SITE CHARACTERIZATION ACTIVITIES AT CONTAMINATED SITES

The characterization of potentially contaminated sites is a process used to establish the presence or absence of contamination at a site, to delineate the nature and extent of site contamination, and to determine possible threats posed by the site to human health and/or the environment. The scope and detail of a site characterization should generally be adequate to determine the:

- Primary and secondary sources of contamination
- Amount and extent of contamination
- Fate and transport characteristics of site contaminants
- Pathways of contaminant migration
- Types of exposure scenarios associated with the site
- Risk to human health and the environment
- Feasible solutions to mitigate receptor exposures to site contaminants

Characterization of contaminant sources, migration pathways, and potential receptors probably form the most important basis for determining the need for site remediation. The completion of an adequate site characterization is therefore considered a very important component of any corrective action program that is designed to effectively remedy a contaminated site problem.

3.1 THE SITE CHARACTERIZATION PROCESS

The site characterization process consists of the collection and analysis of a variety of environmental data necessary for the design of an effectual corrective action program. Box 3.1 enumerates several important elements of site characterization activities that are used to support corrective action decisions at contaminated sites. The implementation of these typical action items will generally help realize the overall goal of a corrective action investigation.

Credible site characterization programs generally involve a complexity of activities that require careful planning. The initial step involves a data collection activity to compile an accurate site description, history, and chronology of significant events. Subsequently, the most important functions are field sampling and laboratory analyses.
The field data are collected to help define the nature and extent of contamination present at, or migrating from, a contaminated site. Consequently, it is important to use proven methods of approach for the sampling and analysis programs designed for potentially contaminated sites.

A wide variety of investigation techniques may be employed in the characterization of potentially Contaminated sites. However, the appropriate methods and applicable techniques will generally be dependent on the type of contaminants, the site’s geologic and hydrogeologic characteristics, site accessibility, availability of resources, and program costs. Several methods of choice used to effectively complete site characterization programs are described elsewhere in the literature of site assessment programs (e.g., BSI, 1988; CCME, 1993, 1994; CDHS, 1990; Driscoll, 1986; OBG, 1988; USEPA, 1985, 1987, 1988a, 1988b, 1989a, 1989b, 1989c). The literature provides technical standards for remedial investigation project scoping, data validation, surveying and mapping of contaminated site sampling locations, hydrogeologic characterization at contaminated sites, surface geophysical techniques, drilling, coring, sampling and logging at contaminated sites, borehole geophysical techniques, the design and construction of monitoring wells and piezometers, groundwater sampling, the design and construction of extraction wells at contaminated sites, etc. These types of guidance will facilitate the implementation of a worthwhile site characterization plan. Overall, the information obtained from a site characterization activity should be adequate to predict the fate and behavior of the contaminants in the environment, as well as to facilitate the design of an effective corrective program.

3.2 DESIGNING COST-EFFECTIVE SITE CHARACTERIZATION PROGRAMS

Several types of decisions are usually made very early in the design of a site characterization program, at which time only very limited information may be available about the case site. Nonetheless, reasonable decisions can be made despite the uncertainties that may surround it. By adopting a phased approach, each phase of a site investigation should, as far as practicable, be based upon previously generated information about the site. Such an approach will help identify the specific information needed to understand the site conditions, as well as help optimize the cost of acquiring that information. A multi-layered, iterative, and flexible survey that emphasizes in situ measurements and focuses on mapping contaminant boundaries is critical to this process (Jolley and Wang, 1993).

The characterization of huge, complex sites may present increased logistical problems, making the design of site characterization programs for such sites more complicated. To allow for a manageable situation in the investigation of extensive or large areas, it usually is prudent to divide the site into “operable units” (OUs) or “waste management units” (WMUs) or “contaminated site zones” (CSZs). The OUs or WMUs or CSZs would define the areas of concern, which are used to guide the identification of the general sampling locations at or near the site. The areas of concern, defined by the individual OUs or WMUs or CSZs, will typically include sections or portions of a site that:

- Have different chemical constituents
- Have different anticipated concentrations or “hot spots”
- Are a major contaminant release source
- Differ from each other in terms of the anticipated spatial or temporal variability of contamination
- Must be sampled using different field procedures and/or equipment and tools

All of the areas of concern (designated as OUs or WMUs or CSZs) together should account for, or be representative of, the entire case site.

The key to a successful and cost-effective site characterization will be to optimize the number and length of field reconnaissance trips, the number of soil borings and wells, and the frequency of sampling and laboratory analyses...
as part of a preliminary assessment. In all situations, before a subsurface investigation is initiated, background information relating to the regional geology, hydrogeology, and site development history should have been fully researched. In general, minimizing well installations and sample analyses during this phase of the characterization can greatly reduce overall costs. Indeed, well installation can even add to the spread of contamination by penetrating impermeable layers containing contaminants and then allowing such contamination to migrate into previously uncontaminated groundwater systems (Jolley and Wang, 1993). Consequently, nonintrusive and screening measurements are generally preferred modes of operations whenever possible, since these tend to minimize both sampling costs and the potential to spread contamination. Ultimately, however, sufficient information should be obtained that will reliably show the identity, areal and vertical extent, and the magnitude of contamination associated with the site.

### 3.2.1 Sampling and Analysis Design Considerations

A preliminary identification of the types of contaminants, the chemical release potentials, and also the potential exposure pathways should be made very early in the site characterization, because these are crucial to decisions on the number, type, and location of samples to be collected.

The type of chemicals at potentially contaminated sites may dictate the sections or areas and environmental media to be sampled. For instance, in the design of a sampling program, if it is believed that the contaminants of concern are relatively immobile (e.g., PCBs and most metals in silty or clayey materials), then sampling will initially focus on soils in the vicinity of the suspected source of contaminant release. On the other hand, the sampling design for a site believed to be contaminated by more mobile compounds (e.g., organic solvents in sandy materials) will take account of the fact that contamination may already have migrated into groundwater systems and/or moved significant distances away from the original source area(s). Then, also, some chemicals that bioaccumulate in aquatic life will likely be present in sediments, requiring that both sediments and biota be sampled and analyzed. Consequently, knowledge on the type of contaminants will generally help focus more attention on the specific media most likely to be impacted.

Similar decisions as above will typically have to be made regarding analytical protocols. For instance, due to the differences in the relative toxicities of the different species of some chemicals (e.g., chromium may exist as trivalent chromium, Cr\(^{3+}\) or as the more toxic hexavalent chromium, Cr\(^{6+}\)), chemical speciation to differentiate between the various forms of the chemicals of potential concern present at a contaminated site may be required in the design of analytical protocols.

