ 24,900	$ 108,260	$ 83,360	77%
Assessment	10	16	$ 34,075	$ 95,509	$ 61,434	64%
Pay-for-Performance Cleanup	3	11	$ 227,550	$ 665,500	$ 437,950	66%
Assessment	26	11	$ 123,768	$ 275,146	$ 151,378	55%
Total			$ 465,544	$ 1,281,215	$ 815,671	64%

What About Quality?

An obvious question at this point is, What about the quality of the work? Do you still get good work at such bargain prices? The answer is yes. The quality of the work performed under the bidding pilot has been as good as typical work under preapproval. That is not to say that there have not been any problems with the work. We did have to provide a few reminders that the scope of work was a bid specification that had to be performed exactly and completely. But all of the problems were resolved satisfactorily.

The Advantages of Bidding PFP

Bidding a PFP cleanup has distinct advantages over negotiating the same cleanup. The one-time bid to establish the price for the cleanup rules out any need to negotiate the price. When you bid the cleanup, the burden for determining the best, most efficient strategy for the cleanup is placed squarely on the consultant. The consultant must price the job as competitively as he or she can.

Bidding the cleanup avoids the common negotiating pitfalls associated with estimating the cost of the treatment technology, estimating total cleanup time, and estimating the monitoring time. In a negotiated PFP, these estimates tend toward the high side to provide as much contingency as possible. This tendency is not necessarily bad, and the need to cover contingencies is real, but it can be difficult and time-consuming to whittle the contingency down to a level that is acceptable to both parties.

Getting the Specs Right

Bidding the cleanup work did initially require considerably more administrative overhead than it would have under conventional preapproval. Much of this additional effort reflected our "learning curve" in developing a precise specification and learning the administrative procedures. Most of this effort is now behind us.

The single most time-consuming aspect of preparing the invitation to bid is the development of the exact bid specification. As is common for bid work, the specification must be exact and precise. In this regard, we found that the assessment bids were more difficult to spec than the PFP bids. The PFP bids were easier to prepare because it is fairly straightforward to write a bid specification for a completed cleanup.

The assessment bids were more time-consuming to prepare because the exact locations and depths of wells had to be specified. Then, because it is nearly impossible to predict exactly how much work will be required to complete the assessment, the specification development effort had to be repeated for each subsequent scope of work.

After our first couple of bids, we found a way to eliminate the need for follow-up bid specifications. We did so by developing a fee schedule that sets forth a precisely defined minimum scope of work that will be awarded. If the minimum amount of work is insufficient to complete the assessment, then we can award the additional work necessary to complete the assessment, using the fee schedule. This approach eliminates the additional overhead of having to prepare and offer a new bid. Bidding the cleanup work will always require a more formalized approach than preapproval, but the net overhead ends up being about the same.

Two Thumbs Up

Bidding petroleum cleanup services has yielded tremendous cost savings with no decrease in the quality of work. The administrative overhead was a burden at first, but we have already made many improvements to our internal processes to reduce that burden. The fee schedule approach will further reduce the administrative overhead for assessment sites. This reduction in administrative overhead, coupled with the dramatically lower prices, suggests strongly that bidding petroleum cleanup services is an unbeatable way to manage Florida's petroleum cleanup program. ■

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Leak Prevention

Tank-nically Speaking

by Marcel Moreau

*Marcel Moreau is a nationally recognized petroleum storage specialist whose column, **Tank-nically Speaking,** is a regular feature of* LUSTLine. *As always, we welcome your comments and questions. If there are technical issues that you would like to have Marcel discuss, let him know at marcel.moreau@juno.com.*

The Quest for the Perfectly Reliable LLD, or *Should Electronic Line Leak Detectors Have an Annual Test of Operation?*

My first encounter with the electronic line leak detector (ELLD) "test of operation" issue came a few years ago during a compliance inspection. The recordkeeping at the facility was pretty good, but there was no record of an annual test of operation of the ELLD. The maintenance person said that he had checked with the manufacturer to obtain test procedures and had been told that the device did not need to be tested.

At the time, this statement seemed to me to be a bit presumptuous on the part of the manufacturer. Nevertheless, the rules did say that test procedures were to be performed "in accordance with the manufacturer's requirements," so the manufacturer did seem to have some ground to stand on.

I have since heard the question, "Do electronic line leak detectors need to be tested?", many times from inspectors and have followed discussions concerning the issue with Internet interest groups. There are two main schools of thought on the issue:

- *The "proof is in the pudding" school. This view holds that, "The rule says a test should be done, and there is only one true test of operation and that is to see if the device can actually find a leak"—a view held primarily by regulators.*
- *The "father knows best" school. This view holds that, "I build these things and I know how they work. These devices are pretty smart, can tell when they are not working right, and don't need any additional testing"—a view held primarily by some manufacturers. This view is also popular with UST owners who have invested in ELLDs, in part, to avoid the cost of annual testing of mechanical devices.*

Although I believed the points made by both sides had some validity, my own tendency has been to lean toward the regulatory view of "the proof is in the pudding." Having done a little more research into the matter, however, I am beginning to lean toward the "father knows best" school.

