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RISK ASSESSMENT OF GROUNDWATER CONTAMINATION AND CURRENT APPLICATIONS IN THE DECISION-MAKING PROCESS

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ABSTRACT

This article assesses the information needs for risk assessments of groundwater contamination in light of attendant liability, regulatory, and economic concerns. Several case studies of environmental remediation alternatives, potential facility liability, and environmental risks are presented.

INTRODUCTION

Risk assessments have become an important information base in the decision-making process of various business and environmental regulatory professionals. One of the greatest concerns is a facility's potential liability if it is found responsible for the off-site impairment of groundwater. Claims made or liens placed upon a property as a result of groundwater impairment can be staggering, and can reach or exceed sums in excess of the net worth of the business and property. For this reason and the obvious risk to health and the environment, the need to conduct effective risk assessments is growing. Some of the specific reasons for conducting risk assessments that will be discussed include 1) lender or investor requirements, 2) state laws requiring risk assessments and subsequent disclosures at the time of any property transfer, 3) insurance requirements, 4) corporate loss control programs, and 5) regulatory enforcement requirements.

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This article summarizes the types of information gathered in a risk assessment and how (and what types of) conclusions and recommendations concerning the potential for groundwater contamination are determined. In addition, the different types of risk assessments are discussed in relation to the users' needs, the facility setting and the type of facility. The two major steps in conducting a risk assessment are discussed. The first phase, or "walk-through" assessment, is where information about land use, facility history, processes, management, and existing environmental data are reviewed. The second step, the site assessment, expands upon the first phase by generating new data through on-site sampling and analysis. The typical procedures available to conduct these assessments will be presented in relation to their relative utility. Also discussed will be the costs and limitations associated with the various types of risk assessments.

Several brief case studies will be presented where the risk assessment has led to the discovery of groundwater contamination and subsequent remediation. These case studies will cover a variety of facilities ranging from residential to heavy industrial, and will demonstrate the ubiquity of groundwater contamination. In the discussion of the case studies, various remedial action alternatives will be presented. The effectiveness of the various remedial alternatives in reducing or eliminating the potential for environmental impairment will be discussed.

PRINCIPAL USERS AND REASONS FOR CONDUCTING RISK ASSESSMENTS

The appropriate risk assessment can be a useful tool to a variety of users to help address the oftentimes overwhelming concerns associated with groundwater contamination. Probably one of the most extensive and historical users of risk assessments have been the environmental regulatory agencies. Regulatory inspections, albeit brief in scope, are a form of risk assessment that can often identify obvious potential groundwater contamination situations (e.g., poor chemical or waste storage). Regulators will often incorporate data collected from routine inspections with a vast array of other available environmental and natural resource data. As a result, the regulatory agencies are typically one of the best sources available of background risk assessment data.

As an alternative or supplement to inspections by their own staff, some regulators have required the regulated community to conduct their own risk assessments by qualified independent parties. These independent risk assessments allow for resources of time and money to be more efficiently directed toward implementing the agencies' programs. Independent regulatory inspections work particularly well in situations where it is necessary to monitor the progress of a facility that was recently determined through a regulatory inspection as being out of compliance. Such independent inspections can provide the guidance and documentation of compliance activities that the regulatory agency may not have the time or resources to provide.

In the past five years there has been a trend in industry to conduct independent environmental risk assessments of their own facilities. By conducting these independent "self" assessments, a company can identify areas of potential concern that may have gone unnoticed for years. Once the problem areas are identified, they can be appropriately corrected before regulatory fines are imposed or additional environmental impairment occurs.

Experience in conducting numerous industrial assessments has shown that many companies that believe that they are in good environmental condition, often have many problem areas that could result in significant environmental impairment if left uncorrected. In these cases the environmental risk assessment more than pays for itself.

About fives years ago, about a dozen insurance companies were underwriting Environmental Impairment Liability (EIL) insurance. The EIL policies were typically written based upon a cursory review of the facility by an underwriter not particularly skilled in environmental auditing. As a result, many poor risks were written, many claims were made and most companies dropped out of the EIL market. Today, only a few insurance companies underwrite EIL insurance. However, the underwriter's decision is now based upon very detailed environmental risk assessments conducted by qualified environmental auditors.

Recently, one of the most dynamic users of risk assessments has become commercial lenders and other business entities seeking to invest substantial assets into a property or industry. Various scopes of risk assessments are now routinely being conducted prior to the transfer of commercial and industrial properties. One of the driving forces (other than good business sense) in conducting risk assessments for property transfers has been the enactment in several states of various forms of "super lien" or environmental disclosure laws. The "super lien"-type laws generally provide that a state may have the authority to remediate an unmitigated release of contaminants if the owner or operator refuses or does not have the resources to conduct the remediation on their own. The state may then have the authority to subordinate any other liens on the property to the State's own claim (hence, the "super lien") in an effort to recover clean-up costs. As a result of the potential for the "super lien," most lenders in states with such a law will request that an environmental risk assessment be conducted prior to finalizing loan documents. The appropriate risk assessment will identify any potential for environmental impairment for which a new owner may be held liable. The risk assessment report then becomes a useful tool to the buyer, lender, or counsel to determine if the identified risks fit into the context of the proposed transaction. For example, $50,000 of potential remedial action for a $5 million transaction is often relatively trivial. However, the same scope of remediation on a $100,000 transaction may be more of a liability than anyone would consider.

