**ENVIRONMENTAL PROTECTION AGENCY**

**40 CFR Part 300**

**[EPA–HQ–SFUND–2010–1086; FRL–9956–58–OLEM]**

**RIN 2050–AG67**

## Addition of a Subsurface Intrusion Component to the Hazard Ranking System

**AGENCY:** Environmental Protection Agency (EPA).

**ACTION:** Final rule.

**SUMMARY:** The U.S. Environmental Protection Agency (EPA) is adding a subsurface intrusion (SsI) component to the Hazard Ranking System (HRS), which is the principal mechanism that EPA uses to evaluate sites for placement on the National Priorities List (NPL). The NPL is a list of national priorities among the known or threatened releases of hazardous substances, pollutants or contaminants throughout the United States. Sites on the NPL are priorities for further investigation to determine if further response actions are warranted. The subsurface intrusion component (this addition) expands the number of available options for EPA and state and tribal organizations performing work on behalf of EPA to evaluate actual and potential threats to public health from releases of hazardous substances, pollutants, or contaminants. This addition enables EPA to directly consider human exposure to hazardous substances, pollutants, or contaminants that enter regularly occupied structures through subsurface intrusion in assessing a site's relative risk, and thus, enable sites with subsurface intrusion contamination to be evaluated for placement on the NPL.

**DATES:** This final rule is effective February 8, 2017.

**ADDRESSES:** The EPA has established a docket for this action under Docket ID No. EPA–HQ–SFUND–2010–1086. All documents in the docket are listed on the *http://www.regulations.gov* Web site. Although listed in the index, some information is not publicly available, *e.g.,* CBI or other information whose disclosure is restricted by statute. Certain other material, such as copyrighted material, is not placed on the Internet and will be publicly available only in hard copy form. Publicly available docket materials are available electronically through *http://www.regulations.gov* or in hard copy at the EPA Docket Center Reading Room (see *https://www.epa.gov/dockets/epa-docket-center-reading-room* for more information).

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### I. Statutory Authority for Regulatory Change

EPA has revised the HRS, the principal mechanism for placing sites on the NPL, to add a component for evaluating the threat or potential threat posed by subsurface intrusion to protect human health and the environment. Without an evaluation of threats posed by subsurface intrusion contamination, the HRS is not a complete assessment because it omits a known pathway of human exposure to contamination. The addition of subsurface intrusion to the HRS is compliant with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 105(a)(8)(A), which requires EPA to prioritize sites based on ''the population at risk, the hazard potential of hazardous substances at such facilities, the potential for contamination of drinking water supplies, the potential for direct human contact [and] the potential for destruction of sensitive ecosystems. This addition to the HRS also improves the agency's ability to identify priority sites for further investigation and enhances EPA's ability, in dialogue with other federal agencies and the states and tribes, to determine the most appropriate state or federal authority to address sites. For information on alternatives to this rulemaking that were considered for addressing subsurface intrusion contamination, please see the

preamble to the proposed HRS SsI Addition [81 FR 10372, February 29, 2016].

Additionally, the Government Accountability Office (GAO) stated in its May 2010 report [1]:

> EPA may not be listing some sites that pose health risks that are serious enough that the sites should be considered for inclusion on the NPL. While EPA is assessing vapor intrusion contamination at listed NPL sites, EPA does not assess the relative risks posed by vapor intrusion when deciding which sites to include on the NPL. By not including these risks, states may be left to remediate those sites without federal assistance, and given states' constrained budgets, some states may not have the ability to clean up these sites on their own . . . However, if these sites are not assessed and, if needed, listed on the NPL, some seriously contaminated hazardous waste sites with unacceptable human exposure may not otherwise be cleaned up.

The authority for these technical modifications to the HRS is in section 105(a)(8)(A) of CERCLA enacted in 1980. Under CERCLA, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR 300) must include criteria for determining priorities among releases or threatened releases for the purpose of taking remedial or removal actions. Section 105(a)(8)(A) of CERCLA required EPA to establish:

> [C]riteria for determining priorities among releases or threatened releases [of hazardous substances] throughout the United States for the purpose of taking remedial action and, to the extent practicable, taking into account the potential urgency of such action, for the purpose of taking removal action. Criteria and priorities . . . shall be based upon relative risk or danger to public health or welfare or the environment. . .taking into account to the extent possible the population at risk, the hazard potential of hazardous substances at such facilities, the potential for contamination of drinking water supplies, the potential for direct human contact [and] the potential for destruction of sensitive ecosystems. . . .

To meet this requirement and provide criteria to set priorities, EPA adopted the HRS as Appendix A to the NCP (47 FR 31180, July 16, 1982). The HRS was last revised on December 14, 1990 (55 FR 51532) to include the evaluation of additional threats to ensure a complete assessment of the relative risk that a site may pose to the public. Section 105(a)(8)(B) of CERCLA requires that the statutory criteria described in section 105(a)(8)(A) be used to prepare a list of national priorities among the known releases, or threatened releases throughout the United States. The NPL is Appendix B of the NCP (40 CFR 300, Appendix B).

In 1986, Congress passed the Superfund Amendments and Reauthorization Act (SARA) (Pub. L. 99–499), which added section 105(c)(1) to CERCLA, requiring EPA to amend the HRS to assure ''to the maximum extent feasible, that the hazard ranking system accurately assesses the relative degree of risk to human health and the environment posed by sites and facilities subject to review.'' In addition, CERCLA section 115 authorizes EPA to promulgate any regulations necessary to carry out the provisions of CERCLA.

Furthermore, the Congressional Conference Report on SARA included the absolute standard against which HRS revisions could be assessed:

> This standard is to be applied within the context of the purpose for the National Priorities List; *i.e.,* identifying for the States and the public those facilities and sites which appear to warrant remedial actions. * * * This standard does not, however, require the Hazard Ranking System to be equivalent to detailed risk assessments, quantitative or qualitative, such as might be performed as part of remedial actions. The standard requires the Hazard Ranking System to rank sites as accurately as the Agency believes is feasible using information from preliminary assessments and site inspections * * * Meeting this standard does not require long-term monitoring or an accurate determination of the full nature and extent of contamination at sites or the projected levels of exposure such as might be done during remedial investigations and feasibility studies. This provision is intended to ensure that the Hazard Ranking System performs with a degree of accuracy appropriate to its role in expeditiously identifying candidates for response actions. [H.R. Rep. No. 962, 99th Cong., 2nd Sess. at 199–200 [1986]]

When the HRS was last revised in 1990, the technology to detect and evaluate subsurface intrusion threats was not sufficiently developed. For example, there were no health-based benchmark concentration values for residences or standardized technologies for sampling indoor air, precision of analytical equipment prior to computerization was limited, and associations between contaminated ground water and soil vapors were not well understood. However, it is now possible for subsurface intrusion threats to be evaluated in a more comprehensive manner. Therefore, it is now appropriate, given the potential that subsurface intrusion presents for direct human contact, to add to the HRS the consideration of threats due to subsurface intrusion.

This final rule ensures the HRS does not omit a known pathway of human exposure to contamination due to subsurface intrusion of released hazardous substances and provides a mechanism for assessing subsurface intrusion threats and identifying sites for placement on the NPL. Furthermore, these sites are now eligible for Superfund-financed remedial actions.

## II. Background

The HRS is a crucial part of the agency's program for determining which sites are a priority for further remedial investigation and possible cleanup under CERCLA. To understand the importance of this rulemaking it is necessary to understand the role of the HRS in identifying sites for the NPL, the role of the HRS in the overall site assessment and Superfund remedial process, and this final rule's impacts on current and future Superfund activities. In addition, it is also necessary to understand the impact of adding the SsI component to the HRS.

### *A. The Hazard Ranking System*

The HRS is a scoring system used to assess the relative risk associated with actual or potential releases of hazardous substances from a site based on the information that can be collected in a preliminary assessment (PA) and site inspection (SI). The HRS is not a tool for conducting a quantitative risk assessment and was designed to be a measure of relative risk among sites rather than absolute site-specific risk. As required by CERCLA, EPA has designed the Superfund program to focus its resources on the priority sites. Consequently, the initial studies—the PA and SI—which are performed on a large number of sites, are relatively modest in scope and cost compared to the remedial investigations and feasibility studies subsequently performed on NPL sites.

Because of the need to expeditiously perform PAs and SIs, Congress placed certain constraints on the data requirements for an HRS evaluation. The required HRS data should be information that, for most sites, can be collected during a screening level site inspection or that are already available. Thus, the HRS does not rely on data that require extensive sampling or repeated sampling over extended periods of time. However, EPA allows for the expansion of the typical SI to allow for additional data collection for more complex sites that cannot be adequately characterized using standard SI methodologies. The HRS has also been designed so that it can be applied consistently to a wide variety of sites, enabling sites to be

[1] EPA's Estimated Costs to Remediate Existing Sites Exceed Current Funding Levels, and More Sites are Expected to Be Added to the National Priorities List, GAO Report to Congressional Requesters, GAO–10–380, May 2010.

ranked relative to each other with respect to actual or potential hazards.

Based on the state of the science, site specific data may be collected beyond that which is normally available after a typical site inspection. In these situations, the HRS in general, and the SsI component, can incorporate that data into the HRS evaluation. For example, the SsI component can use site-specific data as follows:

• Determination of the Hazardous Waste Quantity Factor Value—If the mass of all hazardous substances can be adequately determined (*i.e.,* is known or can be estimated with reasonable confidence), the HRS requires this estimate (identified as a Tier A estimate) be used to assign the hazardous waste quantity for all regularly occupied structures in an area of exposure (AOE) for which this information is available. See section 2.4.2 and 5.2.1.2.2 of the HRS.

• Determining the extent of an ASC—If sufficient data are available and state of the science shows there is no unacceptable risk due to subsurface intrusion into a regularly occupied structure located within an ASC, that structure or subunit can be excluded from the ASC. Therefore, such structures would not be included in the evaluation of the Hazardous Waste Quantity Factor or in the determination of other factors evaluated based on structures or subunits within an ASC. See section 5.2.0 of the HRS.

• Populations within the ASC—If sufficient structure-specific concentration data is available and state of the science shows there is no unacceptable risk of exposure to populations in a regularly occupied structure in an ASC, those populations are not included in the evaluation of the Targets Factor Category. See section 5.2.1.3 of the HRS.

EPA notes that if other site-specific information is available that clearly demonstrates that the site does not pose an unacceptable risk to human health via subsurface intrusion, there are points during the PA or SI process, where further evaluation of the site for the subsurface intrusion threat by the Superfund program can be terminated. Please see section B. of this preamble for further information on the Site Assessment process.

As EPA explained when it originally adopted the HRS, ''the HRS is a means for applying uniform technical judgment regarding the potential hazards presented by a facility relative to other facilities. It does not address the feasibility, desirability, or degree of cleanup required.'' (47 FR 31220, July 16, 1982).

The HRS uses a structured value analysis approach to scoring sites. This approach assigns values to factors related to or indicative of risk. The basic elements of the HRS are factors that are based on information that can be collected in a limited screening assessment. A scale of numerical rating values is provided for each factor and a value is assigned to each factor based on conditions at the site. Individual values are then weighted. The factors are grouped into three factor categories—observed release/route characteristics, waste characteristics, and targets—and are combined to obtain factor category scores. Each factor category has a maximum value, as does each of the component factors within the category. The relevant factor category scores are multiplied together within each pathway and normalized to obtain a pathway score. The pathway scores are combined using a root-mean-square approach to calculate the overall site score; that is, the final HRS score is the square root of the sum of the squares of the pathway scores divided by the square root of the number of HRS pathways. If all pathway scores are low, the HRS score will be low. However, the final score will be relatively high even if only one pathway score is high. EPA considers this an important requirement for the HRS scoring because some extremely dangerous sites pose threats through only one migration mode. For example, at a site, leaking drums of hazardous substances may be contaminating drinking water wells, thereby posing a significant threat via the groundwater migration pathway. But if the drums are buried deeply enough and the hazardous substances are not very volatile, the drums may not release any hazardous substances and not pose a threat to the air or to surface water.

EPA emphasizes that the HRS score is a number between 0 and 100, which reflects relative risk amongst candidate NPL sites. An HRS site score is not a measure of actual site-specific risk.

*B. Site Assessment and the Superfund Remedial Process*

EPA's Superfund remedial site assessment process evaluates sites to ascertain if further investigation is needed for determining whether an unacceptable risk is present.

The majority of sites evaluated through the EPA's site assessment program do not meet the criteria for possible placement on the NPL and are ''screened out'' of the Superfund Remedial process. (See Figure 1. Status of EPA's Site Assessments). Since EPA adopted the HRS, 52, 859 sites have been assessed under EPA's Superfund program. Of those sites, 1,782 were placed on the NPL, as of September 2016.

Site Assessment Strategy

The site assessment process is structured as a series of limited investigations which may include: (1) A Pre-CERCLA screening assessment; (2) a preliminary assessment; and (3) a site inspection or expanded site inspection (Figure 2. Site Assessment Process, below, illustrates this process). If a site progresses through the site assessment process for further investigation, the requirements for documenting risk become increasingly rigorous. The following includes a summary of the major phases of the site assessment process.

• A Pre-CERCLA Screening is an initial review of existing information on a possible Superfund site. If a release of a hazardous substance has occurred or if the potential of a hazardous substance to release exists the site may be eligible for further remedial evaluation under CERCLA authority. If further evaluation is warranted the site should be entered into the remedial assessment active site inventory for further assessment.

• The PA decision process parallels an HRS analysis, but makes environmental ''worst-case'' assumptions of possible significant risk regarding transport of contamination to receptors based on minimal available information and professional judgment.

• The SI collects information to confirm the accuracy of the PA assumptions. The information should be sufficient to support an HRS evaluation with minimal further investigation.

• If placement on the NPL is pursued, the information collected during the SI provides the basis for supporting the HRS scoring scenario.

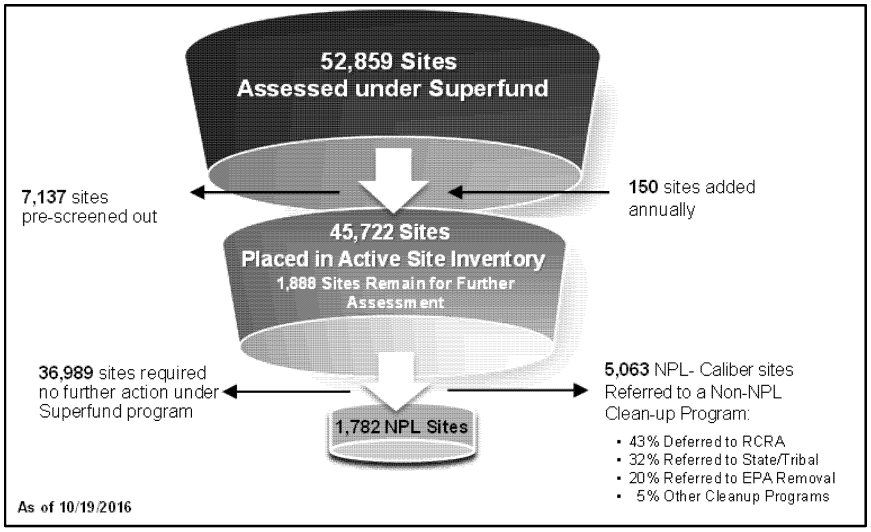



**Figure 1. Status of EPA Site Assessments**

The following discussion provides further information on each of these phases.

Pre-CERCLA Screening Assessment

A Pre-CERCLA Screening is used to establish whether:

- A release or potential release of a hazardous substance has occurred at a site;
- The site is eligible for further remedial assessment under CERCLA authority;
- The site needs further attention under Superfund or another cleanup program; and
- The site warrants entry into the federal Superfund program's active site inventory for further assessment or response.

Determining whether releases of hazardous substances, pollutants, or contaminants can be addressed by CERCLA requires the application of site-specific facts to CERCLA statutory requirements and EPA policy. The initial determination as to whether a site warrants further investigation is based on three site-specific facts including: (1) Evidence of an actual release or potential to release; (2) targets impacted by a release of contamination at the site; and (3) documentation that a target has been exposed to a hazardous substance released from the site. Examples of targets include populations, drinking water wells, drinking water surface intakes, municipal wells, fisheries and sensitive environments.

Preliminary Assessment

A PA uses readily available data to determine if there is evidence of a release that poses an unacceptable possible threat as specified in the NCP (40 CFR 300.420).

- The PA is a limited-scope investigation performed by States and/or EPA on every CERCLA site
- The PA may include the collection of readily available information and an on- or off-site reconnaissance may be conducted
- The PA distinguishes, based on already existing information, between sites that appear to pose little or no threat to human health and the environment and sites that require further investigation to determine if the threat to human health and the environment is unacceptable.

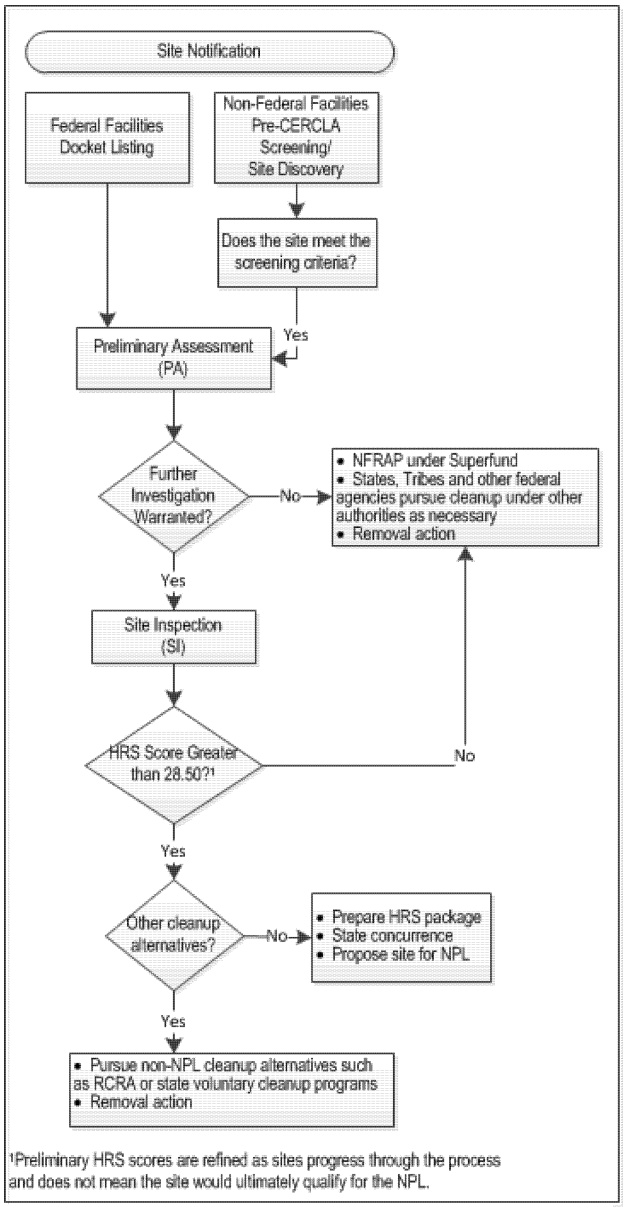



**Figure 2. Site Assessment Process**

If based on the results of a PA, EPA determines that a site warrants further screening under the CERCLA remedial program, the agency initiates a site inspection

Site Inspection

The purpose of the SI is to collect the data necessary to perform an HRS evaluation. An SI determines if a release of a hazardous substance poses an actual or potential threat to human health or the environment, to determine if there is an immediate threat to people or the environment in the area, and to collect sufficient data to enable the site to be scored using the HRS. EPA may expand the site inspection scope as needed. This expanded site inspection (ESI) collects additional data beyond what is collected in the standard site inspection to evaluate sites for HRS scoring. ESIs are reserved for more complex sites that cannot be adequately characterized using standard site inspection methods.