The Electronic LLD and the Testing Issue

For the first 30 years after its introduction in the mid-1950s, the LLD remained an entirely mechanical device (see "Of Blabbermouths and Tattletales," *LUSTLine* #29). Since the implementation of the federal rules, however, a number of manufacturers have developed LLDs that are considerably more sophisticated than the original mechanical models and rely on electronic components to do their job. Although the mechanical devices (MLLDs) are still the most common type in service, the ELLDs are making headway in the marketplace.

Annual testing of MLLDs has been a requirement of the fire codes since long before the federal rule. The federal UST rule (and most state UST rules) have adopted this requirement as well. Typical language states that "an annual test of the operation of the leak detector must be conducted in accordance with the manufacturer's requirements" (40 CFR 280.44(a)).

The testing of MLLDs is fairly straightforward. Because all of the working parts are concealed and the MLLD is self-contained, there is no way to test it other than to generate a leak and see if the MLLD responds. The typical test procedure involves connecting a testing device into the piping system at the crash valve at the base of the dispenser. The testing device typically includes pressure gauges and a small valve that can be carefully adjusted to allow three gallons per hour (gph) of product to leak out of the piping and into a suitable container.

The "test of operation" issue, however, becomes more complex with ELLDs. These devices are usually capable of conducting more accurate 0.2 or 0.1 gph tests, in addition to the 3 gph test. Because the federal definition of a line leak detector is written as a performance standard (detecting 3 gph leaks at 10 psi in one hour), the annual test of operation of LLDs applies only the 3 gph function of ELLDs. There is no requirement in the federal rules to evaluate the ability of the ELLD to detect leaks of 0.2 or 0.1 gph on an annual basis.

The Question Please...

The debate concerning ELLD test procedures boils down to this point: many regulators want to continue the tradition of testing operation by generating leaks and seeing if they are detected; some manufacturers insist that their ELLDs are completely self-testing and need no additional evaluation.

Note that not all manufacturers claim that their ELLDs are self-testing. In fact, some state that the test of operation should consist of generating a leak and verifying that it is detected.

To understand the bases for the opposing opinions, we need to understand a little more about the operating principles of ELLDs and the types of "self-testing" they are capable of conducting.

Types of ELLDs and How They Work

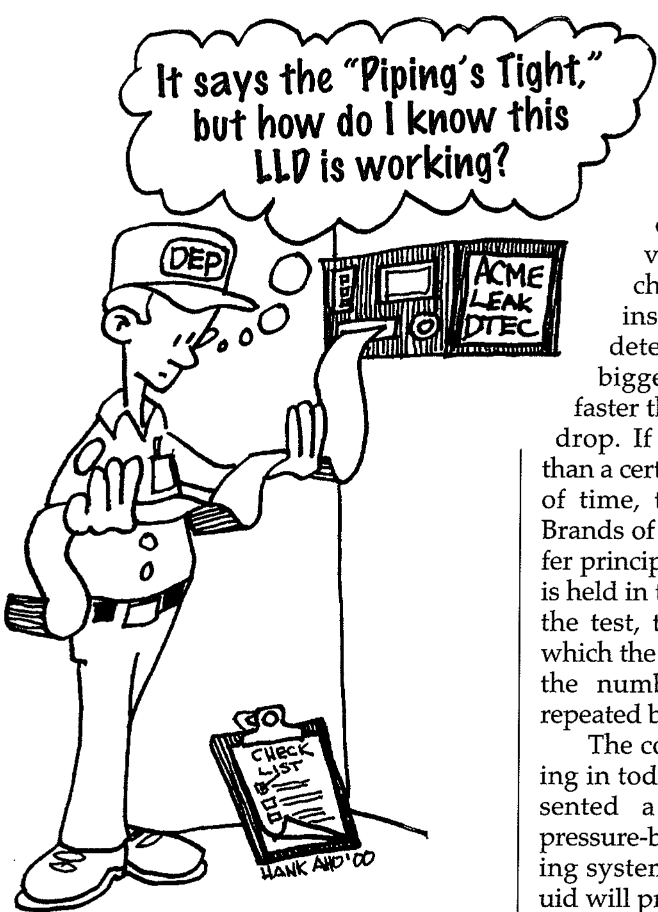
There are two basic types of ELLDs: flow-based and pressure-based. Both types attempt to evaluate the integrity of the piping immediately after each customer has finished dispensing product. The test may require from less than a minute to as long as 10 minutes to complete. If another customer arrives and turns on the pump, the test is aborted and restarted when this customer is finished dispensing.

In general, both types of ELLDs have the ability to turn the pump on and off and to communicate in the form of displays and/or printers. They also have some computational and/or logic circuitry that can determine if a piping run is tight and evaluate, to some degree, how well the ELLD itself is functioning.

