

WATERSHED STRATEGY FACILITATES REMEDIAL DECISION-MAKING

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INTRODUCTION

Over the past fifty years in Oak Ridge, Tennessee, the Department of Energy and its predecessor agencies have conducted uranium enrichment operations, weapons production, and energy research. As a result of this mission, hundreds of contaminated sites covering thousands of acres remain on the Oak Ridge Reservation. A significant obstacle to progress in remediating these sites is the lack of agreement on the level of cleanup required. For instance, as the land use basis for cleanup increases from restricted to unrestricted, the corresponding cleanup requirements for soil and source areas becomes more stringent, the cleanup cost escalates, and the cleanup duration lengthens. Also as the level of groundwater protection required increases, the cost and schedule for source area remediation also increases. Without these basic agreements on the level of cleanup requirements, decision making at Oak Ridge has been severely hampered.

The conventional approach used at Oak Ridge of making a remedial decision for each contaminated site became very difficult because the level of cleanup for the reservation had not been decided. Each decision on the sites either became very aggressive or was deemed an interim decision. Site by site decision making does not adequately accommodate the collective implications of remediating multiple, co-mingled sites nor evaluate overall impacts associated with various potential levels of cleanup. For instance, it may not be appropriate to excavate the contaminated media at one site if at an adjacent site more significantly contaminated media is contained in place. To improve the decision making on the Oak Ridge Reservation, contaminated sites are grouped by geographic areas called watersheds, and remedial decisions are made at the watershed scale. By implementing this watershed strategy, decision-makers are able to make two distinct decisions. First, the appropriate level of cleanup for the watershed is determined by comparing the implications of achieving various levels of cleanup. Then, the optimum set of remedial actions can be identified to achieve the selected level of cleanup. Consistent, synergistic actions necessary to meet an agreed to level of cleanup are considered.

This paper describes how the watershed approach to remedial decision-making compensates for the weaknesses inherent in the conventional decision-making approach by altering the decision-making paradigm.

ISSUE

Historically there have been two approaches used for decision making. The first is to identify specific cleanup levels based on a single predetermined land use, level of protection of groundwater, and level of protection of surface water. Alternative technical approaches for achieving the cleanup requirements are then developed and evaluated. A preferred alternative for implementation is selected. This process may become iterative because the assumed cleanup requirements may be shown in the evaluation phase to be

too costly or technically impossible to achieve. In this case iterations are performed until the decision-makers agree on the solution.

The second approach does not predetermine a level of protection, rather a range of cleanup levels is evaluated and one is selected along with the remedy. This approach was taken historically in Oak Ridge; however it was applied site by site. When applied site by site, two problems can arise. First, the cleanup levels selected at two adjacent sites can be different or even inconsistent. At one site the selected level may be to prevent any leaching to groundwater while an immediately adjacent site has a selected cleanup level that allows continued, albeit reduced, leaching to groundwater. The second problem is that aggressive actions may be taken at a site that has few risks and problems when considered with other sites. Before the watershed approach was applied to Bear Creek Valley in Oak Ridge, common understanding was that the massive burial grounds were the most significant problem because of their inventory and release potential. If remediation decision making had proceeded with this understanding, aggressive expensive actions on the burial grounds would have occurred early in the cleanup program. Under a watershed remedial investigation, it was determined in fact that a smaller soil/debris site about one mile up the valley was the primary contributor to releases of contaminants away from the Bear Creek disposal areas. The cleanup strategy was revised to make an early aggressive decision to remove the soil.

The use of the second site by site decision making approach has led to the deferral or delay of many decisions. Decision-makers in Oak Ridge have been concerned about making a final decision on a site when decisions near and under the site have not even been considered.

WATERSHED DECISION-MAKING

Watershed management was developed under the Clean Water Act and is an integrated approach to restoring and protecting ecosystems by focusing on hydrologically defined drainage basins. The watershed strategy on the Oak Ridge Reservation applies this approach to remedial decision-making. Grouping contaminated sites by watershed for characterization and decision-making allows consistent and appropriate remedy selection. The decision-making process can focus on selecting the appropriate cleanup levels for the watershed and those actions needed to meet the selected cleanup levels.

The predominant contaminant migration pathway on the Oak Ridge Reservation is transport to surface water via subsurface flow paths. This recognition led to an overall strategy to group contaminated sites by watershed and then to develop remedies at that scale. Such a strategy leads to a logical, consistent approach to decision-making and remediation. The five primary watersheds on the Reservation are large enough to ensure that remedial objectives and response actions are optimized and that the remediation of any single contaminated site in the watershed is considered within the larger context of the entire watershed.

To evaluate various cleanup levels for a watershed, a range of remedial action objectives are developed by considering the following questions with regard to land use, protection of human and ecological receptors, and remediation of different media of concern.