- SI investigators typically collect waste and environmental samples to determine the substances present at a site and whether they are being released to the environment, as well as other information to perform an HRS evaluation.
- EPA distinguishes, based on the information collected during the SI, between sites that appear to pose little or no threat to human health and the environment and sites that require further investigation to determine if the threat to human health and the environment exists.
- If the information indicates a threat, EPA determines the best approach for addressing the threat, which can be placement on the NPL or use of an alternative authority.

If at any time in this site assessment process, EPA determines that sufficient information indicates the site poses no unacceptable risk, or if it can be addressed under alternative authorities it can be removed from the process. Also, if an imminent or substantial endangerment to public health is identified, EPA can initiate CERCLA removal actions.

The NPL Rulemaking Process

The NPL is a list of national priorities for further investigation amongst the known or threatened releases of hazardous substances, pollutants or contaminants throughout the United States. The list, which is appendix B of the NCP (40 CFR part 300), is required under section 105(a)(8)(B) of CERCLA, as amended. Section 105(a)(8)(B) defines the NPL as a list of ''releases'' and the highest priority ''facilities'' and requires that the NPL be revised at least annually. The NPL is intended primarily to guide the EPA in determining which sites warrant further investigation to assess the nature and extent of public health and environmental risks associated with a release of hazardous substances, pollutants or contaminants. The NPL is of only limited significance, however, as it does not assign liability to any party or to the owner of any specific property. Also, placing a site on the NPL does not mean that any remedial or removal action necessarily need be taken.

For purposes of listing, the NPL includes two sections, one of sites that are generally evaluated and cleaned up by the EPA (the ''General Superfund section'') and one of sites that are owned or operated by other federal agencies (the ''Federal Facilities section''). With respect to the Federal Facilities sites, these sites are generally being addressed by other federal agencies. Under Executive Order 12580 (52 FR 2923, January 29, 1987) and CERCLA section 120, each federal agency is responsible for carrying out most response actions at facilities under its own jurisdiction, custody or control, although the EPA is responsible for preparing a Hazard Ranking System (''HRS'') score and determining whether the facility is placed on the NPL and having oversight authority at the sites for further actions.

NPL Site Selection Process

The NPL is required to be revised annually and it is intended primarily to guide EPA in determining which sites warrant further investigation to assess the nature and extent of public health and environmental risks associated with a release of hazardous substances, pollutants or contaminants. This selection process is illustrated in figure 3, below. Sites with HRS scores of 28.50 or greater are eligible for placement on the NPL. Only non-Federal Facility sites on the NPL are eligible for Superfund-financed remedial actions. Once a site is determined to be NPL-caliber and a decision has been made that the federal Superfund program should manage the site cleanup, EPA regions apply a strong initial presumption in favor of placement on the NPL.

Once the site is proposed for the NPL (*i.e.,* announced in the **Federal Register**), a 60-day comment period is initiated to allow the public to comment on the proposal. EPA responds to all public comments, and depending on the results of the public comment period, the site could be removed from consideration for placement of the NPL; re-proposed in the future due to public comments; or placed on the NPL. Once the site is placed on the NPL, the rulemaking can be challenged in court under the Administrative Procedure Act (APA). If no challenge is made or if the court finds the rulemaking consistent with APA requirements, it is then eligible for further investigation under the Superfund remedial program. (Figure 3. Process for Placing a Site on the NPL).

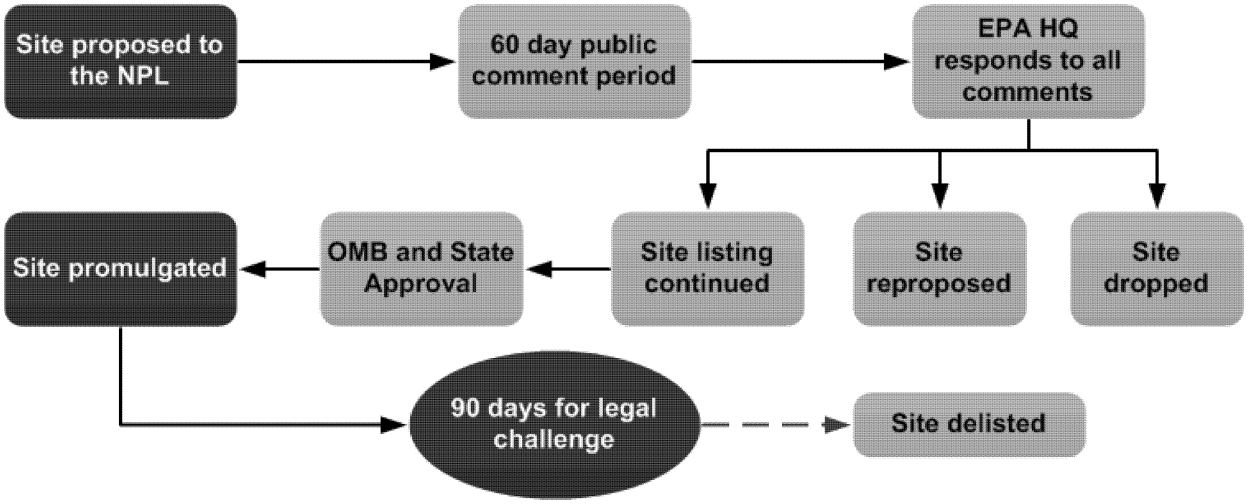



**Figure 3. Process for Placing a Site on the NPL**

*C. Impact of the SsI Addition on Current Cleanup Programs, Resources and Cost*

This SsI addition to the HRS will have the most significant impact on EPA's Superfund cleanup program. This regulatory change expands available options for EPA and organizations performing work on behalf of EPA (state and tribal partners) to evaluate actual and potential threats to public health and the environment from subsurface intrusion contamination. This modification to the HRS, by itself, only augments the criteria for applying the HRS. It has no effect on small businesses.

This final rule will not affect the status of sites currently on or proposed to the NPL. Sites that are currently on or proposed to the NPL have already been evaluated under another pathway (*i.e.,* ground water migration, air migration, surface water migration, or soil exposure) and have been shown to or are projected to qualify for placement on the NPL. The method selected for including the SsI evaluation in the HRS site score can only result in an increase in a site score, Therefore, all sites qualifying for the NPL based on its HRS site score prior to this final rule will continue to do so. It is consistent with section 105(c)(3) of CERCLA, as amended, that these sites will not be re-evaluated. This final rule will not disrupt EPA's placement of sites on the NPL.

The possible impact on federal agencies other than EPA performing Superfund actions will be less than that on private sites being addressed by EPA. Federal agencies currently address subsurface intrusion issues as part of their environmental programs and authorities. Executive Order 12580 delegates broad CERCLA authority to federal agencies for responding to actual and potential releases of hazardous substances where a release is either on, or the sole source of the release is from, any facility or vessel under the jurisdiction, custody, or control of the federal agency. Federal agencies are required to exercise this authority consistent with the requirements of CERCLA section 120, as amended, and implement regulations under the NCP, for both NPL and non-NPL sites. Therefore, federal agencies are in a position to proactively identify and respond to risks posed by subsurface intrusion of hazardous substances into regularly occupied structures for all populations who live and work in areas where the subsurface environment may create exposures. If it is determined that releases of hazardous substances pose immediate threats to public health and the environment, EPA fully expects that the appropriate federal agency will continue to undertake response actions to address such threats. Many federal agencies, including EPA, have developed or are developing new or updated agency-specific policy and guidance documents to address subsurface intrusion threats.

As a result of federal agency existing environmental programs and authorities, this rulemaking is not anticipated to have a significant impact to the resources and costs to federal cleanup programs.

Since EPA's overall appropriated Superfund budget as well EPA's cooperative agreement budget for performing site assessments will continue to remain relatively steady, EPA anticipates that this final rule will not result in additional site assessments nor the placement of more sites on the NPL during any particular interval, but rather a shift in the make-up of the type of sites included on the NPL. EPA will continue to review sites as part of Superfund remedial site assessment to determine whether sites are eligible for further remedial evaluation under CERCLA authorities and prioritize sites that pose the highest risk. This is not a change to how EPA currently evaluates and prioritizes sites for the NPL. Because the level of effort required to evaluate a site, regardless of pathway, varies on a site-by-site basis, depending on the size and extent of contamination at the site, it cannot be predicted with any certainly that there will be an increase in cost or level of effort for any particular site due to this rulemaking.

This rulemaking, which could lead to the inclusion of a site on the NPL that did not qualify for the NPL previously, does not itself impose any costs on outside parties; it does not establish that EPA will necessarily undertake response actions, nor does it require any action by a private party or determine liability for site response costs. Costs are limited to screening relevant sites for subsurface intrusion contamination during site inspections and the resulting HRS evaluation and documentation record preparation. Costs that arise from site remedial responses are the result of site-specific decisions made post-listing, not directly from the act of listing itself. These costs are a result of a release of hazardous substances and would not be incurred if hazardous substances had not been released.

Later Superfund-related decisions that consider information collected under the HRS SsI Addition could separately have specific economic costs and benefits (*e.g.,* remediation costs and reduced risk), but these impacts are contingent upon a series of separate and sequential actions after listing a site on the NPL. Therefore, addition of subsurface intrusion to the HRS is several regulatory steps removed from imposing costs on private entities.

This rulemaking does not impose any requirements on small entities, and therefore can be certified as no Significant Economic Impact on a Substantial Number of Small Entities (SISNOSE). With the exception of other federal agencies, site assessments are performed by EPA and on behalf of EPA by states and tribes in cooperative agreement partnerships with EPA. Under section 601 of the Regulatory Flexibility Act, federal agencies do not fit under the definition of small business, small entity, small organization or small governmental jurisdiction.

### *D. Impact of the Subsurface Intrusion Addition on the Hazard Ranking System*

This final rule, with the addition of a subsurface intrusion component, does not change the purpose of the HRS, its fundamental structure or its application. It does not change the balance between the pathways or calculation of the overall HRS site score and the same cutoff score to qualify a site for the NPL is maintained. The current approach for scoring the ground water, surface water, and air migration pathways is not being altered by the addition of a subsurface intrusion component. EPA added the subsurface intrusion threat as a component to the present soil exposure pathway because its structure already focuses on populations actually or potentially coming into direct contact with hazardous substances. The re-structured pathway is called the ''Soil Exposure and Subsurface Intrusion'' pathway and now allows for the consideration of the threat posed by subsurface contaminant intrusion. The Soil Exposure and Subsurface Intrusion pathway retains the existing two soil exposure threats (resident population and nearby population) in the pathway as one component, with subsurface intrusion as the second component.

The narrow technical modifications resulting from this Final Rule reflect the agency's actions to encompass additional risks posed by releases of hazardous substances and to address the SARA statutory requirement that EPA amend the HRS to assure ''to the maximum extent feasible, that the HRS accurately assesses the relative degree of risk to human health and the environment posed by sites subject to review.'' Thus, the fundamental purpose and structure of the HRS approach has not changed with this amendment to the HRS to include the consideration of subsurface intrusion.

## III. Overview of the Final Rule

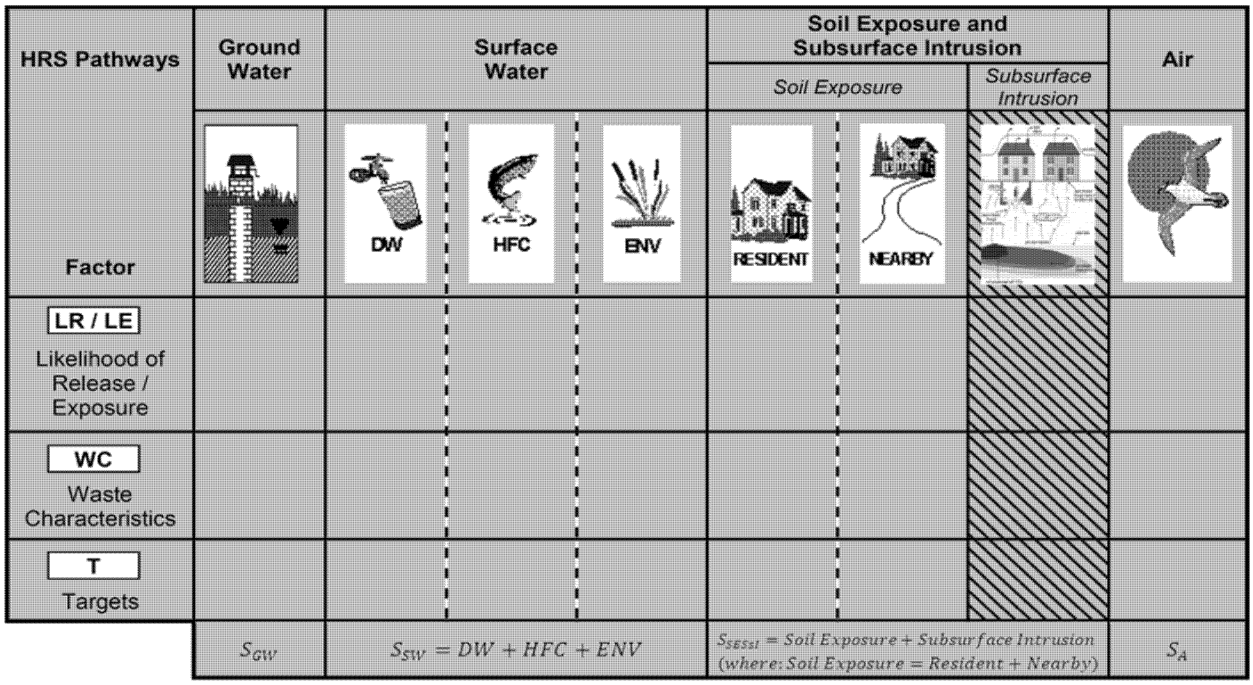
This final rule revises the 1990 HRS to include a component for evaluating the threats posed from subsurface intrusion. The following sections discuss the structure of the HRS, the subsurface intrusion component within the HRS, the major factors of the subsurface intrusion addition, and how the evaluation will be performed using a structure consistent with the other threats, components, and pathways in the HRS, but taking into account the unique parameters impacting the probability of exposure to subsurface intrusion. All sites that qualified for the NPL under the 1990 HRS, would still qualify for the NPL under this revised HRS. For a more comprehensive description and rationale of changes, see the February 29, 2016 Proposed Rule [81 FR 10372, February 29, 2016].

### *A. HRS Structure With the Subsurface Intrusion Component*

EPA added the evaluation of the relative risk posed by subsurface intrusion of hazardous substances into regularly occupied structures by restructuring the soil exposure pathway from the 1990 HRS to include subsurface intrusion. The soil exposure pathway has been renamed the soil exposure and subsurface intrusion pathway to reflect both components of

the new pathway. No changes are included in the other three HRS pathways, with the exception of the use of a reference concentration instead of a reference dose to determine a hazardous substance's health-based benchmark in the air migration pathway. See Figure 4 for a depiction of how the promulgated addition fits into the HRS structure.

**Figure 4. HRS Structure with Subsurface Intrusion Addition**




$S_{GW}$ = *Ground Water Migration Pathway Score*

$S_{SW}$ = *Surface Water Migration Pathway Score*

$S_{SESSI}$ = *Soil Exposure and Subsurface Intrusion Pathway Score*

$S_A$ = *Air Migration Pathway Score*

As explained in the preamble to the proposed HRS SsI addition, the subsurface intrusion component is added as a new component of the soil exposure and subsurface intrusion pathway. The soil exposure pathway included in the 1990 HRS is retained as one component of the Soil Exposure and Subsurface Intrusion pathway. The scoring of the soil exposure component remains unaltered, but the score is assigned as the soil exposure component score, not the pathway score. (See section 5.1 of the HRS). As discussed in greater detail below, the SsI component has the same basic structure, scoring, and weighting as other parts of the HRS.

The score for the soil exposure and subsurface intrusion pathway is based on a combination of the two component scores—soil exposure and subsurface intrusion but the pathway score is capped at the same value as other HRS pathways. The soil exposure component score is added to the subsurface intrusion component score to determine the pathway score. The two component scores are additive to reflect that populations may be exposed via both routes: The soil exposure component reflects exposures to people when outside a structure and focuses on ingestion, and the subsurface intrusion component reflects exposures inside a structure and focuses on inhalation. Hence, the addition of the two component scores reflects the potential cumulative risk of multiple exposure routes and is not double counting the same relative risk.

A maximum pathway score is not contingent on scoring both the soil exposure and subsurface intrusion components. It is possible for a site to have only one component evaluated and still reach the maximum pathway score. Because the scoring of the soil exposure component is not being altered, this component would contribute the same score to the overall site score absent the addition of subsurface intrusion.

*B. SsI Component Addition*

The structure of the HRS is fundamentally the same for all individual pathways, components, and/or threats. The design of the HRS reflects a conceptual understanding of how hazardous substance releases from CERCLA sites can result in risks to public health and welfare and the environment. The risk scenario at these sites is a function of:

- The probability of exposure to (or releases to a medium in a migration pathway of) hazardous substances,
- The expected magnitude and duration of the releases or exposures,
- The toxicity or other potential adverse effects to a receptor associated with a target from the releases,

• For the three migration pathways, the probability that the release will reach a target and the expected change in the concentration of hazardous substances during the movement from the location of the contamination to the targets. For the exposure pathway, the probability a receptor will be exposed at the target location,

• The expected dose to the receptor, and

• The expected number and type of the receptors.

The above considerations are addressed in three factor categories: Likelihood of exposure (or release), waste characteristics, and targets.

The following subsections describe the structure of the subsurface intrusion component and how this structure is consistent conceptually with the existing structure of the other HRS pathways and components: (1) New definitions, (2) delineation of areas of subsurface intrusion, (3) likelihood of exposure, (4) waste characteristics, (5) targets, and (6) calculating and incorporating the subsurface intrusion component score into the HRS site score.

1. New Definitions—See Section 1.1 of the HRS [2]

EPA has added 15 new definitions to the HRS, section 1.1, along with updated nomenclature to existing definitions. EPA received no comments on the 14 proposed new definitions to the rule; therefore, EPA is finalizing the new definitions as proposed with the following change: The term surficial ground water has been changed to shallow ground water for clarity. In addition, EPA has added the term non-aqueous phase liquid (NAPL) to the definition section because EPA added consideration of NAPLs to the assignment of degradation factor values and the weighting of targets in the area of subsurface contamination (ASC).

