DEVELOPMENT OF EXPOSURE SCENARIOS FOR CERCLA RISK ASSESSMENTS AT THE SAVANNAH RIVER SITE (U)

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ABSTRACT

Environmental Restoration (ER) activities at the Savannah River Site (SRS) begin with the characterization of inactive hazardous, radioactive and mixed waste disposal areas by a combined Resource Conservation Recovery Act (RCRA) Facility Investigation (RFI)/Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Remedial Investigation (RI) followed by evaluation of remedial alternatives in a RCRA Corrective Measures Study (CMS)/CERCLA Feasibility Study (FS). A CERCLA Baseline Risk Assessment (BRA) is performed during the RFI/RI characterization to determine if there are any potential risks to human health or the environment from the waste unit. If it is determined that there is need for remedial action, a Risk Evaluation of Remedial Alternatives (RERA) is performed as part of the CMS/FS to provide a basis for selecting a remedy that is protective of human health and the environment. The SRS has numerous waste units to evaluate in the RFI/RI and CMS/FS programs and, in order to provide a consistent approach, four standard exposure scenarios were developed for exposure assessments to be used in human health risk assessments. The standard exposure scenarios are divided into two temporal categories: (a) Current Land Use in the BRA, and (b) Future Land Use in the RERA. The Current Land Use scenarios consist of the evaluation of human health risk for Industrial Exposure (of a worker not involved in waste unit characterization or remediation), a Trespasser, a hypothetical current On-site Resident, and an Off-site Resident. The Future Land Use scenario considers exposure to an On-site Resident following termination of institutional control in the absence of any remedial action (No Action Alternative), as well as evaluating potential remedial alternatives against the four scenarios from the BRA. A critical facet in the development of a BRA or RERA is the scoping of exposure scenarios that reflect actual conditions at a waste unit, rather than using factors such as EPA Standard Default Exposure Scenarios (OSWER Directive 9285.6-03) that are based on upper-bound exposures that tend to reflect worst case conditions. The use of site-specific information for developing risk assessment exposure scenarios will result in a realistic estimate of Reasonable Maximum Exposure for SRS waste units.

INTRODUCTION

The Savannah River Site (SRS) is a major defense nuclear materials production facility located near Aiken, South Carolina. The SRS was constructed in the early 1950's, and is owned by the Department of Energy (DOE) and operated by the WSRC. The SRS, which occupies an almost circular area of approximately 325 square miles, produces nuclear materials by manufacturing fuel and target components, irradiating them in nuclear reactors, chemically separating the desired products (primarily plutonium and tritium), and managing the resultant wastes. Wastes are generated from each of the processes on-site, and have been managed to date in a program referred to as Interim Waste. Historically, interim waste management has included:

- Seepage basins for disposal of low-level liquid radioactive waste, primarily tritium, that in many cases also included hazardous constituents in the discharges and were, therefore, mixed waste;
- Shallow land burial for low-level solid radioactive waste;
- Storage of transuranic wastes retrievably on concrete pads; and
- Storage of high-level wastes in carbon steel waste tanks (4).

The Environmental Restoration Department (ERD) at the SRS is responsible for all inactive waste units at the site. Risk Assessment activities conducted in conjunction with waste unit characterization and remedial action implementation include Baseline Risk Assessment (BRA) evaluation for human health and the environment, the refinement of preliminary remediation goals, and Risk Evaluation of Remedial Alternatives (RERA). The elements of a CERCLA Baseline Risk Assessment (1) are:

- Data collection and evaluation,
- Exposure assessment,
- Toxicity assessment, and
- Risk characterization.

Assessment of risks posed by waste units requires that human exposure scenarios be developed that approximate actual exposures expected at exposure points for each waste unit. In order to maintain a degree of consistency within the SRS risk assessment framework, SRS Standard Exposure Scenarios were developed.

SRS STANDARD EXPOSURE SCENARIOS

Standard exposure scenarios for human health risk assessments at the SRS were developed following the methodology outlined in the Risk Assessment Guidance for Superfund (RAGS), and guidance issued by the EPA on Standard Default Exposure Factors and EPA Region IV Supplemental Guidance (1, 2, 5).

Development of CERCLA exposure assessments involves (a) characterization of the exposure setting, including the physical setting and potentially exposed populations, (b) identification of exposure pathways, (c) quantification of the magnitude, frequency and duration of exposure for the populations and pathways selected for quantitative evaluation, (d) determination of exposure concentrations, and (e) estimation of chemical intake (1). The SRS standard exposure scenarios were developed relying primarily upon site-specific information for characterization of potentially exposed populations, identification of exposure pathways, and quantification of the magnitude, frequency and duration of exposure for the populations and pathways selected for quantitative evaluation.

