INTEGRATING RISK ANALYSES AND TOOLS AT THE U.S. DEPARTMENT OF ENERGY HANFORD SITE

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ABSTRACT

Risk assessment and environmental impact analysis at the U.S. Department of Energy (DOE) Hanford Site in Washington State has made significant progress in refining the strategy for using risk analysis to support closing of several hundred waste sites plus 149 single-shell tanks at the Hanford Site. A Single-Shell Tank System Closure Work Plan outlines the current basis for closing the single-shell tank systems. An analogous site approach has been developed to address closure of aggregated groups of similar waste sites. Because of the complexity, decision time frames, proximity of non-tank farm waste sites to tank farms, scale, and regulatory considerations, various projects are providing integrated assessments to support risk analyses and decision-making. Projects and the tools that are being developed and applied at Hanford to support retrieval and cleanup decisions include:

- *Life Cycle Model (LCM) and Risk Receptor Model (RRM)* – A site-level set of tools to support strategic analyses through scoping level risk management to assess different alternatives and options for tank closure.

- *Systems Assessment Capability for Integrated Groundwater/Vadose Zone (SAC) and the Site-Wide Groundwater Model (SWGM)* – A site-wide groundwater modeling system coupled with a risk-based uncertainty analysis of inventory, vadose zone, groundwater, and river interactions for evaluating cumulative impacts from individual and aggregate waste sites.

- *Retrieval Performance Evaluation (RPE)* – A site-specific, risk-based methodology developed to evaluate performance of waste retrieval, leak detection and closure on a tank-specific basis as a function of past tank leaks, potential leakage during retrieval operations, and remaining residual waste inventories following completion of retrieval operations.

- *Field Investigation Report (FIR)* – A corrective action program to investigate the nature and extent of past tank leaks through characterization activities and assess future impacts to determine if there is a need to implement interim measures or take corrective action before closing the tank farms.

This list is not meant to be all inclusive of risk analysis projects and tools at the Hanford Site. It is intended to highlight a small set of projects and illustrate the process of integrating risk analysis information for a complex set of interrelated interim decisions and issues for various types of waste sites. New and emerging information relative to long-term human health risks during and following tank and non-tank site closure show the importance and usefulness of an integrated risk framework for decision-making. This paper will describe the approach for using risk assessment to support waste site and tank closure decisions, the tools being developed, and how integration of these risk assessments and analyses are being performed to address near-term and long-term decisions.

INTRODUCTION

Cleanup activities have been on-going at the Hanford Site and are scheduled to be completed by site closure in 2050. One current focus is in the middle portion of the site, the 200-Area Central Plateau, where a large number of Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) adjacent waste sites. These sites are being evaluated for cleanup and closure. They are under different regulatory, funding, and managerial control, with the compliance point for tanks defined as the Waste Management Area Boundary. However, it may not be possible or even reasonable to separate tank waste from non-tank waste when evaluating the human and environmental impacts of contamination via the groundwater pathway from the 200-Area Central Plateau. Therefore, responsible cleanup of the 200-Area Central Plateau must account for the cumulative and composite contamination from all waste sites.

Integration of the various risk analyses and management is critical to the ultimate closure of the tanks, the 200 Area, and the entire Hanford Site. A multitude of projects and programs are involved. Some projects use risk analysis and management to develop options and decision points. In the case of single-shell, high-level waste tanks, the current retrieval requirements for the tanks are based on the interim retrieval goal to remove 99% of the waste by volume. The actual amount that will be left or retrieved will be established on a tank-by-tank basis following technology demonstrations and tank-specific considerations. The current understanding with regulators is that risk assessment is a valuable tool (in concert with retrieval demonstrations) to assist in determining the amount of waste that can be left in tanks and in what form. Risk assessments will be used to evaluate the risk associated with the final (performance-based) closure decisions. These final risk-based decisions for tank closure need to be integrated with risk-based efforts associated with non-tank waste sites. This will help ensure that composite and cumulative impacts are understood. The goal of this paper is to 1) provide examples of several risk-based projects related to 200-Area Central Plateau waste sites at the Hanford Site, and 2) describe how their implementation and results are being integrated to provide a holistic look at human and environmental risk.

Because of the number, proximity, and potential interaction of past releases, releases during remediation, and releases following closure of waste sites and contaminated facilities in the 200-Area Central Plateau, it is important that risk-based cleanup decisions be integrated. Work is underway to coordinate the efforts of DOE, regulators, contractors, and stakeholders to establish common assumptions for land use, performance standards, and relevant exposure scenarios for use in evaluating facility closure performance.

In addition to integrating the risk-based cleanup decisions, DOE and the regulatory agencies have embarked on a process to streamline all cleanup work at the Hanford Site. The process called Cleanup, Constraints, and Challenges Team is considering the actions needed to eliminate barriers to progress. Participants agreed to develop a collective and widely accepted vision of the future end state for the Hanford Site, renewed commitment to the Hanford Federal Facility Agreement and Consent Order, otherwise known as the Tri-Party Agreement, as the principal document governing Hanford cleanup, reduction of unnecessary layers of requirements and the development of a strategy to ensure more stable national investment and support for Hanford cleanup activities.

