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Ground Water Surveillance Monitoring Implementation Guide for Use with DOE O 450.1, *Environmental Protection Program*

[This Guide describes suggested nonmandatory approaches for meeting requirements. Guides are not requirements documents and are not to be construed as requirements in any audit or appraisal for compliance with the parent Policy, Order, Notice, or Manual.]

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PREFACE

This Guide is one of a series issued to provide suggested approaches for meeting the requirements of DOE O 450.1 *Environmental Protection Program,* dated 1-15-03, which requires Department of Energy (DOE) Organizations to establish an environmental management system that is part of DOE's Integrated Safety Management System. This Guide provides a description of the elements of an integrated site-wide ground water surveillance monitoring program that can be adapted to unique physical conditions and programmatic needs at each DOE site to meet the requirements of DOE O 450.1.

This Guide is approved for use by the DOE Office of Environment, Safety and Health and is available for use by all DOE elements, including the National Nuclear Security Administration, and their contractors. Suggestions for corrections or improvements to this Guide should be addressed to—

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GROUND WATER SURVEILLANCE MONITORING IMPLEMENTATION GUIDANCE

1. INTRODUCTION.

The purpose of this guidance is to assist Department of Energy (DOE) sites in establishing and maintaining surveillance monitoring programs to detect future impacts on ground water resources from site operations, to track existing ground water contamination, and to assess the potential for exposing the general public to site releases. This implementation guidance—

- describes the essential elements of a site-wide ground water surveillance monitoring network,
- distinguishes the objectives of a surveillance network from a network designed to meet specific external regulatory requirements related to restoration,
- distinguishes short-term monitoring program goals from long-term stewardship monitoring goals, and
- addresses the integration of existing ground water monitoring activities into the site-wide monitoring network.

The concept of an "integrated monitoring program" is based on avoiding or eliminating numerous systems and procedures and their associated costs for achieving the same or similar goals. Ground water monitoring should be viewed as a site-wide activity and the provision of ground water monitoring data as a service that meets the needs of any individual program or activity.

In addition to providing real time environmental measurements for estimating potential human exposure, the site-wide ground water surveillance monitoring system should provide a mechanism for detecting releases to the subsurface environment from a DOE facility or activity that will trigger an appropriate response to prevent or minimize adverse impacts on ground water resources.

The emphasis of this guidance is the creation and maintenance of a site-wide surveillance monitoring program at each DOE site to serve as the basis for long-term surveillance for environmental stewardship.

Section 2 of this Guide addresses integrating internal and external ground water monitoring requirements contained in the following.

- Title 10 Code of Federal Regulations (CFR), 830, Nuclear Safety Management.
- DOE O 450.1, *Environmental Protection Program*, dated 1-15-03.

- DOE 5400.5, *Radiation Protection of the Public and the Environment*, dated 1-7-93.

- DOE O 435.1, *Radioactive Waste Management*, dated 8-28-01.

- DOE M 435.1-1, Radioactive Waste Management Manual, dated 6-19-01.

- DOE G 435.1-1, Chapter 4, *Low-Level Waste Requirements,* dated 7-9-99.

This Guide is a companion document to *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (DOE-EH-0173T, January 1991). Unlike EH-0173T, this guidance addresses radiological and nonradiological ground water monitoring. It does not, however, address the technical aspects of monitoring well construction, sampling or analytical techniques, or innovative technology.

Section 3 addresses the objectives of a site-wide surveillance monitoring program in the context of internal DOE Order requirements for environmental protection, with emphasis on the maintenance and continual optimization of a network designed to provide surveillance over extended periods of time. It also addresses vadose zone monitoring as a possible component of a ground water surveillance monitoring network.

Section 4 discusses the concept of a site-wide monitoring network and the technical basis for its design. Although it is important to design a unique ground water monitoring network that provides information for meeting each specific program objective (e.g., external regulatory requirements, DOE Order requirements), it is also necessary to integrate the individual networks in such a way that individual monitoring wells can be incorporated into more than one network, as appropriate, to achieve cost efficiencies and to optimize the information provided by each well.

Section 5 addresses the integration of DOE Order requirements for surveillance monitoring with requirements of external regulations [the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), etc.] for compliance monitoring.

Section 6 discusses the site-wide program and the need for continuing program evaluation as site conditions change over time and provides suggested criteria for monitoring program optimization.

Section 7 addresses the need for ensuring adequate funding for the ongoing site-wide program.

2. DOE REGULATIONS AND ORDER REQUIREMENTS RELATED TO GROUND WATER MONITORING.

There are specific requirements contained in various DOE Orders that relate to the site-wide ground water surveillance monitoring network. The following discussion cites each specific requirement. Each DOE site should meet these requirements in a manner that is appropriate for the site's unique conditions. It is important, however, for each DOE site to consider the integration of these requirements in designing and upgrading a surveillance monitoring network that is cost effective.

a. 10 CFR, Part 830, Nuclear Safety Management.

All DOE nuclear facilities must perform work in accordance with a safety basis that ensures adequate protection of workers, the public, and the environment. According to DOE's General Statement of Safety Basis Policy (10 CFR, Part 830, Subpart B, Appendix A), the safety basis requirements are generally met by a site-wide Integrated Safety Management System (ISMS) that includes programs that adequately protect the environment. A ground water surveillance monitoring program with appropriately designed networks for each nuclear facility subject to 10 CFR Part 830 is an integral component of the site-wide ISMS and must be developed and maintained to ensure compliance with 10 CFR Part 830.

b. DOE O 450.1, Environmental Protection Program.

The Order requires that each DOE site implement an environmental management system (EMS) as part of the site's ISMS. The site-wide EMS must provide for the systematic planning, integrated execution, and evaluation of programs that ensure public health and environmental protection, pollution prevention, and compliance with DOE Directives and applicable laws and statutes. An effective EMS should integrate plans, procedures, and program assessment and corrective actions.