Are ELLD self-tests sufficient to meet the regulatory standard of "annual test of operation... conducted in accordance with the manufacturer's requirements" or not? Well, it depends...

Pressure-Based ELLDs

Pressure-based ELLDs are the most common type of ELLD. These ELLDs monitor the pressure in the line after the pump has been turned off. A check valve in the system is used to maintain some pressure in the piping. A leak in the piping will reduce the amount of liquid in the pipe and produce a loss of pressure in the piping that can be measured.



A pressure transducer—a device that converts changes in pressure to changes in voltage—is installed in the piping to detect pressure changes. The bigger the leak in the pipe, the faster the pressure in the pipe will drop. If the pressure drops more than a certain amount in a set interval of time, then a failed test results. Brands of pressure-based ELLDs differ principally in how much pressure is held in the pipe at the beginning of the test, the length of time during which the pressure is monitored, and the number of times the test is repeated before a leak is declared.

The common use of flexible piping in today's UST systems has presented a bit of a challenge to pressure-based ELLDs. In a rigid piping system, very small losses of liquid will produce fairly large pressure drops, because the volume of the piping is relatively constant over the operating range of pressures that submersible pumps produce.

In a flexible piping system, however, the range of pressures normally encountered (0 to 30 psi) produces relatively large changes in the volume of the piping system. Like a balloon (though to a much lesser degree), the flexible piping expands as pressure increases and contracts as pressure is reduced. The contraction of the piping has the effect of maintaining some pressure in the piping as liquid leaks out, thereby prolonging the time required for the pressure in the pipe to drop a given amount.

In a rigid piping system, the pressure drop in the piping due to a 3 gph leak is quite rapid. In a flexible piping system, the pressure drops at a much more leisurely pace. Because pressure-based ELLDs monitor pressure change over time to determine whether a leak is present, the device must use a longer test interval to detect a 3 gph leak in flexible piping than in rigid piping.

Pressure-based ELLDs must be programmed at installation so that the length of the test interval is adjusted for the flexibility and length of the piping system in which it is installed. In some models, this information must be entered into the device manually. In other models, a 3 gph leak is created in the piping at the time of installation, and the device is operated in a "learn" mode, whereby a series of tests are run to empirically determine the length of the test interval, based on the pressure decay curve that is actually present.

How Pressure-Based ELLDs Test Themselves

There is no question that pressure-based ELLDs can conduct a certain amount of self-testing. Because the device controller can operate the pump on its own, the controller knows that when the pump is off, the pressure should be at the approximate holding pressure of the check valve; when the pump is on, the pressure should be at the operating pressure of the pump. If the measured pressure is outside of these ranges, then the controller knows that some-

■ *continued on page 26*

■ **Tank-nically Speaking**
from page 25

thing is not right and a warning can be activated.

The warnings will not only determine whether the transducer is malfunctioning, but may also identify other system problems [e.g., running out of product (pump on, but line pressure too low), or a defective pump control that keeps the pump motor running all the time (pump supposedly off, but line pressure too high)].

The comparison of expected versus actual pressure readings is typically conducted as part of the protocol for the 0.2 or 0.1 gph tests. The 0.2 gph tests are initiated whenever the system has not pumped product for some period of time (typically about a half hour) and in all but the most active 24-hour facilities are usually conducted on a nightly basis. Thus the operating condition of the transducer is typically evaluated on a nightly basis, and the successful completion of a 0.2 gph test is a reasonably reliable indicator that the ELLD is functioning properly.

Although I have not investigated all available brands of ELLDs, I expect that there is significant variation in the sophistication of the self-testing that is conducted by the different models. In addition, many of these devices have evolved over time so that earlier software versions may not self-check to the same level as later versions.

To guard against improper programming, some ELLD models establish their default piping (the type of piping assumed to be present unless the installer reprograms the ELLD) as a fairly long run of the most flexible piping type. This assumption lengthens the test interval significantly, which is likely to result in frequent "false alarms" if the piping is, in fact, a more rigid variety. Little can be done to thwart the person who might intentionally program the ELLD for operation in a rigid piping system (when the piping is actually a flexible variety) to reduce this "false alarm" rate.

Flow-Based ELLDs

Flow-based ELLDs typically work by keeping the pump motor operating after the customer has hung up the nozzle. This procedure maintains the piping at operating pressure. The ELLD controller then closes an isolation valve at the pump end of the line. The closing of this valve separates the piping into what I will call the "pump side," which is very short and extends from the pump motor to the isolation valve (in some cases the valve is inserted in the pump manifold in the traditional LLD port), and the "dispenser side," which contains the bulk of the piping and extends from the isolation valve at the pump to the dispenser.