The four standard exposure scenarios evaluated in Baseline Risk Assessments for SRS waste units are:

- Industrial Worker Exposure,
- Trespasser Exposure,
- Off-site Residential Exposure, and
- Hypothetical Current On-site Residential Exposure.

The RERA evaluates the effectiveness of potential remedial alternatives against the four BRA exposure scenarios temporally to determine if the potential remedial actions will be protective of human health and the environment in the future. In addition to evaluating the BRA exposure scenarios against potential remedial actions, the RERA evaluates risk from the waste unit temporally in the absence of any remedial action (No Action scenario).

Although the SRS Standard Exposure Scenarios provide a common basis for risk assessments at the SRS, application of the standard exposure scenarios to individual waste units will require alteration of exposure factors to accommodate site-specific conditions. Indiscriminate use of the standard exposure factors described hereafter would not be appropriate, as each waste unit has peculiar characteristics that should be considered when conducting risk assessments.

This discussion will focus on the development of site-specific exposure scenarios for trespassers and industrial workers with reference to development of the Baseline Risk Assessment for the F- & H-Area Seepage Basins Groundwater Unit (BRA-F&H) (6).

Characterization of Exposure Setting

Characterization of the exposure setting at a waste unit consists of the development of a description of the physical setting of a waste unit. Activities involved in describing the physical setting include the identification of unit topography, biota, stratigraphy, groundwater hydrogeology, surface water and drainage pathways, proximity of the public, and accessibility to the unit, among others.

Characterization of waste unit exposure settings at the SRS requires significant input of site-specific conditions for many exposure factors because of the size of the SRS, site security, and the remoteness or inaccessibility of many of the waste units.

Accessibility is a key component in the exposure setting at the SRS. Since access to the SRS is tightly controlled, it is highly unlikely that unauthorized access will occur at SRS waste units. The effectiveness of the SRS security contractor, Wackenhut Services, Inc., in maintaining control of the SRS is demonstrated in a compilation of trespasser records between 1986 and 1990 (6). These records show that no trespasser gained access to any waste unit at the SRS and the majority of intrusions occurred at the perimeter of the SRS with rapid apprehension of the trespassers. Of 34 intrusion reports, 10 trespassers were apprehended north of U.S. Highway 278 in an area that is not secured from intrusion because of its location in the extreme northern sector of the plant, far removed from SRS activities. There were five instances of transients apprehended walking along railroad tracks and roads near the perimeter of the site. There were five apprehensions of people fishing or boating at the perimeter of the site where site streams emerge. There were four instances of people apprehended at barricades. There were three instances where people were apprehended hunting or fishing in the Crackerneck Wildlife Management Area, an area open to public access, without hunt permits. There were three instances of mentally disturbed individuals apprehended near the administration complex. Two of the intrusion reports relate to detection of physical damage to gates rather than apprehension of trespassers. There was one instance of three men apprehended fishing on-site at Par Pond (Par Pond is locally renowned as an illegal fishing hole). There was one instance of two prospective construction employees being escorted off-site from Central Shops after it was determined that they could not be employed by a construction contractor. Of the 34 trespasser reports, none were repeat offenders. Only the Par Pond incident can be regarded as a significant intrusion, although the fishermen were apprehended shortly after gaining access to the pond.

Wackenhut Services security personnel provide constant surveillance of the SRS on the ground and by air. Access roads to the site are secured by manned barricades. Security clearance identification issued by SRS is required to gain access to the site. Roads that encompass the site perimeter are surveyed physically at least twice a day with particular attention devoted to detecting intrusion. All other site roads and facilities are also physically surveyed at least twice a day. In addition to physical inspection of site roads and facilities, the Wackenhut security personnel routinely fly a grid pattern over the site in helicopters equipped with Forward-Looking Infrared Radar (FLIR). The FLIR can detect heat sources from humans (and animals as small as rabbits) even when concealed under forest detritus. The Wackenhut security management estimates that potential intruders at the perimeter of the site could remain undetected for a maximum of 12 hours. Once a trespasser crosses a perimeter fence, Wackenhut managers assert that the amount of time before he is detected and apprehended shortens appreciably and, as he approaches SRS roads or facilities, his detection and apprehension is imminent.