### 3.3 DEVELOPMENT OF SITE CHARACTERIZATION WORKPLANS

Workplans are generally required to specify the administrative and logistic requirements of site investigation activities. As part of the corrective action program for potentially contaminated site problems, a carefully executed investigative strategy or workplan should be developed to guide all relevant decisions. A typical workplan developed to facilitate the investigation of contaminated site problems will generally

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**Site Characterization Activities at Contaminated Sites**

**Box 3.2

Elements of a Typical Site Characterization Workplan**

- How site mapping will be performed (including survey limits, scale of site plan to be produced, horizontal and vertical control, and significant site features)
- Number of individuals to be involved in each field sampling task and estimated duration of work
- Identification of soil boring and test pit locations on a map to be provided in a detailed workplan
- Number of samples to be obtained in the field (including blanks and duplicates), and the sampling location (illustrated on maps to be included in a detailed workplan)
- List of field and laboratory analyses to be performed
- An elaboration of how investigation-generated wastes will be handled
- A general discussion of data quality objectives (DQOs)
- Identification of pilot or bench-scale studies that will be performed, where necessary, in relationship to recommendations for remedial technologies screening, risk management strategies, and/or site stabilization processes
- A discussion of health and safety plans required for the site investigation or corrective action activities, as well as that necessary to protect populations in the general vicinity of the site

- A sampling and analysis plan
- A health and safety plan
- A waste management plan (for investigation-generated wastes)
- A site activity plan
- A quality assurance/quality control plan

Details of all the workplan elements, as represented in Box 3.2, should be adequately developed. In this regard, any existing information on the fate and behavior of contaminants present at a contaminated site are essential for developing the various workplan components. The major components and tasks required of most site characterization workplans are elaborated further in the following sections.

### 3.3.1 The Sampling and Analysis Plan

Sampling and analysis of environmental pollutants is a very important part of the decision-making process involved in the management of potentially contaminated site problems. Yet, sampling and analysis often turns out as one of the most expensive and time-consuming aspects of a site characterization project. Evidence of this is the fact that errors in sample collection, sample handling, or laboratory analysis can invalidate projects or add to the overall project costs. All environmental samples that are intended for use in the characterization of potentially contaminated sites must therefore be collected, handled, and analyzed properly, in accordance with applicable/ regulatory standards.**
The sampling and analysis plan (SAP) is an essential component of any environmental investigation, and more so in the planning, development, and implementation of corrective action programs for potentially contaminated sites. SAPs generally are required to specify sample types, numbers, locations, and procedures. In fact, the SAP sets the stage for developing a cost-effective and adequate corrective action plan for potentially contaminated sites. Its purpose is to ensure that sampling and data collection activities will be comparable to, and compatible with, previous data collection activities.

SAPs provide a mechanism for planning and approving field activities. The required level of detail and the scope of the planned investigation generally determines the data quality objectives (DQOs). The sampling and analysis strategies should be planned in such a manner as to minimize the costs associated with achieving the DQOs. Typically, the SAP will comprise of two major components (USEPA, 1988a, 1988b, 1989b):

1. A quality assurance project plan (QAPP) that describes the policy, organization, functional activities, and quality assurance and quality control protocols necessary to achieve the DQOs dictated by the intended use of the data.
2. A field sampling plan (FSP) that provides guidance for all fieldwork, by defining in detail the sampling and data-gathering methods to be used in a project. The FSP should be written so that a field sampling team unfamiliar with the site is able to gather the samples and any field information required.

A detailed discussion of sampling considerations and strategies for various environmental matrices can be found in the literature (e.g., CDHS, 1990; Keith, 1988, 1991; USEPA, 1988b, 1989b). Important issues to consider when one is making a decision on how to obtain reliable samples relate to the sampling objective, the sampling approach, the Sample collection methods, sample preservation techniques, sample shipment methods, and sample holding times. Data necessary to meet the project objectives should be specified, including the selection of sampling methods and analytical protocols for the site; this will also include an evaluation of multiple-option approaches that will ensure timely and cost-effective data collection and evaluation. Box 3.3 enumerates a checklist of items that should be reviewed in the development of a SAP (CCME, 1993; Keith, 1988, 1991).

The methods by which data of adequate quality and quantity are to be obtained to meet the overall project goals should be specified and fully documented in the SAP developed as part of a detailed site characterization workplan. It is noteworthy that the use of appropriate sample collection methods can be as important as the use of appropriate analytical methods for sample analyses. Consequently, effective analytical protocols in both the sampling and laboratory procedures should be specified by the SAP, in order to help minimize uncertainties associated with the data collection and evaluation activities.

3.3.1.1 Purpose of Sampling and Analysis

The principle objective of a sampling and analysis program is to obtain a small and informative portion of the statistical population being investigated so that contaminant levels can be established as part of a corrective action assessment program. Sampling and analysis programs are generally designed and conducted in order to (USEPA, 1989b):

- Determine the extent to which soils act as either contamination sources (i.e., situations when significant quantities of selected contaminants are found to be associated with soils initially and these dissolve slowly over relatively long periods of time into other media), or sinks (i.e., situations where significant quantities of contaminants become permanently attached to soil and remain biologically unavailable).
- Determine the presence and concentration of specified contaminants in comparison to natural and/or anthropogenic background levels.
- Determine the concentration of contaminants and their spatial and temporal distribution.
- Obtain measurements for validation or use of existing transport and fate models, or routes, and potential receptors.
- Determine the potential risks to human health and/or the environment (i.e., to flora and fauna) due to site contamination.
- Identify areas of site and potential actions are needed, and measure the efficacy of control actions.
- Contribute to research technology transfer or environmental model development.
- Meet the provisions and intent of environmental laws (such as RCRA, CERCLA, FIFRA, TSCA).

The design of a sampling and analysis program and its associated quality assurance plan takes account of the variability in the entire measurement process along with the sources and magnitude of the variation in the results generated. It also provides a means of determining whether a sampling and analysis program meets the specified...
3.8.1.2 Sampling Requirements

Environmental sampling at contaminated sites are conducted to characterize the site for enforcement and corrective actions. Several site-specific requirements are important in achieving the site characterization goals. Specific factors to consider when preparing the sampling plan include (WPCF, 1988):

- History of activity at the site
- Physical/chemical properties and hazardous characteristics of materials involved
- Topographic, geologic, pedologic, and hydrologic characteristics of the site
- Meteorologic conditions
- Flora and fauna of the site and vicinity (to include the identification of sensitive ecological species and systems, and the potential for bioaccumulation and biotransformation)
- Geographic and demographic information, including proximity of populations potentially at risk

A history of the site, including the sources of contaminants and a conceptual model describing the apparent migration pathways should be developed before a sampling plan is finalized. In certain situations, it may be necessary to conduct an exploratory study so that this preliminary conceptual model can be confirmed or modified, as appropriate. Thus, additional data identify specific areas where a site conceptual model is not valid, the model should be modified to reflect the new information.

