Conf-941256--2

PNL-SA-23997

HANFORD SOLID WASTE MANAGEMENT SYSTEM SIMULATION

S. R. Shaver
L. L. Armacost
H. S. Konynenbelt
R. R. Wehrman

December 1994

Presented at the
Winter Simulation Conference 1994
December 11-14, 1994
Orlando, Florida

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

MASTER

DISCLAIMER

ABSTRACT

This paper describes systems analysis and simulation model development for a proposed solid waste management system at a U.S. Department of Energy Site. The proposed system will include a central storage facility, four treatment facilities, and three disposal sites. The material managed by this system will include radioactive, hazardous, and mixed radioactive and hazardous wastes.

The objective of the modeling effort is to provide a means of evaluating throughput and capacity requirements for the proposed treatment, storage, and disposal facilities.

The model is used to evaluate alternative system configurations and the effect on the alternatives of changing waste stream characteristics and receipt schedules. An iterative modeling and analysis approach is used that provides macro-level models early in the project and establishes credibility with the customer. The results from the analyses based on the macro models influence system design decisions and provide information that helps focus subsequent model development.

Modeling and simulation of alternative system configurations and operating strategies yield a better understanding of the solid waste system requirements. The model effectively integrates information obtained through systems analysis and waste characterization to provide a consistent basis for system and facility planning.

1.0 INTRODUCTION

The Hanford Site is a 560-square-mile U.S. Department of Energy (DOE) installation in southeastern Washington. In 1943, the U.S. Army Corps of Engineers selected the site for the plutonium production and processing facilities of the Manhattan Project. Plutonium production at Hanford peaked during the late 1960s and ended in 1987.

Forty-four years of plutonium production generated significant quantities of liquid and solid waste that were stored onsite or released to the environment. The waste is contaminated with a variety of hazardous and radioactive chemicals.

Estimates for treating and disposing this waste and restoring the Hanford Site run as high as $60 billion over the next 30 years. The high cost of restoration has resulted in a great deal of public interest and scrutiny. Thorough analysis and careful planning are essential to the safe, timely, and cost-effective restoration of the Site.

Solid waste is a significant part of the overall restoration mission. As part of the planning and analysis process for solid waste, the Pacific Northwest Laboratory (PNL) and Westinghouse Hanford Company (WHC) have developed a discrete event simulation model using the SIMSCRIPT II.5 simulation language. The Solid Waste Projection Model (SWPM) is used to assess throughput and capacity requirements for the proposed Hanford Solid Waste Management System. The SWPM provides projections of storage requirements, capacity limitations, and material handling needs for 30 years of system operations. As a more detailed understanding of the system is required, the SWPM will be used to address other system design issues such as material requirements planning, facility layout, and line balancing.

This paper provides a description of the modeling and systems analysis activities involved in the development and use of the SWPM. The four activities of the modeling system include:

- Describing the solid waste streams for model input,
- Parameterizing the system and documenting assumptions,
- Modeling the system based upon the system description,
- Obtaining useful output that supports management's system design decisions.

This paper is organized in sections that discuss each activity listed above. Section 2.0 discusses how the solid waste volumes and characteristics are obtained for input to the SWPM. Section 3.0 describes the development and use of the 1993 Baseline Solid Waste Management System Description (Armacost, 1994) that provides the basis for modeling the system. Section 4.0 includes an overview of the SWPM's development, and Section 5.0 describes the current and potential effects of the SWPM results on design decisions.

2.0 WASTE VOLUMES AND CHARACTERISTICS

Solid waste includes contaminated clothing, equipment, construction material, containerized liquids, and miscellaneous debris from plant operations, restoration projects, and decontamination and decommissioning of facilities. During its 30-year operating life, the Hanford Solid Waste Management System will receive solid waste generated by restoration activities at Hanford and other DOE sites. The system will provide treatment, storage, and disposal for waste generated from past operations and stored in trenches, caissons, and buildings at Hanford and other sites throughout the DOE Complex.

To collect information on future waste stream generation, a 30-year forecast is completed annually by approximately 100 onsite and offsite generators that are planning to ship waste to the Hanford Solid Waste Management System. Each generator provides details about the volume and characteristics of their waste.

streams. Several specific characteristics of solid waste are of particular importance to the design of the treatment, storage, and disposal facilities. These attributes include waste class, chemical contaminants, physical characteristics, and shipping container.

Waste class is determined by the radionuclides present and their concentrations. Based on the radionuclide content, waste is classified as low-level waste (LLW) or transuranic waste (TRU). If chemicals regulated by the U.S. Environmental Protection Agency (EPA) are present, the waste is further classified as low-level-mixed waste (LLMW) or transuranic mixed waste (TRUM). The LLW, LLMW, TRU, and TRUM waste categories are further identified as being contact-handled (CH) or remote-handled (RH) based on the radiation level. These waste classes have distinct storage, treatment, and disposal requirements.