2. Delineation of Areas of Subsurface Intrusion—See Section 5.2.0 of the HRS

EPA has included in the subsurface intrusion component evaluation two areas in which exposure due to subsurface intrusion contamination exists or is likely to exist: (1) Areas of observed exposure—areas in which contaminant intrusion into regularly occupied structures has been documented, and (2) areas of subsurface contamination—areas in which subsurface contamination underlying regularly occupied structures (such as in shallow ground water or soil vapor) has been documented, but at which either sampling of indoor air has not documented that subsurface contamination has entered a regularly occupied structure or no sampling of indoor air has been undertaken.

a. Area of Observed Exposure (AOE) (See Section 5.2.0 of the HRS)

An area (or areas) of observed exposure at a site is identified based on the location of regularly occupied structures with a documented significant increase in hazardous substance concentrations above background levels resulting at least in part from subsurface intrusion attributable to the site being evaluated. The area encompassed by such structures constitutes the area of observed exposure (AOE). Other regularly occupied structures within this encompassed area (or areas) are also inferred to be in the AOE unless available information indicates otherwise.

b. Area of Subsurface Contamination (ASC)—See Section 5.2.0 of the HRS

An area (or areas) of subsurface contamination is identified as an area outside that of the AOE, at which subsurface contamination has been documented at levels meeting observed release criteria (contamination at levels significantly above background and the significant increase can be attributed at least in part to the site). The contamination would be present in subslab or semi-enclosed or enclosed crawl space samples or in a subsurface sample. (See section 2.3 of the HRS for observed exposure criteria.) In addition, EPA is limiting the delineation of an ASC to be based on the location of subsurface contamination meeting the criteria for observed exposure or observed release and has a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to $10^{-5}$ atm-m$^3$/mol. The populations in an ASC are assigned a weighting value ranging from 0.1 to 0.9 depending on such factors as the distance of subsurface contamination to a regularly occupied structure's foundation, the sample media, and the presence of a non-aqueous phase liquid (NAPL).

3. Likelihood of Exposure—See Section 5.2.1.1 of the HRS

A key factor considered in the HRS relative risk ranking is whether any exposure to a hazardous substance via subsurface intrusion has occurred, or if not, whether there is a probability that exposure could occur in a regularly occupied structure. This is termed the likelihood of exposure for the subsurface intrusion component.

a. Observed Exposure—See Section 5.2.1.1.1 of the HRS

For HRS purposes, an observed exposure is established if it can be documented that a hazardous substance from the site being evaluated has moved through the subsurface and has entered at least one regularly occupied structure.

b. Potential for Exposure—See Section 5.2.1.1.2 of the HRS

When an observed exposure has not been established, the potential for exposure can be determined for any regularly occupied structure located in an ASC.

The evaluation of the potential for exposure for the subsurface intrusion component uses the same concept and framework used to estimate the potential to release in other pathways. This involves predicting the probability of exposure in an area of subsurface contamination based on structural containment features of the regularly occupied structure and a hazardous substance's physical and chemical properties and the physical subsurface properties that influence the probability that intrusion is occurring. These factor values include:

• Structure Containment
• Depth to Contamination
• Vertical Migration
• Vapor Migration Potential

Consistent with potential to release determinations in the HRS, the potential for exposure for this component is calculated by summing depth to contamination, vertical migration and vapor migration potential factor values and multiplying the sum by the containment factor value to determine a potential for exposure factor value.

c. Calculation of the Likelihood of Exposure Factor Category Value—See Section 5.2.1.1.3 of the HRS

As in all HRS pathways and components, the likelihood of exposure factor category value is assigned based on the higher of the observed exposure (or release) value or the potential for exposure (or release) value. The maximum value assigned for the likelihood of exposure factor category is 550 and is assigned if observed exposure is documented. If observed exposure is not documented, the value assigned when evaluating potential for exposure ranges between 0 and 500.

[2] *For references to a specific section of the HRS addition, please refer to the regulatory text of the rulemaking.*

4. Waste Characteristics—See Section 5.2.1.2 of the HRS

The waste characteristics factor category is based on factors that are related to the relative risk considerations included in the basic HRS structure. The factors considered in determining the waste characteristics factor category value are the toxicity of the hazardous substances, the ability of the hazardous substance to degrade, and an estimate of the quantity of the hazardous substances to which occupants could be exposed.

a. Toxicity/Degradation—See Section 5.2.1.2.1 of the HRS

The combined toxicity/degradation factor includes consideration of both the toxicity and the possibility for degradation of hazardous substances being evaluated for HRS purposes. The toxicity factor in the overall HRS structure reflects the toxicity of a hazardous substance associated with a source, release or exposure at a site, and is assigned the same factor value for all the pathways and components in the HRS. Any hazardous substance identified in an observed exposure within the AOE or meeting the observed release criteria in either the AOE or ASC will be assigned a toxicity factor value.

The degradation factor represents the possibility for a substance to degrade in the subsurface prior to intruding into a regularly occupied structure. The subsurface intrusion component evaluates degradation based on the substance being evaluated, the depth to contamination, and the presence of a NAPL. It also assumes the presence of biologically active soil unless information indicates otherwise. If it has been documented that a hazardous substance has been found to have entered a regularly occupied structure, regardless of the substance or the site conditions, the degradation value is assigned to reflect the likelihood that the substance is not significantly degrading in the subsurface. Additionally, any eligible hazardous substance present in the subsurface below an AOE or ASC as a NAPL at depth less than 30 feet is assigned a degradation value to reflect the likelihood that the substance will not significantly degrade in the subsurface environment.

The toxicity and degradation factors are multiplied together to assign a combined factor value. If multiple substances are present, the highest combined factor value is selected for use in determining the waste characteristics factor category value, as discussed below.

b. Hazardous Waste Quantity—See Section 5.2.1.2.2 of the HRS

The waste quantity factor value for this component reflects only the amount of hazardous substances that people are exposed to, that is, the amount in regularly occupied structures. EPA has retained a four-tiered hierarchical approach consistent with the HRS as well as minimum waste quantity factors. The estimation of waste quantity for the subsurface intrusion component considers the regularly occupied structures located within the AOE and ASC. For sites at which the component waste quantity (the sum waste quantities for all regularly occupied structures in the AOE and ASC) is below 10, a minimum factor of 10 would apply, the same as in other pathways and components. The minimum waste quantity factors are included because of insufficient information at many sites to adequately estimate waste quantity with confidence.

c. Calculation of the Waste Characteristics Factor Category Value—See Section 5.2.1.2.3 of the HRS

As in all HRS pathways and components, the waste characteristics category value is the product of the waste characteristics factor values (*e.g.,* toxicity/degradation factor value) for the SsI component and the hazardous waste quantity factor value, all of which are scaled so as to be weighted consistently in all pathways. Similar to the likelihood of exposure factor category, the waste characteristics factor category is subject to a maximum value to maintain the balance between factor categories. This approach is consistent with the 1990 HRS structure.

5. Targets—See Section 5.2.1.3 of the HRS

The targets factor is based upon estimates of the expected dose to each receptor associated with a target and the number and type of receptors present at each target. In assessing human risk, it is critical to understand the nature and extent of exposure to individuals, populations, and resources.

a. Identification of Eligible Targets—See Section 5.2.1.3 of the HRS

The soil exposure and subsurface intrusion pathway uses the same target categories used in the HRS soil exposure pathway, including exposed individual, resident populations, workers, and resources. However, unlike the HRS soil exposure pathway, workers are to be evaluated as exposed individuals and as part of the population within an area of subsurface contamination instead of being evaluated under a separate worker factor value.

b. Exposed Individual and Levels of Exposure—See Section 5.2.1.3.1 of the HRS

i. Identifying Levels of Exposure and Benchmarks for Subsurface Intrusion

In the SsI component, targets in the AOE are considered actually contaminated, whereas, those in the ASC are considered potentially contaminated. The targets in an AOE are further divided into Level I and II, based on whether the hazardous substance concentrations are at or above identified health-based benchmarks.

The targets within an ASC are categorized based on the type of sample (*e.g.,* gas, soil, water), the distance of the sample from the targets (*e.g.,* the depth of the sample below the structure), and whether a NAPL is present. Weighting factors ranging from 0.1 to 0.9 are then assigned accordingly.

ii. Exposed Individual—See Section 5.2.1.3.1 of the HRS

The evaluation of exposed individuals in the SsI component includes individuals living, attending school or day care, or working in a regularly occupied structure. Individuals in the eligible target population are expected to be exposed to the highest concentration of the hazardous substance in question for a significant time.

c. Population—See Section 5.2.1.3.2 of the HRS

The population factor for the SsI component includes all populations qualifying as exposed individuals, including residents, students, workers, and those attending day care. Workers are weighted slightly differently than other exposed individuals to reflect that a worker's exposure is limited to the time present in a workplace. The number of workers present in a structure or subunit is adjusted by an appropriate factor reflecting whether or not they are a full-time or part-time worker.

i. Weighting of Targets in the Area of Observed Exposure (AOE)—See Sections 5.2.1.3.2.1 and 5.2.1.3.2.2 of the HRS

Consistent with the weighting of populations throughout the HRS, the subsurface intrusion component will weight targets in an AOE subject to Level I contaminant concentrations by a factor of 10 and weight targets subject to Level II contaminant concentrations by a factor of 1. Eligible populations include individuals living, working, and

attending school or day care in regularly occupied structures.

Within the AOE, those populations in regularly occupied structures for which observed exposures have not been established but the structures are surrounded by regularly occupied structures in which observed exposures have been identified, are also considered as actually contaminated unless evidence indicates otherwise. Targets inferred to be exposed to this contamination will be weighted as Level II as there are no actual sample results to compare against benchmarks.

In the case of multi-story/multi-subunit structures, all regularly occupied subunits on a level with an observed exposure and all levels below are considered to be within an AOE, unless available information indicates otherwise. For multi-story/multi-subunit structures located within an AOE, but where an observed exposure has not been documented, only those regularly occupied spaces on the lowest level are considered to be within an AOE, unless available information indicates otherwise.

ii. Weighting of Targets in the Area of Subsurface Contamination (ASC)—See Section 5.2.1.3.2.3 of the HRS

Due to the variability in subsurface intrusion rates, the potential weighting factor values for targets within an ASC range from 0.1 to 0.9 and depend on where the subsurface contamination has been found and whether a NAPL is present.

Potential targets are weighted to reflect the distance to or the depth at which contamination is found and whether a NAPL is present. The weighting factors applied to populations being evaluated based on the presence of subsurface contamination containing a NAPL reflects greater subsurface source concentrations and an increased probability that contaminant intrusion into a regularly occupied structure from the subsurface will result in a concentration significantly above background levels for the site. In the case of multi-story/multi-subunit structures, all regularly occupied subunits on a level above one where an observed exposure has been documented or inferred, or where a gaseous indoor air sample meeting observed release criteria is present, are considered to be located within an ASC, unless available information indicates otherwise. For multi-story/multi-subunit structures located only within an ASC, only those regularly occupied subunits within the lowest level are considered in an HRS evaluation.

Eligible populations in an ASC include individuals living in, attending school or day care, and working in regularly occupied structures. However, the number of workers is adjusted to reflect that their exposure is limited to the time they are in a workplace.

d. Resources—See Section 5.2.1.3.3 of the HRS

Resources for this component include regularly occupied structures that are located within a defined AOE or ASC and in which populations may be exposed to contamination due to subsurface intrusion. Libraries, recreational facilities, and religious or tribal structures used by individuals may qualify as eligible resources.

e. Calculation of the Targets Factor Category Value—See Section 5.2.1.3.4 of the HRS

The Target Factor Category Value is the sum of all the Target Factor values.

6. Calculation and Incorporation of the SsI Component Score Into the HRS Site Score

The following subsections summarize the calculation of the subsurface intrusion component score, how the component score is used in the calculation of the soil exposure and subsurface intrusion pathway score, and how, in turn, the pathway score is subsequently incorporated into the HRS site score.

a. Calculation of the SsI Component Score—See Section 5.2.2 of the HRS

The SsI Component score is the product of the likelihood of exposure factor category value, the waste characteristics factor category value, and the targets factor category value; that value is divided by a weighting factor so that it has equal magnitude to other component scores (subject to a maximum value).

b. Incorporation of the SsI Component Score into the Soil Exposure and Subsurface Intrusion Pathway Score—See Section 5.3 of the HRS

The Soil Exposure and Subsurface Intrusion pathway score is a combination of the two component scores.

c. Incorporation of the Soil Exposure and Subsurface Intrusion Pathway Score Into a Site Score—See Section 2.1.1 of the HRS

EPA did not change the methodology used to assign an overall site score due to the addition of the subsurface intrusion component to the soil exposure pathway and renaming that pathway the soil exposure and subsurface intrusion pathway. The overall site score remains a function of four pathway scores and the same weighting is given to each pathway score as in the 1990 HRS.

*C. Testing the SsI Component*

The SsI component was tested extensively throughout the development of this rule, using multiple methods. The main goals of testing the component included:

- Ensuring the addition of the SsI component to the soil exposure pathway did not change relative contribution to the site score as the other HRS pathways and maintained the same relative risk of a site with a similar threshold for qualifying for the NPL.
- Ensuring the number of targets subject to actual contamination needed to achieve a site score sufficient for NPL proposal remained consistent across pathways.
- Ensuring that applying the SsI component as part of an HRS evaluation would not result in identification of sites with a low level of risk or would not identify sites with a high level of risk.

These goals were met by using conceptual simulations to project the effectiveness and appropriateness for factor values, by developing and testing numerous example site scenarios to refine the model and by applying the model to test sites to determine its efficacy. The following information provides details on the approaches used to test the SsI component.

1. Conceptual Site Model/Sensitivity Analysis

Sensitivity analyses were performed during development of the rule to test the SsI component and identify and assign the relative magnitude of the factors having the greatest impact on the HRS site score. The analyses illustrated the types of sites that would qualify for the NPL considering subsurface intrusion contamination, and sites that would qualify for the NPL considering the contribution of subsurface intrusion contamination to other pathways. The scenarios illustrate different site characteristics and different factor value weightings. An initial conceptual site scenario evaluation was developed with varying likelihood of intrusion levels, zone of contamination, waste characteristics and levels of contamination. The conceptual site scenario evaluation was varied to reflect possible ranges in the factors considered in the HRS evaluation.

The first phase of testing estimated site scores based on options considered

for identifying eligible targets and delineating target areas. The testing was conducted using factor values, factor category values, and scoring algorithms consistent with other parts of the HRS. This ensured relative risk was evaluated and consistently weighted among pathways. A second phase was conducted for identifying target areas delineated by AOEs and ASCs of various site scenarios to test the HRS addition and to illustrate the features of sites that would qualify for the NPL considering vapor intrusion contamination. To illustrate the subsurface intrusion component and contribution of weighting of factor values, three comprehensive site scoring scenarios were evaluated: A site would not qualify for placement on the NPL (score below 28.50), a site would marginally qualify for the NPL (score of or about 28.50), and a site would exceed the scoring criterion for the NPL (site score considerably above 28.50). Based on this final rule, the results revealed that sites without areas of observed exposures and a typical waste characteristic value would require a minimum of 685 receptors living, working or attending school or daycare above an area of subsurface contamination to receive a score of 28.50 based on shallow subsurface sampling. Sites with documented subsurface intrusion into an occupied structure, a typical waste characteristic value and indoor air samples below health-based benchmarks would require a minimum of 223 receptors to receive a score of 28.50. This illustrates that this final rule will not result in a large number of sites qualifying for the NPL as it is unlikely this number of receptors in an area of subsurface contamination will commonly occur. This is the similar number of receptors needed for a site to qualify for the NPL in other pathways.

2. Test Sites (Tier 1)

To support the final rulemaking, EPA conducted a screening-level assessment of sites with identified subsurface intrusion threats. As a first step in collecting the list of sites potentially affected by the final rule, EPA consulted with site assessment experts that work in Superfund to identify potential site candidates. EPA also reached out to state counterparts, in particular to state programs that were known to have taken a more thorough investigation of the subsurface intrusion pathway at sites. Through this process, EPA identified approximately 1,073 sites. These sites are not currently on the NPL, and all have a potential or identified SsI threat. Within the group of sites potentially affected by the HRS SsI Addition, EPA defined four categories:

1. Tier 4: Sites identified as having a suspected SsI threat based on EPA's Superfund database and Agency for Toxic Substances and Disease Registry keyword searches, as well as EPA or state self-identification, but for which no sampling data were obtained;
2. Tier 3: Sites identified as having characteristics or evidence that indicate SsI may have occurred or will occur;
3. Tier 2: Sites identified as having an SsI threat documented by subslab, crawl space, or indoor air samples, but insufficient HRS-required evaluation factors to qualify for the NPL; and
4. Tier 1: Sites identified as having an SsI threat with documented actual exposure of a sufficient number of targets with enough other HRS-required evaluation factors to suggest the site may qualify for the NPL.

EPA selected the Tier 1 sites for use in testing the SsI component evaluation process. The 11 Test Sites had documentation of indoor contamination due to subsurface intrusion based on actual sampling data and other typically HRS-required data. Of the 11 sites scored, 9 were projected to score 28.50 or higher using only the SsI component. 1 site was projected to score 28.50 or higher only by including both the scores from the SsI component evaluation and the ground water migration pathway evaluation in the site score. It was unknown whether these sites would qualify for the NPL when they were chosen as Test Sites, as the SsI scoring process had not been developed. The Test Site with a projected score below 28.50 did not qualify for the NPL even though the site was located in a mixed-used residential and industrial area, illustrating that not all sites in an urban area will qualify for the NPL.

That 10 of the 11 Test Sites have a projected HRS site score of 28.50 or greater using the SsI component is not an indication that the addition of the SsI component will result in a large number of SsI sites qualifying for the NPL; this would be a possible projection if the Test Sites were chosen randomly so as to represent a typical SsI site. The Test Sites were not randomly chosen, but instead were specifically chosen because they have a documented subsurface intrusion threats at the sites and sufficient available data to test all parts of the SsI component. The Test Sites all had areas of observed exposure; most had more than 38 structures at the site (some with hundreds of structures), and all but two Test Sites had at least 50 targets (more than half had over 100 targets). Each site was also associated with volatile hazardous substances that are considered hazardous to human health at low concentrations. Appendix B of the Technical Support Document (TSD) for this final rulemaking provides a summary of these scoring evaluations.

3. Pilot Study

The main purpose of the Pilot Study was to identify sites currently being evaluated for SsI by the EPA regions with a suspected subsurface intrusion threat and determine whether an SI would provide enough information to score a site under the new component. Additional goals of the Pilot Study were to gather data and determine if design of the SsI model is practical and gives expected results; identify a range for the cost of a projected SsI site assessment; and assist in developing future guidelines for SsI assessments. A total of 10 sites were identified across 5 of the 10 EPA Regions. The pilot studies were not intended to identify sites for placement on the NPL, and not all sites considered for the pilot studies achieved an HRS score greater than (or equal to) 28.50. However, collecting actual data for the purposes of generating an SsI component score, ensured the HRS was considering subsurface intrusion threats appropriately. Ultimately, the pilot studies were used to proof the concept and validate the SsI component in terms of the application of selected weighting factor values and the efficacy for accurately identifying sites with significant relative risk.

## IV. Summary of Changes to the HRS

Comments on the Proposed Rule were received from 15 organizations/individuals. The commenters included state and federal agencies, industry associations, community groups, consultants, and private citizens. No major conceptual or structural changes were necessary based on comments received during the public comment period. While many of the comments focused on the structure of the SsI component, there was not sufficient rationale for making major changes to the basic structure of the SsI component. There were minor revisions made based on comments, which help refine the mechanics of assigning an HRS site score. As a result, the SsI component better reflects current science and better aligns with underlying concepts in the *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Sources to Indoor Air* (VI Guide). These changes had no impact on the overall structure of the SsI component and do not impact the relative weighting among the HRS

pathways or the level of risk required to qualify for the NPL.

