Technical Methodology for Evaluating Risk and Cost Information for Long-Term Resource Management of Contaminated Sites

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Abstract: There has been a significant investment in Long-Term Stewardship (LTS), but most studies have focused on the political and planning component of this issue. This paper summarizes a technical approach to linking the established baseline and remedial risk information (e.g., risk and installation cost) with post-cleanup operations and maintenance to provide estimates of life cycle risk and cost. The key linkage was to map risk assessment land use patterns with LTS levels. The established baseline risk assessment process is linked to a concept of LTS levels based on human health risk metrics (e.g., cancer incidence and hazard quotient). Four different levels of LTS were defined based on a wide range of risk values to allow decision-makers to evaluate different waste sites under different management conditions and regulations. These LTS levels were back calculated to the baseline risk assessment and also calculated to cost to provide a complete life-cycle methodology of risk and cost information for a waste site. An example case study was conducted using this technical approach and the preliminary results will be presented along with plans to advance this approach.

Over the coming decades, the U.S. Department of Energy (DOE) will complete remediation of approximately 2.5 million acres of land. Current resource and technology constraints will result in many of the contaminated sites being closed with significant residual contamination. This has prompted DOE to investigate a LTS program that would include long-term planning processes and risk and cost-based procedures for managing DOE sites now and post-closure. Without this approach and based mainly on compliance drivers, DOE may have limited and costly options for land reuse or release.

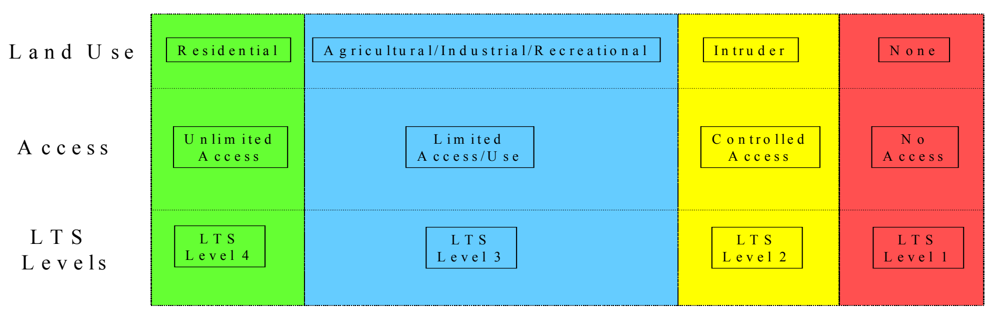
LTS is based on the balanced and responsive management, over time, of human health risk, future uses, and conditions that are anticipated but may change dramatically with advances in technology or public interests. LTS seeks to balance these objectives and uncertainties by enabling the best use of the site (i.e., site missions) at the present time with flexibility to respond to change. This method considers the LTS cost and performance for alternative site remediation scenarios to balance risks and costs.

The method for risk management during LTS starts with compliance calculations for land use categories and intruders. Life cycle cost and land user exposure scenarios are completed to support remediation, facility maintenance, and stewardship activity level decisions. Life cycle cost results determine the long-term value of the remediation plan. Realistic land use exposure scenarios are used to implement specific strategies for long-term land management that allow safe land use and respond to uncertainties in fate and transport, land access control, and containment structure maintenance.

Site managers and potential site users look at the clean up process from a different perspective than regulators and remediation engineers. Site managers and users start with site operations and mission, and move to resource considerations, land use options and land access/controls. Regulators and remediation engineers start with the waste site sources and move to transport media, exposure pathways to land use options and access. The perspective of land users is not a focus in compliance discussions.

There is a relationship between land use, access, and four LTS Levels used in this evaluation shown in Figure 2. The linkage of the land use scenarios to access controls and LTS Levels allows decision-makers to link the risk assessment information to life cycle cost. This linkage is a key component of the methodology developed for LTS and its evaluation. LTS Level 1 corresponds to No Access and No land use. LTS Level 1 will require enforcement of No Access because the health risk potential is unacceptable for the assumed exposure. LTS Level 2 corresponds to Intruder land use and Controlled Access that requires periodic onsite enforcement because of health risk from periodic exposure. LTS Level 3 corresponds to Agricultural, Industrial and Recreational land use and Limited Access/Use that requires administrative enforcement or user participation in risk management by site users because of health risk from continuous exposure. LTS Level 4 corresponds to Residential land use and Unlimited Access that requires no site controls because the health risk is estimated to be below acceptable limits for these uses.