In addition to waste class, chemical contaminants (e.g., corrosives, flammables, toxic metals, etc.) and physical characteristics (e.g., concrete, failed equipment, organic material, metal, containerized liquids, etc.) dictate treatment requirements. Finally, the container in which the material is shipped will impact storage and material handling requirements.

The waste volume and characteristic information is managed in a database which generates an input file for a simulation model. The input data can be varied to determine how sensitive the system is to waste volumes, characteristics, and receipt schedules. The system being proposed to manage these waste streams is described in the following section.

3.0 SYSTEM DESCRIPTION

For the environmental restoration mission to succeed at Hanford, a system must exist which will receive solid wastes, store these wastes until treatment capability is available, and treat the waste for final disposal. This section provides an overview of the treatment, storage, and disposal facilities that comprise the proposed Hanford Solid Waste Management System. The development of the system description is explained, followed by brief discussions of planned storage capabilities, treatment facilities, and disposal sites.

The overview of the Hanford Solid Waste Management System was developed from two primary sources: existing project documents for individual facilities and consensus meetings. Documents such as the functional design criteria (FDC) reports and engineering studies were used to identify the specific waste streams handled by each facility and the principal functions employed to manage the waste.

Consensus meetings were held with the engineers responsible for designing and planning these facilities to verify information in the documentation, and review and record the assumptions being used to design the facilities. These meetings allowed responsible parties to review the system description, ensuring that it reflected the most current thinking. The information and assumptions were documented and published for reference in the 1993 Baseline Solid Waste Management System Description.

The proposed Hanford Solid Waste Management System is shown in Figure 1. The figure identifies the waste sources; the storage, treatment, and disposal facilities that will make up the system; and the primary waste flows between the system components. Primary activities of the storage, treatment, and disposal functions (as currently planned) are discussed in the following paragraphs.

3.1 Storage

As shown in Figure 1, storage facilities receive waste from generators and transfer the waste between the treatment facilities. In addition, these buildings will hold treated waste that is awaiting shipment to a disposal site.

Waste arriving from onsite and offsite generators is planned to be distributed among several buildings for storage:

- The Transuranic Storage and Assay Facility (TRUSAF), 13 small storage buildings, and 4 larger buildings are currently storing waste at the site.

- Phase V Storage is a planned storage facility with multi-purpose capabilities, including work-in-process storage in support of treatment facilities, head gas testing, and general shipping/receiving operations.

3.2 Treatment

Waste materials are sent from storage to one of the five treatment facilities shown in Figure 1. Waste Receiving and Processing (WRAP) Module 1 is planned to certify and package the retrieved and newly generated transuranic waste destined for disposal at the Waste Isolation Pilot Plant (WIPP) in New Mexico. WRAP Module 2A is planned to treat a large portion of the low-level and low-level-mixed waste that will be disposed onsite, and WRAP Module 2B is planned to treat waste that requires special handling due to size or high radiation levels.

The Thermal Treatment Facility (TTF) will accept mixed waste streams contaminated with hazardous chemicals that require thermal destruction to meet disposal requirements. The T-Plant facility is planned for size reduction and processing of the oversize equipment received from onsite waste generators.

3.3 Disposal

After treatment and packaging activities are completed the waste will be sent to one of three disposal sites. Two burial sites are proposed for Hanford, the third is the WIPP. Based on current assumptions, some waste will remain in long-term storage until final treatment and disposal requirements have been determined.

4.0 SIMULATION MODEL

Identifying quantifiable performance measures for comparing alternative system configurations is instrumental to the design of a successful system. Performance measures for the Hanford Solid Waste Management System include work-in-process storage and the ability to meet a 30-year clean-up schedule. Discrete event simulation was selected as the methodology for modeling the system and estimating these performance measures. The development, verification, and validation of the simulation model is discussed in the following sections.

4.1 Objective and Developmemt

The primary objective of the modeling effort is to determine storage and throughput requirements under different operating scenarios and waste generation assumptions. The SWPM was developed in the SIMSCRIPT II.5 simulation language. SIMSCRIPT was selected because of its ability to model systems with virtually any degree of complexity.

The ability to provide useful results at all stages of model development was an important consideration in developing the discrete event simulation model. Therefore, macro-to-micro analysis and modeling techniques guided development of the SWPM. At each stage of the development, specific objectives were agreed to with the client.

A high-level model that addressed issues such as storage needs for incoming waste was developed first. This model used SIMSCRIPT resources to represent treatment facilities with defined capacities. The estimates for incoming storage were developed by summing the resource queues. The initial model was expanded to include logic describing how each facility interacts with other components of the system so that work-in-process and waste awaiting disposal could be estimated to provide complete storage requirements.