*A. Changes Since Proposal*

1. Consideration of Contaminated Ground Water Intrusion

Section 5.2 was revised to clarify that areas of subsurface contamination are only delineated based on the presence of hazardous substances meeting the criteria for observed exposure or observed release and have a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to $10^{-5}$ atm-m$^3$/mol. However, if samples indicate intrusion of liquids containing hazardous substances has occurred into regularly occupied structures, the samples of that liquid are still used in delineating an Area of Observed Exposure to reflect the threat to targets. These revisions were made to correct a seeming inconsistency in wording between the discussion in the preamble to the proposed rule and the proposed regulatory language.

2. Consideration of Non-Aqueous Phase Liquids (NAPLs) in Weighting of Targets in an ASC

Table 5–21, Weighting Factor Values for Populations within an Area of Subsurface Contamination, of the HRS was revised to include consideration of the presence of NAPLs identified in an area of subsurface contamination. These additions increase the weighting of the population in an area of subsurface contamination to the SsI component score. These revisions were in response to comments that the proposed addition did not reflect the magnitude of contaminant concentrations in the evaluation of targets in the area of subsurface contamination. While EPA considers it unlikely that the actual aerial distribution and magnitude of contaminant concentrations can be determined in an area of observed contamination during a site inspection, if NAPLs are identified as present, EPA agrees that there is a greater risk to receptors than if no NAPL is present.

3. Modifications to the Determination of Degradation Factor Values

Section 5.2.1.2.1.2 of the HRS was revised to make it easier for the reader to determine degradation factor values and to add consideration of the presence of NAPLs. Commenters asserted that the text was difficult to follow and that the presence of NAPLs was a major factor in the impact of degradation. A new table, Table 5–18 of the HRS, simplifying the assignment of degradation factor values based on the depth to contamination and a substance's half-life was inserted to replace proposed text. Additionally, if no half-life information is available for a hazardous substance and the substance is not already assigned a degradation factor value of 1, a value of 1 will be assigned. This modification further simplifies the degradation evaluation and is also protective of human health, for if no half-life information is available for a hazardous substance, EPA cannot assume that degradation will occur. In addition, parent-daughter relationships between substances are no longer considered in the assignment of the degradation factor value, in part to simplify the assignment and in part to reflect the variation in rates of degradation due to site-specific subsurface conditions. Even if degradation occurs, if a contaminant is at high enough concentration to exist as a NAPL at depths less than or equal to 30 feet, it is more likely to pose a threat to populations in overlying structure.

4. Modifications Made to Section 5.2.1.1.2.1, Structure Containment and Table 5–12

Section 5.2.1.1.2.1 and Table 5–12 of the HRS were revised in response to comments on the rationale for assigning containment values to individual structures. The assignment of a structure containment factor value assigned to structures in Table 5–12 with vapor mitigation systems or other response actions was revised. These revisions were made in response to a comment questioning why response actions taken by federal, state, and tribal authorities are treated differently than those taken by private entities in determining containment for a structure. The language regarding treatment of removals by federal, state, and tribal authorities has been removed from Table 5–12 and the corresponding containment value was assigned a 1. This change allows a consideration of public and private removal actions to be evaluated in a consistent manner.

Section 5.2.1.1.2.1 and Table 5–12 of the HRS was also revised to remove from the table the direction of the assignment of a structure containment value for a regularly occupied structure with unknown containment features. This direction, which assigns a value of ''greater than zero'' to this situation, was moved to the text in section 5.2.1.1.2.1 of the HRS. This revision was made in response to a comment questioning the rationale for the various containment values and was made to improve the continuity of the table, which directs the assignment of values when containment features of the structure are known. A structure with a containment factor value of greater than zero cannot be used in assigning a potential for exposure factor value. EPA considers it appropriate that the potential for exposure factor value should be based on actual field observations. However a structure with a structure containment value of greater than zero allows the structure to be evaluated for assigning waste characteristics values (*e.g.,* a hazardous waste quantity factor value) and for assigning target factor values. EPA considers the inclusion of structures with unknown containment features in the calculation of waste characteristics and targets values appropriate as it reflects that very few structures are built to be sufficiently air tight to prevent subsurface intrusion.

5. Consideration of Hydraulic Conductivity in Vertical Migration

Table 5–14 of the HRS was revised to allow assignment of an effective porosity/permeability factor value based on site-specific measurements of hydraulic conductivity, if known. This addition was made in response to a comment suggesting the rule be modified to allow use of site-specific information for this purpose when available.

6. Changes to Definitions

The term surficial ground water was re-named shallow ground water and was changed to be consistent with current EPA usage.

EPA has added the term non-aqueous phase liquid (NAPL) to the definition section. EPA added consideration of the identification of concentrations of hazardous substances high enough to indicate the presence of NAPLs in the subsurface during a site inspection to the assignment of degradation factor values and the weighting of targets in the ASC. The presence of NAPLs in the subsurface demonstrates the hazardous substances will be present at high concentrations for a significant time period at that location and the high concentration is not a transient situation.

*B. Summary of Updates to the HRS (Sections 2, 5, 6, and 7)*

1. Addition of an SsI Component to the HRS (Sections 2, 5, and 7)

a. The addition of a subsurface intrusion component is added to the 1990 Soil Exposure pathway as section 5.2 in Chapter 5 of the 2016 Revised HRS. The new pathway name is the soil exposure and subsurface intrusion pathway. The existing method for evaluating the soil exposure threat will remain unchanged.

b. Chapter 2: Evaluations Common to All Pathways is updated to reflect the

addition of the subsurface intrusion component to the renamed the soil exposure and subsurface intrusion pathway. The evaluations for the migration pathways and the soil exposure component remain unchanged. A parallel structure was added for the subsurface intrusion component.

c. Chapter 7: Sites Containing Radioactive Substances is updated to reflect how radioactive substances are evaluated using the added subsurface intrusion component.

2. Terminology Updates Affecting Specific Sections of the HRS (Sections 2, 5 & 6)

The following terms are updated to reflect current terminology and procedures used by EPA in performing risk assessments.

a. Ambient Water Quality Criteria: Ambient Water Quality Criteria (AWQC) are now identified also as National Recommended Water Quality Criteria (NRWQC). In addition, the acute AWQC are now identified as the Criterion Maximum Concentration (CMC) and the chronic criteria are referred to as the Criterion Continuous Concentration (CCC). (See section 1.1 of the HRS.) These criteria are used to determine the level of threat to environmental targets.

b. Reference Concentrations: For inhalation exposures, EPA is adopting the use of Reference Concentrations (RfCs) instead of Reference Doses (RfDs) when determining non-cancer-related risk levels. RfCs are used in determining the level of threat to human targets due to possible inhalation and when determining the toxicity of the substances.

c. Cancer Unit Risk: For inhalation exposures, EPA is adopting the use of Inhalation Unit Risk (IUR) instead of cancer slope factors in determining cancer-related risk levels. IURs are used in determining the level of threat to human targets due to possible inhalation and when determining the toxicity of the substances.

d. Weight-of-Evidence Groupings: The 2005 EPA weight-of-evidence groupings supporting the designation of a substance as a human carcinogen have been incorporated into the HRS algorithm for assigning the toxicity factor value. (The former EPA weight-of-evidence categories included as part of the 1990 HRS have been retained as EPA has not yet completed assigning all substances to the revised categories and are doing so at the time the EPA substance literature reviews are updated.)

## V. Discussion of Major Comments

Comments on the Proposed Rule were received from 15 organizations/individuals. The commenters included state and federal agencies, industry associations, community groups, consultants, and private citizens. This section discusses the major issues raised by commenters, which are summarized, and EPA's summary of responses. In addition, EPA solicited and received input from commenters on three technical questions posed in the Preamble to the Proposed Rule.

A support document, Response to Comments on the 2016 Revisions to the Hazard Ranking System (HRS), that includes all issues raised during the public comment period, comments received on the questions posed in the preamble to the proposed rule and EPA's more comprehensive response to each issue, is available in the docket for this rulemaking.

### *A. Responses to Comments on EPA Questions Posed in the Proposed Rule*

Question 1: Is there a way to determine the presence and extent of biologically active soil at a site during a limited site investigation? If so, what soil characteristics should EPA consider to determine whether biologically active soil is documented to be present?

EPA received multiple comments in response to this question. One commenter suggested that this activity is beyond the scope of the site assessment process, while another commenter suggested that EPA consider measuring specific compounds or other factors reflecting biological activity when conducting soil vapor analysis. A third commenter remarked that half-lives faster than 100 days are presumably due to aerobic biodegradation and that most vadose zone soils that are not grossly impacted are considered biologically active. A commenter also suggested using soil characteristics reflected in soil surveys to reflect the possibility that biologically active soil could be present. No commenter suggested practical methods to determine site-specific biological activity throughout a site or over time.

The HRS SsI addition was revised to clarify the assumption of the presence of biologically soil in evaluating the degradation factor unless evidence indicates otherwise (see section 5.2.1.2.1.2 of the HRS).

Question 2: How could EPA further take into account the difference in dilution and air exchange rates in large industrial buildings as compared to smaller residential and commercial structures when calculating the hazardous waste quantity for the HRS SsI Addition?

EPA received multiple comments in response to this question. One commenter suggested developing intrusion screening values based on exposure scenarios for ''most sensitive individual'' and ''industrial'' models. One commenter indicated that there is not a dependable way to account for the differences between large commercial/industrial structures and smaller residential/commercial structures. Another commenter noted that there are several parameters (*e.g.,* building energy efficiency) that would impact the differences in dilution and air exchange rates and which are generally unavailable during an initial assessment. A commenter discussed developing a sliding scale based on the size of the building and the building's general use to account for the differences in contaminant clearance rates.

EPA did not make any changes to the final rule based on the comments received as the type of information requested in these responses is generally not available during a typical site inspection. The HRS has also been designed so that it can be applied consistently to a wide variety of sites. The HRS is not a tool for conducting quantitative risk assessment and was designed to be a measure of relative risk among sites rather than absolute site-specific risk.

Question 3: The HRS SsI addition considers source strength in delineating ASCs and AOEs, in scoring in likelihood of exposure, in assigning waste quantity specifically when estimating hazardous constituent quantity and in weighting targets in an ASC. The HRS algorithm for all pathways incorporates the consideration of source strength in determining an HRS site score. Could EPA further take into account source strength in performing an HRS evaluation?

EPA received multiple comments in response to this question. One commenter suggested that EPA assign a higher score when the contaminant concentration is high (*e.g.,* when a non-aqueous phase liquid is present) to account for source strength. Comments were also received that reflected the difficulty of accessing large low concentration sources and how to account for that in considering source strength. Another commenter remarked that there may be a large ground water plume without a discrete source that would cause an increased risk of vapor intrusion; and that a large diffuse source is different from having a concentrated discrete source. One commenter

provided a copy of the proposed rule with their suggested edits reflecting the evaluation of source strength in assigning HRS specific factors.

The assignment of a degradation factor value (see section 5.2.1.2.1.2 of the HRS) and the weighting factors for targets in an area of subsurface contamination (see Table 5–21 of the HRS) were revised to include consideration of source strength; specifically in the situation where NAPLs are present.

*B. Major Comment Theme Summaries and Responses*

Statutory Authority and Rationale for the Proposed HRS Addition

Justification for Revising the HRS

EPA received comments suggesting that sufficient justification or rationale for the need to revise the HRS has not been provided and that a revision to the HRS is unnecessary because the 1990 HRS adequately evaluates the relative risk posed by a site and identifies those priority sites for further investigation.

The rationale for revising the HRS to add a subsurface intrusion component is EPA's statutory authority. Specifically, CERCLA 105(a)(8)(A), requires EPA to amend the HRS ''to assure to the maximum extent feasible, that the HRS accurately assess the relative degree of risk to human health and the environment posed by sites and facilities subject to review.'' Contamination due to subsurface intrusion is a known risk to human health and the ability to evaluate those risks is consistent with the CERCLA 105 mandate. The 1990 HRS did not evaluate the risk posed by subsurface intrusion when evaluating sites for the NPL. As part of the development of this rule, EPA identified high priority sites with significant contamination due to SsI that could not be evaluated using the 1990 HRS for possible placement on the NPL. With the addition of the SsI component to the HRS, sites can now be evaluated more comprehensively to consider the relative risk posed by a site.

Priority for Drinking Water Sites

EPA received comments suggesting that the proposed HRS SsI addition conflicts with CERCLA's statutory mandate regarding prioritizing drinking water sites.

The revision to the HRS to add a subsurface intrusion component is not in conflict with the CERCLA 105 mandate to prioritize drinking water sites. The priority given by EPA under CERCLA to sites with a high risk of populations exposed to hazardous substances in drinking water has not decreased with the addition of a subsurface intrusion component to the HRS. In fact, the score for some sites with contaminated drinking water supplies may increase because sites with contaminated drinking water may also be associated with subsurface intrusion contamination and the combination of the ground water migration pathway score and the SsI component score may increase the overall site score. Furthermore, EPA notes that drinking water is a priority identified by CERCLA, but it is not the only priority identified in CERCLA 105, which also mandates the prioritization of dangers of direct human contact, for which SsI is one example.

The addition of the SsI component does not change the priority given to drinking water sites. It does not change the scoring of contaminated drinking water supplies under the HRS, reduce in anyway the overall HRS score for any site based on drinking water contamination (or any other threat due to exposure to released hazardous substances in the HRS), or change the site score of 28.50 being the HRS score that qualifies sites for placement on the NPL. If a site qualifies for placement on the NPL based on its HRS score reflecting drinking water contamination prior to the addition of the SsI component, it will continue to do so. Adding an evaluation of the SsI component can only increase an overall site score. The algorithm used to combine pathways scores to obtain an overall site score results in an increase in the overall site score with the evaluation of additional pathways, components and threats scored. In fact, the SsI addition may raise the overall site score at some sites with ground water drinking water contamination from below the 28.50 cut-off score to above it. This may occur because, as stated above, a site's HRS score can increase with the scoring of additional threats. Sites with ground water contaminated by volatile substances and used for drinking water are also sites at which the ground water contamination may volatilize and intrude into overlying regularly occupied structures. Thus, a site at which ground water contamination has occurred but does not have an HRS score above 28.50 based only on the ground water threat, may have an overall HRS site score above 28.50 based on the combination of the scores for the contaminated drinking water and SsI threats.

Furthermore, EPA notes that CERCLA 118 refers to CERCLA sections104 and 108, which address activities that occur pre- or post-NPL-listing, and not to the section of CERCLA that addresses site ranking using the HRS, which is addressed in CERCLA section 105. CERCLA Section 105 and specifically 105(a)(8)(A) requires EPA to prioritize sites based on ''the population at risk, the hazard potential of hazardous substances at such facilities, the potential for contamination of drinking water supplies, the potential for direct human contact [and] the potential for destruction of sensitive ecosystems.'' Since subsurface intrusion contamination is a direct human contact threat, the addition of a subsurface intrusion component, which addresses this threat, is mandated by CERCLA.

Resource Impacts of the Proposed HRS Addition

Increased Cost and Level of Effort

EPA received comments suggesting that contrary to EPA's suggestion that the HRS SsI addition may not result in more site assessments per year and only minimal cost increases, commenters claimed that there will be substantial increases in cost and level of effort for states and federal agencies, due to the complexity in assessing subsurface intrusion sites.

EPA acknowledges that in some cases the scope of a typical site inspection (SI) may need to be expanded to collect the information necessary to evaluate the SsI threat present at a site. EPA also acknowledges that sites that did not qualify previously for the NPL, may now do so. The number of samples and level of effort required to evaluate a site using the 1990 HRS pathways or components already varies on a site-by-site basis depending on the size and extent of contamination at the site. Therefore, it cannot be predicted with certainty that there will be an overall increase in cost or level of effort for any particular site due to the HRS SsI addition. However, the overall budget for performing site assessments per year is not expected to change significantly. EPA's budget for site assessment is dependent on Congressional appropriation and EPA does not expect the rulemaking to impact the appropriation. EPA's budget for site assessment has remained relatively constant for the last several years. Hence, EPA expects that the allocation of available resources may be changed to reflect this rulemaking but will continue to be optimized by EPA, its state and tribal partners, and with other federal agencies to evaluate priority sites. However, the number of site assessments or NPL proposals conducted each year will not significantly increase.

Potential Limitations With Implementing the HRS SsI Addition

Scope of Site Inspection

EPA received comments stating that the type and amount of information available for collection during a time-limited site inspection would be insufficient to properly evaluate a site using the HRS SsI addition and would be beyond the scope of site evaluations typically conducted at the preliminary assessment or site inspection stage.

During development of the HRS SsI addition EPA considered the type of information that could be collected during a time-limited site inspection when selecting the factors to include in an evaluation of the subsurface intrusion component. The purpose of the site inspection (NCP 300.420(c)) is to determine if a release of a hazardous substance poses an actual or potential threat to human health or the environment, to determine if there is an immediate threat to people or the environment, and to collect sufficient data to enable the site to be scored using the HRS. EPA also notes that neither the NCP nor the HRS requires a certain number of samples be collected during an SI, because the number of samples required to evaluate a site varies on a site-by-site basis and the possible risk pathways being evaluated. However, to properly evaluate the subsurface intrusion component, additional information may be required beyond that collected during a typical current site inspection may be required; this is consistent with the need to collect data on the threat posed by a different pathway. In these instances, as stated in EPA's Guidance for Performing Site Inspections under CERCLA (September 1992), an expanded site inspection (ESI) may be required. The objective of the ESI is to collect data that was not collected during an initial site inspection. Furthermore, EPA found that information required for an SsI evaluation was available based on a pilot study which included several candidate NPL sites. The pilot study was performed in part to demonstrate the availability of the necessary data from screening level investigations. Therefore, EPA considers that the information required to properly evaluate the subsurface intrusion component can be obtained during the site assessment process.

Need for Guidance

EPA received comments questioning or requesting additional information or guidance regarding the type and amount of data to collect, data collection methods, and how to apply the subsurface intrusion component to a site. Commenters also suggested it was difficult to properly evaluate and comment on the proposed HRS SsI addition without a thorough understanding of how the SsI component would be implemented and that promulgation should be delayed until guidance is developed.

The HRS does not provide prescriptive methods for performing site investigations for any HRS pathway evaluation because the methods used during the collection and analysis of environmental samples depend on site conditions and could not be written to cover all possible situations and could also become outdated in the future. Additionally, it is outside the scope of the HRS to identify and describe methods for conducting a subsurface intrusion screening for HRS purposes. The sampling and data collection information in the EPA OSWER VI Guide, (particularly in section 6 of the guide) are an appropriate resource for gathering data for HRS purposes. For example, Section 6.4 of the guide identifies basic principles, methods and procedures for indoor air sampling. In addition, states, federal agencies, and private contractors have considerable experience in VI investigations and collecting VI-related data. Guidance on implementation of the proposed SsI addition is not necessary for evaluating the SsI component, which is a scoring mechanism not procedures for data collection. Any guidance developed will provide details on collecting data to support an HRS SsI evaluation. EPA also notes that to delay addressing sites that may pose a significant human health risk until all necessary guidance documents have been developed would not be consistent with EPA's mandate to protect human health. Therefore, EPA does not agree that promulgation of the HRS SsI addition needs to be delayed until guidance documents related to its implementation have been developed.

Roles of the HRS SsI Addition and the 2015 OSWER VI Guide

EPA received comments suggesting that the HRS SsI addition is not consistent with the VI Guide, published in June 2015 and will create confusion when evaluating sites for SsI.