Figure 2. Linkage Between Land Use, Access and LTHM Levels



The method was applied to a contaminated location on the Hanford Site in Washington State. The contaminated location borders a new national monument and is desirable for recreational and cultural land uses. The example site used for this assessment consisted of the 1301-N and 1325-N Liquid Waste Disposal Facilities that are located in the 100-N Area of the Hanford site. Both disposal facilities are cribs that received radioactive effluents and some hazardous wastes, which included Co-60, Sr-90, Ru-106, Cs-137, and Pu-239/240. Liquid wastes were poured into the cribs and allowed to drain down through the vadose zone.

The site is currently under active pump and treatment of the groundwater and vadose zone source removal is being planned, but for the purpose of investigating alternative remediation or stewardship options, it was necessary to start with a non-remediated site. Therefore, a hypothetical site model was developed for this site for the purposes of demonstrating the methodology. For this assessment, the constituent ^{90}Sr was selected as the controlling risk constituent. Three remedial alternatives were examined. The following is a list of each of the remediation alternatives and a brief description of how each was modeled:

1) Removal - The contaminated source zone was removed and backfilled with clean soil.
2) Treatment Wall - Identical to case 1 (Removal) except that a thin aquifer treatment wall with a high Kd (200 ml/g) was placed between the contaminated aquifer and the receptor well.
3) Pump and Treat - Identical to the removal case except that pump and treat wells were installed to slow the water flow to the receptor well.

For this scenario, the ^{90}Sr concentrations exceed the acceptable water quality standard for the next 150 to 200 years depending on the treatment strategy with groundwater treatment of all types actually prolong stewardship requirements. Most of the reduction of risk with time occurs because of natural attenuation in the environment based on the radioactive decay of the ^{90}Sr (half-life of 30.1 years). This means that after 150 years, only 1/32 of the current amount of ^{90}Sr will be existing, independent of transport. In addition, the water flow rate in the source and the vadose zone is very slow (less than 5cm/yr) and the mobility of the ^{90}Sr at the site is relatively low (Kd = 20 ml/g). This implies that source removal beyond that necessary to manage surface exposures or caps to retard water flow through the vadose zone will not significantly affect concentrations in the saturated zone. Dilution in the river is sufficient that no significant exposures would occur downriver for any of the cases studied.

The LTS costs include operations and administrative costs, sampling and analysis costs, maintenance costs of engineered structures, replacement or rejuvenation costs of engineered structures, and emergency response actions costs. On this location, groundwater contamination could exceed desirable standards for over 150 years with or without remediation. In a conventional approach, it could be argued to either rely on natural attenuation or to do a limited remediation. Remediation, once started, would continue for the long term, would be costly and provide little benefit after the first few decades in comparison to natural attenuation. In any of the treatment scenarios, site management to limit exposures to land users will be needed to either augment or replace engineering treatment strategies. It appears that avoiding groundwater consumption would be protective at this site and may be achievable given restricted land uses of a national monument.

It was concluded for this example that sites with large amounts of residual contamination may have few, if any, uses and high costs if the goal is unrestricted use. In these cases, restricted use via both passive and active measures may make much more land available at lower cost. Passive measures including deed restrictions are in current use. Active measures could include ongoing efforts to make management of exposure a matter of public education and site user responsibility.

It is recommended that compliance-based uses of risk and cost analyses be extended to site management as part of Long Term Stewardship. This extension should be based on realistic exposure scenarios and include the perspective of site users. With these extensions, it is anticipated that potential users will have increased safe access to sites with significant residual contamination. This access will occur sooner and at less cost than current approaches that focus on remediation end points.