Assessing Cumulative Impacts from Source Units within Hanford's Inner Area – 16546

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ABSTRACT

The Central Plateau area at the Hanford Site has a complex mix of waste sites in several operable units, with many comingled source contamination and groundwater plumes. A key component of the evaluation process involves a planned assessment of the potential cumulative impacts resulting from co-mingled plumes and potential contribution from waste sites sources throughout the Inner Area, about 26 million square meters (10 square miles) area located in the middle of the Central Plateau. This assessment will evaluate the fate and transport of contamination at each waste site and remedial actions at those waste sites, providing an integrated vadose zone and groundwater fate and transport assessment. Although DOE's goal is to remediate the entire Inner Area to meet standard requirements in the National Contingency Plan (NCP), the complexity of the contamination including continuing contaminant sources in the Inner Area may not allow restoration of groundwater in a reasonable timeframe. DOE and regulatory agencies may need to evaluate the technical practicability of remedial actions and the potential for establishment of one or more waste management areas where drinking water standards can be obtained and maintained. The cumulative impacts evaluation is the tool to evaluate remedial action effects across source and groundwater operable units, contribute to technical impracticability evaluations, support remedial design and remedial process optimization efforts, identify additional monitoring requirements, and evaluate standard and conditional points of compliance for use considering all contaminant sources and groundwater plumes.

INTRODUCTION

The Hanford Site cleanup mission is nearing completion along the River Corridor source areas and is ramping up in the Central Plateau (Figure 1), specifically in the Inner Area. The Central Plateau Inner Area is where Hanford Site processed fuel rods to produce plutonium and where much of the derived waste was placed during operating years. The area contains cribs, trenches, and ponds for liquid waste disposal, many kilometers of pipelines to transfer liquid material and sometimes contaminated cooling water, large quantities of solid waste disposal landfills, large tanks containing liquid process waste. Many of these areas intentionally placed waste or unintentionally released waste into surface soils, vadose zone, or groundwater. In addition, waste from the entire site (and some off-site waste) has been placed into the Inner Area at the Environmental Restoration Disposal Facility (ERDF), Low Level Burial Grounds, US Ecology, among other disposal facilities. Further, the Integrated Disposal Facility (IDF) will be accepting mixed and low-level waste in the near future.