As of January 1988, the states with some type of "super lien" or similar environmental disclosure laws are New Jersey, Connecticut, Massachusetts, New York, New Hampshire, California, Maine, Arkansas, Tennessee, and Washington State.

TYPES OF RISK ASSESSMENTS

It is difficult to categorize risk assessments, and assign specific types to specific facilities. There are far too many technical, legal, and business-related variables that make each risk assessment unique. (In fact, persons seeking the services of an environmental consultant have commented that, after describing a particular property to four separate consultants, each proposed an entirely different scope of services.) However, a few general categories can be developed depending on the level of effort involved. These categories are as follows.

Definitions

The regulatory review – Some state, county, and local environmental regulatory agencies offer a service that will provide a letter or report stating the current regulatory status of a facility. The regulatory file review may consist of reviews of the agencies' Water, Hazardous Waste, Oil and Chemical Spills, PCB/Toxics, and Air Units. The regulatory file review can also be conducted by an experienced environmental consultant or attorney. However, the file review simply determines if there is presently any outstanding enforcement action against the facility. It is quite possible that the facility could have environmental problems that have not been discovered by a regulatory agency or were simply in a file that was misfiled or sitting on a staff member's desk. Furthermore, these regulatory reviews are not a certification or an opinion as to the "cleanliness" of the site. Most environmental auditors recognize the significant limitations of such a review, and provide many caveats in any report provided.

The Phase I "walk-through" assessment – The "walk-through" assessment consists of an evaluation of existing information regarding a facility's environmental status. The assessment does not involve field sampling, testing, or analysis that would generate new data. The typical Phase I environmental assessment may include a review of the existing site operations, a review of the regulatory files, an evaluation of past land use and site operations, an inspection of the site, and possibly interviews with past and present employees. The results will often be used to determine if a Phase II site assessment is required to develop more site-specific environmental data. The assessment may also identify obvious environmental risks that could indicate significant problems and that further resources of time and/or money may have to be invested. In our experience, a "walk-through" assessment should only be used in limited situations (such as residential properties with no buried fuel oil tanks in relatively non-environmentally sensitive areas with no known prior commercial or industrial uses) because it does not reveal contamination that may exist out of sight below the ground. Accordingly, only limited conclusions can be made regarding the potential for environmental impairment to groundwater based on such a review.

When conducting environmental assessments for insurance underwriting purposes, a detailed walk-through is typically all that is conducted. However, facilities that are assessed for insurance purposes are typically larger industries that may have significant site-specific environmental data available. In these cases, the assessment will focus on evaluation of the available data and its effectiveness in assessing the particular facility. If the data is insufficient in providing the confidence level required, a decision is often made not to underwrite the facility until additional information is obtained.

The Phase II subsurface investigation site assessment – The subsurface site assessment involves actual site sampling and analysis and is the most common mechanism used to satisfy the requirements or concerns under a state's "Super Lien" statute. The level of effort required in a subsurface assessment is highly variable ranging from the collection of a few surface soil samples, to a full scale hydrogeologic analysis involving monitoring well installations and complex groundwater analyses. We recommend this type of investigation for almost any type of site that was ever used for industrial purposes, for many commercial properties, for certain residential properties (such as those where buried fuel tanks exist) and even for certain "bare land" transactions if certain agricultural uses appear in the site's history. The following discussions will review the variety of situations often posed, some of the variables involved, and present some of the considerations in determining the type and scope of site assessment that is best suited to a particular situation.

Environmental Risk Assessments as a Function of the Type of Facility/Property

Residential properties – There are many properties that are clearly not required to undergo an environmental risk assessment or that do not warrant an investigation pursuant to a "Super Lien"-type statute. The most obvious are residential properties. However, residential property is not always free of chemical contamination and the associated environmental liabilities that can pose a threat to lending institutions in terms of the effect on the value of their loan security, or, most importantly, to the residents' health and well-being. Three cases in the past three years come to mind where government funding was required to clean-up hazardous wastes on residential properties. The properties included urban, suburban and rural residences contaminated by creosote from a former asphalt batching operation, spent pesticides buried by a defunct tobacco farm, and mercury dumped by an individual reclaiming silver from dental amalgam in his home.