After the isolation valve is closed, the pump side and the dispenser side remain open to one another via a small passageway in which a flow-sensing device is installed. The pump motor continues to run during the test period to maintain a constant (operating) pressure on the pump side of the isolation valve. In a tight piping system, the dispenser side of the isolation valve will maintain the original (operating) pressure, and there will be no flow through the small passageway, because the pressures on both the pump and dispenser sides of the piping will remain equal.

> ***My gut instinct is that the number of instances where a leak was missed by a malfunctioning ELLD will run a distant third to the instances where a warning light resulted in a service call or was completely ignored.***

If the dispenser side of the piping has a leak, however, the pressure will drop on the dispenser side of the isolation valve. Liquid will now flow through the flow-sensing pathway, because the pressure is greater on the pump side than the pressure on the dispensing side of the piping. This flow rate is measured. If it exceeds the threshold set for the device, a failed test is declared.

In flow-based ELLDs, the pressure in the entire piping run during the test period is maintained at a constant level, because any product leaked from the dispenser side of the piping will be replaced with product from the pump side. Because the test pressure is constant, there is no need to take into consideration variations in leak rate due to pressure changes in the pipe. The ELLD test protocol is the same whether the device is installed in rigid or flexible piping.

How Flow-Based ELLDs Test Themselves

Flow-based ELLDs are capable of some fairly rigorous self-tests. In some devices, after the completion of a 3 gph test, a small bypass valve on the dispenser side of the isolation valve is opened. This valve generates a calibrated 3 gph leak of product from the dispenser side back into the tank. The ELLD then checks whether it can correctly measure this simulated leak with the flow sensor. If it can, then everything is fine; if it can't, then the device communicates a warning to the operator that the system is not operating properly.

Another flow-sensing brand simply keeps the flow-sensing pathway open while the pump is dispensing fuel and checks whether the flow sensor registers flow. While this approach is not as quantitative as the approach described previously, this particular flowmeter has no moving parts, so calibration is not a big issue.

And the Answer Is...

So, are ELLD self-tests sufficient to meet the regulatory standard of "annual test of operation...conducted in accordance with the manufacturer's requirements" or not? Well, it depends...

For Pressure-Based ELLDs

For pressure-based ELLDs, I think the answer is a little murky. Some devices seem to offer a reasonably comprehensive test of operation. The main omission is that the ability to detect a 3 gph leak in a specific piping run is not determined. But the EPA interpretation of the LLD test requirement is that a specific leak rate does not need to be detected (http://www.epa.gov/swerust1/compend/rd.htm, question 16). Thus this omission does not seem significant according to EPA's reading of the rules.

I suspect that some other brands and older models of pressure-based ELLDs probably fall short of a thorough self-test. I can think of two items that would serve as helpful compliance evaluation tools for both inspectors and storage system owners. One would be a list of ELLD devices that includes the manufacturer's official recommendations for the "annual test of operation" for that device. This information would be useful to compliance inspectors who need to know whether documentation of a field test must be produced or whether the manufacturer believes that the ELLD's internal testing is sufficient to meet the regulatory requirements.

The second item would be an independent review of each ELLD model that a manufacturer claims is "self-testing" to evaluate whether that claim seems reasonable or specious. These items are beyond the scope of this article. If there is enough interest, however, perhaps EPA could fund such a review, or the National Work Group on Leak Detection Evaluations might consider undertaking such a review.

For Flow-Based ELLDs

Flow-based ELLDs that generate quantitative leaks and determine whether they are correctly detected should meet most everyone's definition of a self-test. Flow-based ELLDs that use a nonquantitative flow test seem to provide a reasonable test of operation. All of the flow-based ELLDs of which I am aware fall into one of these two categories.

For Those Who Are Still Dissatisfied

My reading of the regulations is that the privilege of deciding what a "test of operation" is rests with the manufacturer of the device. The disagreement arises because of the varying definitions of "operation." My dictionary says that "operation" means "the quality or state of being functional," and that "functional" means "performing or able to perform its regular function." These definitions leave lots of room for manufacturers and regulators to have differing opinions about what is meant by "test of operation."

To tilt the definition in the regulatory direction would require a specific definition of "test of operation." Such a definition might read, "'test of operation' shall mean a procedure to confirm that a LLD will detect a leak of 3 gph by simulating a 3 gph leak and verifying that the LLD responds by shutting off the flow, restricting the flow, or sounding an alarm. Manufacturer's recommendations should be followed when conducting the test of operation." In the absence of a regulatory definition for "test of operation," however, the federal regulations and the dictionary give the manufacturer of the LLD wide latitude in setting its own definition.

My Two Cents

My own thinking has evolved such that I would rather have a well-engineered, self-testing device that evaluates itself on a daily (or nearly daily) basis than a non-self-testing device that is evaluated by a person of uncertain competency on an annual basis.

I've been somewhat reassured in researching this article that the most popular ELLDs do a fair amount of self-checking that will realistically tell the facility operator (if he or she is in a mood to listen) whether the ELLD is functional. While the self-checking may not take into account all possible contingencies, there seem to be clear benefits to automatic self-testing versus an annual test of operation conducted by a fallible human.