DOE sites are responsible for EMSs that will ensure the early identification of environmental impacts from DOE operations and ensure appropriate responses are taken. DOE facilities are responsible for integrating the EMS into the ISMS to consider, as appropriate, the protection of—

- surface and ground water,
- natural resources and biota,
- site resources from wildland and operational fires, and
- cultural resources.

DOE operations/field/site office managers are responsible for implementing DOE O 450.1 requirements for—

- annual budgetary planning and pollution prevention program implementation and monitoring;
- environmental monitoring to detect, characterize, and respond to releases from DOE activities; and
- a consistent, validated approach for environmental sampling and analysis.

To achieve a fully integrated, site-wide ground water surveillance monitoring program and to meet the DOE O 450.1 requirements noted above, DOE field and site office managers must develop the structure of the site-wide program, determine resource needs, evaluate program performance, and identify benefits to be obtained from an integrated program. Headquarters program office managers must provide consistent overall direction to their field and site office counterparts and provide consistent funding to support the integrated program. Section 5 discusses program integration in more detail. Section 7 discusses the need for a consistent source of funding for the integrated program.

c. DOE 5400.5, Radiation Protection of the Public and the Environment.

The Order sets standards for DOE sites and DOE contractors that manage radioactive materials. It includes statements of DOE's radiation protection program objectives.

DOE sites must demonstrate compliance, through effluent monitoring and surveillance programs, with DOE 5400.5 requirements for protecting the general public and the environment. The 5400 series of DOE Directives provide requirements for ensuring that effluent monitoring and environmental surveillance programs are of good quality. DOE 5400.5, Chapter II, describes DOE's policy on protecting the public and the environment from radiological releases by setting a DOE public dose limit (100 millirems annual effective dose equivalent). The chapter also requires that compliance with the dose limits include measurements and calculations to evaluate potential doses and the results of the evaluations. The Order provides further direction on the specific monitoring requirements for compliance with the dose limits.

Environmental monitoring programs developed to comply with DOE 5400.1 (*General Environmental Protection Program,* dated 11-9-88) should continue to be implemented and should be revised, where appropriate, based on this guidance. The recommendations in this guidance should be used to upgrade site-wide monitoring programs to ensure that DOE 5400.5 requirements continue to be met in an effective and efficient manner. A fully integrated site-wide monitoring program should provide sufficient information on releases to the subsurface to allow estimates of radiological dose to demonstrate compliance with DOE 5400.5 dose limits.

d. DOE O 435.1, Radioactive Waste Management, and DOE M 435.1-1, Radioactive Waste Management Manual.

DOE O 435.1 and DOE M 435.1-1 contain specific requirements for management of radioactive waste pursuant to DOE's statutory authority (the Atomic Energy Act and related legislation). The Manual defines procedural requirements and existing practices for DOE organizations and contractors to manage radioactive waste to protect workers, the general public, and the environment.

Chapter I of DOE M 435.1-1 identifies requirements for environmental monitoring at radioactive waste management facilities, operations, and activities that comply with DOE 5400.1 and DOE 5400.5. DOE M 435.1-1 contains additional monitoring requirements for waste facilities (high level, transuranic, and low level) to ensure that passive and active control systems have not failed. The Manual also requires that low-level radioactive waste disposal facilities implement environmental monitoring programs designed to measure and evaluate releases, migration of radionuclides, disposal unit subsidence, and changes in disposal site/facility parameters that could affect long-term performance. DOE G 435.1-1 includes additional guidance for long-term disposal facility performance monitoring, including measuring to detect releases to the subsurface environment.

3. SURVEILLANCE MONITORING.

a. Objectives for the Design of a Site-Wide Surveillance Monitoring Network.

Surveillance monitoring is performed to detect at the earliest possible time any impact on ground water from an operating facility or practice at a DOE site. A surveillance monitoring network should include observation points located and sampled based on prioritized areas of the site where the ground water may be particularly vulnerable to contamination. At many DOE sites, observation points are appropriately located in the unsaturated zone since the occurrence of ground water that may be vulnerable to contamination from DOE activities is well below the surface (i.e., hundreds of feet below ground surface). Early detection of a release to the subsurface may necessitate vadose zone monitoring to detect releases before the ground water is affected.

Objectives of surveillance monitoring are likely to include, but will be broader than, the objectives of a monitoring network designed to control and remediate existing ground water contamination. Where active remediation is being implemented, surveillance monitoring is performed to track existing contamination. Such a monitoring network is designed to identify the dimensions of the contaminated area, to measure contaminant migration and changes in contaminant concentrations over time, and to evaluate the effectiveness of remedial action.

Surveillance monitoring also should address areas that are not already subject to external ground water monitoring. Surveillance monitoring is performed to determine whether the ground water is being affected by site-wide operations that involve management of wastes or other materials that are a potential future source of contamination.

The broader, long-term objective of surveillance monitoring is to provide an early warning to trigger response to unplanned releases to the subsurface. As such, a surveillance monitoring network is designed to anticipate what could happen that may trigger a response according to the contingency plan discussed below. Ground water monitoring data should routinely be compared to an appropriate standard (e.g. local background concentrations, risk-based screening levels), using appropriate quantitative statistical tests, to provide an indication of a potential release.

The site-wide ground water surveillance monitoring network should be designed to meet specific short-term and long-term program objectives. Short-term objectives would typically consider active site-wide operations and active or inactive facilities that are not already subject to external environmental protection requirements. Some examples of these facilities and activities include—

- radioactive material storage areas;
- research or production reactors, both active and inactive;
- underground and above ground liquid storage facilities and associated piping;
- irrigation systems;
- sanitary sewer systems;
- industrial wastewater treatment systems;
- vehicle repair and maintenance systems;
- improperly constructed wells;
- past practice waste management sites, including former soil column discharge sites;
- abandoned wells;
- surplus or decommissioned buildings and facilities; and
- new construction sites.

After considering the materials managed at each site and the vulnerability to contamination of ground water resources in the area, surveillance monitoring networks should be designed to detect any future releases to the subsurface from these and other such facilities and activities.