BACKGROUND

Radioactive waste has been generated since the early 1940s at the Hanford Site in support of national defense activities. Types of waste present on the site include high-level waste from reprocessing, spent nuclear fuel, transuranic waste, and mixed wastes. Major sources of contamination that require remediation or consideration in making cleanup decisions include tank waste, spent fuel processing facilities, burial grounds, and liquid disposal sites (cribs, ponds, and ditches). On the Hanford Site 200-Area Central Plateau, waste management activities currently being conducted include waste disposal, waste retrieval demonstrations, treatment, and planning efforts to establish cleanup priorities and define the extent of cleanup necessary to be protective of human health and the environment. Most waste management facilities are located in either the 200-East or 200-West Area (Figure 1). The 200-East and 200-West Areas are both approximately 3.2 km (2 miles) across and are approximately 4 km (2.5 miles) apart. The U.S Department of Energy, Richland Operations Office is beginning the process of cleaning up contaminated facilities and past practice sites on the 200-Area Plateau. The U.S Department of Energy, Office of River Protection is moving forward with retreival and treatment of the 177 tank wastes and associated facilities, evaluating and mitigating the impacts of past tank leaks and spills, and planning for tank farm closure. Both offices have plans to dispose of low-level mixed waste on the plateau (Environmental Restoration Disposal Facility, low-level waste burial grounds, Immobilized Low Activity Waste (from tank waste treatment). In addition there is a commercial low-level waste disposal facility on the plateau.

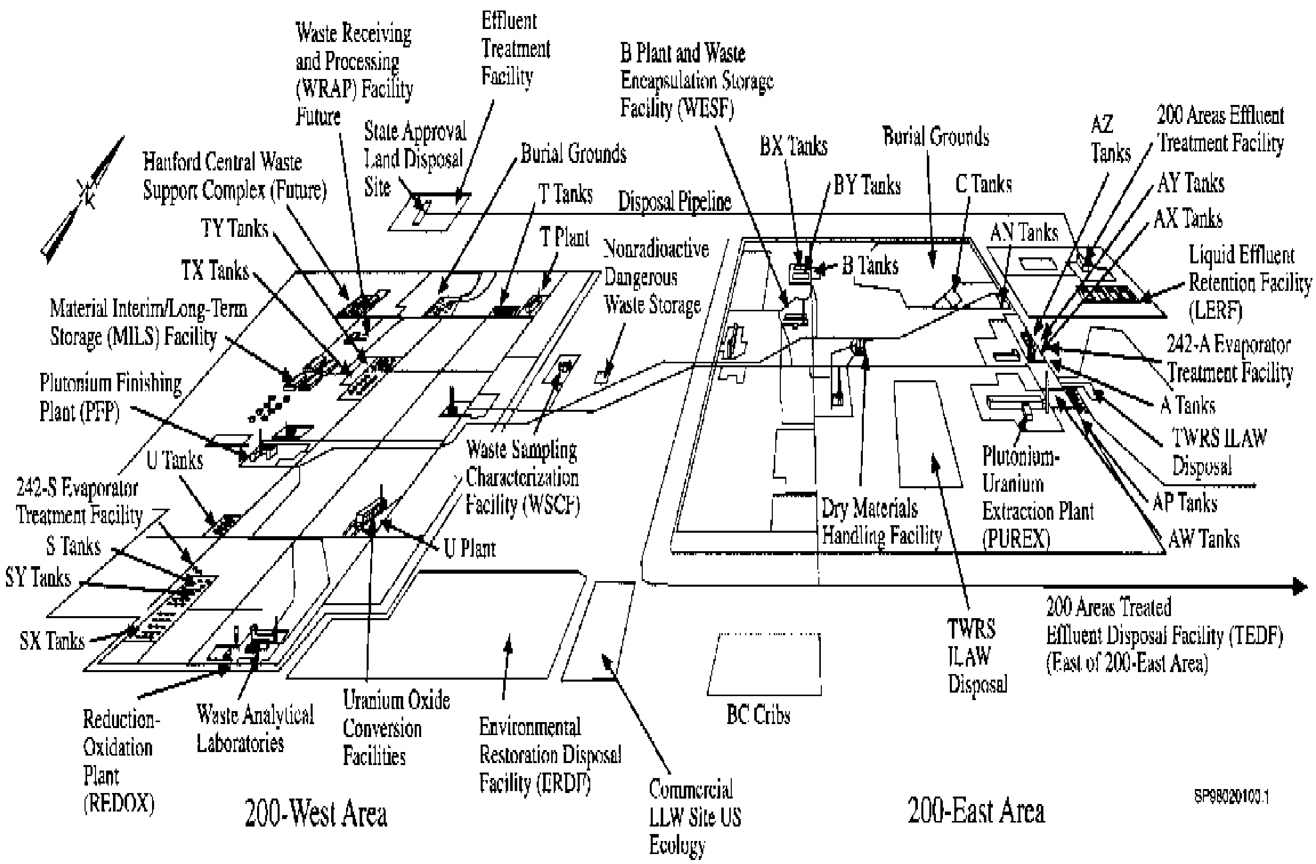

Fig. 1. Waste Storage and Disposal Facilities in the 200 Areas. Source: PNNL-11800, Composite Analysis for Low-Level Waste Disposal in the 200-Area Plateau of the Hanford Site

This paper will focus on tank-specific waste retreival and closure issues, but non-tank waste sites associated with the 200-Area Central Plateau must be addressed in conjunction with tank issues to understand the overall impact to human health and the environment. Liquid radioactive and chemical waste from nuclear materials production and research were transferred to underground, reinforced-concrete, steel-lined tanks for storage. Large volumes of liquid waste (346 billion gal) with lower radionuclide concentrations were also discharged to the ground. The single-shell tanks currently contain 125,000,000 L (33,245,000 gal) of radioactive mixed waste and the double-shell tanks currently contain 78,850,000 L (20,833,000 gal) of radioactive mixed waste.