In the case of the pesticide and mercury contamination incidents, approximately $750,000 per site of USEPA emergency superfund money was spent for clean-ups. In both cases the responsible party was either not determined, or determined to have inadequate assets for recovery of clean-up costs. Clean-up cost recovery from the property owners was considered by EPA, but was determined to be inappropriate. If government funding for these clean-ups was not available, the property owner and the institution holding the mortgage could have suffered severe financial losses. In all instances, the residents were significantly inconvenienced and, in one case, a portion of livestock was rendered unfit for consumption due to exposure to mercury-contaminated soils.

Although the above cases are extreme and quite rare, the point to be made is that some degree of environmental risk, albeit slight, exists at residential properties. To minimize these risks some lending institutions and purchasers are requiring, prior to closing, more detailed environmental testing at properties thought to be high risks. For instance, certain lending institutions writing mortgages for residential properties having private water supply wells in former agricultural areas of the upper Connecticut River Valley are requiring analysis for ethylene dibromide (EDB), which was a common tobacco pesticide.

Other residential areas that may require additional environmental testing beyond the typical water analysis required as a precedent to obtaining a mortgage would include homes or multi-unit dwellings with individual water supply wells near industrial facilities, gas stations, dry cleaners, or any other potential source of groundwater contamination. The existence of a probable source of contamination can often be determined through a review of the surrounding land use.

Another residential development situation that may warrant an environmental investigation would be a development where substantial investment has been made. These situations include the developer buying or the institution financing large tracts of land, or the purchase or financing of large multi-unit dwellings. Depending on the number of housing units involved and the type of ownership, multi-unit dwellings may be considered as commercial properties subject to a "Super Lien"-type statute. Also, many older, multi-unit properties contain large central boilers that were supplied by fuel stored in underground tanks. The existence of underground tanks poses a potential for environmental impairment if leakage has occurred.

Retail and light commercial properties – Properties that, under normal circumstances, would not warrant a subsurface assessment would include commercial facilities where hazardous materials were not being handled, or had historically not been handled at the property (e.g., grocery stores, clothing shops, etc.). A Phase I "walk-through," including a title search with a complete chronology and a review of aerial photographs and insurance maps, may give adequate information regarding the historical use of a property.

Occasions exist when the past and present land use at a property will not be clearly defined from interviews or a title search in terms of the potential for causing environmental impairment. In this case, a "walk-through" assessment by a qualified technical consultant should be considered. With the information obtained through this Phase I assessment, the environmental auditor can determine if a Phase II subsurface site assessment is warranted.

Small commercial facilities that should be considered for a Phase II site assessment simply by virtue of the site operations would include facilities with underground fuel or chemical storage, auto body shops, dry cleaners, machine shops, paint blending facilities, furniture refinishers, and used auto parts dealers. The actual need and scope of the site assessments will depend on the location, as discussed later.

Gas stations and other petroleum distribution operations – Gas stations or other petroleum distribution operations (e.g., oil terminals and home heating oil distributors) can pose significant risks to groundwater quality from leaking underground storage tanks. Pursuant to EPA's new leaking underground storage tank (UST) regulations, gas stations and many other commercial operations storing fuel oil and gasoline in underground tanks will eventually be required to integrity test these tanks for leaks. If a leak is detected it must be reported to the state regulatory agency and remedial measures taken. Considering that many of the underground tanks are carbon steel and over ten years old, it is inevitable that numerous leaking tanks will be discovered. For this reason, site assessments, including groundwater monitoring and underground tank testing should be conducted at these sites.

There may be sites where this information has already been conducted by the existing owner. As a general rule, if the tank testing is over two years old, it should be repeated. Also, groundwater samples should be reanalyzed for gasoline constituents.

Industrial properties – At nearly all industrial properties, a subsurface environmental site assessment will be appropriate in order to develop specific conclusions regarding the potential for impairment to groundwater. Industrial properties pose the most varied and significant risks for impairment to groundwater because most generate or handle hazardous materials or waste. Improper management of even small quantities of hazardous materials and waste can cause significant potential for groundwater contamination. For example, at one industrial facility plant personnel reported only "minor" amounts of spillage of chlorinated solvents used in maintaining the facility's boilers. Although the solvents spilled were less than ten gallons a year, the discharge was significant enough to make the facility a potentially responsible party in the investigation and remediation of a nearby city well field contaminated by similar chlorinated solvents.

For these reasons, potential buyers, lending institutions, and underwriters are protecting their interests by requiring subsurface site assessments for, in many cases, all industrial transactions. Through discussions with various attorneys, lenders, and underwriters, it is apparent that the level of effort being undertaken to assess the potential for environmental impairment at a non-residential facility varies significantly. Some lenders have not required an assessment based upon a simple certification from a regulatory agency that there is currently no outstanding environmental enforcement action against the subject property. However, recent trends indicate that a more conservative approach is being taken, and that an assessment, including hydrogeologic testing, is being conducted for most non-residential facilities. In our experience, lending institutions, buyers, and insurers are typically requiring a greater level of effort for site assessments than would normally be considered adequate by a regulatory agency for a typical enforcement action requiring a similar facility to investigate a potential for contamination.

