OPTIMIZATION OF LONG-TERM GROUNDWATER MONITORING

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The American Society of Civil Engineers Environmental and Water Resources Institute Task Committee on the State of the Art in Long-Term Groundwater Monitoring Design

Introduction

An ASCE/EWRI Task Committee consisting of 30 members from industry, government, and academia is studying the state of the art in designing long-term groundwater monitoring (LTM) programs for subsurface waste sites. The committee's work was motivated by the growing need for, and costs of, LTM as sites complete their active remediation efforts. Groundwater contamination still exists and is likely to remain for a long time at many of these sites. Long-term monitoring is essential at these sites to ensure the protection of human health and the environment and to monitor ongoing changes in the subsurface. Long-term monitoring is also essential for obtaining stakeholder acceptance when active remediation ceases yet contamination remains. The growing need for LTM is accompanied by an increasing realization that LTM costs will become significant in the foreseeable future. This need has led to a substantial interest in optimizing LTM designs in order to reduce long-term costs while protecting human health and the environment. The task committee's purpose is to disseminate methods that can be used for optimizing LTM designs and to provide case studies of field applications of these methods. Future needs for optimal LTM design have also been examined during several panel discussions and workshops, both to provide guidance for research and policy efforts and to help practitioners identify areas where methods are still changing and improving.

This paper summarizes the committee's report on the current state of the art and recommendations for future research and technology transfer to improve LTM design. The full report will be released during the summer of 2003. The document will be a guide, with references to the primary sources for the detailed information, and not an in-depth tutorial. It primarily focuses on the physical design of monitoring networks, rather than on the merits of various sampling methods (e.g., remote sensing methods or indicator samples vs. traditional well-based samples) or on the various goals or strategies for LTM. As we use the phrase, the physical design of monitoring networks involves identifying which constituents and parameters should be measured and their locations and frequencies, the data collection/validation/analysis procedures to be followed, the decision rules used for determining whether a problem exists, and the decision rules for assessing whether the underlying model or perhaps even the program itself needs maintenance. Most of the document concentrates on monitoring locations and frequencies for a single constituent or parameter because the current state of the art primarily addresses those aspects of LTM design. An optimal design should minimize the number of sampling locations and frequencies while meeting the objectives of the LTM system. One of the most important steps in optimizing LTM designs is to identify the objectives of the LTM system. Many objectives are possible, ranging from broad, qualitative objectives, such as "protecting human health and the environment" to focused objectives, such as "verifying flow containment." Monitoring design usually centers on achieving clearer objectives that can be assessed in quantitative terms, as surrogates for the broad, qualitative objectives.

Methods

Most of the early work in monitoring design focused on methods for siting new monitoring wells. At that time, the focus was on site and plume characterization or plume detection. Most of these methods can also be used for LTM design. Recently, methods have been developed specifically for identifying sampling plans that minimize spatial and temporal redundancy in existing monitoring wells. These methods are introduced in the full report, with the primary references provided for the interested reader to obtain details. More detail is given for methods for which accessible primary references are not available. The methods summarized in this chapter are organized according to the types of tools used and the level of complexity involved. In selecting an appropriate method for LTM design, both the monitoring objectives and the amount of data and information currently available should be considered. Guidance is provided for selecting methods that are appropriate for different objectives and levels of data and information.

The report also summarizes nine recent field studies in which LTM design methods have been applied, along with references for previous LTM design field studies. The field studies illustrate several important findings for LTM design, including the relationship between site remedies and performance monitoring and the importance of considering anticipated contaminant plume shrinkage rather than, or in addition to, plume stability in selecting design methods. These findings are summarized below.

Although regulatory and permitting processes usually require that site remedies be approved in a record of decision prior to the initiation of a monitoring plan, the remedy and the monitoring are inextricably related. The performance of the remedy can be evaluated only by monitoring for parameters that indicate whether its performance objective is being met. As data continue to be collected and site knowledge increases, the selected remedy may change, in which case so should the corresponding performance-monitoring scheme. Long-term monitoring plans must be designed to remain compatible with the selected remedies.

The importance of plume shrinkage vs. plume stability is also highlighted; seven of the nine field studies presented in the report involve that objective. The distinction between verifying plume shrinkage and plume stability is particularly important for selecting an appropriate LTM design method. In the first case, the plume is (anticipated to be) moving, and thus complex nonstationary design methods may be needed. In the second case, the rate of plume change is small and simpler methods can be used. In either case, the amount of historical data available for LTM design influences which analysis methods are appropriate, not simply which ones can be used.

Recommendations

Finally, the report presents the committee's recommendations for further research and new implementation guidance needed to improve the state of the art in LTM design. References to other published recommendations are also summarized. The recommendations are organized into two broad categories: research needs and technology transfer needs.

Research Needs: As sites move toward long-term monitoring, monitoring objectives shift from site characterization to performance assessment. Performance assessment involves collecting data to identify whether the remediation is progressing as expected. More accurate and cost-effective performance assessment is needed, which will require research to (1) develop methods for integrating and using nontraditional data, such as sensor or screening technologies in dynamic field sampling approaches; (2) identify and characterize variability in long-term monitoring data; (3) improve decision rules and protocols for long-term management; (4) develop "living" performance assessment models that are updated, refined, and used to analyze current conditions at the site and to predict and accommodate the effects of observed changes over the long term, (5) improve methods for linking remediation processes and LTM, (6) investigate methods for designing LTM systems at sites with fractured bedrock or Karst terrain, (7) develop improved methods for failure analysis and robust LTM design, (8) improve electronic management of and access to data, and (9) create publicly available data archives and test data sets.

Technology Transfer Needs: The committee strongly encourages the development of uniform LTM guidance, regulation, and practice across regulatory jurisdictions. To achieve this goal, the following technology transfer developments are needed: (1) regulatory guidance on the amount and types of data needed to demonstrate system integrity or performance and to identify appropriate LTM plans, (2) regulatory guidance and acceptance of dynamic sampling (or operation) plans, (3) regulatory guidance on incorporating LTM needs early in the remedial process, and (4) professional guidance and education on the special problems associated with LTM and the methods available for LTM design, using mechanisms such as workshops and regulator guidance.

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