The VI Guide and HRS SsI rule work in concert to establish national consistency in the evaluation of SsI threats. The HRS SsI addition and the OSWER VI Guide both address the threat posed by vapor intrusion and use the same principles, sampling procedures and concepts to characterize the threat posed by vapor intrusion as the sites. However, the HRS SsI addition and the OSWER VI Guide serve different purposes and support different phases of EPA's site remediation process with different data quality requirements and different enabling legislations.

The purpose of the OSWER VI Guide is to guide the investigation and assessment of the threat posed by vapor intrusion into structures from all sources under all Office of Land and Emergency Management (OLEM, formerly OSWER) programs, particularly actions taken under CERCLA and RCRA. This guidance is used to support decisions by EPA on whether vapor intrusion is posing an unacceptable risk to human health based on sufficient site specific data. It contains principles for making such a decision, as well as procedures and guidance for collecting the information necessary to make these decisions.

The HRS and the SsI addition is part of the NCP, (the regulations implementing CERCLA) required by CERCLA to identify priority sites for further investigation based on screening level information (Such sites are identified for the public by placing the sites on the NPL, a separate rulemaking process). This prioritization is based on the possible cumulative relative risk amongst all candidate sites posed by releases of hazardous substances to human health and the environment by either migration to receptors or by direct contact with the contamination, such as by subsurface intrusion. The HRS is only a method for assigning a relative score to candidate sites. It is not a method for determining site specific risk. The HRS SsI addition is not guidance. The HRS SsI addition does not address such subjects as data collection and sampling procedures: Many of the procedures and many of the guidelines in the OSWER VI Guide are also applicable for HRS purposes if they can be implemented as part of a screening level assessment.

Given that the purposes for the two documents are considerably different and based on different levels of information, it is not an issue that decision criteria are different in the two documents. It is certainly possible that, based on an HRS evaluation, EPA may determine a site warrants further investigation, and that after further investigation is performed EPA may decide no remediation is necessary. However until further information is collected during a remedial investigation, such an outcome cannot be predicted. Furthermore, such a situation is not an indication the results of the HRS evaluation was incorrect.

Application of HRS SsI Component

Inferring Contamination

EPA received comments suggesting that by inferring contamination between sampling locations, the extent of the risk is overstated. The commenters considered identifying targets as actually or potentially exposed based on inference to inflate the HRS site score. It was also suggested that this method conflicts with the other HRS pathways.

The HRS is not a quantitative risk assessment. Instead, the HRS SsI addition score reflects the possible threat posed by subsurface intrusion at one site relative to other sites. By inferring contamination in an AOE or an ASC between sampling locations, it is not assumed that all populations within the two areas are exposed to contamination from the subsurface. Inferring contamination also allows sites with large populations within the two areas to be ranked higher than sites with smaller populations. If the HRS scoring required sampling every structure a sufficient number of times to assure that all exposed targets were accounted for, the scope of the sampling effort would be beyond that of a screening tool and more consistent with the scope of a remedial investigation.

Inference of contamination between sampling locations is also assumed in other HRS pathways. The other pathways allow the inference of contamination based on the location of samples documenting the presence of contamination attributable to the site being investigated. For example, in the soil exposure component, inference of contamination is done by drawing AOC boundaries based on sample locations and inferring that those targets associated with the properties within the boundaries are actually exposed.

In the SsI component, unless site-specific information indicates otherwise, when delineating an AOE or an ASC, populations in occupied structures within an AOE are inferred to be actually exposed, and, populations in occupied structures within an ASC are inferred to likely be exposed to contamination.

Purpose of Hazardous Waste Quantity

Commenters noted that as explained in the TSD for the proposed HRS SsI Addition, the hazardous waste quantity factor serves as a surrogate for the contaminant dose that populations may be exposed to. Commenters asserted that the hazardous waste quantity factor is not adequately reflective of this dose to be used as a surrogate.

The commenters appear to be confusing consideration of waste quantity as a surrogate for dose in an HRS evaluation with the calculation of a site-specific risk level based on the ratio of waste quantity to receptors. EPA is not projecting a specific risk level based on the waste quantity alone when it performs an HRS evaluation. Other HRS factors such as the population associated with the structures, the probability of a release into the occupied structures, the possibility of degradation, and the toxicity of the substances are also considered,

The decision to include waste quantity as a surrogate for dose in all pathways and components in the HRS algorithm was made when the HRS was last revised in 1990 (see Section V.3 of the proposed 1988 HRS, 53 FR 51692, December 23, 1988; Section III.C of the 1990 HRS, 55 FR 51542, December 14, 1990). The decision was based on the concept that determining an accurate dose that receptors would be exposed to was beyond the scope of information available after a site inspection. It is not possible to accurately predict the hazardous substance concentration that receptors would be exposed to over a representative exposure period based on information collected during a site inspection due to the variability in exposure levels over time and space. Instead, hazardous waste quantity is used as a surrogate for dose in the sense that the quantity of the hazardous substances is at least qualitatively correlated to the magnitude of the exposure. If there is no waste quantity, there will be no exposure; as the waste quantity increases, the greater the possibility of exposure to hazardous substances that a receptor may come in contact with. EPA agrees this is not a perfect correlation, and has built into the HRS four order of magnitude ranges for assigning factor values that reflect the imperfection of this correlation.

In addition, the inclusion of hazardous waste quantity in the subsurface intrusion component is consistent with its inclusion in all the other existing HRS pathway evaluations and is consistent with the goal that the scoring of the new component not impact the balance built into overall HRS site scoring algorithm among the HRS pathways.

Furthermore, for determining waste quantity for the SsI component, EPA made a specific alteration to how waste quantity is calculated as compared to other HRS pathway. EPA decided to only include the amount of hazardous substance that actually enters into or that could enter into occupied structures, not the total amount in the release to the environment, based on the rationale that at least some of the original release in the subsurface would vent directly to the atmosphere. Therefore only the amount of hazardous substances that has entered into occupied structures or the amount located under structures is reflected in the estimate. This was achieved by not estimating the waste quantity based on the area or the volume of the contaminated media in the subsurface, but instead on the volume of the structures, or the basal area if the volume cannot be determined.

Finally, no comments were received that provided a viable alternative to the proposed method of estimating hazardous waste quantity. Commenters stated the amount of exposure was overestimated for large buildings because in general larger buildings have lower air exchange rates and suggested that this consideration be built into the estimation methods for all structures. However, the commenters did not present data to document this generality nor suggest how to determine the air exchange rate for all structures if it is not provided by the building owner. EPA notes that if air exchange rates are available, the present estimation method (which has not changed since proposal) allows for a hazardous waste quantity estimate using that information (see, HRS section 5.2.1.2.2 Tier B, hazardous wastestream quantity).

While some commenters suggested procedures for determining a more accurate hazardous waste quantity for specific situations they did not suggest how the hazardous waste quantity calculated for these situations could be relatively ranked against sites where equivalent information was not available. When developing a hazardous waste quantity factor in 1988, EPA performed studies that showed this level of information was not available at all sites, and was not likely to be collectible during a limited screening assessment. Therefore, EPA considers it inappropriate to incorporate the suggested procedures into the HRS.

In addition, EPA proposed the present hazardous waste quantity estimation process as part of the revision of the HRS in 1988. At that time EPA requested the Science Advisory Board's (SAB's) assistance on the use of concentration data in determining the hazardous waste quantity factor as part of the overall SAB peer review of the HRS changes. The current method for use of concentration data in determining the hazardous waste quantity factor is based on the SAB's recommendation.

Establishment of Attribution

Commenters noted that establishing that indoor air contamination is

attributable to subsurface intrusion will be very complex to demonstrate given all other possible origins of the indoor contamination (*e.g.,* outdoor air, consumer products).

The HRS SsI addition, just as in other HRS pathways and components, does not require absolute proof that the significant increase in indoor contaminant concentrations is due to subsurface intrusion. It only requires at least part of the significant increase be attributable to subsurface intrusion. EPA expects to use multiple lines-of-evidence in meeting the attribution requirement as discussed in various comments. The VI Guide outlines use of multiple lines-of-evidence and provides guidance on how to distinguish subsurface intrusion from other sources of vapor intrusion. As is done for other HRS pathways and components, the HRS standard for establishing attribution is to establish a reasoned explanation that is not shown to be incorrect during public review of placement of a proposed site on the NPL.

Establishing Observed Exposure

EPA received comments suggesting that the criteria for establishing background for the SsI component is too complex given the variability in sampling for SsI and that a significant difference between the background level and release concentration is not an adequate measure for establishing an observed exposure in a regularly occupied structure.

EPA agrees that establishing a background level for indoor air can be difficult. However, it does not mean that the HRS criteria for establishing actual exposure should not be used. Methods for establishing background levels are too site-specific to be discussed in the HRS regulation, which is a scoring methodology. Instead, as occurred after the 1990 HRS was promulgated, criteria for establishing background was refined based on actual experience gained as sites were being scored. EPA expects the same to occur for the HRS SsI component.

Comparison of background levels and indoor air concentrations are used only to establish that the contaminant level in a structure is elevated (*i.e.,* significantly different). This is only the first step in establishing observed exposure. The second step is to attribute at least a part of the significant increase to subsurface intrusion.

The argument that vapor intrusion rates are too variable to justify the use of the same procedure for establishing observed releases or exposures as in other parts of the HRS is invalid. Hazardous substance concentrations are unpredictably variable temporally and spatially for all HRS pathways and SsI variability is no different in that regard. For example, in the surface water migration pathway overland flow threat, the hazardous substance may only be entering surface water via runoff due to rain events. No runoff occurs if it is not raining. The amount entering surface water in this situation has been shown to vary with the length of time between rains, which impacts the amount of material deposited and available for entrainment into the runoff. Runoff also varies with the portion of each rain cycle whether the sample is collected at the beginning, middle or end of a rain event. At the beginning of a rain event all erodible materials are present and available. During the middle or during a high intensity period of rain, the force of the rain drops can dislodge and entrain hazardous substances at greater rates that during low intensity periods. At the end of a rain event, it may be that much of the hazardous substances have already been washed away. In continuous air releases, the contaminant concentration can vary by order of magnitudes with distance from the source, with wind direction and wind speed all of which can cause differences in concentrations spatially due to the three dimensionality of the atmosphere, and cannot be predicted or accounted for based on a screening assessment. Even in ground water contamination, the contaminant plume's concentration can vary spatially depending on the rate of ground water movement from the original spill concentrations. It is not possible to account for these factors that can drastically impact the contaminant concentration at a sampling location, based on screening level information.

For example, variation in the occurrence of releases is no greater in the SsI component than would be expected in point-source air releases or spills to surface water.

Degradation

Commenters suggested changes in how the degradation factor value for the subsurface intrusion component is assigned. Other comments dealt with conditions associated with assigning different degradation factor values based on the depth of biologically active soil and the half-lives of individual hazardous substances. In addition, commenters suggested moving the consideration of degradation from the waste characteristics factor category value calculations to the likelihood of exposure factor category value calculations.

After evaluation of the comments, EPA modified the assignment of the degradation factor to simplify the evaluation and to consider the presence of non-aqueous phase liquids (NAPLs); other changes suggested by commenters were not implemented. Some changes were not made because a sufficient rationale was not provided to justify a change. Regarding the placement of the degradation factor in the HRS equation, the consideration of an individual substance's characteristics in the waste characteristics factor category is consistent with other HRS pathways and components. Furthermore, whether the degradation factor is put in the likelihood of release or waste characteristic factor category, the impact of the factor on the score would be similar.

Targets

EPA received comments on the weightings assigned to targets in both the AOE and ASC. Commenters suggested that the weightings reflect the strength of the attribution argument that the significant increase in indoor air concentrations is due to subsurface intrusion and also reflect the concentration of the contaminants in the subsurface.

After consideration of these comments, EPA has changed the weightings of targets in the ASC to reflect the presence of NAPLs (*i.e.,* to reflect contaminant concentrations in the subsurface). EPA did not incorporate any changes into the weightings of targets based on the strength of attribution or concentration of contaminants in the subsurface. Regarding the strength of an attribution argument, the HRS does not recognize gradations of attribution in any other pathway or component and therefore for consistency, will not in this component. EPA notes that with the limited sampling that occurs during an SI, it is not reasonable to project the concentration of contaminants in the subsurface over time or distance.

## VI. Statutory and Executive Order Reviews

Additional information about these statutes and Executive Orders can be found at *https://www.epa.gov/laws-regulations/laws-and-executive-orders.*

### *A. Executive Order 12866: Regulatory Planning and Review and Executive Order 13563: Improving Regulation and Regulatory Review*

This action is a significant regulatory action that was submitted to the Office of Management and Budget (OMB) for review. This action may raise novel

legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the EO. Any changes made in response to OMB recommendations have been documented in the docket.

EPA prepared an analysis of the potential costs and benefits associated with this action. This analysis, Addition of a Subsurface Intrusion (SsI) Component to the Hazard Ranking System (HRS): Regulatory Impact Analysis is available in the docket for this action.

*B. Paperwork Reduction Act (PRA)*

This action does not impose any new information collection burden under the PRA. OMB has previously approved the information collection activities contained in the existing regulations and has assigned OMB control number 2050–0095.

This regulatory change will only affect how EPA and organizations performing work on behalf of EPA (state or tribal partners) conduct site assessments and HRS scoring at sites where certain environmental conditions exist. This regulatory change will result in data collection at these types of sites to allow evaluation under the HRS. EPA expects that the total number of site assessments performed and the number of sites added to the NPL per year will not increase, but rather expects that there will be a realignment and reprioritization of its internal resources and state cooperative agreement funding.

*C. Regulatory Flexibility Act (RFA)*

I certify that this action will not have a significant economic impact on a substantial number of small entities under the RFA. This action will not impose any requirements on small entities. This regulatory change enables the HRS evaluation to directly consider human exposure to hazardous substances that enter building structures through subsurface intrusion. This addition to the HRS would not impose direct impacts on any other entities. For additional discussion on this subject, see section 4.9 of the Regulatory Impact Analysis (see the docket for this action).

*D. Unfunded Mandates Reform Act (UMRA)*

This action does not contain any unfunded mandate as described in UMRA, 2 U.S.C. 1531–1538, and does not significantly or uniquely affect small governments. The action imposes no enforceable duty on any state, local, or tribal governments or the private sector.

*E. Executive Order 13132: Federalism*

This action does not have federalism implications. It will not have substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government.

*F. Executive Order 13175: Consultation and Coordination With Indian Tribal Governments*

This action does not have tribal implications, as specified in Executive Order 13175. EPA's evaluation of a site using the HRS does not impose any costs on a tribe (except those already in a cooperative agreement relationship with EPA). Thus, Executive Order 13175 does not apply to this action.

Although Executive Order 13175 does not apply to this action, EPA consulted with tribal officials through meetings and correspondence, including a letter sent to all federally recognized tribes asking for comment on the ''Notice of Opportunity for Public Input'' that was published in the **Federal Register** on January 31, 2011 (76 FR 5370), and public listening sessions regarding the decision to proceed with the development of this action. All tribal comments indicated support for this action.

*G. Executive Order 13045: Protection of Children From Environmental Health Risks and Safety Risks*

EPA interprets Executive Order 13045 as applying only to those regulatory actions that concern environmental health or safety risks that EPA has reason to believe may disproportionately affect children, per the definition of ''covered regulatory action'' in section 2–202 of the Executive Order. This action is not subject to Executive Order 13045 because it does not concern an environmental health risk or safety risk.

*H. Executive Order 13211: Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution or Use*

This action is not a ''significant energy action'' because it is not likely to have a significant adverse effect on the supply, distribution, or use of energy. The site assessment activities affected by this rule are limited in scope and number and rely on existing energy distribution systems. Further, we have concluded that this rule would not significantly expand the energy demand for site assessments, and would not require an entity to conduct any action that would require significant energy use, that would significantly affect energy supply, distribution, or usage. Thus, Executive Order 13211 does not apply to this action.

*I. National Technology Transfer and Advancement Act*

This rulemaking does not involve technical standards.

*J. Executive Order 12898: Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations*

The EPA believes the human health or environmental or environmental risk addressed by this action will not have potential disproportionately high and adverse human health or environmental effects on, low-income or indigenous populations. The results of this evaluation are contained in section 4.3 (and all subsections) of the Regulatory Impact Analysis for this rulemaking. A copy of the Addition of a Subsurface Intrusion (SsI) Component to the Hazard Ranking System (HRS): Regulatory Impact Analysis is available in the docket for this action.

*K. Executive Order 12580—Superfund Implementation*

Executive Order 12580, section 1(d), states that revisions to the NCP shall be made in consultation with members of the National Response Team (NRT) prior to publication for notice and comment. Revisions shall also be made in consultation with the Director of the Federal Emergency Management Agency (FEMA) and the Nuclear Regulatory Commission (NRC) to avoid inconsistent or duplicative requirements in the emergency planning responsibilities of those agencies. Executive Order 12580 delegates responsibility for revision of the NCP to EPA.

The agency has complied with Executive Order 12580 to the extent that it is related to the addition of a new component to the HRS, through consultation with members of the NRT.

*L. Congressional Review Act (CRA)*

This action is subject to the CRA, and the EPA will submit a rule report to each House of the Congress and to the Comptroller General of the United States. This action is not a ''major rule'' as defined by 5 U.S.C. 804(2).

**List of Subjects in 40 CFR Part 300**

Environmental protection, Air pollution control, Chemicals, Hazardous substances, Hazardous waste, Intergovernmental relations, Natural resources, Oil pollution, Penalties, Reporting and recordkeeping

requirements, Superfund, Water pollution control, Water supply.

Dated: December 7, 2016.

**Gina McCarthy,**

*Administrator.*

For the reasons set out in the preamble, Title 40, Chapter 1 of the Code of Federal Regulations is amended as follows:

## PART 300—NATIONAL OIL AND HAZARDOUS SUBSTANCES POLLUTION CONTINGENCY PLAN

■ 1. The authority citation for part 300 continues to read as follows:

**Authority:** 33 U.S.C. 1321(d); 42 U.S.C. 9601–9657; E.O. 13626, 77 FR 56749, 3 CFR, 2013 Comp., p. 306; E.O. 12777, 56 FR 54757, 3 CFR, 1991 Comp., p. 351; E.O. 12580, 52 FR 2923, 3 CFR, 1987 Comp., p. 193.

■ 2. Amend Appendix A to Part 300:

■ a. In section 1.1 by:

■ i. Removing the definition heading ''Ambient Water Quality Criteria (AWQC) and adding ''Ambient Water Quality Criteria (AWQC)/National Recommended Water Quality Criteria'', in its place; and removing the text ''maximum acute or chronic toxicity'' and adding ''maximum acute (Criteria Maximum Concentration or CMC) or chronic (Criterion Continuous Concentration or CCC) toxicity.'' in its place;

■ ii. Adding in alphabetical order the definition ''Channelized flow'';

■ iii. Revising the definition ''Chronic toxicity'';

■ iv. Adding in alphabetical order the definition ''Crawl space'';

■ v. Revising the definitions ''Distance weight'' and ''Half-life'';

■ vi. Amending the definition ''HRS pathway'' by removing the word ''soil,'' and adding ''soil exposure and subsurface intrusion,'' in its place;

■ vii. Adding in alphabetical order the definitions ''Indoor air'', ''Inhalation Unit Risk (IUR)'', ''Non-Aqueous Phase Liquid (NAPL)'', ''Preferential subsurface intrusion pathways'', and ''Reference concentration (RfC)'';

■ viii. Revising the definition ''Reference dose (RfD)'';

■ ix. Adding in alphabetical order the definition ''Regularly occupied structures'';

■ x. Revising the definition ''Screening concentration'';

■ xi. Adding in alphabetical order the definition ''Shallow ground water'';

■ xii. Revising the definition ''Slope factor (also referred to as cancer potency factor)'';

■ xiii. Adding in alphabetical order the definitions ''Soil gas'', ''Soil porosity'', ''Subslab'', ''Subsurface intrusion'', ''Unit risk'', and ''Unsaturated zone''; and

■ xiv. Revising the definition ''Weight-of-evidence''.