The single-shell tank system includes 12 individual single-shell tank farms that contain 133 large volume tanks (1.9 to 3.8 million L [500,000 to 1 million gal]); 16 smaller volume tanks (208,000 L [55,000 gal]); ancillary equipment associated with the tank farms; 17 active miscellaneous underground storage tanks; 41 inactive miscellaneous underground storage tanks; and soils contaminated from past spills and leaks. The inactive miscellaneous underground storage tanks range in size from 500 to 50,000 L (130 to 13,000 gal) capacity. The DST system includes 28 large volume (3.8 to 4.5 million L [1 to 1.2 million gal]) tanks. The double-shell tank are newer generation tanks with secondary containment. Current plans include continued use of the double-shell tanks for storing, managing, and staging waste retrieved from single-shell tanks prior to transfer to the waste treatment plant. Figure 2 provides the geographic locations of the waste sites in 200-Area Central Plateau.

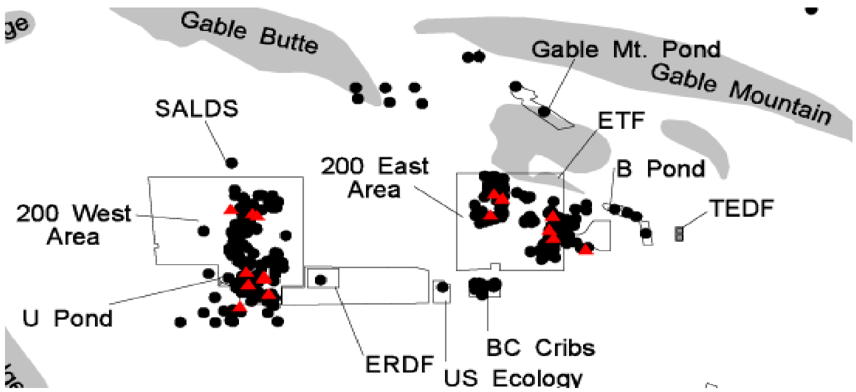

Fig. 2. Location of the Various Tank and Non-Tank Waste Sites in the 200-Area Central Plateau. (Source: Kincaid et al. 2001; ERDF = Environmental Restoration Disposal Facility; ETF = 200-Areas Effluent Treatment Facility; SALDS = State and Approved Land Disposal Site; TEDF = 200-Areas Treated Effluent Disposal Facility).

The Hanford Federal Facility Agreement and Consent Order signed by DOE, the Washington State Department of Ecology, and the U.S. Environmental Protection Agency in 1989, is an agreement to clean up radioactive and hazardous waste at the Hanford Site (1). The Tri-Party Agreement establishes an action plan for cleanup that addresses priority actions and methods for resolving problems and milestones. The Agreement sets milestones to achieve coordinated cleanup of the Hanford Site and provides for the enforcement of these milestones to keep the program on schedule. The Agreement was revised in 2001 to modify the tank waste retreival strategy to focus on maximizing risk reduction. It also incorporated risk-based decision processes for evaluating potential leakage from tanks during waste retrieval and for determining allowable residual waste inventories following retreival.

In 1996, DOE and the Department of Ecology issued an environmental impact statement to address alternatives for the safe management and remediation of the radioactive, mixed, and hazardous waste stored in 149 single-shell tanks and 28 double-shell tanks (2). This Environmental Impact Statement did not evaluate alternatives for closure of the tank farms because there was insufficient information concerning the amount of contamination to be remediated.

The following list of activities summarizes recent developments and information that influence risk-based decision making on the 200-Area Central Plateau:

- Waste management area S-SX Tank Farm field investigation report concludes that future impacts from existing vadose zone contamination will impact the groundwater at contaminant concentrations that exceed drinking water standards and risk thresholds (RPP-7884, Draft).

- Spectral gamma logging program established a baseline for the depth and extent of gamma contamination resulting from past leaks and spills in the single-shell tank farms. A baseline of spectral gamma logging for waste sites outside of single-shell tanks but within the 200-Area Central Plateau is underway.

- Eight of the 12 single-shell tank farms have been placed into the RCRA Corrective Action Program because of indications that past leaks from these farms have impacted the groundwater

- The Hanford soil inventory model (3) for technetium-99 has been completed. It is one of the principal constituents of concern for long-term human health risk. The model estimates that approximately 1,030 curies of technetium-99 were discharged to liquid waste disposal sites compared to 194 curies discharged from tank leaks.

- The 200 Areas environmental restoration program assumes an industrial-exclusive land use and risk-based cleanup level of 10^{-4} to 10^{-6} incremental lifetime cancer risk (4).

- Clean closure (removal of the tanks and ancillary equipment and remediation of contaminated soil) of the AX tank farm would result in a substantial short-term risk worker risk for minor reductions in long-term impacts.

- Land-use planning decision was reached through the Comprehensive Land Use Plan Environmental Impact Statement to designate the 200 Area Central Plateau for industrial-exclusive use.

- A plan has been deployed to dispose of immobilized low-activity tank waste in the 200-East Area.

- CERCLA decisions have been made to dispose of wastes from the 100 and 300 Areas in the Environmental Remediation Disposal Facility located in the 200-West Area. A large volume of this waste has already been transported to this facility since 1996.

- A plan has been developed to landfill close the commercial low-level radioactive disposal site, which is adjacent to the 200-East Area.

- Appendix H of the Tri-Party Agreement provides the framework for establishing landfill closure criteria.