In working towards the development of a representative conceptual model for a site, it is important to be aware of the fact that some significant model features may not be very apparent, but rather will remain latent. For example, consider the case of contaminated non-soil debris present in the soil mass at a potentially contaminated site. This debris must be taken into account when evaluating the hazard posed by the site. In fact, in some cases, the debris (e.g., wood chips or shredded wood, for instance, used as absorbents for liquid wastes) rather than the soil itself may be the major source of contaminant releases. Consequently, screening the non-soil debris out of the soil material and excluding it from a hazard and/or risk analysis may bias the results and, therefore, the final conclusions reached about the site.

Elements of a Sampling Plan

An initial site evaluation should provide insight into the types of site contaminants, the populations potentially at risk, and possibly the magnitude of the site risk. These factors can be combined to design a sampling plan and to specify the size of sampling unit appropriate for the site characterization program. All sampling plans should contain the following common elements:

- Site background (that includes a description of the site and surrounding areas and a discussion of known and suspected contamination sources, probable transport pathways, and other information about the site)
- Sampling objectives (describing the intended uses of the data)
- Sampling location and frequency (that also identifies each sample matrix to be collected and the constituents to be analyzed)

Regardless of the medium sampled, data variability problems may arise from temporal and spatial variations in field data. That is, sample composition may vary depending on the time of the year and weather conditions when the sample is collected. Ideally, samples from various media should be collected in a manner that accounts for temporal factors and weather conditions. If seasonal fluctuations cannot be characterized in the investigation, details of meteorological, seasonal, and climatic conditions during sampling must be well documented. Choosing an appropriate sampling interval that spans a sufficient amount of time to allow one to obtain, for example, an independent groundwater sample will generally help reduce the effects of autocorrelation. Also, sampling both background and compliance wells at the same point in time should reduce temporal effects. Consequently, the ideal sampling strategy will incorporate a full annual sampling cycle. If this strategy cannot be accommodated in an investigation, at least two sampling events should be considered that take place during opposite seasonal extremes (such as high-water/low-water, high-recharge/low-recharge, etc.).

**BOX 3.4**

**Sampling Plan Checklist**

- What are the DQOs, and what corrective measures are planned if DQOs are not met (e.g., resampling or revision of DQOs)?
- Do program objectives need exploratory, monitoring, or both sampling types?
- Have arrangements been made for site entry or access?
- Is specialized sampling equipment needed and/or available?
- Are field crews who are experienced in the required types of sampling available?
- Have all analytes and analytical methods been listed?
- Have required good laboratory practice and/or method QA/QC protocols been listed?
- What type of sampling approach will be used (i.e., random, systematic, judgmental, or combinations thereof)?
- What type of data analysis methods will be used (e.g., geostatistical, control charts, hypothesis testing, etc.)?
- Is the sampling approach compatible with data analysis methods?
- How many samples are needed?
- What types of QC samples are needed, and how many of each type of QC samples are needed (e.g., trip blanks, field blanks, etc.)?

- Sample designation (that establishes a sample numbering system for the specific project, and should include the sample or well number, the sampling round, the sample matrix, and the name of the site)
- Sampling equipment and procedures (including equipment to be used and material composition of equipment, along with decontamination procedures)
- Sample handling and analysis (including identification of sample preservation methods, types of sampling jars, shipping requirements, and holding times)
Box 3.4 provides a convenient checklist of the issues that should be verified when planning a sampling activity for contaminated sites (CCME, 1993).

3.3.1.3 Sampling Protocols

Sampling protocols are written descriptions of the detailed procedures to be followed in collecting, packaging, labeling, preserving, transporting, storing, and documenting samples. The selection of analytical methods is also an integral part of the processes involved in the development of sampling plans, since this can strongly affect the acceptability of a sampling protocol. For example, the sensitivity of an analytical method could directly influence the amount of a sample needed in order to be able to measure analytes at prespecified minimum detection (or quantitation) limits. The analytical method may also affect the selection of storage containers and preservation techniques (Keith, 1988).

The overall sampling protocol must identify sampling locations and include all of the equipment and information needed for sampling, including the types, number and sizes of containers, labels, field logs, types of sampling devices, numbers and types of blanks; sample splits and spikes, sample volume, any composite samples, specific preservation instructions for each sample type, chain-of-custody procedures, transportation plans, field preparations (such as filter or pH adjustments), field measurements (such as pH, dissolved oxygen, etc.), and the reporting requirements (King, 1988). The sampling protocol should also identify those physical, meteorological, and hydrological variables to be recorded or measured at the time of sampling (Keith, 1988). In addition, information concerning the analytical methods to be used, minimum sample volumes, desired minimum levels of quantitation, and analytical bias and precision limits may help sampling personnel make better decisions when unforeseen circumstances require changes to the sampling protocol.

Table 3.1 lists the minimum documentation needed for sampling activities (CCME, 1993). The more specific a sampling protocol is, the less chance there will be for errors or erroneous assumptions. In general, the devices used to collect, store, preserve, and transport samples must not alter the sample in any manner. For example, special procedures may be needed to preserve samples during the period between collection and analysis.

<table>
<thead>
<tr>
<th>Table 3.1 Minimum Requirements for Documenting Environmental Sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling date</td>
</tr>
<tr>
<td>Sampling time</td>
</tr>
<tr>
<td>Sampling site</td>
</tr>
<tr>
<td>Sample identification number</td>
</tr>
<tr>
<td>Sampler's name</td>
</tr>
</tbody>
</table>

Sampling Approach

There are three basic sampling approaches: systematic, random, and judgmental. There are also three primary combinations of each of these, i.e., stratified-judgmental, systematic-random, and systematic-judgmental (CCME, 1993; Keith, 1991). Additionally, there are further variations that can be found among the three primary approaches and the three combinations thereof. For example, the systematic grid may be square or triangular; samples may be taken at the nodes of the grid, at the center of the spaces defined by a grid, or randomly within the spaces defined by a grid.

3.3.1.4 Laboratory and Analytical Program Requirements

Oftentimes, the initial analyses of environmental samples may be performed with a variety of field methods used for screening purposes. The purpose of using initial field screening methods is to decide if the level of pollution at a site is high enough to warrant more expensive (and more specific and accurate) laboratory analyses. Methods that screen for a wide range of compounds, even if determined as groups or homologues, are useful because they allow more samples to be measured faster and more inexpensively than with conventional laboratory analyses.

In the more detailed assessment, environmental sample analysis is generally performed by the so-called contract laboratory program (CLP) and non-CLP services. The CLP consists of routine and nonroutine standardized analytical procedures and associated quality control requirements managed under a broad quality assurance program (that includes sample projections, sample scheduling, chain-of-custody requirements, reporting and documentation requirements, audits, and data evaluations); CLP services are provided through routine analytical services and special analytical services. Non-CLP services will include field analytical support methods. The investigation of a potentially contaminated site will typically utilize both CLP and non-CLP services designed to meet the DQOs of the investigation.