Either way, there are no guarantees that *every* leak will be detected in a timely fashion. As former OUST employee David Wiley has been known to say, "We should not let the perfect become the enemy of the good."

It would be helpful to have some real-world data that would reveal the number/percentage of the following events:

- The number of piping leaks that have occurred where the ELLD did not detect the leak;
- The number of times service personnel have responded to customer reports of ELLD warning lights or messages; and
- The number of times service personnel responding to other problems have *discovered* ELLDs in warning mode.

My gut instinct (what's yours?) is that the number of instances where a leak was missed by a malfunctioning ELLD will run a distant third to the instances where a warning light resulted in a service call or was completely ignored.

Maybe what is really needed is an annual test to verify that facility operators understand their leak detection equipment. ■

ELLDs – Tips for Inspectors

- If an internal diagnostics system detects a problem, some ELLDs will not proceed with the more sensitive 0.2 gph test. If an ELLD has not completed a 0.2 gph test in the last week, it may indicate that the device is not working correctly (unless the facility is extraordinarily busy).
- Read alarm messages carefully (this task may require consulting an owner's manual or technical manual for the device) to understand what the ELLD is telling you (and the owner).
- For pressure-based ELLDs, consult the programming manual for the device to find out how to verify that the type and length of piping that have been programmed into the ELLD are consistent with the piping actually present at the facility.
- Get a copy of the California State Water Resources Control Board's (SWRCB's) new booklet, *Understanding Line Leak Detector Systems*. The booklet discusses the technological principles of LLDs and provides an overview of installation, inspection, maintenance, and special features of these devices. While you're at it, check out SWRCB's *Understanding Automatic Tank Gauging Systems* booklet. To obtain copies of either booklet, fax your request to the SWRCB UST Program at (916) 341-5707, call (916) 341-5775, or visit its Web site at http://www.swrcb.ca.gov/cwphome/ust. ■

Field Notes

by Robert N. Renkes, Executive Vice President, Petroleum Equipment Institute

PEI'S RECOMMENDED PRACTICE FOR UST SYSTEM INSTALLATION (RP100) REVISED

The federal underground storage tank regulations (40 CFR 280.20) require that all USTs and piping subject to these rules be properly installed in accordance with a code of practice developed by a nationally recognized association or independent testing laboratory and in accordance with the manufacturer's instructions.

Of the three recommended practices mentioned in 40 CFR 280, only one, PEI's *Recommended Practices for Installation of Underground Liquid Storage Systems* (PEI RP100-2000), has been updated and revised about every three years since it was first issued in 1985.

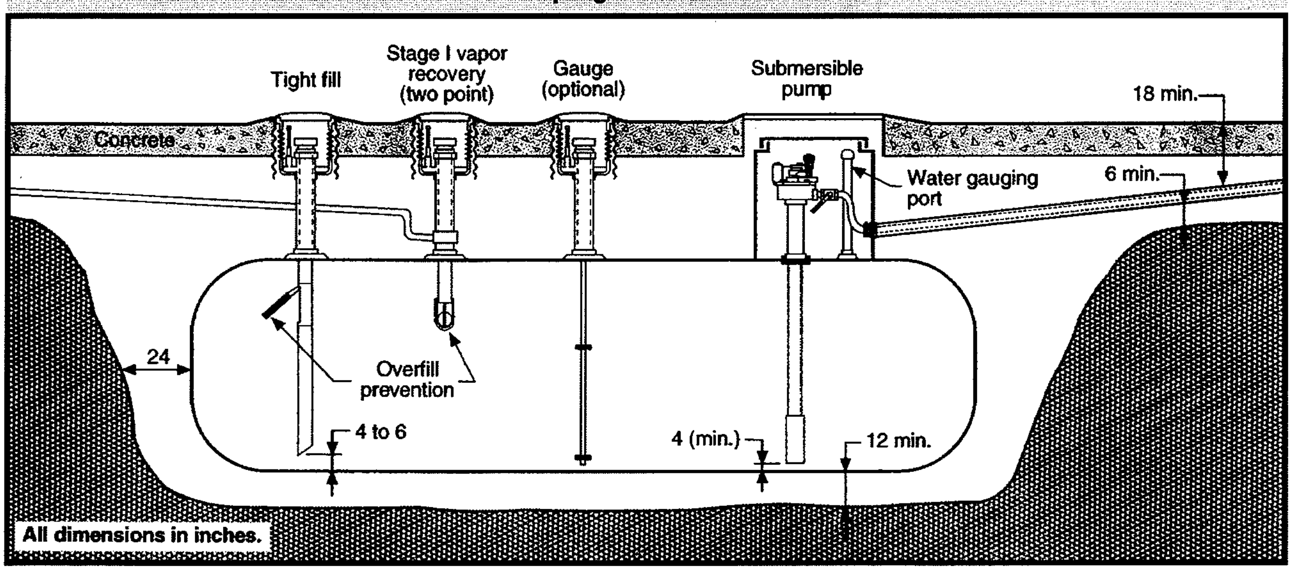
RP100 has been revised once again and is now available to individuals and firms interested in the latest guidance on proper techniques and methods for installing UST systems.