Additionally, a site-wide ground water surveillance monitoring network should be designed to meet long-term objectives for areas where wastes and other subsurface contaminants will remain after all active site operations have ceased. These long-term objectives, which may fall into the category of environmental stewardship, address closed waste disposal units and contaminated areas of the subsurface where active remediation has ceased. In such circumstances, physical containment measures and control systems and institutional access controls have been established to provide primary long-term care. (Specific stewardship requirements are frequently included in CERCLA Records of Decision and RCRA post-closure permits.) Surveillance monitoring should be considered as a secondary or backup control system with the primary objective of detecting releases following failure of primary controls. The site-wide surveillance monitoring network should be designed to meet specific CERCLA or RCRA requirements and to provide long-term surveillance beyond the time period where the applicability of the external requirements has ceased.

The ground water surveillance monitoring network should be reviewed periodically and revised as necessary. As time passes, conditions change and the efficiency of the monitoring network needs to be continuously reevaluated. It is possible that certain facilities or practices that had been considered high priority areas for potential future releases to the subsurface no longer present any significant threat to the ground water resources. This could occur if a practice ceased (e.g., a material storage area has been moved), an active facility is no longer in operation, or hazardous or radioactive materials are no longer managed at the site.

It is also necessary to periodically revise the sampling plan for the surveillance monitoring network to reflect changing conditions at the site. As historical data is gathered and analyzed, frequency of sampling and types of analyses performed may be reevaluated and modified to provide more useful information. Optimization software is available to allow program managers to statistically determine the value of data provided by the monitoring network and to propose modifications, where appropriate.

b. <u>Contingency Plans</u>.

A carefully prepared contingency plan is a critical element in a site-wide ground water surveillance monitoring network. Fundamentally, the contingency plan identifies ranges of action levels and corresponding responses to be taken if contaminants are detected in the surveillance monitoring network. The contingency plan should define actions or responses to the detection of contaminant releases associated with a facility or practice that is the object of the surveillance monitoring network, the detection of ground water plumes that have migrated further than predicted, or the detection of a contaminant that is unexpected and requires investigation to determine its source.

Appropriate actions or responses could range from a simple matter of comparing monitoring results against a regulatory standard or a risk assessment guideline, to resampling more frequently, to reporting the detection level to external regulators, to conducting a site investigation to determine the source and need for corrective action. The contingency plan also should provide guidance on lines of authority and responsibility for invoking contingencies and for reporting and evaluating results. The data quality objectives (DQO) process described in Section 4 should be followed in the development and revision of a site-wide contingency plan and in the design of a site-wide monitoring network.

c. Site-Wide Review of Historic and Current Operations and Practices.

Each site should institutionalize a process for periodic site-wide review of historic operations and practices that may have affected ground water or current practices that could have impact in the future. The site-wide review should provide input to periodic reevaluation and revision of the surveillance monitoring network. Although most DOE sites have performed site characterizations to determine the extent of existing contamination and the size and scope of remedial actions needed, there is a need to periodically revisit areas of the site that may not have been included in ongoing remedial actions but may have experienced impact from site-wide operations or may be vulnerable to future contamination resulting from new site operations.

The site-wide review of historic and current operations should be conducted at a frequency and scale appropriate for the site's history and current or future mission. Such a review will have additional benefits for new technical staff who will not have had the advantage of institutional memory in providing an opportunity to identify past practices that may be having an impact on the ground water that had not previously occurred or been detected.

d. Prioritization of Vulnerable Areas of the Site.

There should be a process for assigning priority to site areas where ground water may be vulnerable to contamination and may, therefore, need to be included in the surveillance monitoring network. Such prioritization should be used to formulate future budget requests. Since budgetary and other constraints are always a limitation on the size and scope of the monitoring program, a system is needed to prioritize potentially vulnerable areas. Whenever a review of site-wide historic and current operations and practices is performed, or whenever new activities, new construction, or new missions for existing facilities are initiated, there is a need to determine the vulnerability of local ground water resources and to reevaluate priorities for the current surveillance monitoring network.

e. Subsurface Characterization and Hydrology.

The basic hydrogeologic conditions of the site should be identified and quantified to the extent possible to construct an adequate ground water surveillance monitoring network. Most DOE sites have extensive historical knowledge of subsurface geologic and hydrologic conditions and water quality monitoring results. It is important that this information be assessed consistently when designing or modifying a site-wide surveillance monitoring network. Frequently, models are employed to evaluate ground water conditions at a local area (a waste management unit or an area where active ground water remediation is being performed) or for a short-term purpose (e.g., for plume identification as part of a CERCLA remedial investigation).

In designing a site-wide monitoring system, it is important to construct a site-wide conceptual model of the subsurface. This conceptual model should be based on observed data from previous subsurface investigations, and it should also be the basis for future characterization. It is important to perform a site-wide water balance to ensure that the occurrence and movement of water onto and away from the site and flow conditions within the site are accounted for when designing an effective surveillance monitoring system. In the ongoing process of monitoring system optimization, it will always be necessary to reevaluate the conceptual model, based on new monitoring data, and to use the revised and more accurate conceptual model to reevaluate the monitoring system. This process provides continual improvement to the system and greater value to the users of ground water surveillance monitoring data.

4. MONITORING NETWORK DESIGN.

a. What Constitutes a Monitoring Network?

Ground water monitoring wells, vadose zone monitoring techniques, piezometers, springs, seeps, and other observation points where measurements are taken constitute the site-wide ground water monitoring network. Each observation point should be a component of one or more unique facility-specific or area-specific monitoring networks. A facility-specific monitoring network is a unique set of ground water observation points designed to detect releases to the subsurface that have affected the ground water or may cause ground water impact in the future. A series of ground water and vadose zone monitoring wells and methods that have been placed up and down gradient from, and below, an operating facility (e.g., a reactor, an accelerator, a low-level radioactive waste disposal unit) is an example of a facility-specific network. The information provided by this network of wells will allow site managers to determine whether any releases from the facility are occurring that may trigger specific actions included in the site-wide contingency plan, discussed in Section 3.