Corporate mergers, changes in identity or financial reorganizations – The corporate merger, change in identity or financial reorganization often requires special considerations for environmental risk assessments. Under normal circumstances these types of corporate transactions may not require bank financing, thereby eliminating a principal party that may be concerned with a "Super Lien"-type statute. However, the "Super Lien" statute may still apply to the restructured corporation. Therefore, parties previously not associated with the existing corporation would be well advised to evaluate the environmental status of the facility. These parties may include insurance companies underwriting environmental impairment liability insurance, corporations merging with the existing facility or investors in the new entity.

The most common method to evaluate these concerns is a very detailed and comprehensive environmental audit or risk assessment. If the corporation is to continue its current operations, the risk assessment should include a detailed audit of the facility operations. This audit will help identify operating practices that may create a potential for environmental impairment.

Factors Affecting the Scope of the Environmental Assessment

The scope of the environmental assessment can vary greatly depending upon the nature of the property and its location. The level of effort required can range from a site walk-through and "paper" audit to a full-scale hydrogeologic assessment. Since there are no definitive regulatory standards for this type of effort, the scope can be very subjective and a function of the opinion or expertise of a consultant, as well as be limited by a client and its attorney through the amount of money or time available to spend on the study and any resulting remediation. However, there are many other factors which could also be used to determine the scope of an assessment and by letting only these few factors alone establish a scope, the environmental auditor may be doing a disservice to his/her client. An inadequate assessment may fail to address what may later become a substantial environmental liability.

The following discussion will focus on the key items that should be considered to determine the scope of the environmental assessment. If any point is to be made in this discussion, it is that the scope can be highly variable.

Location – The facility location is a critical factor in assessing the potential for environmental impairment to groundwater and the level of environmental remediation that may be required at a site. The State of Connecticut has recognized this basic premise and has developed what some have considered a model program to assess facility location in regard to potential groundwater impairment. Groundwater classifications have been adapted for the entire state that specify the expected groundwater quality in any given area. For instance "GA" groundwater has been recognized as being drinkable without treatment and must be protected accordingly. Areas designated as "GB" groundwater are recognized as having degraded groundwater, groundwater that has the potential to be degraded by the existing land use, or groundwater that has little or no potential for development. Groundwater in "GB" areas typically is not drinkable without treatment. A typical "GB" area would be an industrialized zone with no nearby drinking water supply wells and next to a major hydrogeologic boundary such as a river or ocean. The State's long-term goal is to return "GB" areas back to "GA" areas by eliminating the sources of contamination. Finally, the lowest groundwater classification is the "GC" area. Groundwater in "GC" areas has been recognized as having been degraded with little chance of eliminating the contaminant source. An example of a "GC" area would be an existing sanitary landfill.

Connecticut's groundwater classification system serves as a useful tool in defining the scope of site audits and assessments because when a clean-up involving groundwater treatment or soil removal is required, the groundwater classification zone can help in determining how "clean" a site should be. For instance, a facility handling hazardous materials in a "GA" area would typically require a more comprehensive groundwater and soils analysis than a similar facility located in a "GB" area. Similarly, a contaminated facility in the "GA" area would require a more extensive mitigation of the contamination than the facility in the "GB" area. To further facilitate site cleanups, Connecticut has established "clean standards" for many chemical contaminants that are keyed into these groundwater classifications. Although a groundwater policy similar to Connecticut's may not exist in all areas being assessed, the model provides a general idea of the decision-making process in evaluating location as a factor in the potential for groundwater impairment. During an environmental risk assessment, a specific "groundwater classification" should be developed for the facility. To do this, some basic information will be required that includes site geology, groundwater usage, off-site hydrologic receptors (e.g., wells, streams, lakes, etc.), past and present land usage, and knowledge of existing groundwater contamination.

Some environmental professionals are of the opinion that location should have little or no bearing on the risk assessment or remedial action decision-making process; that all sites, regardless of location, should be considered as equal, and should be remediated to the best available technology. However, in consideration of the number of contaminated and potentially contaminated sites throughout North America, it is important to prioritize sites. This prioritization of sites has been recognized by the USEPA in its Hazard Ranking System for "Superfund Sites" and by various other quantitative risk assessment models (e.g., Mitre Model). Without such prioritization of sites, valuable resources (e.g., secure landfill space and money) may be directed away from those more environmentally sensitive sites.

Facility type – The second major factor involved in determining the scope of the environmental audit/assessment is the nature, size, and history of the facility. This is where a technical consultant with a broad knowledge of various commercial and industrial facilities can be invaluable in identifying the potential problems of areas of contamination at a site. There are certain key activities at a facility that can give an indication as to what may be expected in terms of contamination. The obvious activities that would trigger a more detailed assessment include underground storage of wastes, chemicals, or fuel stocks, the surface disposal of any wastes (e.g., pits, ponds and lagoons), known chemical spills, and unaccounted waste disposal at a facility that clearly generated wastes.