Effective analytical programs and laboratory procedures are necessary to help minimize uncertainties in site investigation activities that are required to support corrective action decisions. Table 3.2 lists the minimum requirements for documenting laboratory work performed to support site characterization activities (CCME, 1993; USEPA, 1989c). The applicable analytical procedures, the details of which are outside the scope of this book, should be strictly adhered to.

<table>
<thead>
<tr>
<th>Table 3.2 Minimum Requirements for Documenting Laboratory Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method of analysis</td>
</tr>
<tr>
<td>Date of analysis</td>
</tr>
<tr>
<td>Laboratory and facility carrying out analysis</td>
</tr>
<tr>
<td>Analyst's name</td>
</tr>
<tr>
<td>Calibration charts and other measurement charts (e.g., spectral)</td>
</tr>
</tbody>
</table>

3.3.1.5 Laboratory and Analytical Protocols

Analytical protocol and constituent parameter selection are usually carried out in a way that balances costs of analysis with adequacy of coverage. If specific chemical constituents are known to be associated with previous site activities, they should definitely be targeted for analysis. Otherwise, a widely used and more general parameter list such as the USEPA 'Priority Pollutant List' is adopted. For instance, if a metals processing and finishing plant is known to have existed at a site, then some
priority pollutant metals and VOCs, both associated with cleaning and degreasing, may become the target constituents/parameters. In addition, a select but limited number of samples from the more strongly suspected areas and media may be subjected to the full priority pollutant analyses.

In general, methods such as the extraction procedure (EP) toxicity and the toxicity leaching characteristic procedure (TCLP) testing should not be used as a primary indicator of contamination. Instead, total constituent analysis should be used to indicate the magnitude and extent of contamination. If significant contamination is confirmed, then it may become necessary to conduct supplemental testing (e.g., by using EP toxicity or TCLP testing) to determine if characteristic hazardous waste definitions (based on toxicity criteria) are applicable to the particular situation.

Another noteworthy point to make relates to the analyses of groundwater samples. In this procedure, it is always important to distinguish between total (i.e., without sample filtration) and dissolved (i.e., with sample filtration) metal concentrations since the former (i.e., the total metal analyses performed without filtration) may falsely suggest extensive groundwater contamination (possibly due to the presence of naturally occurring metals associated with suspended solids).

Guidelines for the selection of analytical methods are offered elsewhere in the literature (e.g., CCME, 1993). Usually there are several methods available for most environmental analytes of interest. Some analytes may have up to a dozen methods to select from. On the other hand, some analytes may have no proven methods available. In the latter case, it usually means that some of the specific isomers that were selected as representative compounds for environmental pollution have not been verified to perform acceptably with any of the commonly used methods (CCME, 1993).

### 3.3.2 The Health and Safety Plan

Contaminated sites, by their nature and definition, contain concentrations of chemicals that may be harmful to a variety of human population groups. One significant group potentially at risk from site contamination is the field crew who enters the contaminated site to collect samples and/or to monitor the extent of contamination. To minimize risks to site workers as a result of exposure to site contamination, health and safety issues must always be addressed as part of the site characterization activities. Proper planning and execution of safety protocols will help protect the site investigation team from accidents and needless exposure to hazardous or potentially hazardous chemicals. Protecting the health and safety of the field investigation team, as well as the general public, is indeed a major concern during the investigation of potentially contaminated sites.

The objective of the Health and Safety Plan (HSP) is to specify safety precautions needed to protect the populations potentially at risk during on-site activities. Consequently, a site-specific HSP should be prepared and implemented prior to the commencement of any work activities at potentially contaminated sites.

The HSP should be developed to conform with all the requirements for occupational safety and health, and also with applicable national, state, and local laws, rules, regulations, statutes, and orders necessary to protect all populations potentially at risk. Furthermore, all personnel involved with on-site activities should have received adequate training, and there should be a contingency plan in place that meets all safety requirements. For instance, in the U.S., the HSP developed and implemented in the investigation of a potentially contaminated site should be in full compliance with all the requirements of the Occupational Safety and Health Administration (OSHA) (i.e., OSHA: 29 CFR 1910.120), the requirements of USEPA (i.e., EPA: Orders 1420.2 and 1440.3), and indeed any other relevant state or local laws, rules, regulations, statutes, and orders necessary to protect the populations potentially at risk. Also, all personnel involved with on-site activities should have received the 40-hour OSHA Hazardous Waste Operations and Emergency Response Activities (HAZWOPER) training including the 8-hour refresher course, where necessary.

Box 3.5 contains the relevant elements of a HSP that will satisfy the general requirements of a safe work activity (CDHS, 1990; USEPA, 1987). Appendix D of this book provides a generic example and format of a typical HSP, that could be tailored to the needs of a specific site.

### 3.3.2.1 Levels of Protection

Health and safety data are generally required to establish the level of protection needed for the site investigation crew entering potentially contaminated sites. Such data are also used to determine if there should be immediate concern for any population living in proximity of the site. Typically, protection at contaminated sites is categorized into four general levels:
1. **Level A**: Highest level of respiratory, skin, eye, and mucous membrane protection. This level is used if a chemical substance has been identified at concentrations that warrant using fully encapsulating equipment, or the chemical substance presents a high degree of contact hazard that warrants using fully encapsulating equipment. Work performed in a confined or poorly ventilated area also requires Level A protection until conditions change and a lower level of protection is appropriate.

2. **Level B**: Highest level of respiratory protection, but lesser level of skin and eye protection. This is the minimum level recommended during initial visits to a site until the nature of the site hazards are determined to demand less protection.

3. **Level C**: Appropriate for situations where criteria for using air-purifying respirators are met, but skin and eye exposure is unlikely. Generally, hazardous airborne substances are known and their concentrations have been measured.

4. **Level D**: No special safety equipment required other than those typically used at any construction site.

In general, safety plans should include requirements for hard hats, safety boots, safety glasses, respirators, self-contained breathing apparatus, gloves, and hazardous materials suits, if needed. In addition, personal exposure monitoring and/or monitoring ambient air concentrations of some chemicals may be necessary to meet safety regulations. Details of specific items of required safety equipment are discussed elsewhere (e.g., OBG, 1988).

The health and safety officer establishes the level of protection required and determines whether the level should be advanced or reduced. For most of the typical site activities conducted in the U.S., direct worker contact with hazardous materials in soil can be mitigated by using Health and Safety “Level-D” personal protective equipment — consisting of coveralls, safety boots, glasses, and a hard hat. To protect workers from unacceptable levels of airborne materials, at least “Level-C” equipment that includes a full-facepiece air-purifying respirator will be required. In certain other cases, worker exposure to toxic materials will be such as to warrant “Level-B” or even “Level-A” equipment, in order to provide yet greater levels of protection against exposure.