■ b. Revising section 2.0;

■ c. Revising section 5.0;

■ d. In section 6.0 by revising Table 6–14; and

■ e. In section 7.0 by:

■ i. Revising Table 7–1;

■ ii. Under Table 7–1, the second undesignated paragraph, revising the third sentence;

■ iii. Revising sections 7.1, 7.1.1, and 7.1.2; 7.2.1; 7.2.3; 7.2.4; 7.2.5.1, 7.2.5.1.1 through 7.2.5.1.3; 7.2.5.2; 7.2.5.3; 7.3, 7.3.1, and 7.3.2; and

■ iv. Adding section 7.3.3.

The revisions and additions read as follows:

## Appendix A to Part 300—Hazard Ranking System

* * * * *

### 1.1 Definitions

* * * * *

*Channelized flow:* Natural geological or manmade features such as karst, fractures, lava tubes, and utility conduits (*e.g.,* sewer lines), which allow ground water and/or soil gas to move through the subsurface environment more easily.

*Chronic toxicity:* Measure of toxicological responses that result from repeated exposure to a substance over an extended period of time (typically 3 months or longer). Such responses may persist beyond the exposure or may not appear until much later in time than the exposure. HRS measures of chronic toxicity include Reference Dose (RfD) and Reference Concentration (RfC) values.

* * * * *

*Crawl space:* The enclosed or semi-enclosed area between a regularly occupied structure's foundation (*e.g.,* pier and beam construction) and the ground surface. Crawl space samples are collected to determine the concentration of hazardous substances in the air beneath a regularly occupied structure.

* * * * *

*Distance weight:* Parameter in the HRS air migration pathway, ground water migration pathway, and the soil exposure component of the soil exposure and subsurface intrusion pathway that reduces the point value assigned to targets as their distance increases from the site. *[unitless].*

* * * * *

*Half-life:* Length of time required for an initial concentration of a substance to be halved as a result of loss through decay. The HRS considers five decay processes for assigning surface water persistence: Biodegradation, hydrolysis, photolysis, radioactive decay, and volatilization. The HRS considers two decay processes for assigning subsurface intrusion degradation: Biodegradation and hydrolysis.

* * * * *

*Indoor air:* The air present within a structure.

*Inhalation Unit Risk (IUR):* The upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent (*i.e.,* hazardous substance) at a concentration of 1μg/m$^3$ in air.

* * * * *

*Non-Aqueous Phase Liquid (NAPL):* Contaminants and substances that are water-immiscible liquids composed of constituents with varying degrees of water solubility.

* * * * *

*Preferential subsurface intrusion pathways:* Subsurface features such as animal burrows, cracks in walls, spaces around utility lines, or drains through which a hazardous substance moves more easily into a regularly occupied structure.

* * * * *

*Reference concentration (RfC):* An estimate of a continuous inhalation exposure to the human population that is likely to be without an appreciable risk of deleterious effects during a lifetime.

*Reference dose (RfD):* An estimate of a daily oral exposure to the human population that is likely to be without an appreciable risk of deleterious effects during a lifetime.

*Regularly occupied structures:* Structures with enclosed air space, where people either reside, attend school or day care, or work on a regular basis, or that were previously occupied but vacated due to a site-related hazardous substance(s). This also includes resource structures (*e.g.,* library, church, tribal structure).

* * * * *

*Screening concentration:* Media-specific benchmark concentration for a hazardous substance that is used in the HRS for comparison with the concentration of that hazardous substance in a sample from that media. The screening concentration for a specific hazardous substance corresponds to its reference concentration for inhalation exposures or reference dose for oral exposures, as appropriate, and, if the substance is a human carcinogen with either a weight-of-evidence classification of A, B, or C, or a weight-of-evidence classification of carcinogenic to humans, likely to be carcinogenic to humans or suggestive evidence of carcinogenic potential, to that concentration that corresponds to its $10^{-6}$ individual lifetime excess cancer risk for inhalation exposures or for oral exposures, as appropriate.

*Shallow ground water:* The uppermost saturated zone, typically unconfined.

* * * * *

*Slope factor (also referred to as cancer potency factor):* Estimate of the probability of response (for example, cancer) per unit intake of a substance over a lifetime. The slope factor is typically used to estimate upper-bound probability of an individual developing cancer as a result of exposure to a particular level of a human carcinogen with either a weight-of-evidence classification of A, B, or C, or a weight-of-evidence classification of carcinogenic to humans, likely to be carcinogenic to humans or having suggestive evidence of carcinogenic potential. [(mg/kg-day)$^{-1}$ for non-radioactive substances and (pCi)$^{-1}$ for radioactive substances].

*Soil gas:* The gaseous elements and compounds in the small spaces between particles of soil.

*Soil porosity:* The degree to which the total volume of soil is permeated with pores or cavities through which fluids (including air or gas) can move. It is typically calculated as the ratio of the pore spaces within the soil to the overall volume of the soil.

* * * * *

*Subslab:* The area immediately beneath a regularly occupied structure with a basement foundation or a slab-on-grade foundation. Subslab samples are collected to determine the concentration of hazardous substances in the soil gas beneath a home or building.

*Subsurface intrusion:* The migration of hazardous substances from the unsaturated zone and/or ground water into overlying structures.

* * * * *

*Unit risk:* The upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent (*i.e.,* hazardous substance) at a concentration of 1 μg/L in water, or 1 μg/m³ in air.

*Unsaturated zone:* The portion of subsurface between the land surface and the zone of saturation. It extends from the ground surface to the top of the shallowest ground water table (excluding localized or perched water).

* * * * *

*Weight-of-evidence:* EPA classification system for characterizing the evidence supporting the designation of a substance as a human carcinogen. The EPA weight-of-evidence, depending on the date EPA updated the profile, includes either the groupings:

- Group A: Human carcinogen—sufficient evidence of carcinogenicity in humans.
- Group B1: Probable human carcinogen—limited evidence of carcinogenicity in humans.
- Group B2: Probable human carcinogen—sufficient evidence of carcinogenicity in animals.
- Group C: Possible human carcinogen—limited evidence of carcinogenicity in animals.
- Group D: Not classifiable as to human carcinogenicity—applicable when there is no animal evidence, or when human or animal evidence is inadequate.
- Group E: Evidence of noncarcinogenicity for humans.

Or the descriptors:

- Carcinogenic to humans.
- Likely to be carcinogenic to humans.
- Suggestive evidence of carcinogenic potential.
- Inadequate information to assess carcinogenic potential.
- Not likely to be carcinogenic to humans.

**2.0 Evaluations Common to Multiple Pathways**

2.1 *Overview.* The HRS site score (S) is the result of an evaluation of four pathways:

- Ground Water Migration ($S_{gw}$).
- Surface Water Migration ($S_{sw}$).
- Soil Exposure and Subsurface Intrusion ($S_{sessi}$).
- Air Migration ($S_a$).

The ground water and air migration pathways use single threat evaluations, while the surface water migration and soil exposure and subsurface intrusion pathways use multiple threat evaluations. Three threats are evaluated for the surface water migration pathway: Drinking water, human food chain, and environmental. These threats are evaluated for two separate migration components—overland/flood migration and ground water to surface water migration. Two components are evaluated for the soil exposure and subsurface intrusion pathway: Soil exposure and subsurface intrusion. The soil exposure component evaluates two threats: Resident population and nearby population, and the subsurface intrusion component is a single threat evaluation.

The HRS is structured to provide a parallel evaluation for each of these pathways, components, and threats. This section focuses on these parallel evaluations, starting with the calculation of the HRS site score and the individual pathway scores.

2.1.1 *Calculation of HRS site score.* Scores are first calculated for the individual pathways as specified in sections 2 through 7 and then are combined for the site using the following root-mean-square equation to determine the overall HRS site score, which ranges from 0 to 100:

$$S = \sqrt{\frac{S_{gw}^2 + S_{sw}^2 + S_{sessi}^2 + S_a^2}{4}}$$

2.1.2 *Calculation of pathway score.* Table 2–1, which is based on the air migration pathway, illustrates the basic parameters used to calculate a pathway score. As Table 2–1 shows, each pathway (component or threat) score is the product of three ''factor categories'': Likelihood of release, waste characteristics, and targets. (The soil exposure and subsurface intrusion pathway uses likelihood of exposure rather than likelihood of release.) Each of the three factor categories contains a set of factors that are assigned numerical values and combined as specified in sections 2 through 7. The factor values are rounded to the nearest integer, except where otherwise noted.

2.1.3 *Common evaluations.* Evaluations common to all four HRS pathways include:

- Characterizing sources.
  - —Identifying sources (and, for the soil exposure and subsurface intrusion pathway, areas of observed contamination, areas of observed exposure and/or areas of subsurface contamination [see sections 5.1.0 and 5.2.0]).
  - —Identifying hazardous substances associated with each source (or area of observed contamination, or observed exposure, or subsurface contamination).
  - —Identifying hazardous substances available to a pathway.

TABLE 2–1—SAMPLE PATHWAY SCORESHEET

| Factor category | Maximum value | Value assigned |
|---|---|---|
| **Likelihood of Release** | | |
| 1. Observed Release | 550 | |
| 2. Potential to Release | 500 | |
| 3. Likelihood of Release (higher of lines 1 and 2) | 550 | |
| **Waste Characteristics** | | |
| 4. Toxicity/Mobility | (a) | |
| 5. Hazardous Waste Quantity | (a) | |
| 6. Waste Characteristics | 100 | |
| **Targets** | | |
| 7. Nearest Individual | | |
| 7a. Level I | 50 | |
| 7b. Level II | 45 | |
| 7c. Potential Contamination | 20 | |
| 7d. Nearest Individual (higher of lines 7a, 7b, or 7c) | 50 | |
| 8. Population | (b) | |
| 8a. Level I | (b) | |
| 8b. Level II | (b) | |

TABLE 2–1—SAMPLE PATHWAY SCORESHEET—Continued

| Factor category | Maximum value | Value assigned |
|---|---|---|
| 8c. Potential Contamination | (b) | |
| 8d. Total Population (lines 8a+8b+8c) | | |
| 9. Resources | 5 | |
| 10. Sensitive Environments | (b) | |
| 10a. Actual Contamination | (b) | |
| 10b. Potential Environments | (b) | |
| 10c. Sensitive Environments (lines 10a+10b) | (b) | |
| 11. Targets (lines 7d+8d+9+10c) | (b) | |
| 12. Pathway Score is the product of Likelihood of Release, Waste Characteristics, and Targets, divided by 82,500. Pathway scores are limited to a maximum of 100 points. | | |

[a] Maximum value applies to waste characteristics category. The product of lines 4 and 5 is used in Table 2–7 to derive the value for the waste characteristics factor category.

[b] There is no limit to the human population or sensitive environments factor values. However, the pathway score based solely on sensitive environments is limited to a maximum of 60 points.

- Scoring likelihood of release (or likelihood of exposure) factor category.
  - —Scoring observed release (or observed exposure or observed contamination).
  - —Scoring potential to release when there is no observed release.
- Scoring waste characteristics factor category.
  - —Evaluating toxicity.
    - ▪ Combining toxicity with mobility, persistence, degradation and/or bioaccumulation (or ecosystem bioaccumulation) potential, as appropriate to the pathway (component or threat).
    - ▪ Evaluating hazardous waste quantity.
  - —Combining hazardous waste quantity with the other waste characteristics factors.
    - ▪ Determining waste characteristics factor category value.
- Scoring targets factor category.
  - —Determining level of contamination for targets.

These evaluations are essentially identical for the three migration pathways (ground water, surface water, and air). However, the evaluations differ in certain respects for the soil exposure and subsurface intrusion pathway.

Section 7 specifies modifications that apply to each pathway when evaluating sites containing radioactive substances.

Section 2 focuses on evaluations common at the pathway, component, and threat levels. Note that for the ground water and surface water migration pathways, separate scores are calculated for each aquifer (see section 3.0) and each watershed (see sections 4.1.1.3 and 4.2.1.5) when determining the pathway scores for a site. Although the evaluations in section 2 do not vary when different aquifers or watersheds are scored at a site, the specific factor values (for example, observed release, hazardous waste quantity, toxicity/mobility) that result from these evaluations can vary by aquifer and by watershed at the site. This can occur through differences both in the specific sources and targets eligible to be evaluated for each aquifer and watershed and in whether observed releases can be established for each aquifer and watershed. Such differences in scoring at the aquifer and watershed level are addressed in sections 3 and 4, not section 2.

2.2 *Characterize sources.* Source characterization includes identification of the following:

- Sources (and areas of observed contamination, areas of observed exposure, or areas of subsurface contamination) at the site.
- Hazardous substances associated with these sources (or areas of observed contamination, areas of observed exposure, or areas of subsurface contamination).
- Pathways potentially threatened by these hazardous substances.

Table 2–2 presents a sample worksheet for source characterization.

2.2.1 *Identify sources.* For the three migration pathways, identify the sources at the site that contain hazardous substances. Identify the migration pathway(s) to which each source applies. For the soil exposure and subsurface intrusion pathway, identify areas of observed contamination, areas of observed exposure, and/or areas of subsurface contamination at the site (see sections 5.1.0 and 5.2.0).

**Table 2–2—Sample Source Characterization Worksheet**

Source: ____

A. Source dimensions and hazardous waste quantity.

Hazardous constituent quantity: ____

Hazardous wastestream quantity: ____

Volume: ____

Area: ____

Area of observed contamination: ____

Area of observed exposure: ____

Area of subsurface contamination: ____

B. Hazardous substances associated with the source.

| Hazardous substance | Available to pathway | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Air | | Ground Water (GW) | Surface Water (SW) | | Soil Exposure/Subsurface Intrusion (SESSI) | | | |
| | | | | | | Soil exposure | | Subsurface Intrusion | |
| | Gas | Particulate | | Overland/ flood | GW to SW | Resident | Nearby | Area of observed exposure | Area of subsurface contamination |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

2.2.2 *Identify hazardous substances associated with a source.* For each of the three migration pathways, consider those hazardous substances documented in a source (for example, by sampling, labels, manifests, oral or written statements) to be

associated with that source when evaluating each pathway. In some instances, a hazardous substance can be documented as being present at a site (for example, by labels, manifests, oral or written statements), but the specific source(s) containing that hazardous substance cannot be documented. For the three migration pathways, in those instances when the specific source(s) cannot be documented for a hazardous substance, consider the hazardous substance to be present in each source at the site, except sources for which definitive information indicates that the hazardous substance was not or could not be present.

For an area of observed contamination in the soil exposure component of the soil exposure and subsurface intrusion pathway, consider only those hazardous substances that meet the criteria for observed contamination for that area (see section 5.1.0) to be associated with that area when evaluating the pathway.

For an area of observed exposure or area of subsurface contamination (see section 5.2.0) in the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, consider only those hazardous substances that:

- Meet the criteria for observed exposure, or
- Meet the criteria for observed release in an area of subsurface contamination and have a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to $10^{-5}$ atm-m$^3$/mol, or
- Meet the criteria for an observed release in a structure within, or in a sample from below, an area of observed exposure and have a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to $10^{-5}$ atm-m$^3$/mol.

2.2.3 *Identify hazardous substances available to a pathway.* In evaluating each migration pathway, consider the following hazardous substances available to migrate from the sources at the site to the pathway:

- Ground water migration.
  —Hazardous substances that meet the criteria for an observed release (see section 2.3) to ground water.
  —All hazardous substances associated with a source with a ground water containment factor value greater than 0 (see section 3.1.2.1).
- Surface water migration—overland/flood component.
  —Hazardous substances that meet the criteria for an observed release to surface water in the watershed being evaluated.
  —All hazardous substances associated with a source with a surface water containment factor value greater than 0 for the watershed (see sections 4.1.2.1.2.1.1 and 4.1.2.1.2.2.1).
- Surface water migration—ground water to surface water component.
  —Hazardous substances that meet the criteria for an observed release to ground water.
  —All hazardous substances associated with a source with a ground water containment factor value greater than 0 (see sections 4.2.2.1.2 and 3.1.2.1).
- Air migration.
  —Hazardous substances that meet the criteria for an observed release to the atmosphere.
  —All gaseous hazardous substances associated with a source with a gas containment factor value greater than 0 (see section 6.1.2.1.1).
  —All particulate hazardous substances associated with a source with a particulate containment factor value greater than 0 (see section 6.1.2.2.1).
- For each migration pathway, in those instances when the specific source(s) containing the hazardous substance cannot be documented, consider that hazardous substance to be available to migrate to the pathway when it can be associated (see section 2.2.2) with at least one source having a containment factor value greater than 0 for that pathway.

In evaluating the soil exposure and subsurface intrusion pathway, consider the following hazardous substances available to the pathway:

- Soil exposure component—resident population threat.
  —All hazardous substances that meet the criteria for observed contamination at the site (see section 5.1.0).
- Soil exposure component—nearby population threat.
  —All hazardous substances that meet the criteria for observed contamination at areas with an attractiveness/accessibility factor value greater than 0 (see section 5.1.2.1.1).
- Subsurface intrusion component.
  —All hazardous substances that meet the criteria for observed exposure at the site (see section 5.2.0).
  —All hazardous substances with a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to $10^{-5}$ atm-m$^3$/mol that meet the criteria for an observed release in an area of subsurface contamination (see section 5.2.0).
  —All hazardous substances that meet the criteria for an observed release in a structure within, or in a sample from below, an area of observed exposure (see section 5.2.0).

2.3 *Likelihood of release.* Likelihood of release is a measure of the likelihood that a waste has been or will be released to the environment. The likelihood of release factor category is assigned the maximum value of 550 for a migration pathway whenever the criteria for an observed release are met for that pathway. If the criteria for an observed release are met, do not evaluate potential to release for that pathway. When the criteria for an observed release are not met, evaluate potential to release for that pathway, with a maximum value of 500. The evaluation of potential to release varies by migration pathway (see sections 3, 4 and 6).

Establish an observed release either by direct observation of the release of a hazardous substance into the media being evaluated (for example, surface water) or by chemical analysis of samples appropriate to the pathway being evaluated (see sections 3, 4 and 6). The minimum standard to establish an observed release by chemical analysis is analytical evidence of a hazardous substance in the media significantly above the background level. Further, some portion of the release must be attributable to the site. Use the criteria in Table 2–3 as the standard for determining analytical significance. (The criteria in Table 2–3 are also used in establishing observed contamination for the soil exposure component and for establishing areas of observed exposure and areas of subsurface contamination in the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, see section 5.1.0 and section 5.2.0). Separate criteria apply to radionuclides (see section 7.1.1).