It is the less obvious past and present activities at a site that may come back to "haunt" a buyer, lending institution, or insurer if left undetected. In this category there are numerous "horror stories" where apparently clean property was transferred to an unsuspecting buyer who ended up with a large financial obligation for clean-up and legal costs. A typical example would be the average shopping plaza in an area where there are private water supply wells with a grocery store and other small shops. At first, the facility may appear relatively innocuous. However, one of the small shops may have been a dry cleaner, or a used auto parts store that historically dumped waste solvents out the back door. Only a few gallons of these materials can contaminate nearby water supply wells to levels significantly above drinking water standards.

HOW TO CONDUCT AN ENVIRONMENTAL ASSESSMENT

The first step in conducting the environmental audit/assessment is to determine its need as previously discussed. After determining that the audit/assessment is required and a consultant has been hired, an approximate scope can be determined and an approach to the investigation established. The approach, like the scope, is also dependent on numerous variables, the two most frequently raised being the timing and the funds available. Unfortunately, it is often difficult to balance both factors easily.

The Phased Approach vs. the Non-Phased Approach

If money is the primary consideration, a phased approach is often the most cost-effective one. The phased approach usually begins with a walk-through and paper audit of the facility. During the walk-through the current operations are evaluated in regard to their potential for causing environmental impairment. Items considered are chemicals used, wastes generated, quantities of chemicals and wastes used/generated, disposal methods, storage and handling practices, and interview of appropriate personnel. The audit typically consists of evaluating existing environmental data, researching files for regulatory compliance and groundwater classifications, and researching land records. Interviews with past and present facility personnel when possible can offer revealing information during the site audit. Many times the informal conversation with a veteran maintenance worker, or similar personnel reveals the location of the old tank, disposal area, or some other environmental degradation of the property.

After the audit phase, it can be reasonably determined if a more detailed site assessment, including sampling, is required. If the assessment is not required, relatively little money has been spent to conduct the initial environmental evaluation of the property. A facility in this category may include, for example, a gas station in an industrial groundwater area that has conducted within the past year groundwater monitoring and underground tank testing results showing satisfactory results.

At many facilities, a Phase I "walk-through" can show that a more detailed assessment, including on-site testing, is required. The type of facilities requiring subsurface assessments are numerous, but generally include: facilities in sensitive groundwater areas that handle hazardous materials or have underground storage tanks, any facilities where the audit has revealed questionable hazardous material handling, storage or disposal practices, or facilities or property where historical activities may have caused environmental impairment.

In the phased approach, the environmental auditor may wish to conduct a scaled-down "preliminary" assessment in an effort to reduce costs. The preliminary assessment may propose a limited field sampling program that can eliminate excess costs if the preliminary results are satisfactory. However, this approach can be a gamble. If the results show significant contamination, or are inconclusive, more field sampling will be required. In this case valuable time and money have have been lost by having to remobilize the field sampling team.

Where scheduling is a critical factor (and it usually is in the real estate or corporate transaction), the environmental auditor may decide to proceed directly to a full scale site assessment. This approach may also be appropriate at a facility where contamination is obvious from the start of the transaction and it is obvious that this level of effort would be appropriate. There are, of course, varying levels of "full scale" field programs, as discussed below.

Field Programs

The scope of the site assessment field investigation is dependent on the hydrogeologic setting, the groundwater classification, the contaminants of concern, the property size, and the proximity to any other sensitive environmental receptors. The following is a brief discussion of the factors involved in a subsurface site assessment field program.

Groundwater monitoring – Groundwater is considered the primary concern in most site assessments since it is typically the media where contamination manifests itself and will typically create the greatest environmental liabilities. Accordingly, borings and/or groundwater monitoring wells are usually required. During the installation of the wells, soil samples are usually collected at various depths and are retained. A qualified geologist or geotechnical engineer should be present to log the subsurface conditions and screen soil, rock, and groundwater samples for obvious signs of contamination. In areas where groundwater is shallow (less than eight to ten feet) a backhoe can often be used for subsurface investigations instead of a drill rig, saving both time and money. Also, in sandy soils a hand auger can sometimes access groundwater for sampling.

In most sensitive groundwater areas, the rate and direction of groundwater flow will be critical to the site investigation in order to determine the impact on surrounding groundwater supplies. Also, at less sensitive groundwater areas where the hydrogeologic setting can not be used to accurately predict these conditions (e.g., upland areas away from major rivers or hydraulic boundaries), the rate and direction of groundwater flow will be critical. At these locations certain hydrogeologic parameters must be established during the subsurface investigation. These parameters include the formation permeability and the slope and orientation of the groundwater table. Permeability is determined by a variety of field and laboratory methods that are dependent on the soil texture. To determine the slope of the water table and the direction of flow, a minimum of three wells must be installed. The relative location and elevations of the wells must then be established.