What is the future land use for the watershed? Future land uses include unrestricted, industrial, open space/recreation, and controlled access. These land uses require varying levels of institutional controls to be built into the alternatives.

What level of protection is required for human receptors? Based on the land uses, appropriate on-site users and off-site public receptors are protected to excess cancer risk levels between 10^{-4} and 10^{-6} and a hazard index of 1.

What level of protection is required for ecological receptors? Two possible levels are considered. Ecological protection is defined as protecting specific community level populations of ecological receptors identified within the immediate area potentially impacted by contamination or watershed-wide populations of ecological receptors identified within the habitat that encompasses the entire watershed.

What controls should be placed on groundwater? In many places the groundwater cannot be restored to clean conditions and therefore has no future use; however, the National Contingency Plan requires remedies to not allow overall plume growth when groundwater cannot be restored to beneficial use. Should the plume be contained or reduced in size?

Possible answers to these questions are then logically and consistently grouped together as remedial action objectives for which alternatives can be developed and evaluated. An example of the remedial action objectives that could be developed for one of the Oak Ridge watersheds follows. Early discussions with the stakeholders may eliminate some of these options, if appropriate, thereby reducing the range of remedial action objectives. These hypothetical remedial action objectives have both unique and common elements among them.

Remedial Action Objective 1

- restore land for unrestricted use
- provide ecological protection to community level populations
- minimize size of groundwater plume
- achieve ambient water quality criteria in all waters of the state
- achieve recreational risk-based levels for all media in waters of the state

Remedial Action Objective 2

- maintain access controls for the watershed (watershed has no future use)
- protect maintenance workers
- provide ecological protection to community - level populations
- minimize size of groundwater plume
- achieve ambient water quality criteria in all waters of the state

Remedial Action Objective 3

- maintain access controls for the watershed (watershed has no future use)
- protect maintenance workers
- provide ecological protection to valley-wide populations
- prevent contaminated groundwater plume growth
- achieve ambient water quality criteria in all waters of the state

Once a range of remedial action objectives are developed with stakeholder input, remedial alternatives are developed by mixing and matching the developed remedial action objectives with any of the following general remediation strategies:

- source control through removal
- source control through in situ treatment source control through source containment migration control

The remediation strategies consist of different methods to mitigate risk by controlling either the contaminant source or the migration pathway. The source control strategy maximizes use of source actions such as excavation, grouting, or capping to cut a contaminant migration or exposure pathway. Migration control is a remediation strategy emphasizing groundwater or surface water collection to control contaminant migration to potential receptors. The remedial action objectives are matched with appropriate remediation strategies to form alternatives. Some objectives such as restoration to unrestricted use cannot be combined with some strategies such as source control through containment or migration control. Table 1 shows the results of this effort for the example watershed. These alternatives represent a range of specific remedial action objectives and remediation strategies that allow the stakeholders to explicitly determine the level of cleanup desired for the watershed as well as the specific actions to be employed.

Table 1. Developed Example Remedial Alternatives

Alternative	Remedial Action Objective	Remedial Strategy
1	N/A	No Action
2	3	Migration Control
3	3	Source Containment
4	2	Source Containment
5	2	Source Containment
6	1	Source Removal

After an alternative is developed with a remedial action objective and remediation strategy, a series of actions---one per contaminated site, area, or media are generated. These actions, when combined, must meet the assigned objective. The actions generally follow the strategy, but there will be numerous exceptions. If the strategy is insitu treatment, many of the minor sites may still just be covered leaving the insitu treatment for the sites with a significant impact on the remedial action objective.

In addition to meeting the objectives, actions are assigned to optimize cost-effectiveness. Most of the remedial alternative costs should be to the sites causing the most exceedances of the remedial action objectives. If one site is causing 80% of the offsite risk and controlling that risk is required under the remedial action objective, it would be wise to focus efforts and cost on that site.

The final important point of watershed-wide alternatives is that the actions are sequenced in order of implementation. The first criteria for sequencing is construction logic. Some activities such as well plugging and abandonment on a burial ground must occur before other actions such as capping the burial ground. Then, if there are key differences in risk between areas or sites, the actions are sequenced to maximize early risk reduction. If the sites are somewhat equally of concern, larger contracting packages can be developed by sequencing like work together.

The evaluation of these alternatives can be comprehensive, complete, and cumulative because the alternatives consider all actions required for a certain area.

CONCLUSIONS

The watershed approach for decision-making used on the Oak Ridge Reservation provides a process for the decision-makers to determine the appropriate level of cleanup based on the future use of the watershed and level of protection of the environment. By focusing on the objectives to be achieved, a comprehensive, integrated program is developed that uses scarce resources wisely.