Industrial worker exposure scenarios at the SRS are developed on a site-by-site basis. This is necessary due to the vast area of the SRS and the distribution of waste units over the site. Most SRS waste units are not accessible to SRS personnel, either because they are fenced and regulated or because of the remoteness of their location. Industrial exposure at SRS waste units should be significantly less than those expected in general industry because of the inaccessibility of waste units and the specialized training in health protection and safety for work in hazardous or radioactive environments required of all SRS personnel. Also, the general population of site workers are not allowed free access to the entire site, thereby preventing potential exposure to contaminants that have migrated via environmental transport pathways from a waste unit.

Identification of Exposure Pathways

Exposure pathways at the SRS are evaluated on a site-by-site basis. The transport of contaminants from a waste unit is characterized either by direct sample collection or use of computer modeling codes. Once contaminant concentrations are established at exposure points, the four standard exposure scenarios are evaluated individually for potential to gain access to the exposure points.

Accessibility once again becomes an issue in the identification of trespasser exposure pathways. Because of the thoroughness of SRS security, exposure pathways rely on contaminants being transported over great distances by some mechanism, such as site streams, before reaching exposure points which could be accessible to trespassers. Transport of contaminants over long distances, regardless of the transport medium, offers the opportunity for dilution of contaminant concentrations and the possible mixing with contaminants released from other sources. The dilution of the mixture of contaminants as they travel to exposure points is a source of uncertainty that must be considered when evaluating risk at exposure points far removed from the waste unit.

Industrial worker exposure pathways are developed independently for each waste unit. Site-specific factors, such as site location, waste form, environmental transport mechanisms, and locations of exposure points, among others, are considered before an assessment of site activities is conducted to determine the reasonable maximum exposure factors for industrial workers. Once the extent of contamination is known, an assessment is made of all site facilities and infrastructure in close proximity to the site exposure points. A determination is then made of the potential for SRS industrial workers to gain access to exposure points. With the exposure routes and points determined, the appropriate *SRS departments* are contacted to determine the frequency and duration of worker exposure in the area(s) of concern.

Exposure pathways in the BRA-F&H for the trespasser and industrial worker exposure scenario were developed for activities occurring along the Fourmile Branch (Fig. 1.). Since the basins are covered with a RCRA cap there is no direct contact possible with the waste unit. The only point for direct contact is along the Fourmile Branch seepline where contaminated groundwater emerges and downstream from that point. Because of the central location of the F- & H-Area Seepage Basins and the effectiveness of the site security forces, the trespasser is placed along Fourmile Branch a considerable distance from the seepline. The industrial worker exposure scenario was developed for a SRS Power Department employee working along Fourmile Branch at the point where a steam line, power transmission line, and power transmission control cable cross the stream.

Quantification of Magnitude, Frequency and Duration of Exposure

Once the exposure setting is characterized and the exposure pathways identified, site-specific exposure frequencies and durations for exposures can be developed for the four SRS standard exposure scenarios. Once these values are established, an estimation of exposure concentrations and calculation of intakes is developed for each pathway. The main concern of the SRS standard exposure scenarios in this step is determining the site-specific exposure frequencies and durations. The lack of accessibility due to SRS security will limit the exposure for trespassers. The lack of access to waste units for the general employee population will limit the exposure of