The group responsible for writing the recommended practice, PEI's Tank Installation Committee, reviewed over 160 comments—with more than 40 percent coming from regulators—and made many changes throughout the document. Here are a few examples of the revisions:

- A more extensive list of post-installation testing recommendations is included in the reformatted chapter on testing.
- The requirement that the bottom of the excavation be covered with **leveled** backfill material has been removed. Instead, the instructions read that tanks should be installed to facilitate water removal. In addition, a new section asks the installer to consider the installation of a water-gauging port at the end opposite the tank fill pipe. (See diagram below.)
- New and stronger warnings on the use of vent restriction devices have been incorporated into the chapter on piping.
- A new section on fill piping has been added.
- About a dozen drawings and figures have been revised.
- Substantial releases from secondarily contained pressure piping systems have occurred because of the failure of interstitial sensors or leakage of product out of the secondary containment before the product could reach the sensor. The document now recommends that line leak detectors be installed on all pressurized piping systems, including those with secondary containment.

RP100-2000 supersedes the previous recommended practice of the same name, published in 1997. Copies are available for $30 (includes postage and handling) from PEI, P.O. Box 2380, Tulsa, Oklahoma 74101-2380. Phone: (918) 494-9696. Fax: (918) 491-9895. On-line orders can also be placed on PEI's secure server at www.pei.org/catalog. ■

Piping Dimensions



Dimensions shown are generally accepted limits. Sloping all lines to the tank facilitates future testing. (Revised diagram.)

MTBE

Santa Clara Study Examines Causes of Fuel/MTBE Releases at Active UST Sites

In May, the Santa Clara Valley Water District released a report titled *An Evaluation of MTBE Occurrence at Fuel Leak Sites with Operating Gasoline USTs*. The report presents the results of a study the District undertook because of concern over a disturbing rate of occurrence and magnitude of MTBE releases at facilities where gasoline USTs are still in use, compared with sites no longer storing or dispensing fuel. The study was designed to evaluate potential causes of significant MTBE contamination at operating UST facilities, including evaluation of the occurrence of undetected releases and identification of actual and potential weaknesses in fuel storage, management, and delivery operations.

To identify the most reasonable source and cause of the MTBE contamination, available MTBE data for more than 150 LUST sites with operating USTs were reviewed. A final study population of 16 LUST sites with operating UST systems and high concentrations of MTBE in groundwater was selected. The sites were evaluated in detail to determine whether new releases were occurring and not being detected by the monitoring systems.

The results of the 16 case studies reveal that 13 sites are suspected of having an undetected release from the current UST system, and 2 sites are suspected of having a pre-upgrade release. Releases at two of the sites with significant MTBE plumes were discovered only because of significant nuisance conditions that warranted investigation. In one case, vapors in an off-site sewer prompted investigation of the USTs. In the other case, detection of MTBE in a nearby municipal well prompted an investigation. The release locations for these two sites have been confirmed.

In one case, a leak in the primary piping drained to the submersible turbine pump but was not contained or detected. In the other case, the owner identified the release mechanism as a vapor release associated with the vapor recovery system, as well as potential breaches in various portions of the system.

A specific release mechanism could not be definitely identified for the other 14 sites. At two sites where detailed testing of the secondary containment portions of the systems was conducted, components, such as dispenser pans and turbine sumps, were not liquid-tight, but a release from these components was not confirmed.

An attempt was made to determine the most likely source location and release scenario resulting in significant MTBE concentrations at each of the 14 sites. An evaluation of the available data indicated the following suspected source areas:

- Twelve of the sites appeared to have source locations around the tank complex. Five of these are suspected of having releases associated with inadequate or absent sumps around the submersible turbine pump.
- Two sites appeared to have problems associated with lined trenches.
- Two sites appeared to have source areas located around the tanks and piping.
- Three sites appeared to have source areas near the piping/dispenser.
- One site had inconclusive data.

At least 7 of the 16 sites had received notices of violation or had problems noted by an inspector related to monitoring system components. Four other sites had undergone third-party inspections during which components were found to be either not liquid-tight or not vapor-tight.

Increased Vigilance Needed

Inadequate, or lack of, secondary containment and improper monitoring seemed to be the common theme associated with suspected undetected releases. The study concluded that the results of this and similar studies should be used to assess the threat to water resources posed by storage of fuels in USTs and the operation of fueling facilities.