TABLE 2–3—OBSERVED RELEASE CRITERIA FOR CHEMICAL ANALYSIS

| |
|---|
| Sample Measurement < Sample Quantitation Limit.[a] |
| No observed release is established. |
| Sample Measurement ≥ Sample Quantitation Limit.[a] |
| An observed release is established as follows: |
| • If the background concentration is not detected (or is less than the detection limit), an observed release is established when the sample measurement equals or exceeds the sample quantitation limit.[a] |
| • If the background concentration equals or exceeds the detection limit, an observed release is established when the sample measurement is 3 times or more above the background concentration. |

[a] If the sample quantitation limit (SQL) cannot be established, determine if there is an observed release as follows:
—If the sample analysis was performed under the EPA Contract Laboratory Program, use the EPA contract-required quantitation limit (CRQL) in place of the SQL.
—If the sample analysis is not performed under the EPA Contract Laboratory Program, use the detection limit (DL) in place of the SQL.

2.4 *Waste characteristics.* The waste characteristics factor category includes the following factors: Hazardous waste quantity, toxicity, and as appropriate to the pathway or threat being evaluated, mobility, persistence, degradation, and/or

bioaccumulation (or ecosystem bioaccumulation) potential.

2.4.1 *Selection of substance potentially posing greatest hazard.* For all pathways (components and threats), select the hazardous substance potentially posing the greatest hazard for the pathway (component or threat) and use that substance in evaluating the waste characteristics category of the pathway (component or threat). For the three migration pathways (and threats), base the selection of this hazardous substance on the toxicity factor value for the substance, combined with its mobility, persistence, and/or bioaccumulation (or ecosystem bioaccumulation) potential factor values, as applicable to the migration pathway (or threat). For the soil exposure component of the soil exposure and subsurface intrusion pathway, base the selection on the toxicity factor alone. For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, base the selection on the toxicity factor value for the substance, combined with its degradation factor value. Evaluation of the toxicity factor is specified in section 2.4.1.1. Use and evaluation of the mobility, persistence, degradation, and/or bioaccumulation (or ecosystem bioaccumulation) potential factors vary by pathway (component or threat) and are specified under the appropriate pathway (component or threat) section. Section 2.4.1.2 identifies the specific factors that are combined with toxicity in evaluating each pathway (component or threat).

2.4.1.1 *Toxicity factor.* Evaluate toxicity for those hazardous substances at the site that are available to the pathway being scored. For all pathways and threats, except the surface water environmental threat, evaluate human toxicity as specified below. For the surface water environmental threat, evaluate ecosystem toxicity as specified in section 4.1.4.2.1.1.

Establish human toxicity factor values based on quantitative dose-response parameters for the following three types of toxicity:

- Cancer—Use slope factors (also referred to as cancer potency factors) combined with weight-of-evidence ratings for carcinogenicity for all exposure routes except inhalation. Use inhalation unit risk (IUR) for inhalation exposure. If an inhalation unit risk or a slope factor is not available for a substance, use its $ED_{10}$ value to estimate a slope factor as follows:

$$\text{Slope factor} = \frac{1}{6\ (ED_{10})}$$

- Noncancer toxicological responses of chronic exposure—use reference dose (RfD) or reference concentration (RfC) values as applicable.
- Noncancer toxicological responses of acute exposure—use acute toxicity parameters, such as the $LD_{50}$.

Assign human toxicity factor values to a hazardous substance using Table 2–4, as follows:

- If RfD/RfC and slope factor/inhalation unit risk values are available for the hazardous substance, assign the substance a value from Table 2–4 for each. Select the higher of the two values assigned and use it as the overall toxicity factor value for the hazardous substance.
- If either an RfD/RfC or slope factor/inhalation unit risk value is available, but not both, assign the hazardous substance an overall toxicity factor value from Table 2–4 based solely on the available value (RfD/RfC or slope factor/inhalation unit risk).
- If neither an RfD/RfC nor slope factor/inhalation unit risk value is available, assign the hazardous substance an overall toxicity factor value from Table 2–4 based solely on acute toxicity. That is, consider acute toxicity in Table 2–4 only when both RfD/RfC and slope factor/IUR values are not available.
- If neither an RfD/RfC, nor slope factor/inhalation unit risk, nor acute toxicity value is available, assign the hazardous substance an overall toxicity factor value of 0 and use other hazardous substances for which information is available in evaluating the pathway.

TABLE 2–4—TOXICITY FACTOR EVALUATION

| | Assigned value |
|---|---|
| **Chronic Toxicity (Human)** | |
| Reference dose (RfD) (mg/kg-day): | |
| RfD < 0.0005 | 10,000 |
| 0.0005 ≤ RfD < 0.005 | 1,000 |
| 0.005 ≤ RfD < 0.05 | 100 |
| 0.05 ≤ RfD < 0.5 | 10 |
| 0.5 ≤ RfD | 1 |
| RfD not available | 0 |
| Reference concentration (RfC) ($mg/m^3$): | |
| RfC < 0.0001 | 10,000 |
| 0.0001 ≤ RfC < 0.006 | 1,000 |
| 0.006 ≤ RfC < 0.2 | 100 |
| 0.2 ≤ RfC < 2.0 | 10 |
| 2.0 ≤ RfC | 1 |
| RfC not available | 0 |

| Carcinogenicity (human) | | | |
|---|---|---|---|
| A or Carcinogenic to humans | B or Likely to be carcinogenic to humans | C or Suggestive evidence of carcinogenic potential | Assigned value |
| **Weight-of-evidence[a]/Slope factor (mg/kg-day)$^{-1}$** | | | |
| 0.5 ≤ SF[b] | 5 ≤ SF | 50 ≤ SF | 10,000 |
| 0.05 ≤ SF < 0.5 | 0.5 ≤ SF < 5 | 5 ≤ SF < 50 | 1,000 |
| SF < 0.05 | 0.05 ≤ SF < 0.5 | 0.5 ≤ SF < 5 | 100 |
| | SF < 0.05 | SF < 0.5 | 10 |
| Slope factor not available | Slope factor not available | Slope factor not available | 0 |
| **Weight-of-evidence[a]/Inhalation unit risk (μg/m$^3$)** | | | |
| 0.00004 ≤ IUR[c] | 0.0004 ≤ IUR | 0.004 ≤ IUR | 10,000 |
| 0.00001 ≤ IUR < 0.00004 | 0.0001 ≤ IUR < 0.0004 | 0.001 ≤ IUR < 0.004 | 1,000 |
| IUR < 0.00001 | 0.00001 ≤ IUR < 0.0001 | 0.0001 ≤ IUR < 0.001 | 100 |
| | < 0.00001 | IUR < 0.0001 | 10 |
| Inhalation unit risk not available | Inhalation unit risk not available | Inhalation unit risk not available | 0 |

[a] A, B, and C, as well as Carcinogenic to humans, Likely to be carcinogenic to humans, and Suggestive evidence of carcinogenic potential refer to weight-of-evidence categories. Assign substances with a weight-of-evidence category of D (inadequate evidence of carcinogenicity) or E (evidence of lack of carcinogenicity), as well as inadequate information to assess carcinogenic potential and not likely to be carcinogenic to humans a value of 0 for carcinogenicity.

[b] SF = Slope factor.

[c] IUR = Inhalation Unit Risk.

| Acute Toxicity (human) | | | | |
|---|---|---|---|---|
| Oral $LD_{50}$ (mg/kg) | Dermal $LD_{50}$ (mg/kg) | Dust or mist $LC_{50}$ (mg/l) | Gas or vapor $LC_{50}$ (ppm) | Assigned value |
| $LD_{50}$ < 5 | $LD_{50}$ < 2 | $LC_{50}$ < 0.2 | $LC_{50}$ < 20 | 1,000 |

| Acute Toxicity (human) | | | | |
|---|---|---|---|---|
| Oral $LD_{50}$ (mg/kg) | Dermal $LD_{50}$ (mg/kg) | Dust or mist $LC_{50}$ (mg/l) | Gas or vapor $LC_{50}$ (ppm) | Assigned value |
| $5 \leq LD_{50} < 50$ | $2 \leq LD_{50} < 20$ | $0.2 \leq LC_{50} < 2$ | $20 \leq LC_{50} < 200$ | 100 |
| $50 \leq LD_{50} < 500$ | $20 \leq LD_{50} < 200$ | $2 \leq LC_{50} < 20$ | $200 \leq LC_{50} < 2{,}000$ | 10 |
| $500 \leq LD_{50}$ | $200 \leq LD_{50}$ | $20 \leq LC_{50}$ | $2{,}000 \leq LC_{50}$ | 1 |
| $LD_{50}$ not available | $LD_{50}$ not available | $LC_{50}$ not available | $LC_{50}$ not available | 0 |

If a toxicity factor value of 0 is assigned to all hazardous substances available to a particular pathway (that is, insufficient toxicity data are available for evaluating all the substances), use a default value of 100 as the overall human toxicity factor value for all hazardous substances available to the pathway. For hazardous substances having usable toxicity data for multiple exposure routes (for example, inhalation and ingestion), consider all exposure routes and use the highest assigned value, regardless of exposure route, as the toxicity factor value. For HRS purposes, assign both asbestos and lead (and its compounds) a human toxicity factor value of 10,000.

Separate criteria apply for assigning factor values for human toxicity and ecosystem toxicity for radionuclides (see sections 7.2.1 and 7.2.2).

2.4.1.2 *Hazardous substance selection.* For each hazardous substance evaluated for a migration pathway (or threat), combine the human toxicity factor value (or ecosystem toxicity factor value) for the hazardous substance with a mobility, persistence, and/or bioaccumulation (or ecosystem bioaccumulation) potential factor value as follows:

- Ground water migration.
  —Determine a combined human toxicity/mobility factor value for the hazardous substance (see section 3.2.1).
- Surface water migration—overland/flood migration component.
  —Determine a combined human toxicity/persistence factor value for the hazardous substance for the drinking water threat (see section 4.1.2.2.1).
  —Determine a combined human toxicity/persistence/bioaccumulation factor value for the hazardous substance for the human food chain threat (see section 4.1.3.2.1).
  —Determine a combined ecosystem toxicity/persistence/bioaccumulation factor value for the hazardous substance for the environmental threat (see section 4.1.4.2.1).
- Surface water migration—ground water to surface water migration component.
  —Determine a combined human toxicity/mobility/persistence factor value for the hazardous substance for the drinking water threat (see section 4.2.2.2.1).
  —Determine a combined human toxicity/mobility/persistence/bioaccumulation factor value for the hazardous substance for the human food chain threat (see section 4.2.3.2.1).
  —Determine a combined ecosystem toxicity/mobility/persistence/bioaccumulation factor value for the hazardous substance for the environmental threat (see section 4.2.4.2.1).
- Air migration.
  —Determine a combined human toxicity/mobility factor value for the hazardous substance (see section 6.2.1).

Determine each combined factor value for a hazardous substance by multiplying the individual factor values appropriate to the pathway (or threat). For each migration pathway (or threat) being evaluated, select the hazardous substance with the highest combined factor value and use that substance in evaluating the waste characteristics factor category of the pathway (or threat).

For the soil exposure and subsurface intrusion pathway, determine toxicity and toxicity/degradation factor values as follows:

- Soil exposure and subsurface intrusion—soil exposure component.
  —Select the hazardous substance with the highest human toxicity factor value from among the substances that meet the criteria for observed contamination for the threat evaluated and use that substance in evaluating the waste characteristics factor category (see section 5.1.1.2.1).
- Soil exposure and subsurface intrusion—subsurface intrusion component.
  —Determine a combined human toxicity/degradation factor value for each hazardous substance being evaluated that:
    - Meets the criteria for observed exposure, or
    - Meets the criteria for observed release in an area of subsurface contamination and has a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to $10^{-5}$ atm-m$^3$/mol, or
    - Meets the criteria for an observed release in a structure within, or in a sample from below, an area of observed exposure and has a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to $10^{-5}$ atm-m$^3$/mol.
  —Select the hazardous substance with the highest combined factor value and use that substance in evaluating the waste characteristics factor category (see sections 5.2.1.2.1 and 5.2.1.2).

2.4.2 *Hazardous waste quantity.* Evaluate the hazardous waste quantity factor by first assigning each source (or area of observed contamination, area of observed exposure, or area of subsurface contamination) a source hazardous waste quantity value as specified below. Sum these values to obtain the hazardous waste quantity factor value for the pathway being evaluated.

In evaluating the hazardous waste quantity factor for the three migration pathways, allocate hazardous substances and hazardous wastestreams to specific sources in the manner specified in section 2.2.2, except: Consider hazardous substances and hazardous wastestreams that cannot be allocated to any specific source to constitute a separate ''unallocated source'' for purposes of evaluating only this factor for the three migration pathways. Do not, however, include a hazardous substance or hazardous wastestream in the unallocated source for a migration pathway if there is definitive information indicating that the substance or wastestream could only have been placed in sources with a containment factor value of 0 for that migration pathway.

In evaluating the hazardous waste quantity factor for the soil exposure component of the soil exposure and subsurface intrusion pathway, allocate to each area of observed contamination only those hazardous substances that meet the criteria for observed contamination for that area of observed contamination and only those hazardous wastestreams that contain hazardous substances that meet the criteria for observed contamination for that area of observed contamination. Do not consider other hazardous substances or hazardous wastestreams at the site in evaluating this factor for the soil exposure component of the soil exposure and subsurface intrusion pathway.

In evaluating the hazardous waste quantity factor for the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, allocate to each area of observed exposure or area of subsurface contamination only those hazardous substances and hazardous wastestreams that contain hazardous substances that:

- Meet the criteria for observed exposure, or
- Meet the criteria for observed release in an area of subsurface contamination and have a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to $10^{-5}$ atm-m$^3$/mol, or
- Meet the criteria for an observed release in a structure within, or in a sample from below, an area of observed exposure and have a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to $10^{-5}$ atm-m$^3$/mol.

Do not consider other hazardous substances or hazardous wastestreams at the site in evaluating this factor for the subsurface intrusion component of the soil exposure and subsurface intrusion pathway. When determining the hazardous waste quantity for multi-subunit structures, use the procedures identified in section 5.2.1.2.2.

2.4.2.1 *Source hazardous waste quantity.* For each of the three migration pathways, assign a source hazardous waste quantity

value to each source (including the unallocated source) having a containment factor value greater than 0 for the pathway being evaluated. Consider the unallocated source to have a containment factor value greater than 0 for each migration pathway.

For the soil exposure component of the soil exposure and subsurface intrusion pathway, assign a source hazardous waste quantity value to each area of observed contamination, as applicable to the threat being evaluated.

For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, assign a source hazardous waste quantity value to each regularly occupied structure within an area of observed exposure or an area of subsurface contamination that has a structure containment factor value greater than 0. If sufficient data is available and state of the science shows there is no unacceptable risk due to subsurface intrusion into a regularly occupied structure located within an area of subsurface contamination, that structure can be excluded from the area of subsurface contamination.

For determining all hazardous waste quantity calculations except for an unallocated source or an area of subsurface contamination, evaluate using the following four measures in the following hierarchy:

- Hazardous constituent quantity.
- Hazardous wastestream quantity.
- Volume.
- Area.

For the unallocated source, use only the first two measures. For an area of subsurface contamination, evaluate non-radioactive hazardous substances using only the last two measures and evaluate radioactive hazardous substances using hazardous wastestream quantity only. See also section 7.0 regarding the evaluation of radioactive substances.

Separate criteria apply for assigning a source hazardous waste quantity value for radionuclides (see section 7.2.5).

2.4.2.1.1 *Hazardous constituent quantity.* Evaluate hazardous constituent quantity for the source (or area of observed contamination) based solely on the mass of CERCLA hazardous substances (as defined in CERCLA section 101(14), as amended) allocated to the source (or area of observed contamination), except:

- For a hazardous waste listed pursuant to section 3001 of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976 (RCRA), 42 U.S.C. 6901 *et seq.,* determine its mass for the evaluation of this measure as follows:

—If the hazardous waste is listed solely for Hazard Code T (toxic waste), include only the mass of constituents in the hazardous waste that are CERCLA hazardous substances and not the mass of the entire hazardous waste.

—If the hazardous waste is listed for any other Hazard Code (including T plus any other Hazard Code), include the mass of the entire hazardous waste.

- For a RCRA hazardous waste that exhibits the characteristics identified under section 3001 of RCRA, as amended, determine its mass for the evaluation of this measure as follows:

—If the hazardous waste exhibits only the characteristic of toxicity (or only the characteristic of EP toxicity), include only the mass of constituents in the hazardous waste that are CERCLA hazardous substances and not the mass of the entire hazardous waste.

—If the hazardous waste exhibits any other characteristic identified under section 3001 (including any other characteristic plus the characteristic of toxicity [or the characteristic of EP toxicity]), include the mass of the entire hazardous waste.

Based on this mass, designated as C, assign a value for hazardous constituent quantity as follows:

- For the migration pathways, assign the source a value for hazardous constituent quantity using the Tier A equation of Table 2–5.
- For the soil exposure and subsurface intrusion pathway—soil exposure component, assign the area of observed contamination a value using the Tier A equation of Table 5–2 (section 5.1.1.2.2).
- For the soil exposure and subsurface intrusion pathway—subsurface intrusion component, assign the area of observed exposure a value using the Tier A equation of Table 5–19 (section 5.2.1.2.2).

If the hazardous constituent quantity for the source (or area of observed contamination or area of observed exposure) is adequately determined (that is, the total mass of all CERCLA hazardous substances in the source and releases from the source [or in the area of observed contamination or area of observed exposure] is known or is estimated with reasonable confidence), do not evaluate the other three measures discussed below. Instead assign these other three measures a value of 0 for the source (or area of observed contamination or area of observed exposure) and proceed to section 2.4.2.1.5.

If the hazardous constituent quantity is not adequately determined, assign the source (or area of observed contamination or area of observed exposure) a value for hazardous constituent quantity based on the available data and proceed to section 2.4.2.1.2.

TABLE 2–5—HAZARDOUS WASTE QUANTITY EVALUATION EQUATIONS

| Tier | Measure | Units | Equation for assigning value [a] |
|---|---|---|---|
| A | Hazardous constituent quantity (C) | lb | C |
| B [b] | Hazardous wastestream quantity (W) | lb | W/5,000 |
| C [b] | Volume (V) | | |
| | Landfill | $yd^3$ | V/2,500 |
| | Surface impoundment | $yd^3$ | V/2.5 |
| | Surface impoundment (buried/backfilled) | $yd^3$ | V/2.5 |
| | Drums [c] | gallon | V/2.5 |
| | Tanks and containers other than drums | $yd^3$ | V/2.5 |
| | Contaminated soil | $yd^3$ | V/2,500 |
| | Pile | $yd^3$ | V/2.5 |
| | Other | $yd^3$ | V/2.5 |
| D [b] | Area (A). | | |
| | Landfill | $ft^2$ | A/3,400 |
| | Surface impoundment | $ft^2$ | A/13 |
| | Surface impoundment (buried/backfilled) | $ft^2$ | A/13 |
| | Land treatment | $ft^2$ | A/270 |
| | Pile [d] | $ft^2$ | A/13 |
| | Contaminated soil | $ft^2$ | A/34,000 |

[a] Do not round to nearest integer.
[b] Convert volume to mass when necessary: 1 ton = 2,000 pounds = 1 cubic yard = 4 drums = 200 gallons.
[c] If actual volume of drums is unavailable, assume 1 drum = 50 gallons.
[d] Use land surface area under pile, not surface area of pile.

2.4.2.1.2 *Hazardous wastestream quantity.* Evaluate hazardous wastestream quantity for the source (or area of observed contamination or area of observed exposure) based on the mass of hazardous wastestreams plus the mass of any additional CERCLA pollutants and contaminants (as defined in CERCLA section 101[33], as amended) that are allocated to the source (or area of

observed contamination or area of observed exposure). For a wastestream that consists solely of a hazardous waste listed pursuant to section 3001 of RCRA, as amended or that consists solely of a RCRA hazardous waste that exhibits the characteristics identified under section 3001 of RCRA, as amended, include the mass of that entire hazardous waste in the evaluation of this measure.