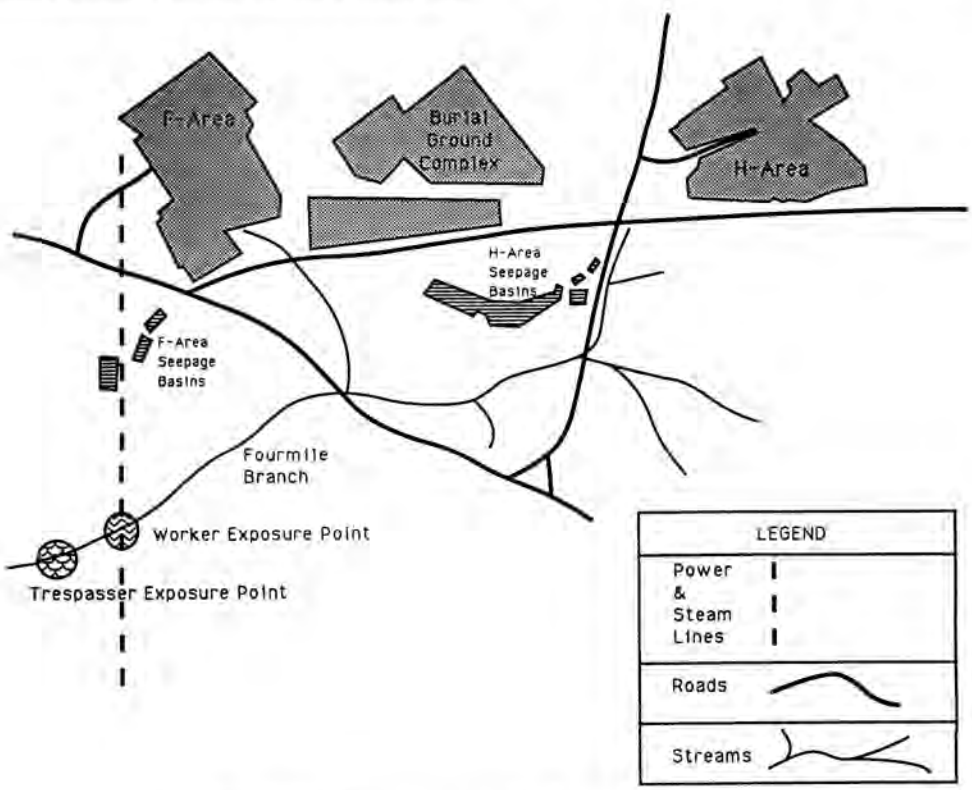

Fig. 1. F-&H-area seepage basins exposure points.

industrial workers to those who may contact exposure pathways at some distance from the actual waste unit in the course of other SRS related work.

The exceptional record of Wackenhut Services, Inc., in controlling intrusion by quickly apprehending trespassers provides the SRS with a reasonable estimate of on-site intrusion by trespassers. The exposure factor for the duration of a trespasser at SRS is estimated to be 8 hours or less at or near the site boundary. This will place trespassers in remote areas of the SRS far downstream from waste units so that no direct contact with waste units is possible. The only potential exposure to trespassers will be from contaminants transported by surface streams to the perimeter of the site. The reasonable frequency of exposure for a trespasser at SRS is once per year, which may be an overestimation of frequency when projected over a 30 year exposure period. It is unlikely that an individual would be a repeat trespasser at the SRS after being caught the first time, since trespass at the SRS is prosecutable under Federal statutes. By eliminating direct contact with the waste unit, the SRS trespasser exposure setting deviates significantly from EPA Standard Default Exposure Factors, but the deviations are reasonable and are supported by documented evidence (6).

Exposure frequencies and durations for industrial workers are evaluated on a case-by-case basis. This requires the risk assessor to have a thorough knowledge of the SRS and site activities. The risk assessor must determine potential exposure points, determine which SRS departments may have workers in the area, and then poll the departments for data on worker activities in the vicinity of exposure points.

The BRA-F&H used site-specific inputs for trespasser and industrial worker exposure frequencies and durations (6). The trespasser exposure factors were developed using the Wackenhut Services trespasser records. The industrial worker exposure factors were developed from SRS Power Department maintenance records.

The trespasser at the Fourmile Branch exposure pathway was determined to have a reasonable maximum exposure frequency of once per year with a 8-hour duration. This frequency and duration was calculated for a 30-year exposure period (6). The industrial worker at the Fourmile Branch exposure pathway was determined to have a reasonable maximum exposure frequency of once per year with a 40-hour duration. This frequency and duration was calculated for a 25-year industrial exposure period.

In contrast, the EPA "Standard Default Exposure Factors" (2) requires that industrial worker exposure frequency be 8 hours per day, 250 days per year for 25 years duration. The EPA default exposure factors provides a recreational scenario, which is also described as the trespasser or site visitor scenario, that requires an exposure frequency of 350 days per year for 30 years duration.

CONCLUSIONS

The use of site-specific exposure factors within the SRS Standard Exposure Scenarios provides a framework for realistic estimations of risk. The use of EPA "Standard Default Exposure Factors" is inappropriate at the SRS because of differences in operations and accessibility at the SRS from those encountered in the private industrial world. The use of SRS Standard Exposure Scenarios and factors will benefit Environmental Restoration activities by providing a consistent framework within which to build the conceptual model for risk assessment. This consistent risk assessment framework will, in turn, establish the basis for risk-based prioritization of waste unit assessments and remedial actions at the SRS. Overall, the improvement in accuracy and quality of risk assessments using site-specific exposure factors is expected to result in cost savings and streamlining of the remedial action process at the Savannah River Site.

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