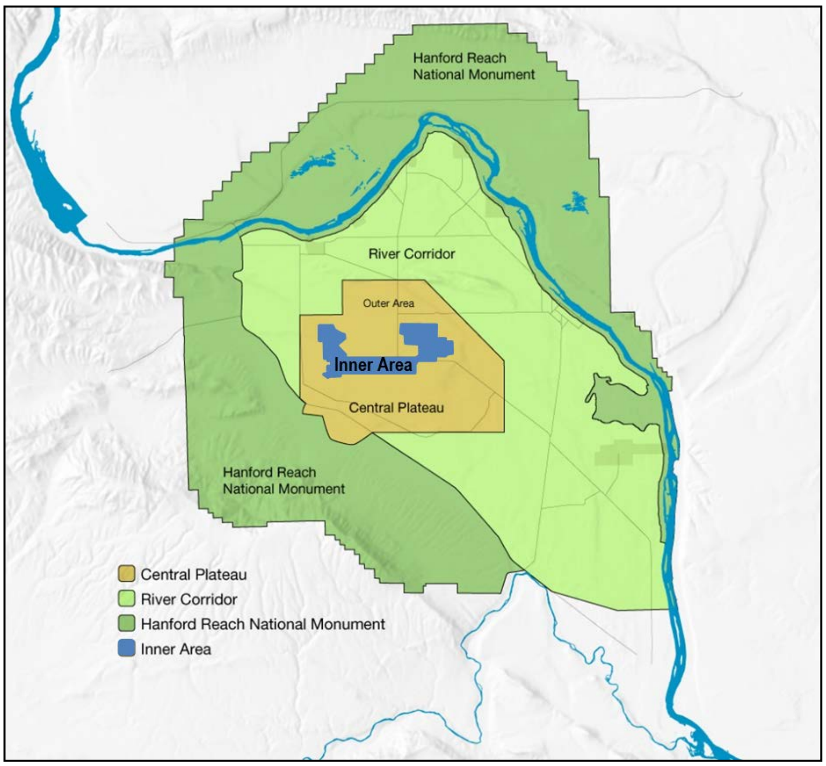

Fig. 1. The Hanford Site

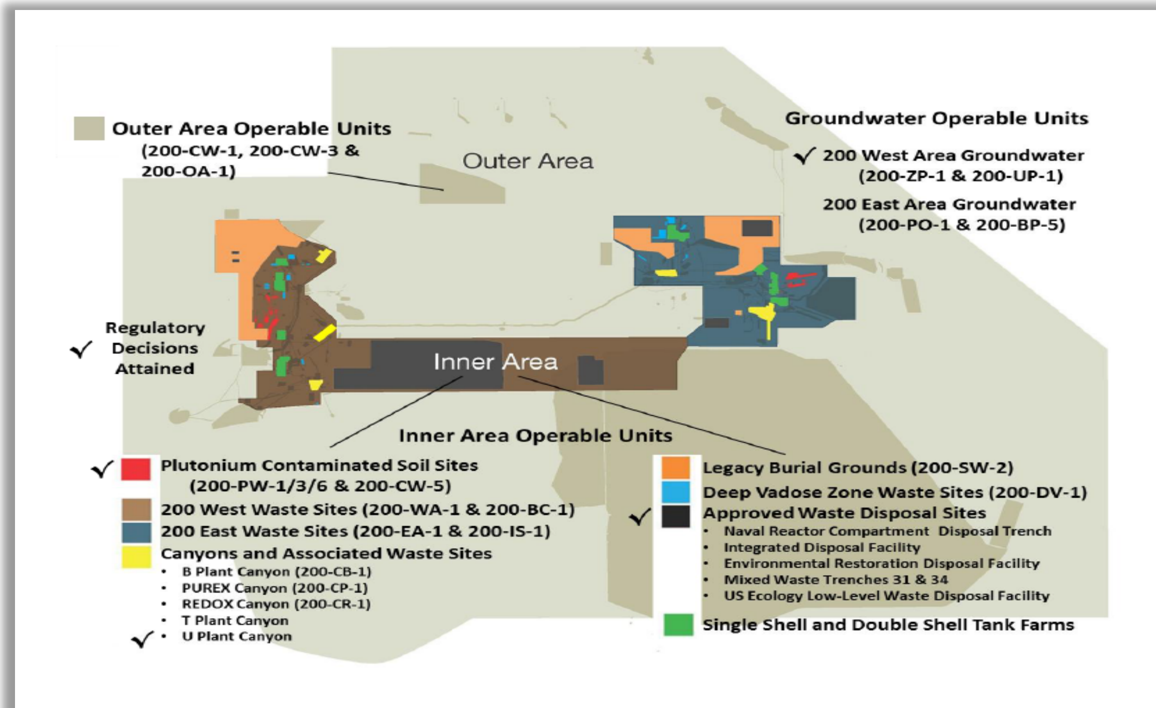

Fig. 2. The Inner Area

The Inner Area is very complex, containing multiple operable units with waste sites that are not in geographically contiguous areas. These operable units include liquid and solid waste disposal sites, pipelines, solid waste burial grounds, tanks, canyon buildings, and large process water ponds. There is also a number of Waste Management Areas which contain single-shell and double-shell steel tanks, with varying degrees of integrity and with different historical releases, including unplanned release, tank over-fill events, and pressurized releases. This led to a complex configuration (Figure 2) of operable units as well as comingled vadose zone and groundwater contamination (Figure 3). To add to the complexity of the situation, some contaminated water has also been retained in perched saturated conditions in the vadose zone well above the groundwater unconfined aquifer. Figure 3 shows existing major groundwater contamination as measured during calendar year 2014 (DOE/RL-2015-07).