Soil sampling – Soil sampling is often a critical part of the site assessment and should be conducted at areas of obvious contamination (e.g., lagoons), or where contamination is known or presumed to have occurred (e.g., under drum storage areas or outdoor storage or process tanks). Random soil sampling is usually of limited value unless it is known (or presumed) that the contamination is evenly distributed (e.g., agricultural areas). A site assessment consisting of only random soil sampling is risky. It is quite possible that a source of groundwater contamination may have been missed and, without groundwater monitoring, may go unchecked until a future environmental problem arises.

Field meters and instrumentation – Meters are available that can determine the relative presence of various volatile organic compounds and other selected contaminants (e.g., mercury) during the field program. These meters are good reconnaissance tools that give an indication of where the contaminated "hot spots" may be and, in highly contaminated areas, can alert field personnel to the presence of any fire or respiratory hazards. Field gas chromatographs used in soil vapor surveys are gaining acceptance as a useful tool for assessment of volatile organic contaminant plumes. However, most field meters have limitations and should not be substituted for laboratory analysis of samples.

Surface geophysical methods (e.g., seismic, electromagnetic, radar, or resistivity) may be used to locate large accumulations of waste, contaminated groundwater plumes, and abandoned underground tanks. If conducted prior to the drilling, the information obtained can help to better locate the boreholes or wells. However, like field analytical meters, surface geophysical methods have limitations and are no substitute for subsurface investigations. The field meters and geophysical methods should not be construed as quick and inexpensive methods to conduct a site assessment. Their primary purpose is to provide a higher level of technical confidence that typically adds to the reliability of the assessment.

Laboratory analysis – After the field sampling is completed, the soil and water samples are submitted to a qualified laboratory for analysis. Unfortunately there is not one "test" that will determine if a sample is contaminated. Therefore, it is important that the environmental auditor be able to determine the contaminants of concern. For instance, at a gas station petroleum products would be analyzed. At a metal finisher, metals, cyanide and perhaps solvents, would be the contaminants of concern. In an agricultural area, pesticides and herbicides will be critical analyses.

At the average commercial or industrial property, one of the most ubiquitous contaminants seems to be a chlorinated solvent such as tetrachloroethylene or trichloroethane. These compounds are used in a multitude of products including engine and parts' degreasers, dry cleaning fluids, and industrial moisture displacers. Because even a quantity as small as one gallon of certain solvents can cause significant groundwater contamination, these compounds should be included in a request for analysis if even a remote chance of their use is suspected at a facility.

Another problem arises at facilities that use "exotic" chemicals or a facility that has had varied industrial uses. In these cases more complex analyses may be required to provide the confidence that all contaminants were found. For these cases, a full gas chromatograph/mass spectrophotometer (GC/MS) analysis for all 129 priority pollutants would be appropriate. In addition, most laboratories will offer (at a relatively small additional cost) a library search of the GC/MS data that will identify any additional chemical constituents found in the sample. When submitting samples to a laboratory, the consultant should always submit chain of custody documents. These documents provide a legal record of the sample handling that can make the integrity of the sample defensible if a case ends up in a regulatory proceeding or in court.

A factor that adds to the reliability (and costs) of any site assessment is the collection of quality control samples. These can include duplicate samples, samples "spiked" with a measured quantity of a compound, or "blanks" that consist of a sample known to be free of contamination. Quality control samples submitted to the laboratory as normal samples test the integrity of the lab and the field sampling program. Quality control samples should always be considered in a situation where future litigation is possible. Quality control in the field sampling portion of the project is also critical. The consultant should have developed a good field sampling protocol to prevent the cross contamination of samples, or collection of non-representative samples. In some cases that have gone to court, very expensive analytical data have been invalidated because improper field sampling techniques were used.

Safety – Safety is an important consideration in any field program, especially those involving hazardous materials. The consultant and his/her staff should be fully informed of any potential hazard on site prior to starting the job (e.g., underground tanks, buried wastes, etc.). The consultant should not find by "mistake" that a hazard exists. Also, the consultant should be well versed in safety protocols around potentially contaminated sites. Poor safety practices by the consultant or its subcontractors only add to the property owners' liability.

The consultant should have at least minimal safety gear on hand for the average site. This may include disposable splash suits, rubber gloves, goggles, hard hat and a respirator. If it is known that a site may be highly contaminated, only a consultant trained in working on such a site should be considered.

Another very important safety consideration in site assessments involving subsurface explorations is the identification of underground utilities before digging. If the locations of these utilities are unknown by facility personnel, use the "Call Before You Dig" service listed in the yellow pages for assistance.