An area-specific monitoring network is a unique set of ground water observation points designed to monitor existing subsurface conditions (i.e., hydrological parameters and contaminant concentration levels) to determine if significant deviations from expected conditions are observed that may warrant further investigation. An example of an area-specific network is a series of wells designed to monitor a contaminant plume where active remediation has ceased and monitored natural attenuation is being implemented. Another example is a series of wells within the site boundary designed to determine whether contaminants from any one of a number of possible sources may potentially affect off-site ground water resources.

A series of monitoring wells designed to measure the effectiveness of active remediation of a contaminant plume, as a component of a CERCLA or RCRA remedial action, is another type of ground water monitoring network. This type of network which is typically developed and described in a regulatory compliance document should also be included in a surveillance monitoring network, either facility-specific or area-specific. Monitoring performed to comply with external regulatory requirements provides the framework for the long-term monitoring program that will provide surveillance and site maintenance information for closed waste management units and passive remediation sites. Eventually, active remediation will be completed and post-closure monitoring and maintenance will become the responsibility of appropriate DOE program offices and field elements. The monitoring network developed to provide information on current remediation activities should continue to be modified to address needs for long-term site surveillance.

The description of the site-wide surveillance monitoring network, and identification of facility- and area-specific networks should be included in a site-wide monitoring plan, as discussed later in this section. Each network should be made up of designated wells or observation points. The plan should specify frequency of sampling and specific data to be obtained from each well at each sampling event. Each network design should be based on the conceptual site model (discussed in Section 3) and should be regularly reevaluated based on numeric modeling using monitoring network results.

b. Basic Understanding of the Flow System.

An effective monitoring system should be designed with full consideration of the site-wide hydrologic conditions. Location of subsurface observation points (e.g., monitoring wells, piezometers, temporary wells, seeps, springs) should be determined on the basis of an adequate understanding of the local flow system and the chemical and physical properties of the analytes that will be monitored. Understanding the local flow system is critical to predicting potential contaminant migration pathways from a facility or activity that may eventually release contaminants to the subsurface.

A surveillance monitoring network that is designed and operated for early detection of releases to the subsurface at a specific facility would be completely ineffective if the wells that constituted the monitoring network were located where they would not intercept a contaminant plume, should one occur, due to a lack of understanding of the local flow system. Releases to the subsurface that go undetected for many years due to a monitoring network designed without careful attention to the local flow system may result in significant impacts on the ground water and perpetuation of the expensive and, in some cases, intractable contamination events that the Department is now addressing.

Periodic reevaluation of the local flow system is necessary to account for seasonal fluctuations in water usage, rainfall, snowmelt, etc., that may affect local flow and physical changes in site facilities, structures, or operating practices. Examples of physical changes at the site that may impact the local flow system include the following:

(1) removal of a building and its utility lines (sewer, water supply, process liquid conduits, etc.);

(2) pavement of previously unpaved land;

(3) drainage and removal from operations of water retention basins, settling ponds, impoundments, etc.;

(4) repair or replacement of water lines that had been leaking significant quantities of liquid to the subsurface; and

(5) operation of pumping wells or dewatering sumps and any changes in their use (e.g. removal from service, change in pumping rate).

Certain types of DOE facilities are operated only periodically during the course of a typical year. When in operation, the facility may use and discharge significant quantities of water for operational purposes (e.g., primary or secondary cooling, other processing). When the facility is not in operation, water use ceases or is drastically reduced. These sporadic operations can have significant but temporary impact on the local flow system. Such impact should be anticipated and should be fully accounted for in the design of a surveillance monitoring network and in interpreting the results.

c. Data Quality Objectives Process Applied to Network Design.

The design of a ground water surveillance monitoring network should be based on a systematic process for ensuring that the data produced by the network will effectively meet the end user's needs. The DQO process has been employed for the design of environmental data collection and monitoring systems and is quite suitable for the design of an effective ground water surveillance monitoring network.

The basic steps in the DQO process are the following.

(1) State the Problem. It is important to state the basic purpose of the surveillance monitoring network as unambiguously as possible. The following statement would be acceptable.

> *Monitoring of the ground water for increased levels of tritium should be performed to determine whether tritium is being released from the XYZ reactor. It is necessary to maintain a series of monitoring wells (at least three) immediately down-gradient of the XYZ reactor, screened in the upper 10 feet of the water table aquifer, to detect increased levels of tritium of greater than 25 percent over baseline levels, that may indicate a release of tritium from the reactor.*

An adequate monitoring network for this facility could be designed to meet the problem stated here.

(2) <u>Identify the Decision</u>. The surveillance monitoring network should be designed to provide sufficient information to ensure that appropriate actions are taken at the appropriate time. In the example above, the information that would be obtained from the network whenever the wells were sampled is whether the tritium levels in the water table aquifer have increased by 25 percent over baseline levels to indicate that a release may have occurred and would trigger an investigation.

(3) <u>Identify the Input to the Decision</u>. Input to the design of the surveillance monitoring system includes—

(a) the nature of the facility or activity to be monitored,

(b) the type of contaminant that may be released to the subsurface,

(c) the local ground water flow system and how it responds to seasonal or episodic perturbations,

(d) the frequency by which decisions need to be taken on whether responses are needed, and

(e) the consequences of not making appropriate and timely responses.

Additional input includes certain metadata on samples that provide crucial information for complete and correct interpretation of the results. Metadata, which should be identified in the monitoring plan, include—

(a) sampling procedures,

(b) analytical methods, and

(c) qualifiers placed on the monitoring results during data validation.