### 3.3.3 The Investigation-Derived Waste Management Plan

Investigation-derived wastes (IDWs) are those wastes generated during site characterization and remedial activities. There are several ways by which IDWs may be produced, including drill cuttings or core samples from soil boring or monitoring-well installations, drilling muds, purge water removed from sampling wells before groundwater samples are collected, water, solvents or other fluids used to decontaminate field equipment, groundwater and surface water samples that must be disposed of after analysis, and waste produced by on-site pilot-scale facilities constructed to test technologies best suited for remediation of a contaminated site. Other IDWs may result from disposable sampling equipment (DE), and disposable personal protective equipment (PPE).

The objective of an IDW management plan is to specify procedures needed to address the handling of both hazardous and nonhazardous IDWs. The site-specific procedures should prevent contamination of clean areas and should comply with existing regional and/or local regulations. Specifically, the IDW plan should include the characterization of IDW, delineation of any areas of contamination, and the identification of waste disposal methods. Ultimately, the site manager should select investigation methods that minimize the generation of IDWs.

An IDW management plan describing the storage, treatment, transportation, and disposal of any materials (both hazardous and nonhazardous) generated during a site characterization activity should be included in the project workplan. The most important elements of the IDW management approach are summarized in Box 3.6 (USEPA, 1991). To the extent practicable, the handling, storage, treatment, or disposal of any IDWs produced during site characterization and remedial activities must satisfy all regulatory requirements and stipulations that are applicable or relevant and appropriate to the site location (e.g., federal and state ARARs under EPA programs). The procedures must also satisfy any limit requirements on the amount and concentration of the hazardous substances, pollutants, or contaminants involved.

To handle IDWs properly, the site manager must, among other things, determine the waste types (e.g., soil cuttings, groundwater, decon fluids, PPE, or DE), the waste characteristics, and the quantities of anticipated wastes. Minimizing the amount of wastes generated during a site characterization activity ultimately reduces the number of IDW handling problems and costs for disposal. Insofar as possible, provisions should be made for the proper handling and disposal of IDWs on-site. In general, most regulatory agencies do not recommend removal of IDWs from the site of origin, especially in situations where the wastes do not pose any immediate threat to human health or the environment. This is because removing wastes from such sites usually would not benefit human health and the environment, and could result in an inefficient spending of a significant portion of the total funds available for the site characterization and corrective action programs.

### BOX 3.6

**Requirements for the IDW Management Process**

- Characterize IDW through the use of existing information (manifests, Material Safety Data Sheets [MSDS], previous test results, knowledge of the waste generation process, and other relevant records) and best professional judgment
- Leave a site in no worse condition than existed prior to the investigation
- Remove those wastes that pose an immediate threat to human health or the environment
- Delineate an “area of contamination” unit for leaving on-site wastes that do not require off-site disposal or extended above-ground containerization (e.g., RCRA hazardous soil cuttings)
- Comply with all regulatory requirements (e.g., federal and state ARARs) to the extent practicable
- Carefully plan and coordinate the IDW management program (e.g., containerize and dispose of RCRA hazardous groundwater, decontamination fluids, and PPE or DE [if generated in excess of 100 kg/month] at RCRA Subtitle C facilities; but leave RCRA nonhazardous soil cuttings, groundwater, and decontamination fluids — preferably without containerization and testing — on-site)
- Minimize the quantity of wastes generated
3.3.3.1 An Illustrative Decision Process for Screening IDWs

For illustrative purposes, consider an inactive site located in Southern California — at which site characterization activities are underway. Initial sampling and analysis of some drummed IDWs indicated several contaminants in both soil and groundwater samples. The question has been raised as to whether these IDWs should be put back on the site, or if they should be trucked out for off-site disposal.

The goal here is to present a decision process that will help manage the IDWs in a cost-effective manner. The process involved should ensure that the resulting decision or action does not increase site risks, and that it minimizes the quantity of IDWs that require off-site handling.

**The Decision Process**

The following discussion represents a screening procedure that will facilitate decisions on whether or not leaving soil cuttings and purged groundwater on-site will present significantly increased site risks. The rationale and justification for the proposed decision process include the following:

- Several important elements of an effective IDW management approach can be fulfilled by adopting a systematic process that allows cost-effective decisions to be made without compromising the technical effectiveness of disposal options selected to address the IDWs from the site.
- Typically, leaving IDWs on-site results in a more cost-effective way to manage such wastes without increasing risks. Based on this premise, appropriate soil IDWs can be backfilled into shallow pits or spread around the locations where the wastes had come from; appropriate liquid IDWs can be discharged and allowed to infiltrate into soils at the site.
- Should a particular site be considered a candidate for “no further action” (NFA) or closure, the proposed methodology will not reduce the likelihood of an NFA or closure decision. Conversely, returning IDWs to a site for which remediation is a likely future activity will neither affect the feasibility study program nor the remedial action selected.

Based on these rationales, one can use the proposed approach as a guide to screen and categorize the IDWs so that appropriate (i.e., technically justifiable and cost-effective) disposal practices can be selected. The methodologies involved will help determine if liquid IDWs can be discharged at the site to grade or into unlined impoundments, or if such wastes need special treatment and handling. The process should also help determine whether solid IDWs (i.e., soil cuttings) can be put back and spread out at the site of origination, or if such wastes should be disposed of in a Class III, II, or Class I landfill.

Figure 3.1 shows a flow chart for the decision process proposed for use as a guide in the screening of IDWs containing several chemical constituents. Foremost, it should be determined whether or not the IDWs constitute hazardous wastes under prevailing local regulations — in this case the California Code of Regulations (CCR). Title 22 of the CCR establishes compound-specific concentration limits (i.e., the Soluble Threshold Limit Concentrations [STLCs] and the Total Threshold Limit Concentrations [TTLCs]) for selected toxic substances, whereas Title 23 CCR contains regulations related to discharges of wastes to land. In general, the material tested is of

![Figure 3.1 Decision process for screening IDWs.](image-url)

Extraction Test (WET)](of its toxic constituents (in mg/L) equals or exceeds the STLC and/or if any of the total concentrations of its toxic constituents (in mg/kg) equals or exceeds the TTLC (CRWQCB, 1989). As appropriate, IDWs determined to be hazardous wastes may be transferred to a RCRA waste-handling facility for further management actions, or such wastes may be handled at other TSDFs.