When the activities described above are considered together, there is compelling evidence that clean closure might not be viable, and assessment of RCRA landfill closure might be the only viable path forward for the single-shell tank farms (5). Landfill closure will require establishment of performance standards that may require negotiation because of limitations associated with leak detection and waste retrieval technologies. Integration of risk assessments is needed to address the allocation of human health and environmental impacts from tank and non-tank waste management units. For example, it doesn't make sense to establish leak detection criteria for a tank waste retrieval system based on a risk of 10^{-4} if an downstream waste site is being cleaned up to a risk of 10^{-6}.

Because of the number, proximity, and potential interaction of past releases, releases during remediation, and releases following closure of waste sites and contaminated facilities in the 200-Area Central Plateau, it is important that risk-based cleanup decisions be integrated. Work is underway to coordinate the efforts of DOE, regulators, contractors, and stakeholders to establish common assumptions for land use, performance standards, and relevant exposure scenarios for use in evaluating facility closure performance.

OFFICE OF RIVER PROTECTION MISSION AND CURRENT STRATEGY

The Office of River Protection's mission is to store, retrieve, treat, immobilize, and dispose of the highly radioactive Hanford Site waste (current and future tank waste and cesium and strontium capsules) in a safe, environmentally sound, and cost-effective manner (6).

The separations and immobilization of tank waste will take place in new facilities in two phases. In the initial phase (Phase I), approximately 10% of waste by mass and 25% by radioactivity will be treated. The remaining waste will be treated in the second phase (called Balance of Mission). Design and construction activities for the initial phase are currently underway. The decision about how and when to implement Phase II will not be made for several years. However, the decisions made regarding Phase I will influence the timing of the Phase II decision and the options available for Phase II implementation. The Office of River Protection is required to submit a plan for completing the waste treatment mission 3 years after the start of commercial operations in the Phase I vitrification plants.

Waste retrieval strategies must account for not only the waste types (i.e., liquid, salt cake, sludge/hard heel, or a combination) but also for whether the tank has leaked in the past. Retrieving waste from tanks known to have leaked in the past without causing significant additional leakage of waste to the soil presents a major technological challenge. Waste retrieval from single-shell tanks is planned using fluid-based retrieval technologies that minimize, to the extent possible, water or fluid additions. Other methods of waste retrieval are being investigated for tanks classified as "leakers" via EM-50 initiatives.

Schedules and milestones have been established for the overall tank waste retrieval and closure endpoints, tank-specific milestones have been established for near-term waste retrieval activities (before September 2006), and dates have been established for re-negotiation of the balance of the waste retrieval activities. The current strategy for retrieving waste from single-shell tanks is based on technology demonstrations and technology deployments in tanks with different waste types. Initial deployment of waste retrieval systems via milestones is scheduled for completion in 2006-2007. Office of River Protection is leveraging with interim stabilization on a key waste removal demonstration in U-107 now to support future retrieval design enhancements.

Following completion of waste retrieval activities, the tanks will be transitioned to closure. Under the Tri-Party Agreement milestone M-45-06*, "Closure of all single-shell tank farms in accordance with approved closure/post closure plans*" is to occur by 9/30/24. Although single-shell tank farm closure occurs toward the end of the Office of River Protection mission, near-term decisions for elements of the River Protection Project are inter-related with future closure decisions. The tank waste retrieval projects and the Tank Farm Vadose Zone Project are the principal near-term program elements affected.

RISK-BASED DECISION MAKING

Risk-based decision-making is a process that can be used to make determinations on priority, extent, and criteria for remediation of contaminated waste sites. Risk-based decisions typically consider long-term human health risk as one of several inputs to a decision. Risk, within the context of making cleanup decisions for waste tanks, contaminated facilities, or past practice sites, could include current risk, risks during remediation, and risks to future site users following closure. Risk-based decision-making provides a technical basis for selecting and implementing actions that protect human health and the environment and consider site-specific conditions and exposure pathways. Risk-based decision-making has been widely used within DOE (7) and industry (8).

Concerns over the consideration of risk have included credibility of a group to quantify risks, lack of data, and uncertainties associated with future site conditions, exposure scenarios, and points of compliance. The incorporation of uncertainties into the risk assessment process helps to resolve these concerns. The National Academy of Science has evaluated the use of risk to support decisions and determined that a risk-based approach could have value if its purpose and limitations are well defined (9).

Many regulations that govern cleanup decisions are based on protection of human health and the environment; however, there are likely to be cases when compliance with the regulations (i.e., drinking water standards) cannot be met, and the limits of technology or practicality warrant consideration of risks through site-specific exposure pathways. The risk levels considered could be outside of established guidelines, and site-specific situations could warrant consideration of the tradeoffs between short-term risks to workers and the public and long-term risks to potential future site users. For example, remediation of a contaminated soil site to meet future groundwater protection standards may result in an unacceptably high short-term risk to workers and the environment.

The consideration of risks has been integrated into the River Protection Project for both near-term and longer-range decisions. Because of the number of sites, their proximity to each other, and the environmental setting, potential interactions or cumulative effects need to be considered for long-term risks. To this end, the Systems Assessment Capability for Integrated Groundwater/Vadose Zone involves assessing the composite effects of all waste sites across the Hanford Site, including the 200-Area Central Plateau assuming all the cleanup actions in the current plans are carried out (10). Site-specific impacts for individual sites are evaluated case by case with more detailed tools depending on the purpose of the assessment and the type of decision (i.e., interim decision for one site within a group or a final decision for a waste management area). There is a need to make near-term decisions and move forward with cleanup actions before the final end state is known for all waste sites. Examples where risk-based decisions have been incorporated into the Office of River Protection program include the following:

- RCRA Corrective Action decisions for past tank leaks – near-term decisions need to be made to evaluate the need for action to be taken before tank farm closure. This process will use the RCRA Corrective Action process to characterize past leaks and evaluate measures that could be taken to mitigate impacts on human health and the environment.