(4) Define the Boundaries of the Problem. For a specific surveillance monitoring network, it is important to identify the physical (spatial and temporal) boundaries of the facility or activity and the physical, legal, or other institutional barriers to the network design. A potential future source of contamination could impact offsite ground water resources. If this is the case, there may be legal or political barriers that would affect the design of the network. If the facility or activity encompasses a very large area (e.g., square miles), the network should be designed to minimize potentially excessive costs without significant reduction in effectiveness. Additionally, if the ground water occurs at substantial depth below the surface or below the point where a potential future release may occur, there may be a significant period of time between the first occurrence of a release and the actual arrival of the contaminant in the ground water. Considerations such as these should be made in the design phase to ensure that the network will function effectively once it is implemented.

(5) Develop a Decision Rule. A set of rules that describe as quantitatively as possible outcomes or actions to be taken, based on the range of monitoring network results, is important in the design of a network. If the decision rule is fairly simple and easily stated in quantitative terms, the design of the network should be relatively straightforward. For example, a series of monitoring wells that are sampled quarterly to detect release of a specific chemical should be governed by a fairly simple rule such as the following.

> *If any level of chemical X is detected above the method detection level, then the following actions will be taken . . . .*

If the decision rule is more complicated in that a large number of samples should be taken and analyzed for a number of parameters which may lead to various potential responses, then a more elaborate network design may be warranted.

(6) Specify the Tolerable Limits on Decision Errors. It is important to consider possible types of errors and their related consequences as part of the network design. Depending on the decision rule, it is possible that failure to detect an identified contaminant or take immediate action, or the taking of an action based on a false positive, may have minor or severe consequences and immediate or long-term consequences. The range of reasonable scenarios and their expected consequences should be considered carefully when designing a surveillance monitoring network.

(7) Optimize the Design for Obtaining Data. The endpoint of the DQO process is optimal network design that is responsive to needs and constraints and that balances those considerations with cost to create and maintain the network. The specific network features arrived at through

this process should be sufficiently detailed to allow the construction of a monitoring system and the development of a sampling plan.

The thinking process inherent in the DQO process should be applied to the reduction in the size and scope of the monitoring network when the needs for ground water monitoring information begin to subside. This situation may be encountered at sites that have conducted extensive ground water monitoring for subsurface characterization and plume identification in the early stages of designing and installing an active remediation system. As the remediation progresses towards the attainment of cleanup goals, the ground water monitoring information needs are likely to change, thus justifying reduction in number of samples, reduction in number of analyses, and closure of certain monitoring wells. The process of optimizing the site-wide monitoring network, through application of the DQO process, should be included in the site's "exit strategy" for active subsurface restoration projects. (Attachment I contains a March 2000 DOE guide, *Developing Exit Strategies for Environmental Restoration Projects,* that sets the issue of reducing the size and scope of the monitoring network into the context of the long-term disposition of active subsurface remediation.)

d. Ground Water Monitoring Plan.

Each site should prepare a site-wide ground water surveillance monitoring plan that serves as an internal management tool and also can be shared with regulators and the public. The plan should be structured to be as useful as possible for site managers and technical staff and updated to accurately reflect current designs and operations of the site-wide network and to provide descriptions of future plans to improve or optimize the ground water monitoring network. The plan should serve as a historical record of the ground water monitoring program as it changes and evolves over time. There is no set format or single approach that each DOE site should follow in developing this plan.

There are a number of elements that should be included, where appropriate, in each site's monitoring plan. The following lists the basic elements of a ground water surveillance monitoring plan.

(1) Network design that associates each well or other observation point with a facility-specific or area-specific surveillance monitoring network.

(2) Monitoring methods such as wells, cone penetrometers, temporary wells, piezometers, vadose zone monitoring, etc., and seeps, springs, and other observation points.

(3) Sample type, frequency, analytes, and protocols (e.g., well purging method, security procedures) followed at each well or other observation point to indicate the information to be provided to meet the purpose of the specific network.

(4) Responsibilities for each aspect of the site-wide network, to include organizational designations and actual points of contact.

(5) A routine system for inspecting and maintaining the monitoring network to ensure proper performance and the collection of representative data.

(6) Process description that details the flow of data from sampling to the point at which specific final results are transmitted to the end user.

(7) References to specific technical documents that contain detailed information needed for day-to-day operations, including geologic and hydrologic studies, and modeling analyses that form the technical basis for the monitoring network.

(8) Descriptions of data management systems and reporting procedures.

(9) References to historical documents and data that describe the technical and organizational aspects of the program throughout the site's history.

The site-wide monitoring plan should contain an information management component that addresses the needs of present and future users. There should be a detailed process for ensuring that sampling data is evaluated as appropriate to meet the needs of data users and is maintained for future analyses. The plan should describe quality control and quality assurance procedures and indicate how data is classified according to any qualifications on its accuracy and precision. The monitoring plan should describe the process for storing data on sampling procedures and analytical methods used by each laboratory and the process to be followed by future data users for obtaining specific quality assurance and quality control and metadata information. The plan should describe the long-term repository for each type of data and the procedures for data retrieval.

5. INTEGRATION OF THE GROUND WATER MONITORING NETWORK.

Consistent with the requirements of DOE O 450.1 and with the stated objective to be achieved by a site-wide EMS, an integrated ground water surveillance monitoring network should replace the fragmented, independent monitoring system that has typically been developed at many DOE sites. Historically, ground water monitoring activities at DOE sites have been undertaken in response to an immediate need and are frequently determined through negotiation with external regulators who are implementing a single regulatory program (e.g., RCRA, CERCLA) at a single operable unit, waste area grouping, or waste management facility. Monitoring that is being conducted and funded by a specific DOE program for a specific facility or area is not always coordinated with other monitoring activities at the same site. At certain DOE sites, surveillance monitoring has been conducted by taking samples wherever they can be quickly, easily, and inexpensively obtained (e.g., from a seep or spring or from an existing production well). As a result of these historical circumstances, a fragmented monitoring system has been developed at many DOE sites. In addition to the physical fragmentation of site-wide monitoring, organizational fragmentation (i.e., lack of a single organization responsible and accountable for ground water monitoring across the site) can occur.

Where organizational responsibilities are fragmented, program funding sources are generally fragmented as well.