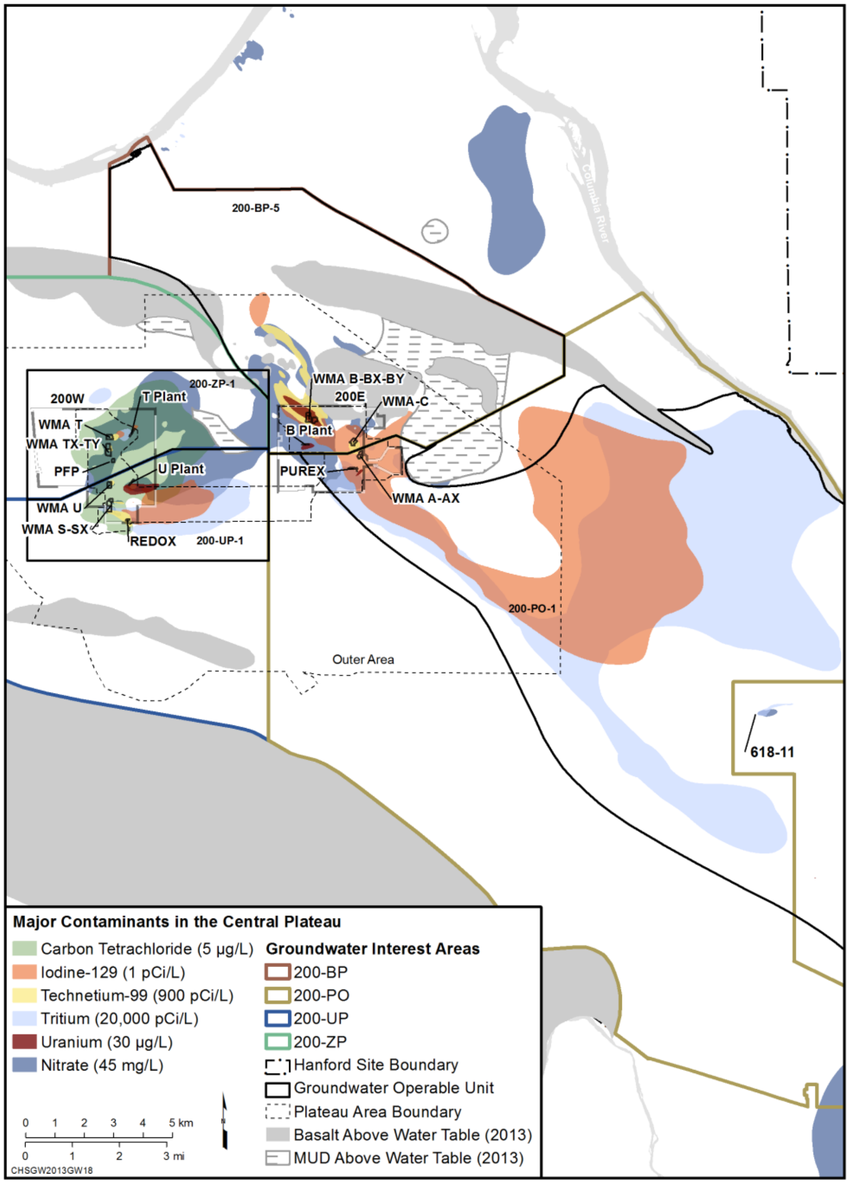

Fig. 3. Groundwater Contaminants in the Central Plateau.

CUMULATIVE IMPACTS EVALUATION

Cumulative impacts can be defined as: “Effects on the environment that result from the proposed action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions” (40 CFR 1508.7). The objectives of the long-term groundwater impacts analysis are to: (1) present a comprehensive evaluation to allow an informed decision making process, and (2) provide a context for comparison of the alternatives evaluated in the Feasibility Studies (conducted under CERCLA) for the source Operable Units (OUs). The cumulative impacts evaluation integrates understanding of contributions from all waste sites, potential sources, and existing groundwater contamination for sound decision making.

A similar analysis is required for low-level radioactive waste disposal under Department of Energy Order 435.1. The Order requires the performance of a Composite Analysis, an analysis that accounts for all sources of radioactive material that may contribute to the long-term dose projected to a hypothetical member of the public from an active or planned low-level waste disposal facility. The analysis is required as part of facility authorization, but is also a planning tool intended to provide a reasonable expectation that current low-level waste disposal activities will not result in the need for future corrective or remedial actions to ensure protection of the worker, public health and safety, and the environment (DOE Manual 435.1-1, Radioactive Waste Management).

Source units in the Inner area cover a large range of contaminants within the vadose zone. For large liquid discharge sites, contamination has already reached the groundwater aquifer, with mobile contaminants within large areas of the groundwater aquifer. Some waste sites have remaining surface contamination and deeper vadose zone contamination. Because the major driving force for this contamination through the vadose zone no longer exists and the vadose zone is relatively thick (about 100 m or 300 ft), much of this contamination will continue to move slowly and can potentially impact the groundwater aquifer over a long time horizon (tens to hundreds of years). However, this groundwater contamination is not expected to reach the Columbia River at significant levels (above aquatic protection standards), mainly due to success of existing groundwater remediation near the Columbia River and the aforementioned lack of driving force after the cessation of liquid waste discharges on the Central Plateau. Several technologies for removal or stabilization of vadose zone contaminants are currently being evaluated or are actually implemented.