For IDWs that are not considered hazardous following the CCR screening, further screening is conducted to determine if the wastes can be left at the site, based on appropriate regulatory limits or action levels (such as preliminary remediation goals [PRGs], background threshold concentrations, etc.). Consequently, for the chemicals that remain after the initial screening, analytical levels can be compared to local background threshold concentrations (where available), or to appropriate PRGs (e.g., the U.S. EPA Region IX PRGs), or to “total designated levels” (derived from ARARs or comparable regulatory limits, environmental attenuation factors, and leachability factors for the waste constituents [CRWQCB, 1989]). In general, where no standards are available, contaminant action levels can be established using the best scientifically
Elements of a Site Activity Plan

- Site background information summary
- Workplan objectives
- Personnel required (including training, organization, and equipment)
- Nonstandard equipment description and contract services
- Hazards expected (physical/chemical) and project impact
- Site location/contacts (including effect on sampling and remediation plans)
- Project schedule and budget
- Equipment and personnel mobilization/demobilization

should be part of the site characterization project workplan. The plan requirements will typically relate to, but not be limited to the following: the use of blanks, spikes, and duplicates; sampling procedures, cleaning of sampling equipment, storage, transportation, DQOs/chain-of-custody, and methods of analysis. The practices to be followed by the site investigation team and the oversight review which will ensure that DQOs are met, must be clearly described in the QNQC plan.

Some aspects of the field program can and should be subjected to a quality assessment survey. This is accomplished by submitting sample blanks (alongside the environmental samples) for analysis on a regular basis. The various blanks and checks are recommended as part of the quality assurance plan include the following (CCME, 1994):

- **Trip Blank:** required to identify contamination of bottles and samples during travel and storage. To prepare the trip blank, the laboratory fills containers with contaminant-free water and delivers them to the sampling crew; the field sampling crew subsequently ship and store these containers with the actual samples obtained from the site characterization activities. It is recommended to include one trip blank per shipment, especially where volatile contaminants are involved.

- **Field Blank:** required to identify contamination of samples during collection.

  This is prepared in the same manner as the trip blank (i.e., the laboratory fills containers with contaminant-free water and delivers them to the sampling crew); subsequently, however, the field sampling crew expose this water to site air (just like the actual samples obtained from the site characterization activities). It is recommended to include one field blank per site or sampling event/day.

- **Equipment Blanks:** required to identify contamination from well and sampling equipment. To obtain an equipment blank, casing materials and sampling devices are flushed with contaminant-free water, which is then analyzed. Typically, equipment blanks become important only if a problem is suspected, such as using a bailer to sample from multiple wells.

- **Blind Replicates:** required to identify laboratory variability. To prepare the blind replicate, a field sample is split into three containers and labeled as different samples before shipment to the laboratory for analyses. It is recommended to include one blind replicate per day, or an average of one per 10 to 25 samples where large numbers of samples are involved.

  - **Spiked Samples:** required to identify errors due to sample storage and analysis.

    To obtain the spiked sample, known concentration(s) are added to the sample bottle and then analyzed. It is recommended to include one spiked sample per site, or an average of one per 25 samples where large numbers of samples are involved.

Data generated during a site characterization will provide a basis for site restoration decisions. The data should therefore give a valid representation of the true site conditions. The development and implementation of a QNQC program during a sampling and analysis program is critical to obtaining reliable analytical results. The soundness of the QA/QQC program has a particularly direct bearing on the integrity of the environmental sampling and also the laboratory work. Thus, the general design process for an adequate QNQC program, as discussed elsewhere in the literature (e.g., CCME, 1994; USEPA, 1987b, 1987c), should be followed religiously.

3.4 THE IMPLEMENTATION OF A SITE INVESTIGATION PROGRAM

Site investigations are conducted in order to characterize site conditions and environmental samples collected from the site. Collected samples will generally be submitted to a certified analytical laboratory for analysis. The sample characterization considers detailed information in relation to the following:

- Field operations (including the role of individuals, chain-of-custody procedures, maintaining field log book, and site monitoring)
- Sampling locations and rationale
- Field sampling and mapping
- Field quality control samples
- Decontamination procedures
- Analytical requirements and sample handling
- Sample delivery
- Data compilation and analyses
- Summary site evaluations

Essentially, the characterization of environmental samples helps determine the specific type(s) of contaminants, their abundance/concentration, the lateral and vertical extent of contamination, the volume of materials involved, and the background contaminant levels for native soils and water resources in the vicinity of the site.

3.4.1 Initial Site Inspection

Geophysical surveys, limited field screening, or limited field analyses may be performed during an initial site inspection. These types of preliminary screening activities may help determine the variability of the media, provide general interest
Table 3.3A (continued)  Proposed Contaminant Limits for Screening Soil Cutting Investigation-Derived Wastes (IDWs) for On-Site Disposal to a Hypothetical Site Located in Southern California