An integrated ground water surveillance monitoring network, however, should evolve from the typical fragmented system to provide results that meet regulatory compliance requirements and commitments, that meet management needs for operating program information (including waste management, stewardship, restoration, and institutional controls), and that should function in a manner that allows demonstration of cost-effectiveness. The integrated, site-wide ground water surveillance monitoring program should be capable of providing adequate quality data for all program needs and should ensure efficiency and cost-effectiveness by avoiding duplication.

The concept of an "integrated monitoring program" is based on avoiding or eliminating numerous systems and procedures and their associated costs for achieving the same or similar goals. Ground water monitoring should be viewed as a site-wide activity and the provision of ground water monitoring data as a service that meets the needs of any individual program or activity. There is no justification for a separate ground water monitoring program for each specific DOE program function or activity at any DOE site. There should be no designation of certain monitoring wells as "landlord' wells and others as "program office" wells or "restoration" wells. There should be no separate databases for managing data from individual programs' monitoring systems. There should be only one site-wide organization that routinely manages the integrated system by accepting requests for sampling events; scheduling and facilitating sampling events; providing results per the requestors' specifications, to include adequate but not excessive quality assurance and quality control; and ensuring coordination across all site-wide program activities. There should be one designated site-wide source for current or historical ground water monitoring information. This single source should be responsible for providing all of the data needed by any program at the site for meeting reporting requirements and for responding to management information needs.

6. <u>GROUND WATER MONITORING PROGRAM EVALUATION</u>.

At most DOE sites, ground water monitoring will be conducted for surveillance purposes for many years, possibly for many decades, as well as for regulatory compliance in the relative short term. Given the long-term, ongoing nature of ground water surveillance monitoring, there is a need for periodic evaluation of the site-wide program. Each site should establish a process for determining whether the existing program is providing useful information to its clients and is being operated and managed effectively. Following are some suggested criteria for periodic ground water surveillance monitoring program evaluations.

a. <u>Ambient Quality of Ground Water Resource</u>. The monitoring program provides quantitative information on ground water quality in a consistent manner across the site, consistent from year to year. Ground water quality data includes the levels of natural constituents (chemical, biological, radiological, and physical characteristics) and the types and levels of contaminants in ground water across the site.

b. Specific Data Needs. The monitoring program provides the specific ground water quality data needed for resource management and regulatory compliance. Specific ground water quality data is needed for planning, designing, and operating facilities related to site missions, including environmental protection and pollution prevention activities, as well as demonstrating compliance with regulatory requirements, and ongoing assessment of waste management and disposal unit performance.

c. Scope of Site-Wide Monitoring. The monitoring program should document the number of wells, number of samples per well per year, and number of analyses per sample and should provide a quantitative basis for estimating future modifications to the site-wide network, including a schedule for monitoring well replacement and abandonment.

d. Purpose and Design of Monitoring Network. The monitoring program defines purposes for monitoring the ground water and the design of networks related to each purpose. The monitoring program is reviewed regularly to ensure that the monitoring networks adequately address these purposes.

e. Data Management. The monitoring program ensures users are getting the right data, enough data, and adequate quality data and not getting superfluous data. Historic data are retained and are retrievable for future use.

f. Ensuring Efficiency and Cost-Effectiveness. The monitoring program provides the minimum necessary ground water data at the appropriate quality at the lowest cost. The monitoring program includes a method for demonstrating that costs are justified.

g. Utility of the Monitoring Data. The monitoring program provides data that meet the needs of users. A process is developed to ensure that monitoring data satisfy users' needs and are being used effectively by users.

h. Continuous Improvement of Existing Monitoring Programs. Monitoring methods that reduce the costs of the monitoring program without reducing the amount or quality of data are regularly investigated and adopted, where appropriate.

i. Alternative Monitoring Methods. Alternatives to conventional monitoring methods that will provide adequate data for meeting monitoring program purposes are regularly being investigated and adopted, where appropriate.

j. Analysis of Trends. The monitoring program includes analyses of trends in ground water quality across all areas of the site. Each site's analyses allow similar review of long-term trends collectively at all DOE sites. Summarized data on the size, scope, and results of the site-wide ground water monitoring program should be easily obtainable from the site's data management system and should be included in the annual site environmental report in a manner consistent with annual guidance prepared by the Office of Environment, Safety and Health to allow consistent Department-wide analyses of program performance.

7. SURVEILLANCE MONITORING PROGRAM FUNDING.

Ground water surveillance monitoring is an activity that will be conducted at DOE sites for many years. Where wastes remain after all other site operational activities have been completed, and where the site is closed after active environmental restoration has been completed, and even where no releases from any disposal units have occurred, there will continue to be a need for ground water surveillance monitoring. This is especially true where the area of the site that is dedicated to waste management is in close proximity to lands and facilities that are no longer under any formal use restrictions. Industrial, residential, or recreational land use at former DOE sites may be subject to future releases if long-term surveillance monitoring is not faithfully conducted where waste or contaminated areas remain.

Each DOE site and each DOE program that is associated with a DOE site should request sufficient resources in the annual budgetary process to support the site-wide surveillance monitoring network. Annual budgets should be prepared to include a specific request for funding and staffing of the site-wide program as a line item, recognizing the continued long-term importance of the network in meeting DOE O 450.1 requirements and ensuring effective environmental stewardship. If DOE program and site-wide budgets do not typically address environmental monitoring as a specific budgetary item, the possibility exists that a site-wide surveillance monitoring program may not be adequately funded.

Consistent with an integrated ground water monitoring program is the need for an integrated site-wide funding source for ground water monitoring program activities. The site-wide needs for well construction/abandonment, sampling and analysis, data management and reporting, quality assurance/quality control, etc., should be addressed in a composite budget request rather than in a fragmented or piecemeal fashion. Each DOE program office that is responsible for any facility, program, or activity at a specific DOE site that may impact ground water resources should provide its share of the cost for fully funding the integrated site-wide surveillance monitoring program. This is important from a corporate and a site-wide DOE management perspective, since an integrated budget identifies the full costs associated with operating a site-wide ground water monitoring program. Management can determine the full cost of sampling and analyzing ground water and demonstrating the cost-effectiveness of monitoring system improvements with a single budgetary amount for the full site-wide program.