Through the CERCLA process, the source units will evaluate available technologies, develop remedial alternatives, evaluate these alternatives, and select some alternatives for consideration within the remedial design. Because of the complexity of the inner area, including the comingling contaminant plumes, a 100-meter (about 300 feet) thick vadose zone that is not homogeneous, and complex groundwater flow characteristics, DOE may not be able to find viable remedial alternatives for all parts of groundwater and vadose zone. DOE is committed to remediation where technically practicable using all known, available, and reasonable technologies, but that will be a significant challenge. The evaluation of remedial alternatives is anticipated to include the possibility for alternative or conditional points of compliance for groundwater protection. The standard point of compliance will consider groundwater impacts immediately under each waste site. Conditional points of compliance can consider one or more areas whose boundaries are used to demonstrate compliance with the groundwater cleanup standards.

Establishment of a conditional point of compliance will require the analysis of all potential sources in the vadose zone combined with the existing and projected groundwater contamination. This evaluation is termed the cumulative impacts evaluation and is expected to provide a tool that can be efficiently used to prioritize remedial actions and evaluate residual contamination.

COMPUTATIONAL FRAMEWORK

The implementation of the cumulative impacts evaluation tool involves fate and transport evaluation of contaminants that have already been released to the environment in addition to contaminants that can potentially be released to the environment in the future. Vadose zone and groundwater fate and transport models are required for this evaluation. The design and implementation of the groundwater and vadose zone modeling system involves several components. Specifically, these components include the following: source term, vadose zone flow and transport, groundwater flow, groundwater transport, and linkages of all the components in the overall modeling system. Source-term representation lies at the beginning of the process for the general modeling strategy developed for the long-term groundwater impacts analysis. Inventory estimates must be provided, gathered, organized, and applied to the release models for each source term. Results from the release models are then provided to the vadose zone models in order to evaluate fate and transport of these releases into the environment. The vadose zone model results are then provided for the groundwater models to provide fluxes of mass and radioactive contamination in order to evaluate fate and transport of this contamination in the groundwater aquifer(s). Figure 4 shows the major components of the cumulative impacts modeling system.