- Disposal decisions for Immobilized Low Activity Waste – near-term decisions need to be made for onsite disposal of immobilized tank waste. This process follows the traditional DOE Performance Assessment path.

- Retrieval decisions for single-shell tanks (leak detection) – near-term decisions are needed to move forward with retrieval of waste from the single-shell tanks. Recent modifications to the Tri-Party Agreement established a requirement for a functions and requirements document to be completed before waste retrieval system design. The functions and requirements document will include an environmental and human health risk evaluation for the estimated waste volumes to be retrieved, potential retrieval leakage, and risk from residual waste remaining in the tank following retrieval. The relationship between residual waste and retrieval leakage is then used to establish criteria for the leak detection systems. CH2M HILL Hanford Group recently subcontracted Sandia National Laboratories to modify the "deterministic" Retrieval Performance Evaluation methodology to include capabilities for sensitivity and uncertainty analyses. The stochastic or probabilistic version of the Retrieval Performance Evaluation is to be demonstrated on Tanks S-112 and C-104.

- Tank closure – longer-term decisions are needed for closure of the tank farms. Recent modifications of the Tri-Party Agreement included the addition of a risk-based process for setting, evaluating, and revising criteria for determining the allowable residual waste following waste retrieval operations for single-shell tanks.

There is an ongoing need to incorporate risk allocation into the decision-making process to allow tanks and non-tank waste sites to move forward to closure. Risk and other considerations must be balanced using a common framework for land use, point of compliance, and exposure pathways.

RISK ASSESSMENTS AND ANALYSES PROJECTS AND TOOLS

This section of the paper will briefly describe the four primary projects involved in estimating human health and environmental impacts from tank waste sites and how they are being integrated to provide a holistic look at tank closure. Many other projects are involved in overall evaluations of tank closure, but these four projects illustrate the types of integration that is occurring at the Hanford Site with respect to risk analysis and assessment. Figure 3 show the relationship between these four projects with respect to scale and assessment type.

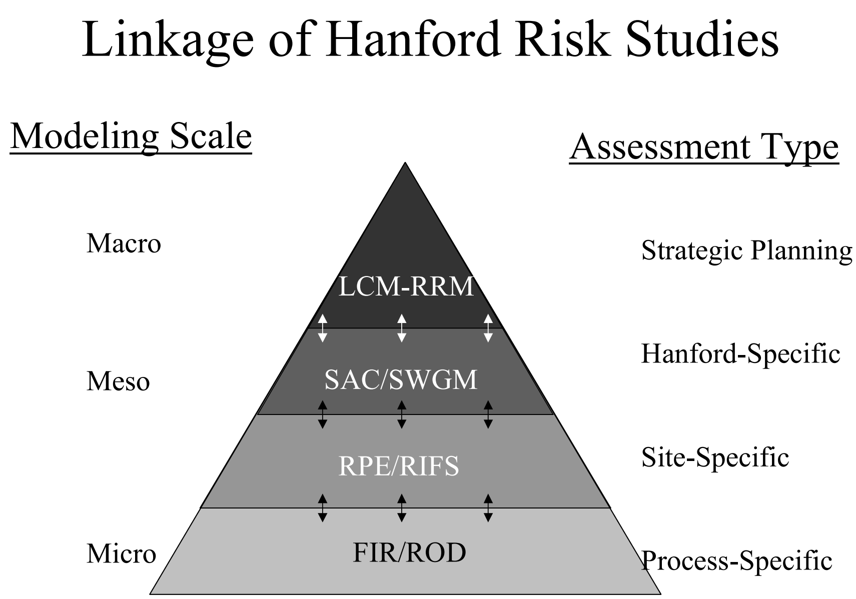

Fig. 3. Diagram of the Various Modeling Scaled and Assessment Type Associated with the Four Projects (LCM = Life Cycle Model; RPM = Risk Receptor Model; SAC = Systems Assessment Capability for Integrated Groundwater/Vadose Zone; SWGM = Site-Wide Groundwater Model; RPE = Retrieval Performance Evaluation; RIFS = Remedial Investigation Feasibility Study; FIR = Field Investigation Report; ROD = Record of Decision)

Life Cycle and Receptor Risk Model Project

To better understand the ramifications of various cleanup alternatives associated with the Office of River Protection mission, a macro-level method for estimating long-term human health risk was developed. The Receptor Risk Model was developed to provide long-term human health impacts associated with tank waste. It can be used as a stand-alone tool or integrated with the Life Cycle Model. The Life Cycle Model is a scoping-level tool that provides budget, schedule, short-term work risk and long-term human health risk, as provided by Risk Receptor Model. It supports the Office of River Protection in strategic planning of tank closure. One main goal of the Risk Receptor Model is to quickly evaluate a number of different alternatives for screening down the number of alternatives that are evaluated in detail.