8. REFERENCES.

a. 10 CFR, Part 830, Nuclear Safety Management.

b. DOE O 450.1, *Environmental Protection Program,* dated 1-15-03 (online at http://www.directives.doe.gov/pdfs/doe/doetext/neword/450/o4501.html).

c. DOE O 435.1, *Radioactive Waste Management,* dated 7-9-99 (online at http://www.directives.doe.gov/pdfs/doe/doetext/neword/435/o4351c1.pdf).

d. DOE M 435.1-1, *Radioactive Waste Management Manual,* dated 7-9-99 (online at www.directives.doe.gov/pdfs/doe/doetext/neword/435/m4351-1c1.html).

e. DOE G 435.1-1, *Implementation Guide for Use with GOE M 435.1-1,* Chapter 4, "Low-Level Waste Requirements," dated 7-9-99 (online at http://www.directives.doe.gov/pdfs/doe/doetext/neword/435/g4351-1ch4.html).

f. DOE 5400.1, *General Environmental Protection Program*, dated 11-9-88.

g. DOE 5400.5, *Radiation Protection of the Public and the Environment,* dated 2-8-90 (online at http://www.directives.doe.gov/pdfs/doe/doetext/oldord/5400/o54005c2.html).

h. DOE-EH-0173T, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance,* dated January 1991 (online at http://tis.eh.doe.gov/oepa/guidance/aea/effluent/eh0173t.pdf).

i. EPA/600/R-00/007, *Data Quality Objectives Process for Hazardous Waste Site Investigations*. January 2000 (online at http://www.epa.gov/quality1/qs-docs/g4hw-final.pdf).

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Developing Exit Strategies for Environmental Restoration Projects

This guide is primarily intended for personnel with line management responsibility for Department of Energy (DOE) environmental remediation projects conducted pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA). It highlights the importance of establishing clear, measurable performance metrics for remediation technologies, and discusses how these measures can be used to demonstrate that response objectives have been attained and project activities terminated.

Introduction

Many planned or on-going environmental restoration projects involve remedial strategies that will require some form of long-term monitoring or operation and maintenance. These long-term obligations will constitute a significant commitment of resources and, therefore, it is important that these requirements be fully understood, both in terms of the types of activities and the length of time the activities are likely to be required. In addition, project managers need to ensure that *exit strategies* are in place that will ultimately allow these long-term requirements to be terminated once remedial objectives have been reached.

[Note: For those actions that will require activities in perpetuity (e.g., monitoring disposal cells), the focus shifts to establishing an appropriate "ramp-down" strategy as confidence is gained that engineered systems are functioning as intended and human health and the environment are fully protected. A brief discussion of ramp down strategies is provided in Highlight 2 at the back of this fact sheet.]

Experience has shown that without an exit strategy, it is difficult to reach consensus on when to stop active remediation or associated monitoring. The difficulty arises from a failure to define how it will be determined that a response objective has been met. The default position – continually extend operations until some undefined event makes it clear that termination is appropriate – is particularly problematic because without a clear definition as to what that undefined event would look like, the likelihood of generating consensus that it has been reached is diminished. Therefore, it is prudent to understand what is required to stop an activity before the activity is begun. This is particularly important at sites relying on long-term ground water remediation systems.

What is an Exit Strategy?

An exit strategy may be viewed simply as the set of information that will be used to demonstrate the desired performance has been achieved, the response objective has been met and that associated activities (e.g., pump and treat systems, monitoring) can be terminated. An exit strategy is particularly important for any activity that is performance based as opposed to design based, since it defines the data necessary and sufficient to demonstrate that the desired performance has taken place. Too often, however, the necessary level of detail to clarify how performance will be measured is lacking in project work plans. Such detail is embedded in the four essential elements of an exit strategy:

1) A description of the objective of the activity, i.e., the response action objective;

2) A performance "model" that describes the expected course of the remediation process, i.e., how conditions are expected to change over time from the current state until the response objective is attained;

3) A listing of the performance metrics, decision criteria, and endpoints that will be used to assess how the response is progressing and demonstrate when the objective has been reached; and

4) A contingency plan that will be implemented if data indicate that objectives will not be met.

Developing an Exit Strategy

Defining Response Objectives

Response objectives establish the desired condition of the site once response activities are complete. Response objectives may specify allowable level(s) of residual contamination in environmental media, a required level of contaminant mass reduction within media, or a required reduction in contaminant flux between media. Whatever the objective, it is critical that it be understood and agreed to before a response action is initiated. Without such agreement, it is difficult, if not impossible to develop the performance model and metrics that will be used to assess a technology's progress in achieving the stated objective.

Performance Model

In order to develop an appropriate monitoring strategy and performance metrics, a performance model should be developed in advance to define the expected system response to the remedial technology. The Performance Model may be anything from a simple diagram to a set of numerical constructs designed to predict what remedy performance will be and what the site will look like at various times in the future after remediation is initiated.[1] As performance assessment data are collected they are compared to the performance model to determine if the remedy is indeed performing as planned. In turn, the understanding gained from this activity is fed back into the conceptual site model (CSM), to ensure that the linkages are accurately portrayed based on any new findings.

Performance Metrics

Exit strategies must include quantitative criteria that will be used to assess response action performance, and ultimately to determine when the response has achieved its intended purpose. Without predefined metrics, any uncertainty resulting from collected data may lead to a seemingly endless process of additional sampling and analysis to support a decision ("Let's collect one more round of samples to see what that tells us."). Although ultimately a decision may be reached, the latter is not an efficient or effective approach.