Whereas most of the cases examined in this study involved double-walled tanks and piping—14 of the 16 sites had double-walled tanks, 10 had double-walled piping, and 6 had lined piping trenches—the study recommended that particular attention be paid to single-walled UST systems that have no protection against low-volume leaks that may not be detected by monitoring or integrity testing. Conversely, the mere presence of a double-walled UST system does not guarantee protection against undetected and/or significant releases.

The study also recommended that although operating UST facilities are not currently required to conduct environmental monitoring at non-LUST sites, such monitoring should be considered the only method to confirm the presence of MTBE in groundwater and evaluate the threat that past and continuing undetected releases pose to groundwater resources.

The report is available on the District's Web site at http://www.scvwd.dst.ca.us/wtrqual/factmtbe.htm. A slide presentation based on the report is also available from the same Web site. ■

For more information, contact James S. Crowley, P.E., Engineering Unit Manager Leaking Underground Storage Tank Oversight Program, Santa Clara Valley Water District, at (408) 265-2607 (x2638).

"There's Still a Lot of Work to Do"

OUST Director Announces New UST Program Initiatives

It seems clear that EPA's new Director of the Office of Underground Storage Tanks (OUST), Cliff Rothenstein, has a mission. He is no stranger to the goings-on of EPA's storage tank program. Rothenstein assumed his position at OUST after serving three years as Deputy Assistant Administrator for the Office of Solid Waste and Emergency Response (OSWER), where he worked on EPA and the Administration's positions and strategies on Superfund, solid and hazardous waste, and UST legislation. He was also the agency's chief negotiator on Superfund and solid waste legislation, directing the Administration's congressional negotiating teams.

Since taking up up his new role at OUST in June, Rothenstein has been quick to get down to business. "I think it's great," he says. "This program presents a whole new and different type of challenge. There is a lot of good work being done here. I just want to help the program gain a little more visibility, so people realize there is still more work to be done. We've done some creative things in the past, and we'll continue to try to do that."

As Director, Rothenstein is gearing up to implement four new UST program initiatives:

- Launching numerous USTfields pilots to assess, clean up, and foster redevelopment of abandoned or closed UST sites;
- Taking steps to improve and maintain UST system compliance with spill, overfill, corrosion protection, and leak detection requirements;
- Taking steps to accelerate cleanups for the 160,000 petroleum releases that have already occurred; and
- Evaluating the performance of UST systems to determine what's working and what, if any, regulatory changes should be made.

On October 23, Tim Fields, EPA's Assistant Administrator for OSWER, sent a memorandum to all 10 of EPA's Regional Division Directors for Underground Tanks discussing the four initiatives. See EPA's Web site at www.epa.gov/oust/ and click on the "What's New" button to view the complete memo.

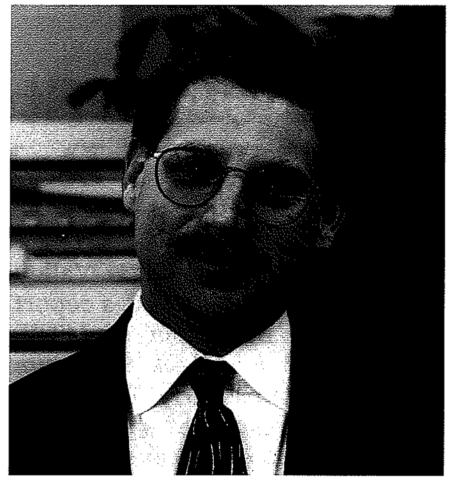
"Right now, we will continue to work with the regions and states to develop the details on these initiatives," says Rothenstein.

OUST will step up its USTfield efforts by conducting a series of pilot programs where the states and the local communities work together to perform site assessments of the abandoned tank universe in selected cities, particularly in areas where communities are trying to promote redevelopment.

As part of this initiative, EPA announced on November 2 that it has targeted communities in 10 states to receive $100,000 each for assessment and cleanup of abandoned tanks. The 10 communities include: Nashua, New Hampshire; Trenton, New Jersey; Wilmington, Delaware; Anderson, South Carolina; Chicago, Illinois; Kansas City, Missouri; Albuquerque, New Mexico; Salt Lake City, Utah; Oakland, California; and Portland, Oregon. EPA plans to select 40 more USTfields pilot projects in 2001.

"We will focus on filling in the gap at Brownfield sites, where tanks exist but Superfund money cannot be used," says Rothenstein. "Almost every Brownfield site has some abandoned tanks. If they find them, they can't do anything about them, because they can't use that money. Our USTfields initiative will allow the state and the community to actually do the assessment and maybe even the cleanup at those tank locations."

"As for increasing compliance, we might look to establishing targets, whereby we try to get more and more compliance each year, "says Rothenstein. "We need to come up with a good, common definition of 'operational compliance,' so that



Oust Director Cliff Rothenstein.

everybody's working off of the same page—to the extent that we can. We might see if there is a way to promote the idea of multisite compliance agreements with owners—maybe for cleanup, too—so that you basically negotiate one agreement that applies everywhere and save time and resources."