The Risk Receptor Model uses a unit factor approach to develop long-term human health risk values that can be used for strategic planning (these results should not be used for final decisions). The Risk Receptor Model is a macro-scale-level risk analysis tool that can provide a more comprehensive risk analysis while meeting the schedule and resources required for the Office of River Protection mission. It is not meant to replace more detailed or site-specific analyses. The Risk Receptor Model produces risk and environmental concentrations contours for specific tank farm(s), time(s), exposure scenario, and release type(s). These contours are a useful way to display a large amount of data at one time to decision makers and stakeholder. A key effort of this task is to use information and data from more detailed projects and programs related to the Office of River Protection mission and ensure consistency and extensibility to these other efforts.

The Receptor Risk Model includes the following characteristics:

- It is a macro-level scoping tool for long-term human health risk.
- It is deterministic in nature for this analysis, with options to be stochastic in the future.
- It builds on information and approaches used by previous and current projects related to the RPP.
- It tiers with more detailed project results as they become available.
- It is coordinated with Tank and Tank Farm Risk analyses being performed in the Single-Shell Tank Program.
- It provides enhanced capability to plan alternative analyses.
- It is incorporated into the Life Cycle Model (links to schedule and budget information).
- It provides the choice of receptor types, locations, time of interest, and activities.
- It is extensible to consider non Office of River Protection sources terms and additional receptor locations.

Systems Assessment Capability for Integrated Groundwater/Vadose Zone

The System Assessment Capability is a tool for conducting site-wide, Hanford-specific assessments of the cumulative impacts of waste remaining at the Hanford Site at the time of site closure and beyond. The tool was developed in response to recommendations by the Defense Nuclear Facilities Safety Board (11), DOE orders, and input from regulators, and stakeholders. DOE Order 435.1 (12) now requires a site-wide assessment of dose for all pathways associated with radioactive wastes. The first such analysis was completed in 1998 (13). In addition, the Columbia River Comprehensive Impact Assessment provided guidance to DOE regarding the design and completeness for an assessment of impacts to the Columbia River from Hanford waste. A group representing federal and state regulatory agencies, stakeholders, and Tribal Nations prepared this information (14). As a result, the Systems Assessment Capability was designed to produce a probabilistic, cumulative assessment of Hanford-derived radioactive and hazardous chemical contaminants, and to perform this assessment for the Hanford Site and Columbia River environments.

The tool currently can perform stochastic simulation of approximately 1,000 waste discharges and disposal sites for 10 contaminants for a modeling period of 1,000 years. The analysis models contaminant fate and transport from the waste site, through the vadose zone, groundwater, and into the Columbia River. Human health and ecological risk as well as impacts to the regional economy and culture are estimated. The tool integrates models that are specific to the Site, e.g., the Site-Wide Groundwater Model, as well as generic models that have been parameterized for the site, e.g., the Ecological Contaminant Exposure Model.

The System Assessment Capability has a flexible design and, consequently, is able to perform the following types of analyses:

- Probabilistic simulations
- Deterministic simulations
- Partial environmental pathway analyses (e.g., though vadose zone releases to groundwater)
- Complete environmental pathway analyses
- Risk and impacts analyses based on archived environmental simulations
- Complete environment/cleanup and risk/impact scenarios.

Uncertainty and sensitivity analyses can be performed based on the results of the probabilistic simulations to the key conceptual models and parameters for the variety of performance measures include in the tool.

Retrieval Performance Evaluation

The retrieval performance evaluation methodology has been developed to evaluate performance of waste retrieval and closure decisions on a tank-specific basis. The Retrieval Performance Evaluation is a site-specific analysis tool that can evaluate a single tank or several tanks within the same tank farm. A risk-based retrieval release protection strategy and the retrieval performance evaluation process are the basis for establishing functions and requirements for waste retrieval system design and leak detection, monitoring, and mitigation system requirements. The Tri-Party Agreement specifies an interim retrieval goal for waste retrieval to remove 99% by volume of the waste from the single-shell tanks. The methodology was developed in response to a 1996 memorandum of understanding between the Department of Ecology and DOE that acknowledged the uncertainty in the 99% interim retrieval goal and associated Leak Detection Monitoring and Mitigation requirements (15). Under the memorandum of understanding, DOE was tasked to assess retrieval performance criteria for the AX Tank Farm as a means of improving the agency's understanding of the applicability of various performance requirements (e.g., the Hanford Federal Facility Agreement and Consent Order, State Dangerous Waste Regulations, and DOE Orders). Efforts are currently underway through Sandia National Laboratory to develop a stochastic version of the Retrieval Performance Evaluation transport tool to evaluate system uncertainties and sensitivities for Tanks S-112 and C-104.

The Retrieval Performance Evaluation process takes a systems approach to evaluating potential impacts from tank waste retrieval and closure actions by considering the impacts from past tank leaks, potential releases during retrieval, and residual waste remaining in the tank and tank farm following closure. The process involves applying different tools to assess remediation risks to 1) workers and the public from routine and accident conditions, 2) future site users following closure, and 3) regulatory compliance. Where possible, the process uses the site-specific data and numerical models from the Field Investigation Report work to facilitate consistency and project integration.

Assessing impacts to the groundwater from past tank leaks, potential retrieval leaks, and tank residuals following closure involves evaluation of the fate and transport of contaminants. Because of the environmental setting and the time frame of interest, the interaction of the three source terms (i.e., past leaks, retrieval losses, and tank residuals) is a concern for the analysis. Impacts from individual tanks as well as the combined impacts from a tank farm are of interest in the process. Tank-specific impacts at the tank farm fence line are of interest in establishing leak detection, monitoring, and mitigation criteria for the waste retrieval systems. However, the combined impacts from all tanks within the farm are also considered because the tanks will be closed farm by farm.