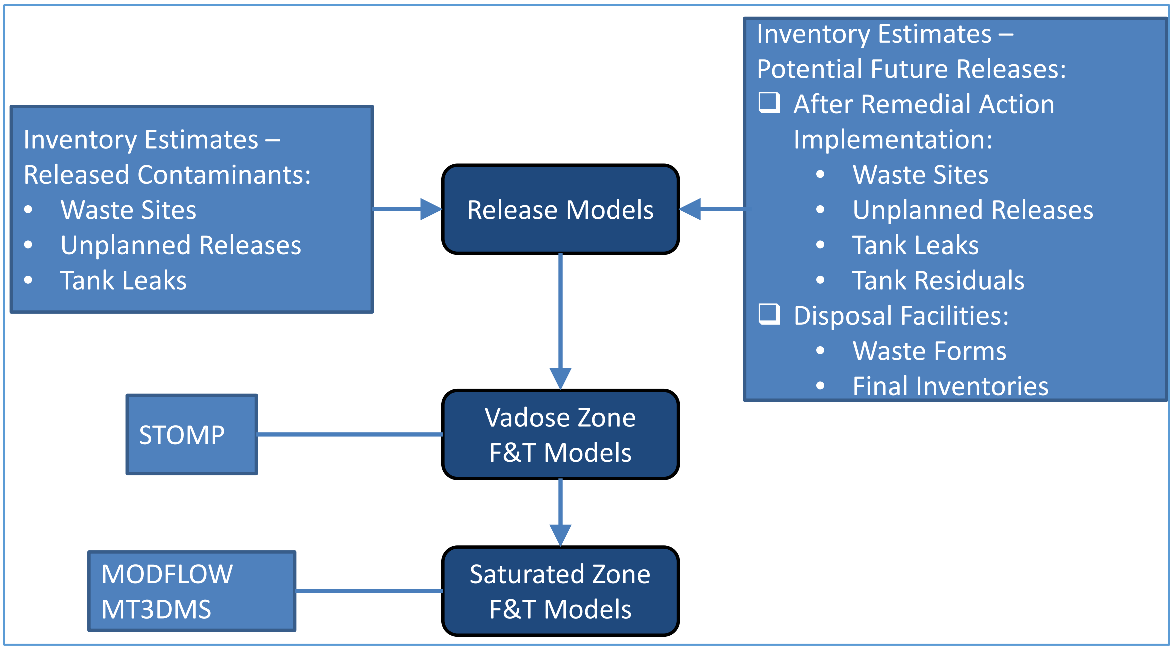

Fig. 4. Major Components of the Cumulative Impacts Evaluation Framework

For existing waste sites, unplanned releases, and previous tank leaks, inventory estimates will be provided for the range of chemicals and radioactive constituents in existing databases. These estimates are often provided as a range, which can be used for sensitivity and uncertainty analyses. The nature and extent evaluation of contamination will integrate field characterization information with historic waste discharge records. This integration step can also be iterative as additional characterization information is collected through the data quality objectives (DQO) process in support of the CERCLA work plans.

For future conditions, existing waste sites will assume a range of end-state conditions, including no-further action. These end-state conditions can also assume a range of remedial alternatives such as sequestration of contaminants, evapotranspiration barriers, and removal actions. The computational framework can then be used not only to evaluate different alternatives in a Feasibility Study but also the interaction between different remedial alternatives implemented at different locations, including the saturated groundwater aquifer. This can provide a valuable tool for planning of remedial actions, including prioritization of actions that can result in the most reduction of potential environmental impacts.

The Hanford Site includes a number of permitted disposal facilities and burial grounds. These sources can also contribute to future releases. The framework must be capable of evaluating different waste forms such as grouted and vitrified wastes. For these specialized evaluations, detailed performance evaluations (Performance Assessments) that have already been performed for these facilities will be incorporated into the cumulative impacts evaluation. A Performance Assessment is an analysis of a radioactive waste disposal facility conducted to demonstrate whether there is reasonable expectation that performance objectives established for the long-term protection of worker, public health and safety, and the environment will not be exceeded following closure of the facility (DOE Manual 435.1-1, Radioactive Waste Management).

Similarly, the Hanford Site includes underground single shell steel and double shell stainless steel tanks. Wastes from these tanks will be retrieved over time but some residual contamination is expected to remain in the tanks. Estimates of final tank residuals (provided as a range) will also be included for the evaluation, with the range providing useful information for sensitivity and uncertainty analyses. Finally, the underground tanks will be grouted and wastes will be released from them over time. These detailed release evaluations will also be obtained from existing performance evaluations conducted for the tanks as they become available.

Fate and transport models will be used to evaluate the future conditions of these contaminants. A variety of fate and transport models can be readily used for these evaluations. However, over the previous ten years, two codes have been approved to support the decision making process. These codes are STOMP (PNNL-11216) and MODFLOW (McDonald and Harbaugh, 1996; including more recent versions). For transport calculations in the saturated zone, the companion code for MODFLOW is MT3DMS (Zheng and Wang, 1999; also including more recent versions).

DISCUSSION

For source operable units within the Inner Area of the Hanford Site, a range of remedial alternatives will likely be developed and evaluated through the CERCLA process. First, near surface contamination will be evaluated for potential exposure by individuals or biota, in addition to the contamination’s potential to reach groundwater. Deeper vadose zone contamination will also be evaluated for its potential to reach groundwater. If such contamination is deemed significant, all known, available, and reasonable technologies (AKART) will be evaluated and remedial alternatives developed through the Feasibility Studies. However, some residual contamination can remain and might continue to leach into the groundwater aquifer for tens or hundreds of years. For these situations, the cumulative impacts evaluation tools can provide valuable insights for prioritizing remedial actions and guiding future monitoring efforts. It must also be stated that pump-and-treat remediation of contaminated groundwater has been ongoing and is expected to expand to remove contaminant mass in accordance with the Records of Decision (RODs) for the groundwater operable units. These P&T operations will likely reduce contamination levels at the high concentration areas. At the River Corridor, pump-and-treat systems have already removed much of the groundwater contamination at the high concentration areas. The groundwater remedial actions, additional characterization and remediation efforts for surface and vadose zone contamination, combined with the evaluation of cumulative impacts as described in this manuscript will provide the Hanford Site Central Plateau with valuable tools to guide future remediation, characterization, and monitoring efforts.

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