"I know a lot of cleanups have been done, but there is still a bit of a backlog," he explains. "We're looking at different ideas—perhaps establishing annual targets for cleaning up sites. We envision that the regions and the states will work together to establish these targets. We are also looking for ways to use innovative approaches, such as pay for performance, to speed up cleanups."

He says the agency will go back and evaluate the UST requirements. "We won't get all the answers immediately, but we want to focus on some of the critical questions so we can at least get some preliminary answers."

Rothenstein has a mission for the tank program. "I think there's been a sense that this program's been working well and nothing needs to be done," he says. "But frankly, there are 160,000 releases out there that still need to be cleaned up—far more than Superfund or RCRA combined. There are still a lot of active tanks that are not in compliance. There's a whole universe of abandoned tanks that people aren't really sure what to do about—part of the reason for the USTfields initiative. We've done a great job, but there is still a lot of work left to do." ■

Health & Safety

Alaska Tank Explosion Linked to Polyester Coveralls

by Ben Thomas

On May 16, 2000, a Soldotna, Alaska, UST owner was hospitalized with first- and second-degree burns on his face after one of three underground tanks he was preparing for removal exploded. The three tanks had been out of service for some time and were mostly empty. Anticipating the arrival of the tank removal contractors, the tank owner was using an electric pump to try and remove the last bit of gasoline from the tank when the explosion occurred. At the time, the tank owner was wearing an insulated jumpsuit that was a polyester/cotton blend.

The Ignition Source

The owner had unknowingly created what is known in the fire-fighting business as a "fire triangle." For a fire to occur, three critical ingredients must be present: fuel, oxygen, and an ignition source.

The tank already contained a sufficient fuel–oxygen mixture. Because it was mostly empty, there was plenty of space for the gasoline at the bottom of the tank to vaporize. When the owner tried to remove the product, there was probably a high level of explosive vapors in the tank. This environment set the stage for a dangerous situation.

The owner's coveralls were 35 percent cotton and 65 percent polyester—enough polyester to create some static while the tank owner was working. The static buildup from the polyester suit, plus the dry Soldotna air, created a spark. All the spark needed was a fuel source and oxygen. When the owner got near enough to the gasoline vapors fuming out of the fill pipe, the static from his coveralls was the ignition source needed to trigger the explosion.

▶ *Picture of charred pump and baseball cap after tank explosions sends owner to hospital in Soldotna, Alaska*

Think Twice Before...

Be careful when working around gasoline. It may be easier than you think to create a "fire triangle." A tank that is mostly empty can be a greater fire hazard than one that is full of gasoline. Hire trained professionals to properly and safely remove a UST from the ground. And seriously consider using cotton-only work garments when working around gasoline. ■

Ben Thomas is with the Alaska Department of Environmental Conservation UST program. He can be reached at Ben_Thomas@envircon.state.ak.us.

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EPA HQ UPDATE

Two New Compliance Assistance Tools Now Available

The EPA Office of Underground Storage Tanks (OUST) is distributing the following two new compliance assistance tools to Regional and state UST programs to help increase compliance levels:

■ **Operating and Maintaining Underground Storage Tank Systems: Practical Help and Checklists** (EPA 510-B-00-008) is a 50-page manual containing brief summaries of the federal UST requirements for operation and maintenance (O&M), as well as practical help that goes beyond the requirements. Checklists prompt the user—the UST owner or operator—to look closely at the kinds of equipment in use and explain how to keep that equipment working properly over the lifetime of the UST system. The manual provides recordkeeping forms that also help the UST owner and operator keep equipment operating properly. If the user has questions, the manual provides contact information for additional help. The O&M manual is available in electronic form for free viewing, printing, and downloading at www.epa.gov/swerust1/pubs/index.htm#ommanual. The manual will be updated periodically, and the most current edition will always be available at this Web site.

■ **Automatic Tank Gauging Systems for Release Detection: Reference Manual for Underground Storage Tank Inspectors** (EPA 510-B-00-009) is a 140-page manual that can help state and EPA inspectors of USTs evaluate how well UST owners and operators are using their automatic tank gauging (ATG) systems to comply with release detection requirements. The manual also provides handouts that UST inspectors can distribute to UST owners and operators to help them understand the proper operation and maintenance of their ATG systems.

The manual contains a summary of specifications, based on third-party evaluations, for ATG systems that detect leaks from USTs and their piping. Each summary provides information on certified detectable leak rate/threshold, test period duration, product applicability, calibration requirements, restrictions on reports, sample reports, and more. The ATG manual is available in electronic form for free viewing, printing, and downloading at www.epa.gov/swerust1/pubs/index.htm#automatic. The manual will be updated periodically, and the updated version will always be available at this Web site.

Both manuals can be adapted and tailored by states or industry to match precisely their specific requirements (for assistance, contact Jay Evans at 703-603-7149 or evans.jay@epa.gov).

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