After storage requirements were assessed, representation of the treatment facilities was expanded in detail to incorporate routing of the waste through functional areas within facilities. This model provided insight into the capacities required to treat specific waste forms within each treatment facility.

The SWPM development continues to be a cyclical process. For example, the system description is revised based upon output obtained from the SWPM and the output changes based upon new parameters in the system description and/or variations in the waste stream input data. This cyclical process provides the capability to study the effects of "what-if" scenarios. Examples of these special studies include varying the schedule of waste shipments to Hanford by manipulating the input data, or adjusting the capacities of facilities that are defined in the system description.

4.2 Verification and Validation

Verification runs were designed to test the model constructs by placing counters at strategic points in the model and comparing counter values with values hand calculated directly from the input data. For example, containers of specific waste types were counted as they were read in from the data file and again as a resource was requested for treatment. The counter values were consistent with the values expected based on the hand calculations.

Additional verification runs kept all treatment facilities off-line throughout the run length so that all waste streams were forced to remain in queues. This run verified that the waste streams were following the correct routings. Treatment facility utilizations were also used for verification. The expected utilization for each facility was determined by hand calculations and compared to utilizations based on the system simulation.

Special scenario cases were developed that extended beyond the capability of SWPM. These trials were hand verified, and tested model limits, required output, and other system responses.

Pure validation of a model which has no physical analog is not possible. Therefore, validation of the simulation model was performed by comparing against accepted results that were generated from an existing spreadsheet model. Scenarios that were run using the original model were compared with the results of running the same scenarios in the simulation model. Discrepancies were investigated and the simulation model was changed until identical results were produced. When the simulation model emulated the original model exactly, the customer accepted the model as valid and enhancements were identified to expand the capability and usefulness of the SWPM.

5.0 RESULTS AND ANALYSIS

Output data from the SWPM provides detailed information that can be used to address system design issues such as treatment capacity and material handling requirements. The output data includes:

- annual volumes of waste requiring storage by waste class and container type
- annual volumes of waste waiting for specific treatment facilities
- annual treatment facility throughputs of waste by waste class and container type
- annual waste shipments to disposal facilities.

As more is learned from the SWPM's output data about the Hanford Solid Waste Management System, the system description can be revised. For example, if the output data show storage volumes above the available storage capacity, then system designers can determine if treatment capacities need to be increased to process the waste waiting in storage.

This analysis of the output data also allows for SWPM users to study the effects of "what-if" scenarios. Examples of these special studies include varying the schedule of waste shipments to Hanford by manipulating the input data and/or adjusting the operating life of disposal sites and treatment facilities.

6.0 CONCLUSIONS AND FURTHER DEVELOPMENT

Modeling and simulation of alternative system configurations and operating strategies yield a better understanding of the solid waste system requirements. The model effectively integrates information obtained through systems analysis and waste characterization to provide a consistent basis for system and facility planning. Improvements to the model have been identified and discussed with the client. Some of these are discussed below.

Currently, the simulation model provides information on capacity requirements based on a deterministic systems description and input data. Future model expansion will include the imposition of stochastic characteristics on model elements. For example, the 30-year forecasts provide point estimates of the waste volumes and attributes. By representing the volumes and the characteristics of the waste with appropriate probability distributions and using the full capability of discrete event simulation to provide data for statistical experiments, better estimates of system performance might be obtained.

Processing resources within the model will also be evaluated to determine realistic stochastic parameters. Some of these parameters involve the processing rate variability and maintenance functions.

It might be necessary to represent individual facilities with submodels to test more detailed aspects of the system. To support this concept, the model was developed in modules. The results of the submodel experimentation will yield insight as to the stochastic characteristics of the higher level systems model.

A graphical user interface is also planned so that engineers and system planners can interact with the model by easily changing key parameters such as incoming waste volumes, facility start dates, and operating scenarios.

7.0 REFERENCES

Armacost, L.L., et al, 1994. 1993 Baseline Solid Waste Management System Description. PNL-8990, Pacific Northwest Laboratory, Richland, Washington.

Valero, O.J., et al, 1993. 1993 Solid Waste Reference Forecast Summary. WHC-EP-0567-1, Westinghouse Hanford Company, Richland, Washington.

Russell, E.C., 1983. Building Simulation Models with SIMSCRIPT II.5. CACI, Inc., Los Angeles, California.

U.S. Congress, Office of Technology Assessment, 1991 Complex Cleanup: The Environmental Legacy of Nuclear Weapons Production. OTA-O-484 U.S. Government Printing Office, Washington, DC.

Law, A.M., et al, 1991. Simulation Modeling and Analysis. McGraw-Hill, Inc. New York, New York.

Tang, Y.S., et al, 1990. Radioactive Waste Management. Hemisphere Publishing Corp. New York, New York.