The quantitative criteria established to assess performance need to specify not only where and how the criteria apply, but how they will be measured (See Highlight 1). As an example, a decision document may state that "*operation of groundwater pump and treat system will continue until MCLs are met in the aquifer*." Yet, such language is not sufficiently clear to differentiate among alternative measures to which the MCL is to be compared such as average concentration, the concentration from two consecutive quarterly sampling events, or some other measure. Similarly, the language fails to clarify whether the MCL must be met everywhere in the aquifer, at specified monitoring wells, or along an agreed to compliance boundary.

Highlight 1: Exit Strategy Metrics

- The type of data required
- Sample locations
- Sample frequency
- Target parameter
- Duration required to demonstrate sustainability
- Statistical algorithms to be applied to data (e.g., confidence limit, type of mean, etc.)

Performance metrics may be defined according to interim milestones to evaluate progress (e.g., concentrations reduced by 50 percent within a specified time frame; specified mass removal rates at different times during the

[1] Because some uncertainty on technology performance will always exist, a certain degree of flexibility should be allowed to refine performance model expectations as data are collected and evaluated over time.

remediation). Alternately, monitoring criteria may be defined in terms of conditions at a specified location such as concentrations along the leading edge of a plume, or hydraulic gradients around a containment system.

The development of performance metrics should be viewed as a dynamic process that continues throughout the duration of the remedial action. In this way, performance monitoring can serve multiple purposes; to demonstrate the efficacy of remediation when the system is operating as anticipated (e.g., conditions are being met at specified points of compliance), or to allow for expedient action (e.g., technology enhancement) should performance deviate from predefined expectations. In addition, monitoring results are used to update and refine both the conceptual site model and the performance model, thus increasing confidence in our ability to predict performance over time.

Contingency Plans

A contingency plan establishes a predefined course of action should performance monitoring indicate remediation is not progressing as expected. Project managers should utilize contingency planning to address potential deviations that would significantly impact the expected system performance.[2] The contingency plan should not only define the criteria to signify a deviation has occurred, but also the course of action to be taken. For example, contingencies may include: 1) the collection of additional data to better assess performance, 2) re-evaluation of performance data to determine whether expectations need to be redefined, *or in limited situations*, 3) implementation of an alternative remediation strategy, or 4) re-analysis of response objectives to determine whether they are indeed attainable.

Essential activities in contingency planning include:

- Identifying potential deviations from the expected performance (the latter defined by the performance model);
- Evaluating the likelihood a deviation will occur;
- Assessing the potential impacts should a deviation occur, i.e., potential impacts on system performance, or project schedule, and the time needed to respond;
- Defining the required data, data quality criteria, and baseline comparison to be used to recognize a deviation has occurred (as opposed to expected variability in data); and
- Defining the appropriate course of action for specified deviations and developing implementation plans.

The level of detail described for each element can and should be in simple terms. The purpose is not to perform a feasibility study, but rather to define acceptable and unacceptable performance/conditions, identify required data for evaluation of performance, and come up with some initial considerations of suitable contingencies.

Some examples of performance measures or conditions that may be addressed through contingency plans follow:

- If new sources are identified or plume distribution is different than originally characterized, install additional source control measures or reconfigure the existing monitoring well system to capture plume data.

- If treatment plant influent concentrations are different than expected (higher, lower, different toxic constituents, or different inorganic compounds that affect the treatment process), modify the existing treatment configuration to enhance system's capabilities to meet the performance criteria.

- If a new policy or guidance from regulatory agencies becomes available, that provides remedial options or flexibility not available at the time the original remedy was selected, and the application of these provisions will significantly reduce long-term monitoring obligations or enhance the long-term protection of human health and the environment, proceed as appropriate to formally incorporate the policy.

[NOTE: The concept of an exit strategy can be applied not only to a single activity as discussed in this fact sheet, but expanded to a site or facility in its entirety. At the site level, however, potential variability in end state conditions (which can range from unrestricted use to access controls in perpetuity) will require exit strategies for individual activities across the site be defined to reflect the facility's projected end state. A fact sheet on "site closure strategies" is in prep.**]**

[2]See related fact sheet, *Uncertainty Management: Expediting Cleanup through Contingency Planning, DOE/EPA's Principles of Environmental Restoration Workshop*.

Highlight 2: Ramp-Down Strategies

Ramp-down strategies help conserve resources spent on monitoring. They can be viewed as: 1) an intermediate step in an exit strategy in situations where eventually all monitoring will be terminated or 2) the final phase of a monitoring strategy for those remedies where monitoring in perpetuity will be required. Ramp-down strategies should include criteria that can allow the following.

Eliminate unnecessary analytes, including:

- Analytes not found in initial samples and for which there is no evidence of a release (some analytes may be included to monitor geochemical conditions pursuant to demonstrating conditions will support natural attenuation mechanisms;
- Analytes not identified above detection limits in three successive samples; and
- Analytes detected at less than half the action level for at least three successive samples and displaying a static or downward trend.

Eliminate redundant locations (wells), including:

- Wells in the interior of plumes whose boundaries are defined by other wells (these wells may be needed to support performance monitoring for response such as monitored natural attenuation);
- Wells outside plumes and not deemed to be in the pathway of on-coming plumes and not required to establish background;
- Wells duplicated by proximate wells on the same isopleth; and
- Wells for which analytical data will have no clear use in future decision making such as consideration of when to implement a contingency.

Reduce sampling frequency:

- Initial quarterly sampling is needed to establish seasonal variations. Annual monitoring helps identify variations from changes in precipitation (wet versus dry years). Beyond those distinctions, sampling frequency should be selected on the basis of the slope of the observed trend lines, the degree to which empirical data match predictions, and the relative velocity of groundwater. The more predictable the data are, the less need there is for frequent confirmation.
- Monitoring is only required when there is uncertainty as to the fate and transport of contaminants and the effectiveness of remedies that are implemented. As the uncertainty is reduced, or as its consequences become less significant, the need for further monitoring is diminished. Similarly, slow moving groundwater requires less frequent monitoring because trends are slower to develop and there is more time to respond.

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