THE ENVIRONMENTAL RISK ASSESSMENT REPORT

After all the data are collected and analyzed, the environmental auditor must present the facts, conclusions and recommendations to the user in a comprehensive and concise report. It is during this reporting phase that good communication between the technical consultant and any non-technical professional user of the risk assessment is extremely important.

A site assessment that included a very comprehensive field program with detailed chemical analysis is next to meaningless to the non-technical person if presented as page after page of data. The consultant must make concise summaries and conclusions, keeping in mind that an important business decision may be made based on his/her report. The data must be compared to applicable standards and put into perspective. If tetrachloroethylene exists in groundwater at 50 parts per billion, what does it mean? Does it meet standards? Are there standards? Does it require remediation? If so, how much? If contamination exists, remedial measures including costs should be recommended. These are the facts of interest to the non-technical user of a risk assessment. The technical data are presented to support these conclusions.

Abstract conclusions based upon limited data, followed by a host of precautionary disclaimers, usually means nothing. Accordingly, the environmental auditor must avoid making conclusions that cannot be substantiated with data. For instance, it cannot be concluded that groundwater contamination does not exist at a facility where the site assessment consisted only of surface soil sampling. If the data were not sufficient to address a particular factor, it should be so stated in the report. Finally, before commencing work, the user of the risk assessment and the environmental auditor should agree on for whom and for what purpose the report is being prepared. Considerations of confidentiality may be paramount and the contractual arrangements and may require structuring so as to provide maximum safeguards on the release of the report.

A common concern of a facility undergoing an assessment is its reporting obligations if an environmental problem is discovered. The problem of dealing with so-called "smoking gun" assessment reports is a difficult one at best. These situations are very complex and are best left to counsel well versed in environmental law. Finally, any one contracting an environmental assessment must realize that the final result does not necessarily eliminate all risks of environmental impairment nor does the consultant assume any outstanding risks. The assessment provides a degree of confidence needed to proceed with a business decision and, as with any decision, there are certain risks that must be assumed.

SCHEDULING

The time required to complete the environmental investigation can range from two weeks up to six months or more depending on the scope and approach of the investigation. There are many factors involved in scheduling, many of which the environmental auditor has little or no control over. This is particularly true of site assessments where various subcontractors must be relied upon.

The Phase I "walk-through" assessment generally has the fastest turn around time. At small, simple facilities the site visit and paper audit usually can be conducted and a report written within two to four weeks assuming the prompt availability of a consultant. Because the Phase I environmental assessment can often develop into a subsurface site assessment, considerably more time should be allocated. The time required to conduct a subsurface site assessment is usually at least a month or more. Since the time required is so variable, the following example provides some insight into the factors which affect it.

An assessment must be conducted at a five-acre manufacturing facility. A preliminary walk-through of the facility shows that the facility stores piles of metal shavings and drummed waste and chemicals in an unpaved area. Some soil staining is evident. There are two underground fuel storage tanks, and four old transformers on the roof. It is determined that groundwater monitoring is required due to the operations observed. The assessment schedule may be as follows:

• Contact and hire consultant	One to four weeks
• Conduct preliminary evaluation and develop scope	One to two weeks
• Contract and schedule drilling subcontractor and/or tank testing subcontractor	One to three weeks
• Drill the monitoring wells, collect soil and water samples, test tanks	One to two weeks
• Laboratory time to analyze samples	One to four weeks
• Prepare report	One to four weeks
TOTAL TIME	Six to Nineteen weeks

The above example is a fairly typical case and does not include any time required for remediation (if needed), or regulatory review if needed. The only time in the above schedule that could be lowered is the laboratory's turn-around time. Some laboratories offer "priority" one- to two-day service at a premium price of about double the normal rate.

COSTS

Costs are also highly variable. A simple Phase I "walk-through" environmental assessment can cost as little as $1,500 to $2,000 with a major site assessment costing over $50,000. The example presented in the previous scheduling discussion would cost in the range of $7,500 to $20,000, depending upon the soil and groundwater analyses required, and assuming no major problems with the drilling tasks.

The following list provides some approximate ranges of costs that may be incurred during a site assessment:

• Consulting engineer or hydrogeologist (depending upon level of experience)	$300-$1,000/man day
• Well drilling or soil boring rig w/crew	$800-$1,200/day
• Well construction materials (pipe, casing, grout, etc.)	$7-$20/lineal foot
• Backhoe with operator	$600-$1,000/day

• Rental of field meters	$75-$500/day
• Sample Analyses:	
– EP Toxicity Metals (soils only)	$125-$225/sample
– Dissolved Metals (water only)	$75-$200/sample
– Volatile Organics (solvents)	$125-$200/sample
– Gross hydrocarbons (petroleum products)	$125-$200/sample
– PCB's	$75-$200/sample
– Pesticides and herbicides	$125-$350/sample
– Base/Neutral extractable priority pollutants	$350-$600/sample
– Acid extractable priority pollutants	$200-$350/sample
– Ethylene Dibromide (EDB), Water	$75-$150/sample
• Underground Tank Testing	$600-$1,200/tank

The above costs are general ranges based upon recent experiences with subcontractors in the northeastern United States. The prices shown do not include other direct costs (e.g., travel, mobilization charges, expendable equipment costs, etc.), and standard mark-up and overhead costs incurred. These added costs can increase the overall project costs by 10 to 25 percent.