<table>
<thead>
<tr>
<th>Analyte/Compound</th>
<th>Action Level Based on the U.S. EPA Region IX Preliminary Remediation Goal (mg/kg)</th>
<th>Total Designated Level Based on ARARs (as an Action Level) (mg/kg)</th>
<th>Local Background Threshold Concentration (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Volatile</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>300</td>
<td>20</td>
<td>NA</td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td>5.1</td>
<td>3.2</td>
<td>NA</td>
</tr>
<tr>
<td>2-Butanone (methyl ethyl ketone)</td>
<td>5,200</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>4- Methyl-2-pentanone (MIBK)</td>
<td>1,590 (estimate)</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Acetone</td>
<td>13,000</td>
<td>70</td>
<td>NA</td>
</tr>
<tr>
<td>Benzene</td>
<td>4.6</td>
<td>0.1</td>
<td>NA</td>
</tr>
<tr>
<td>Carbon disulfide</td>
<td>74</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>cis-1,2-Dichloroethene</td>
<td>300</td>
<td>0.6</td>
<td>NA</td>
</tr>
<tr>
<td>Dichloromethane (methylene chloride)</td>
<td>39</td>
<td>10</td>
<td>NA</td>
</tr>
<tr>
<td>Ethyl Benzene</td>
<td>310</td>
<td>68</td>
<td>NA</td>
</tr>
<tr>
<td>Tetrachloroethylene (PCE)</td>
<td>58</td>
<td>0.5</td>
<td>NA</td>
</tr>
<tr>
<td>Toluene</td>
<td>280</td>
<td>100</td>
<td>NA</td>
</tr>
<tr>
<td>Trichloroethylene (TCE)</td>
<td>25</td>
<td>0.5</td>
<td>NA</td>
</tr>
<tr>
<td>Trichloromethane (Chloroform)</td>
<td>1.6</td>
<td>10</td>
<td>NA</td>
</tr>
<tr>
<td>Xylenes (total)</td>
<td>99</td>
<td>175</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Semivolatile</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-Methylnaphthalene</td>
<td>NA</td>
<td>0.7 (based on PQL)</td>
<td>NA</td>
</tr>
<tr>
<td>4-Methylphenol</td>
<td>5,100</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Anthracene</td>
<td>1.9</td>
<td>960</td>
<td>NA</td>
</tr>
<tr>
<td>Benzo(a)anthracene</td>
<td>3.9</td>
<td>0.01</td>
<td>NA</td>
</tr>
<tr>
<td>Benzo(a)pyrene</td>
<td>0.39</td>
<td>0.02</td>
<td>NA</td>
</tr>
<tr>
<td>Benzo(b)fluoranthene</td>
<td>3.9</td>
<td>0.02</td>
<td>NA</td>
</tr>
<tr>
<td>Benzo(g,h,i)perylene</td>
<td>NA</td>
<td>0.00028</td>
<td>NA</td>
</tr>
<tr>
<td>Benzo(k)fluoranthene</td>
<td>3.9</td>
<td>0.00028</td>
<td>NA</td>
</tr>
<tr>
<td>Benzoic acid</td>
<td>100,000</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Bis(2-ethylhexyl)phthalate</td>
<td>200</td>
<td>0.4</td>
<td>NA</td>
</tr>
<tr>
<td>Butylbenzylphthalate</td>
<td>100,000</td>
<td>10</td>
<td>NA</td>
</tr>
<tr>
<td>Carbazole</td>
<td>140</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Chrysene</td>
<td>390</td>
<td>0.02</td>
<td>NA</td>
</tr>
<tr>
<td>Dibenzo(a,h)anthracene</td>
<td>0.39</td>
<td>0.03</td>
<td>NA</td>
</tr>
<tr>
<td>Dibenzofuran</td>
<td>NA</td>
<td>0.001 (estimate)</td>
<td>NA</td>
</tr>
<tr>
<td>Diethyphthalate</td>
<td>100,000</td>
<td>2,300</td>
<td>NA</td>
</tr>
<tr>
<td>Di-n-butylphthalate</td>
<td>204,000 (estimate)</td>
<td>3,000 (estimate)</td>
<td>NA</td>
</tr>
<tr>
<td>Di-n-octylphthalate</td>
<td>20,000</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Fluoranthene</td>
<td>41,000</td>
<td>30</td>
<td>NA</td>
</tr>
<tr>
<td>Fluorene</td>
<td>28</td>
<td>130</td>
<td>NA</td>
</tr>
<tr>
<td>Indeno(1,2,3-c,d)pyrene</td>
<td>3.9</td>
<td>0.04</td>
<td>NA</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>80</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Pentachlorophenol</td>
<td>24</td>
<td>0.1</td>
<td>NA</td>
</tr>
<tr>
<td>Phenanthrene</td>
<td>NA</td>
<td>10 (estimate)</td>
<td>NA</td>
</tr>
<tr>
<td>Pyrene</td>
<td>31,000</td>
<td>96</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Pesticides/Herbicides/PCBs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4,4' - DDT</td>
<td>8.4</td>
<td>0.001</td>
<td>NA</td>
</tr>
<tr>
<td>Aldrin</td>
<td>0.17</td>
<td>0.005</td>
<td>NA</td>
</tr>
<tr>
<td>alpha - BHC (HCH alpha)</td>
<td>0.45</td>
<td>0.07</td>
<td>NA</td>
</tr>
<tr>
<td>gamma - BHC (Lindane)</td>
<td>2.2</td>
<td>0.4</td>
<td>NA</td>
</tr>
<tr>
<td>Polychlorinated Biphenyls (PCBs)</td>
<td>0.37</td>
<td>0.05</td>
<td>NA</td>
</tr>
</tbody>
</table>

**Notes:**
This list represents analytical parameters with results above their detection limits.
NA = not available/applicable.
PQL = sample/practical quantitation limit.
USEPA Region IX Preliminary Remediation Goals (PRGs) are reported for industrial soils.
Total Designated Levels are estimated by applying an attenuation factor (of 100 for inorganics and 10 for organics) and a leachability factor of 1–100 to appropriate regulatory limits.
### Proposed Contaminant Limits for Screening Groundwater Investigation-Derived Wastes (IDWs) for On-Site Disposal to a Hypothetical Site Located in Southern California

#### Screening Levels for Liquid Wastes (Groundwater)

<table>
<thead>
<tr>
<th>Analyte/Compound</th>
<th>Action Level Based on the U.S. EPA Region IX Preliminary Remediation Goals (mg/L)</th>
<th>Total Designated Level Based on ARARs and Regulatory Limits (mg/L)</th>
<th>Local Background Threshold Concentration (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Metals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td>3,700</td>
<td>100</td>
<td>1.2</td>
</tr>
<tr>
<td>Antimony</td>
<td>15</td>
<td>0.6</td>
<td>0.026</td>
</tr>
<tr>
<td>Beryllium</td>
<td>0.002</td>
<td>0.4</td>
<td>0.0003</td>
</tr>
<tr>
<td>Cadmium</td>
<td>1.8</td>
<td>1</td>
<td>0.01</td>
</tr>
<tr>
<td>Chromium (total)</td>
<td>3,700</td>
<td>5</td>
<td>0.06</td>
</tr>
<tr>
<td>Chromium (VI)</td>
<td>18</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Iron</td>
<td>NA</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Lead</td>
<td>0.4</td>
<td>5</td>
<td>0.01</td>
</tr>
<tr>
<td>Manganese</td>
<td>18</td>
<td>5</td>
<td>2.6</td>
</tr>
<tr>
<td>Nickel</td>
<td>73</td>
<td>10</td>
<td>0.05</td>
</tr>
<tr>
<td>Selenium</td>
<td>18</td>
<td>10</td>
<td>0.05</td>
</tr>
<tr>
<td>Thallium</td>
<td>0.29 (estimate)</td>
<td>0.2</td>
<td>0.005</td>
</tr>
<tr>
<td><strong>Volatiles</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1-Dichloroethane</td>
<td>10</td>
<td>0.05</td>
<td>NA</td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>0.00068</td>
<td>0.06</td>
<td>NA</td>
</tr>
<tr>
<td>2-Butanone (MEK)</td>
<td>25</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Acetone</td>
<td>7.7</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>cis-1,2-Dichloroethene</td>
<td>0.77</td>
<td>0.06</td>
<td>NA</td>
</tr>
<tr>
<td>Dichloromethane (methylene chloride)</td>
<td>0.062</td>
<td>0.05</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Semivolatiles</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toluene</td>
<td>9.3</td>
<td>10</td>
<td>NA</td>
</tr>
<tr>
<td>trans-1,2-Dichloroethene</td>
<td>1.5</td>
<td>0.1</td>
<td>NA</td>
</tr>
<tr>
<td>Trichloroethylene(TCE)</td>
<td>0.025</td>
<td>0.05</td>
<td>NA</td>
</tr>
<tr>
<td>Trichlorofluoromethane</td>
<td>17</td>
<td>1.5</td>
<td>NA</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>0.00028</td>
<td>0.005</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Notes:</strong></td>
<td>This list represents analytical parameters that exceeded state and/or federal MCLs for groundwater IDWs, or where the analytical results are above their detection limits where no MCLs exist. NA = not available/applicable. PQL = sample/practical quantitation limit. USEPA Region IX Preliminary Remediation Goals (PRGs) are reported for tap water; the groundwater action levels are estimated by applying an attenuation factor (of 100 for inorganics and 10 for organics) to the PRG. Total Designated Levels are estimated by applying an attenuation factor (of 100 for inorganics and 10 for organics) to an ARAR or other regulatory limit.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
justifiable information and professional judgment made on a site- and matrix-specific basis. If the contaminant concentrations in the IDWs fall within the range provided by the action levels (viz., background thresholds, PRGs, total designated levels, etc.), then an “acceptable” contaminant concentration is indicated, which should allow the IDWs to be put back on-site.