Field Investigation Report

The Tank Farm Vadose Zone Project is preparing Field Investigation Reports for groups of tank farms (waste management areas) that have been placed in RCRA Corrective Action based on evidence of contamination from past leaks impacting groundwater. The purpose of the corrective action program is to investigate the nature and extent of past tank leaks through characterization activities and assess future impacts to determine if there is a need to implement interim measures or take corrective action before closing the tank farms. The two major functions of a field investigation report are 1) documenting data and the assessment of impacts using a process-specific analysis under existing conditions, and 2) the evaluating potential actions that could be taken to reduce or mitigate impacts. The data include geologic, hydrologic, geochemical, and vadose zone contaminant inventories. Data from other sources are integrated into the Field Investigation Report to enhance interpretation of subsurface conditions. The impact assessments provide predictions of groundwater impacts and associated human health risks at compliance point(s) over a period of 1,000 years.

The investigation of past leaks is conducted at a detailed site-specific and process-specific level that focuses on major leak events within a tank farm and includes a comprehensive data collection effort to evaluate subsurface conditions followed by numerical simulations to evaluate fate and transport of contaminants. The primary compliance point for assessment of groundwater impacts is the tank farm boundary. Numerous sensitivity cases are evaluated to examine system uncertainties. Science and technology activities have been integrated into the report to examine contaminant behavior and transport phenomena.

The numerical simulations consider the distribution of contaminants presently in the vadose zone and the migration of contaminants through the vadose zone to groundwater and to points of compliance within the unconfined aquifer. A suite of two-dimensional simulations is used to investigate the impact of the no action alternative (which includes a surface closure barrier); interim surface barriers; water-line leaks; clastic dikes; non-uniform inventories; concentration-dependent density and viscosity for the transporting fluid (i.e., water); and meteoric recharge. Three-dimensional simulations are used to investigate the impact of dimensionality on the numerical predictions.

Integration of Risk-Related Projects and Tools

Although integration of activities and results between projects that impact waste sites (in this case tank-related waste sites) seems like an obvious thing to do (because of the complex organizational, managerial, and funding scheme at large facilities like the Hanford Site) integration is difficult and a lower priority to the project-specific goals. Therefore, the story of how the four projects mentioned in this paper are integrating their efforts to provide not only the project-specific goals but also the Site-specific goals of cleanup and closure is a significant message.

One process called Cleanup Constraints and Challenges Team is considering the actions needed to eliminate barriers to progress. The DOE and the regulatory agencies have embarked on this process to streamline all cleanup work at the Hanford Site. Participants agreed to develop a collective and widely accepted vision of the future end state for the Hanford Site, renewed commitment to the Tri-Party Agreement as the principal document governing Hanford cleanup, reduction of unnecessary layers of requirements, and development of a strategy to ensure more stable national investment and support for Hanford cleanup activities.

Despite the fact that there are generally no project-specific goals to integrate efforts between projects, the clients (U.S. Department of Energy, Richland Operations Office and U.S. Department of Energy, Office of River Protection) and contractors have gone beyond the project-specific requirements without impacting the individual project requirements. This has provided a more useful product overall for the Hanford Site. Figure 3 shows the integration relationships between the four projects and their relative scales and assessment types.

The figure shows the range of scales analyzed by these projects from macro-level strategic planning to micro-level process-specific analysis and data collection. The range of scale and types of analyses makes the integration of the projects more difficult but more critical to ensure consistency in the cleanup and closure of the Hanford Site. Integration includes modeling scenarios and assumptions, input data, methodology, compliance points, as well as risk metrics and endpoints. The following discussion includes examples of the integration across the projects.

Common assumptions have been used through many of the meso- and macro-scaled assessments that require generalizations to be included as appropriate for the assessment. For instance, Systems Assessment Capability and Risk Receptor Model have shared information on the conceptualization and parameters associated with tank leak release rates for past leaks. They also have shared information on losses during retrieval and releases after closure of various sites used to simulate contamination and flow from the waste sites into the vadose zone. In many cases, the Field Investigation Report and Retrieval Performance Evaluation have process- and site-specific information for some but not all of waste sites included in Systems Assessment Capability and Risk Receptor Model.

Model parameters and source-term data are shared among all the projects. Hydraulic parameters for subsurface analyses can be site specific, aggregated based on multiple sites that are similar, or based on literature values. The Tank Farm Vadose Zone project has been working on collecting site-specific data for hydraulic parameters, physical properties, and concentration and mobility of numerous contaminants of concern for the Hanford Site. Data have been collected and evaluated for two tank farms, and additional farms are being characterized. Other projects have used these parameters as the best available information. Source-term information has been developed for the S/SX Tank Farms by Field Investigation Report and Retrieval Performance Evaluation and then shared and used with the Systems Assessment Capability and Risk Receptor Model projects. In addition, the Systems Assessment Capability applied a similar process to that used by Retrieval Performance Evaluation for developing source-term information at other tank farms where data were lacking. As the Tank Farm Vadose Zone Project continues to develop site-specific data for past leaks, and Retrieval Performance Evaluation efforts continue to work through the analyses of waste retrieval of these other tank farms, the Systems Assessment Capability will update its source term for use in future assessments.

Another important aspect of integration has been the use of a common methodology for the assessments. An example of this is the grid spacing for groundwater modeling in Systems Assessment Capability and Risk Receptor Model. Although the Systems Assessment Capability and Risk Receptor Model are using different approaches for modeling groundwater transport of contaminants, the common grid spacing will allow direct comparison of contaminant concentration results, spatially and temporally, and assist in anchoring the two different scaled models to each other.