CASE HISTORIES

To the practitioner in the environmental risk assessment field, the number of "horror stories" involving groundwater contamination appears endless. The problems encountered are not isolated to a specific group of industries, or to particular geographic areas. The following are some brief case histories that we have encountered within the past few years that demonstrate the ubiquity of groundwater contamination.

- *Former Tobacco Farm Turned Residential*

  A lead from a past employee of a defunct tobacco farm alleged that spent farm chemicals were disposed of in a "pit" on property that was now residential and on private wells. An intensive program of subsurface exploration and surface geophysics was employed in an attempt to locate the dump. These efforts were fruitless until a long-time resident was located that could locate the "pit" on aerial photographs and in the field. Subsequently, a dump of over 85 cubic yards of spent pesticide was located in a resident's backyard. The pesticides were removed using EPA emergency superfund money. The pesticides dumped were in dry sand, and were relatively immobile and insoluable. Fortunately, no impact to the local groundwater was detected.
- *Small Commercial Furniture Store*

  A routine assessment of a small furniture store revealed that refinishing of furniture with chlorinated solvents was ongoing in a garage on the property. Records showed that the waste resulting from the furniture stripping operation had been properly disposed of and manifested for only the past three years. Prior to this time the owner was vague regarding the waste disposal. It was later learned that the paving of the parking lot and the stormwater catch basins correlated exactly to the date the waste began to be properly disposed of. Simple deduction, confirmed by exploration borings and monitoring wells showed that waste solvents and lead-bearing paint sludges were disposed of in a former stormwater collection vault. The vault contents were removed as hazardous wastes, thus removing the source of groundwater contamination. Because the waste was encapsulated in the vault, limited impact to groundwater was detected. However, because the site is in a potential aquifer area, the need for groundwater remediation is currently being assessed through additional groundwater monitoring.

- *Automotive Tubing Manufacturer*

  A fairly comprehensive assessment of a moderate-sized manufacturing plant showed that ambient groundwater quality was not significantly impacted considering the facility's industrial location. However, a detailed site inspection of the operations showed that cooling water and dragout from a methylene chloride degreasing operation had been discharged to a concrete sump in the basement for the past eight years. Sampling of the sump contents showed high levels of methylene chloride. Methylene chloride (and other chlorinated solvents) is permeable to concrete. Subsequent testing of soils and groundwater below the sump showed significant concentrations of methylene chloride. The situation resulted in the installation of a groundwater recovery well through the basement floor. Contaminated groundwater was pumped to an air-stripping treatment unit prior to discharging to a sanitary sewer.

- *Steel Bar Processing Plant*

  An environmental assessment of this major steel plant for corporate auditing purposes identified various areas of environmental concern. One of these areas was an uncontained nitric acid tank with an old underground feed line. In accordance with the recommendations of the assessment, the company decided to renovate the acid feed system. The renovation was designed, installed, and supervised by plant personnel. Apparently, improper fittings for the feed lines were obtained. Rather than waste time and money on obtaining the proper fittings, the fittings on-hand were used. The line was installed, backfilled, and a new concrete floor laid. Within one month it was realized that over 1,000 gallons of nitric acid were lost into the ground. Because the facility was directly upgradient of the city's well field, quick remedial action was warranted.

  The remedial action consisted of the installation of a two-foot diameter recovery well. Because the company had conducted an environmental risk assessment that included groundwater monitoring, groundwater flow dynamics were known. Immediately after pumping the well, acidified groundwater began to be detected. The acidified groundwater was comingled with the plant's typically high pH discharge from its wastewater treatment system. The resulting discharge to the sewer was neutral. The recovery well was pumped continuously. Groundwater monitoring wells flanking the well confirmed it was intercepting the acid plume. A head of water was maintained on the flanking monitoring wells to better direct the plume to the recovery well. The acid-contaminated soils were remediated by bathing the area of the release with a continuous discharge of a mild caustic solution. This caustic will serve to neutralize the residual acids in the unsaturated zone. In addition, the caustic will indicate complete acid plume migration when the pH of the recovery well begins to increase and stabilize above background.

The above case histories identify only some of the applied methods used in the risk assessment decision-making process. Experience with hundreds of risk assessments has shown that nearly every site is unique, and that overly standardized approaches to the assessment are difficult to apply. Therefore, creativity and experience combined with good technical knowledge of groundwater assessment techniques provide the optimal combination for conducting an effective risk assessment.

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