Use of the proposed approach will enable logical and consistent waste management decisions to be made, and will help determine which categories of IDWs can be disposed of at the site of origin. The overall decision process will also allow a systematic determination to be made as to whether an IDW contains hazardous substances, and whether the hazardous substances are present in such amounts as to be of significant concern, or to constitute RCRA hazardous wastes, or to be considered as Titles 22 and 23 CCR wastes, or to be perceived as wastes requiring regulation under other statutes. It is expected that this type of site-specific and matrix-specific decision process used to screen IDWs for on-site disposal will result in a more cost-effective way to manage such wastes than would otherwise be the case.

**Proposed Contaminant Limits for an Example Problem**

Tables 3.3A and 3.3B show the contaminant screening limits proposed for use as a guide in the screening of IDWs from the hypothetical site contaminated by a suite of chemicals shown in these tables. By comparing analytical results of the IDWs with the background thresholds, PRGs, and/or total designated levels shown in these tables, a decision can be made on the “status” of specific IDWs. If the contaminant concentrations in the IDWs fall within the range provided by the action levels, then, in general, the IDWs may be put back on the site.

3.3.4 The Site Activity Plan

The objective of the site activity plan is to review and critically evaluate previous site investigation activities, establish goals for proposed new activities, describe the proposed site activities (to include their relevance, possible impact, execution criteria, and associated logistical requirements), establish procedures/methods to be followed during the execution of site activities, and to confirm the format for reporting the results of site activities. Box 3.7 lists several specific elements required as part of a detailed site activity workplan (USEPA, 1985, 1989b).

3.3.5 The Quality Assurance/Quality Control Plan

Quality assurance (QA) refers to a system for ensuring that all information, data, and resulting decisions compiled from an investigation (e.g., monitoring and sampling tasks) are technically sound, statistically valid, and properly documented. The QA program consists of a system of documented checks used to validate the reliability of a data set.

Quality control (QC) is the mechanism through which quality assurance achieves its goals. Quality-control programs define the frequency and methods of checks, audits, and reviews necessary to identify problems and corrective actions, thus verifying product quality. All QC measures should be performed for at least the most sensitive chemical constituents from each sampling event/date.

A detailed quality assurance/quality control (QA/QC) plan describing specific requirements for QA and QC of both laboratory analysis and field sampling/analysis.
background information, or determine if the site conditions have changed in comparison to what may have been reported in previous investigations.

Typically, the goals of the initial site inspection include the accomplishment of several tasks, as indicated in Box 3.8. Available information should be carefully reviewed and evaluated to provide the foundation for executing additional on-site activities. The preliminary data receive confirmation from observations made during site visits. The types of information generated serve as a useful database for project scoping. The review and initial site visit are used in a preliminary interpretation of site conditions.

### 3.4.2 Sampling and Sample Handling Procedures

The collection of representative samples generally involves different procedures for different situations. USEPA (1987), among others, discusses several sampling methods that can be used in various types of situations. In every situation, all sampling equipment is cleaned using a nonphosphate detergent, a tap-water rinse, and a final rinse with distilled water prior to a sampling activity. Decontamination of equipment is necessary so that sample results do not show false positives. Decontamination water generated from the site activities (e.g., during decontamination of hand-auger and soil-sampling equipment) is transferred into containers and sampled for analysis.

All sampling should be conducted in a manner that maintains sample integrity and encompasses adequate quality assurance and control. Specific sample locations should be chosen such that representative samples can be collected. Also, samples should be collected from locations with visual observations of surface contamination, so that possible worst-case conditions may be identified. The use of field blanks and standards, and also spiked samples, can account for changes in samples which occur after sample collection. The following general statements apply to most sampling efforts:

- Refrigeration and protection of samples should minimize the chemical alteration of samples prior to analysis.
- Field analyses of samples will effectively avoid biases in determinations of parameters/constituents which do not store well (e.g., gases, alkalinity, pH).
- Field blanks and standards will permit the correction of analytical results for changes which may occur after sample collection (i.e., during preservation, storage, and transport). That is, field blanks and standards enable quantitative correction for biases due to systematic errors arising from handling, storage, transport, and laboratory procedures.
- Spiked samples and blank controls provide the means to correct combined sampling and analytical accuracy or recoveries for the actual conditions to which the samples have been exposed.

In general, sampling equipment should be constructed of inert materials. Collected soil samples are placed in resealable plastic bags; fluid samples are placed in air-tight glass or plastic containers. When samples are to be analyzed for organic constituents, glass containers are required. The samples are then labeled with an indelible marker. Each sample bag or container is labeled with a sample identification number. Sample depth (where applicable), sample location, date, and time of sample collection, preservation and possibly a project number and the sampler's initials (a chain-of-custody form listing the sample number, date and time of sample collection, analyses requested, a project number, and persons responsible for handling the samples) is then completed. Samples are generally kept on ice prior to and during transport/shipment to a federal- or state-certified laboratory for analysis; completed chain-of-custody records should accompany the samples to the laboratory. Further details of the appropriate technical standards for sampling and sample handling procedures can be found in the literature (e.g., CCME, 1994; CDHS, 1990).

### 3.4.3 Monitoring Programs

Decisions regarding monitoring network design and operation are generally made in the light of available data. To a great extent, monitoring can be considered as an evolutionary process that should be refined as more relevant information is obtained. In fact, effective monitoring efforts are both dynamic and flexible, and this should be explicitly indicated in the site characterization plan. Overall, it is prudent to specify monitoring programs that will permit the collection of high-quality, representative data for the most sensitive chemical constituents of interest.

Most monitoring programs designed for contaminated site problems are directed at groundwater investigations and, to some extent, surface water quality assessment. The practical elements of a viable long-term groundwater monitoring effort typically will consist of an evaluation of the hydrogeologic setting, proper well placement and construction, evaluation of well performance and purging strategies, and the execution of effective sampling protocols (to include the selection of appropriate sampling mechanisms and materials, as well as sample collection and handling procedures) (USEPA, 1985). Most of these elements, or variations thereof, are also applicable to monitoring programs in other environmental media.
REFERENCES