The drivers for evaluating risk vary across the projects, yet the projects have worked together to use common risk metrics, compliance points, and scenarios. The Hanford Site Risk Assessment Methodology (16) is a document developed by DOE, technical staff, and stakeholders to provide a consistent set of exposure scenarios and parameters to be used for risk analyses and assessments at the Hanford Site. Typically, the calculation of dose to humans can be done rather quickly in comparison to the transport analyses. The Risk Receptor Model has included several risk scenarios to match with the Hanford Site Risk Assessment Methodology scenarios as well as scenarios used in Systems Assessment Capability, Retrieval performance Evaluation, and other studies to allow direct comparison of results. Such efforts to anchor to other projects assist in ensuring consistency of analyses Site-wide, determining uncertainties in the assessments, and indicating areas of improvement within an assessment.

The greatest challenge to continued integration of these projects has been communication and providing resources for integration. All projects can continue to improve through forums where uncertainties and data gaps are discussed. Assessors have found numerous formal (e.g., inviting project members to peer review presentations) and informal ways (e.g., phone calls and brown bag presentations) to confer on the assessments, and management continues to look for means to encourage further cooperation between the projects.

ISSUES

The following are technical and managerial issues that need to be addressed and integrated to ensure the overall goal of all these projects. The issues also are important to complete Site cleanup and closure within the limits of resources and ensure the health and safety of the public, workers, and the environment.

- Schedule and timing of activities – as schedules get accelerated or moved out, there is a need to make sure programs and projects continue to coordinate efforts and ensure tools are in place to support decisions quickly and efficiently.

- Understanding and determining the scale of analysis – the scale and level of detail of the analysis is a critical required of a project to support decisions. For example, it is unlikely that the Risk Receptor Model would be used to support a tank closure decision. The Systems Assessment Capability currently has a one-dimensional vadose zone model for each waste tanks, and there is a concern that it is not suited to making tank-specific decisions. This would not be a problem if the output from the Retrieval Performance Evaluation or Field Investigation Report-like model were integrated into the input to the Systems Assessment Capability. However, there are other programmatic decisions that can be made using analyses that do not have such fine-scale parameters.

- Model response time and appropriate tool – need to understand the response time of the various tools and the use the appropriate tool for the required response time of the decision. This may mean that a less rigorous tool be used to meet the required response time (a macro-level strategic tool first, then more Site-specific tools when response time is less an issue). There is a tendency to use detailed analysis to support all types of decisions.

- Tools need to be flexible – as the various conceptual site models, exposure scenarios, points of compliance, and land use plans change, tools need to be flexible to accommodate these changes with as few modifications as possible.

- Ongoing model validation – the Site-Wide Ground Water Model, Systems Assessment Capability and STOMP groundwater models are in various stages of model calibration and validation, including both inverse and uncertainty analyses. Other codes will be evaluated as needed.

- Reducing the uncertainty in the tank inventory data – there is an effort underway to enhance the Tank Inventory Database to accurately reflect key contaminants of concern for future risk-based decisions.

- More formalized interfaces and integration opportunities – need to develop a technical and managerial network of key personnel that can focus common goals and activities and reduce the differences between the various groups involved.

CONCLUSIONS

Integration of assessments is critical to risk-based decision making to ensure consistency in approach, underlying data, and that impacts at local (facility boundary), regional (cumulative impacts at the plateau), and Site-wide (cumulative impacts to the Columbia River) scales are considered. Integration of risk-based analyses can and is occurring at various levels at the Hanford Site.

The overall goal of all risk-based analyses being conducted is to clean up and close the Hanford Site in a safe and efficient way. To this end, integration of activities related to the various waste sites and contamination issues need to be considered. It is important to coordinate and integrate efforts so waste sites are cleaned up in a consistent manner.

From a managerial level, integration must occur between U.S. Department of Energy, Headquarters; U.S. Department of Energy, Richland Operations Office; and U.S. Department of Energy, Office of River Protection; as well as regulators and stakeholders, to ensure that schedules, budgets, and goals for individual programs and projects are consistent and reasonable for the overall cleanup and closure of the Hanford Site. To this end, an integration program led by U.S. Department of Energy, Richland Operations Office is coordinating with U.S. Department of Energy, Office of River Protection and Department of Energy, Headquarters staff and projects. This coordination is to integrate activities to the appropriate level, and to communicate the activities across the Site.

At an organizational level, DOE and its contractors are coordinating activities and efforts to ensure technical defensibility and consistency between programs and projects. In many cases, these organizations work together on project teams. A good example of this is the Life Cycle and Receptor Risk Model effort where Pacific Northwest National Laboratory is developing a risk-based tool with support from Jacobs Engineering Group, to be implemented by CH2M HILL Hanford Group in support of Office of River Protection. The Office of River Protection is coordinating all of these activities and communicating with U.S. Department of Energy, Richland Operations Office on potential linkages and integration.

At program and project levels, integration of risk-based analyses is being accomplished by being consistent in the conceptual site models, assumptions, modeling methodologies, input data, exposure scenarios, points of compliance, and risk metrics, where possible and appropriate. This paper has focused on four such projects that are working together to meet their project-specific goals, as well as the site-wide cleanup and closure goals. A key element of this integration is the process of calibrating tools and anchoring results between the various projects to ensure consistency and technical defensibility. At the site-specific level, projects calibrate their tools to monitoring data. These tools can then be used as a secondary standard and allow Hanford-specific and strategic planning tools to be calibrated to them. This ensures consistency between the various types of assessments and different modeling scales.

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