Based on this mass, designated as W, assign a value for hazardous wastestream quantity as follows:

• For the migration pathways, assign the source a value for hazardous wastestream quantity using the Tier B equation of Table 2–5.

• For the soil exposure and subsurface intrusion pathway—soil exposure component, assign the area of observed contamination a value using the Tier B equation of Table 5–2 (section 5.1.1.2.2).

• For the soil exposure and subsurface intrusion pathway—subsurface intrusion component, assign the area of observed exposure a value using the Tier B equation of Table 5–19 (section 5.2.1.2.2).

Do not evaluate the volume and area measures described below if the source is the unallocated source or if the following condition applies:

• The hazardous wastestream quantity for the source (or area of observed contamination or area of observed exposure) is adequately determined—that is, total mass of all hazardous wastestreams and CERCLA pollutants and contaminants for the source and releases from the source (or for the area of observed contamination) is known or is estimated with reasonable confidence.

If the source is the unallocated source or if this condition applies, assign the volume and area measures a value of 0 for the source (or area of observed contamination) and proceed to section 2.4.2.1.5. Otherwise, assign the source (or area of observed contamination) a value for hazardous wastestream quantity based on the available data and proceed to section 2.4.2.1.3.

2.4.2.1.3 *Volume.* Evaluate the volume measure using the volume of the source (or the volume of the area of observed contamination, area of observed exposure, or area of subsurface contamination). For the soil exposure and subsurface intrusion pathway, restrict the use of the volume measure to those areas of observed contamination, areas of observed exposure, or areas of subsurface contamination as specified in sections 5.1.1.2.2 and 5.2.1.2.2.

Based on the volume, designated as V, assign a value to the volume measure as follows:

• For the migration pathways, assign the source a value for volume using the appropriate Tier C equation of Table 2–5.

• For the soil exposure and subsurface intrusion pathway—soil exposure component, assign the area of observed contamination a value for volume using the appropriate Tier C equation of Table 5–2 (section 5.1.1.2.2).

• For the soil exposure and subsurface intrusion pathway—subsurface intrusion component, assign the value based on the volume of the regularly occupied structures within the area of observed exposure or area of subsurface contamination using the Tier C equation of Table 5–19 (section 5.2.1.2.2).

If the volume of the source (or volume of the area of observed contamination, area of observed exposure, or area of subsurface contamination, if applicable) can be determined, do not evaluate the area measure. Instead, assign the area measure a value of 0 and proceed to section 2.4.2.1.5. If the volume cannot be determined (or is not applicable for the soil exposure and subsurface intrusion pathway), assign the source (or area of observed contamination, area of observed exposure, or area of subsurface contamination) a value of 0 for the volume measure and proceed to section 2.4.2.1.4.

2.4.2.1.4 *Area.* Evaluate the area measure using the area of the source (or the area of the area of observed contamination, area of observed exposure, or area of subsurface contamination). Based on this area, designated as A, assign a value to the area measure as follows:

• For the migration pathways, assign the source a value for area using the appropriate Tier D equation of Table 2–5.

• For the soil exposure and subsurface intrusion pathway—soil exposure component, assign the area of observed contamination a value for area using the appropriate Tier D equation of Table 5–2 (section 5.1.1.2.2).

• For the soil exposure and subsurface intrusion pathway—subsurface intrusion component, assign a value based on the area of regularly occupied structures within the area of observed exposure or area of subsurface contamination using the Tier D equation of Table 5–19 (section 5.2.1.2.2).

2.4.2.1.5 *Calculation of source hazardous waste quantity value.* Select the highest of the values assigned to the source (or areas of observed contamination, areas of observed exposure, or areas of subsurface contamination) for the hazardous constituent quantity, hazardous wastestream quantity, volume, and area measures. Assign this value as the source hazardous waste quantity value. Do not round to the nearest integer.

2.4.2.2 *Calculation of hazardous waste quantity factor value.* Sum the source hazardous waste quantity values assigned to all sources (including the unallocated source) or areas of observed contamination, areas of observed exposure, or areas of subsurface contamination for the pathway being evaluated and round this sum to the nearest integer, except: If the sum is greater than 0, but less than 1, round it to 1. Based on this value, select a hazardous waste quantity factor value for the pathway from Table 2–6.

TABLE 2–6—HAZARDOUS WASTE QUANTITY FACTOR VALUES

| Hazardous waste quantity value | Assigned value |
|---|---|
| 0 | 0 |
| 1 [a] to 100 | [b] 1 |
| Greater than 100 to 10,000 | 100 |
| Greater than 10,000 to 1,000,000 | 10,000 |
| Greater than 1,000,000 | 1,000,000 |

[a] If the hazardous waste quantity value is greater than 0, but less than 1, round it to 1 as specified in text.

[b] For the pathway, if hazardous constituent quantity is not adequately determined, assign a value as specified in the text; do not assign the value of 1.

For a migration pathway, if the hazardous constituent quantity is adequately determined (see section 2.4.2.1.1) for all sources (or all portions of sources and releases remaining after a removal action), assign the value from Table 2–6 as the hazardous waste quantity factor value for the pathway. If the hazardous constituent quantity is not adequately determined for one or more sources (or one or more portions of sources or releases remaining after a removal action) assign a factor value as follows:

• If any target for that migration pathway is subject to Level I or Level II concentrations (see section 2.5), assign either the value from Table 2–6 or a value of 100, whichever is greater, as the hazardous waste quantity factor value for that pathway.

• If none of the targets for that pathway is subject to Level I or Level II concentrations, assign a factor value as follows:

—If there has been no removal action, assign either the value from Table 2–6 or a value of 10, whichever is greater, as the hazardous waste quantity factor value for that pathway.

—If there has been a removal action:

▪ Determine values from Table 2–6 with and without consideration of the removal action.

▪ If the value that would be assigned from Table 2–6 without consideration of the removal action would be 100 or greater, assign either the value from Table 2–6 with consideration of the removal action or a value of 100, whichever is greater, as the hazardous waste quantity factor value for the pathway.

▪ If the value that would be assigned from Table 2–6 without consideration of the removal action would be less than 100, assign a value of 10 as the hazardous waste quantity factor value for the pathway.

For the soil exposure component of the soil exposure and subsurface intrusion pathway, if the hazardous constituent quantity is adequately determined for all areas of observed contamination, assign the value from Table 2–6 as the hazardous waste quantity factor value. If the hazardous constituent quantity is not adequately determined for one or more areas of observed contamination, assign either the value from Table 2–6 or a value of 10, whichever is greater, as the hazardous waste quantity factor value.

For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, if the hazardous constituent

quantity is adequately determined for all areas of observed exposure, assign the value from Table 2–6 as the hazardous waste quantity factor value. If the hazardous constituent quantity is not adequately determined for one or more areas of observed exposure, assign either the value from Table 2–6 or assign a factor value as follows:

• If any target for the subsurface intrusion component is subject to Level I or Level II concentrations (see section 2.5), assign either the value from Table 2–6 or a value of 100, whichever is greater, as the hazardous waste quantity factor value for this component.

• If none of the targets for the subsurface intrusion component is subject to Level I or Level II concentrations and if there has been a removal or other temporary response action that does not permanently interrupt target exposure form subsurface intrusion, assign a factor value as follows:

—Determine the values from Table 2–6 with and without consideration of the removal or other temporary response action.

—If the value that would be assigned from Table 2–6 without consideration of the removal or other temporary response action would be 100 or greater, assign either the value from Table 2–6 with consideration of the removal action or a value of 100, whichever is greater, as the hazardous waste quantity factor value for the component.

—If the value that would be assigned from Table 2–6 without consideration of the removal or other temporary response action would be less than 100, assign a value of 10 as the hazardous waste quantity factor value for the component.

• Otherwise, if none of the targets for the subsurface intrusion component is subject to Level I or Level II concentrations and there has not been a removal action, assign a value from Table 2–6 or a value of 10, whichever is greater.

2.4.3 *Waste characteristics factor category value.* Determine the waste characteristics factor category value as specified in section 2.4.3.1 for all pathways and threats, except the surface water-human food chain threat and the surface water-environmental threat. Determine the waste characteristics factor category value for these latter two threats as specified in section 2.4.3.2.

2.4.3.1 *Factor category value.* For the pathway (component or threat) being evaluated, multiply the toxicity or combined factor value, as appropriate, from section 2.4.1.2 and the hazardous waste quantity factor value from section 2.4.2.2, subject to a maximum product of $1x10^8$. Based on this waste characteristics product, assign a waste characteristics factor category value to the pathway (component or threat) from Table 2–7.

TABLE 2–7—WASTE CHARACTERISTICS FACTOR CATEGORY VALUES

| Waste characteristics product | Assigned value |
|---|---|
| 0 | 0 |
| Greater than 0 to less than 10 | 1 |
| 10 to less than $1x10^2$ | 2 |
| $1x10^2$ to less than $1x10^3$ | 3 |
| $1x10^3$ to less than $1x10^4$ | 6 |
| $1x10^4$ to less than $1x10^5$ | 10 |
| $1x10^5$ to less than $1x10^6$ | 18 |
| $1x10^6$ to less than $1x10^7$ | 32 |
| $1x10^7$ to less than $1x10^8$ | 56 |
| $1x10^8$ to less than $1x10^9$ | 100 |
| $1x10^9$ to less than $1x10^{10}$ | 180 |
| $1x10^{10}$ to less than $1x10^{11}$ | 320 |
| $1x10^{11}$ to less than $1x10^{12}$ | 560 |
| $1x10^{12}$ | 1,000 |

2.4.3.2 *Factor category value, considering bioaccumulation potential.* For the surface water-human food chain threat and the surface water-environmental threat, multiply the toxicity or combined factor value, as appropriate, from section 2.4.1.2 and the hazardous waste quantity factor value from section 2.4.2.2, subject to:

• A maximum product of $1x10^{12}$, *and*

• A maximum product exclusive of the bioaccumulation (or ecosystem bioaccumulation) potential factor of $1x10^8$.

Based on the total waste characteristics product, assign a waste characteristics factor category value to these threats from Table 2–7.

2.5 *Targets.* The types of targets evaluated include the following:

• Individual (factor name varies by pathway, component, and threat).

• Human population.

• Resources (these vary by pathway, component, and threat).

• Sensitive environments (included for the surface water migration pathway, air migration pathway, and soil exposure component of the soil exposure and subsurface intrusion pathway).

The factor values that may be assigned to each type of target have the same range for each pathway for which that type of target is evaluated. The factor value for most types of targets depends on whether the target is subject to actual or potential contamination for the pathway and whether the actual contamination is Level I or Level II:

• Actual contamination: Target is associated either with a sampling location that meets the criteria for an observed release (or observed contamination or observed exposure) for the pathway or with an observed release based on direct observation for the pathway (additional criteria apply for establishing actual contamination for the human food chain threat in the surface water migration pathway, see sections 4.1.3.3 and 4.2.3.3). Sections 3 through 6 specify how to determine the targets associated with a sampling location or with an observed release based on direct observation. Determine whether the actual contamination is Level I or Level II as follows:

—Level I:

▪ Media-specific concentrations for the target meet the criteria for an observed release (or observed contamination or observed exposure) for the pathway and are at or above media-specific benchmark values. These benchmark values (see section 2.5.2) include both screening concentrations and concentrations specified in regulatory limits (such as Maximum Contaminant Level (MCL) values), or

▪ For the human food chain threat in the surface water migration pathway, concentrations in tissue samples from aquatic human food chain organisms are at or above benchmark values. Such tissue samples may be used in addition to media-specific concentrations only as specified in sections 4.1.3.3 and 4.2.3.3.

—Level II:

▪ Media-specific concentrations for the target meet the criteria for an observed release (or observed contamination or observed exposure) for the pathway, but are less than media-specific benchmarks. If none of the hazardous substances eligible to be evaluated for the sampling location has an applicable benchmark, assign Level II to the actual contamination at the sampling location, or

▪ For observed releases or observed exposures based on direct observation, assign Level II to targets as specified in sections 3, 4, 5, and 6, or

▪ For the human food chain threat in the surface water migration pathway, concentrations in tissue samples from aquatic human food chain organisms, when applicable, are below benchmark values.

—If a target is subject to both Level I and Level II concentrations for a pathway (component or threat), evaluate the target using Level I concentrations for that pathway (component or threat).

• Potential contamination: Target is subject to a potential release (that is, target is not associated with actual contamination for that pathway or threat).

Assign a factor value for individual risk as follows (select the highest value that applies to the pathway, component or threat):

• 50 points if any individual is exposed to Level I concentrations.

• 45 points if any individual is exposed to Level II concentrations.

• Maximum of 20 points if any individual is subject to potential contamination. The value assigned is 20 unless reduced by a distance or dilution weight appropriate to the pathway. Assign factor values for population and sensitive environments as follows:

• Sum Level I targets and multiply by 10. (Level I is not used for sensitive environments in the soil exposure component of the soil exposure and subsurface intrusion and air migration pathways.)

• Sum Level II targets.

• Multiply potential targets in all but the soil exposure and subsurface intrusion pathway by distance or dilution weights appropriate to the pathway, sum, and divide by 10. Distance or dilution weighting accounts for diminishing exposure with increasing distance or dilution within the different pathways. For targets within an area

of subsurface contamination in the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, multiply by a weighting factor as directed in section 5.2.1.3.2.3.

• Sum the values for the three levels.

In addition, resource value points are assigned within all pathways for welfare-related impacts (for example, impacts to agricultural land), but do not depend on whether there is actual or potential contamination.

2.5.1 *Determination of level of actual contamination at a sampling location.* Determine whether Level I concentrations or Level II concentrations apply at a sampling location (and thus to the associated targets) as follows:

• Select the benchmarks applicable to the pathway (component or threat) being evaluated.

• Compare the concentrations of hazardous substances in the sample (or comparable samples) to their benchmark concentrations for the pathway (component or threat), as specified in section 2.5.2.

• Determine which level applies based on this comparison.

• If none of the hazardous substances eligible to be evaluated for the sampling location has an applicable benchmark, assign Level II to the actual contamination at that sampling location for the pathway (component or threat).

In making the comparison, consider only those samples, and only those hazardous substances in the sample, that meet the criteria for an observed release (or observed contamination or observed exposure) for the pathway, except: Tissue samples from aquatic human food chain organisms may also be used as specified in sections 4.1.3.3 and 4.2.3.3 of the surface water-human food chain threat. If any hazardous substance is present in more than one comparable sample for the sampling location, use the highest concentration of that hazardous substance from any of the comparable samples in making the comparisons.

Treat sets of samples that are not comparable separately and make a separate comparison for each such set.

2.5.2 *Comparison to benchmarks.* Use the following media-specific benchmarks for making the comparisons for the indicated pathway (or threat):

• Maximum Contaminant Level Goals (MCLGs)—ground water migration pathway and drinking water threat in surface water migration pathway. Use only MCLG values greater than 0.

• Maximum Contaminant Levels (MCLs)—ground water migration pathway and drinking water threat in surface water migration pathway.

• Food and Drug Administration Action Level (FDAAL) for fish or shellfish—human food chain threat in surface water migration pathway.

• EPA Ambient Water Quality Criteria (AWQC/National Recommended Water Quality Criteria) for protection of aquatic life—environmental threat in surface water migration pathway.

• EPA Ambient Aquatic Life Advisory Concentrations (AALAC)—environmental threat in surface water migration pathway.

• National Ambient Air Quality Standards (NAAQS)—air migration pathway.

• National Emission Standards for Hazardous Air Pollutants (NESHAPs)—air migration pathway. Use only those NESHAPs promulgated in ambient concentration units.

• Screening concentration for cancer corresponding to that concentration that corresponds to the $10^{-6}$ individual cancer risk for inhalation exposures (air migration pathway or subsurface intrusion component of the soil exposure and subsurface intrusion pathway) or for oral exposures (ground water migration pathway; drinking water and human food chain threats in surface water migration pathway; and soil exposure and subsurface intrusion pathway).

• Screening concentration for noncancer toxicological responses corresponding to the RfC for inhalation exposures (air migration pathway and subsurface intrusion component of the soil exposure and subsurface intrusion pathway) or RfD for oral exposures (ground water migration pathway; drinking water and human food chain threats in surface water migration pathway; and soil exposure and subsurface intrusion pathway).

Select the benchmark(s) applicable to the pathway (component or threat) being evaluated as specified in sections 3 through 6. Compare the concentration of each hazardous substance from the sampling location to its benchmark concentration(s) for that pathway (component or threat). Use only those samples and only those hazardous substances in the sample that meet the criteria for an observed release (or observed contamination or observed exposure) for the pathway, except: Tissue samples from aquatic human food chain organisms may be used as specified in sections 4.1.3.3 and 4.2.3.3. If the concentration of any applicable hazardous substance from any sample equals or exceeds its benchmark concentration, consider the sampling location to be subject to Level I concentrations for that pathway (or threat). If more than one benchmark applies to the hazardous substance, assign Level I if the concentration of the hazardous substance equals or exceeds the lowest applicable benchmark concentration.

If no hazardous substance individually equals or exceeds its benchmark concentration, but more than one hazardous substance either meets the criteria for an observed release (or observed contamination or observed exposure) for the sample (or comparable samples) or is eligible to be evaluated for a tissue sample (see sections 4.1.3.3 and 4.2.3.3), calculate the indices I and J specified below based on these hazardous substances.

For those hazardous substances that are carcinogens (that is, those having either a carcinogen weight-of-evidence classification of A, B, or C or a weight-of-evidence classification of carcinogenic to humans, likely to be carcinogenic to humans, or suggestive evidence of carcinogenic potential), calculate an index I for the sample location as follows:

$$I = \sum_{i=1}^{n} \frac{C_i}{SC_i}$$

Where:

$C_i$ = Concentration of hazardous substance i in sample (or highest concentration of hazardous substance i from among comparable samples).

$SC_i$ = Screening concentration for cancer corresponding to that concentration that corresponds to its $10^{-6}$ individual cancer risk for applicable exposure (inhalation or oral) for hazardous substance i.

n = Number of applicable hazardous substances in sample (or comparable samples) that are carcinogens and for which an $SC_i$ is available.

For those hazardous substances for which an RfD or RfC is available, calculate an index J for the sample location as follows:

$$I = \sum_{j=1}^{m} \frac{C_j}{CR_j}$$

Where:

$C_j$ = Concentration of hazardous substance j in sample (or highest concentration of hazardous substance j from among comparable samples).

$CR_j$ = Screening concentration for noncancer toxicological responses corresponding to RfD or RfC for applicable exposure (inhalation or oral) for hazardous substance j.

m = Number of applicable hazardous substances in sample (or comparable samples) for which a $CR_j$ is available.

If either I or J equals or exceeds 1, consider the sampling location to be subject to Level I concentrations for that pathway (component or threat). If both I and J are less than 1, consider the sampling location to be subject to Level II concentrations for that pathway (component or threat). If, for the sampling location, there are sets of samples that are not comparable, calculate I and J separately for each such set, and use the highest calculated values of I and J to assign Level I and Level II.

See sections 7.3.1 and 7.3.2 for criteria for determining the level of contamination for radioactive substances.

* * * * *

**5.0 Soil Exposure and Subsurface Intrusion Pathway**

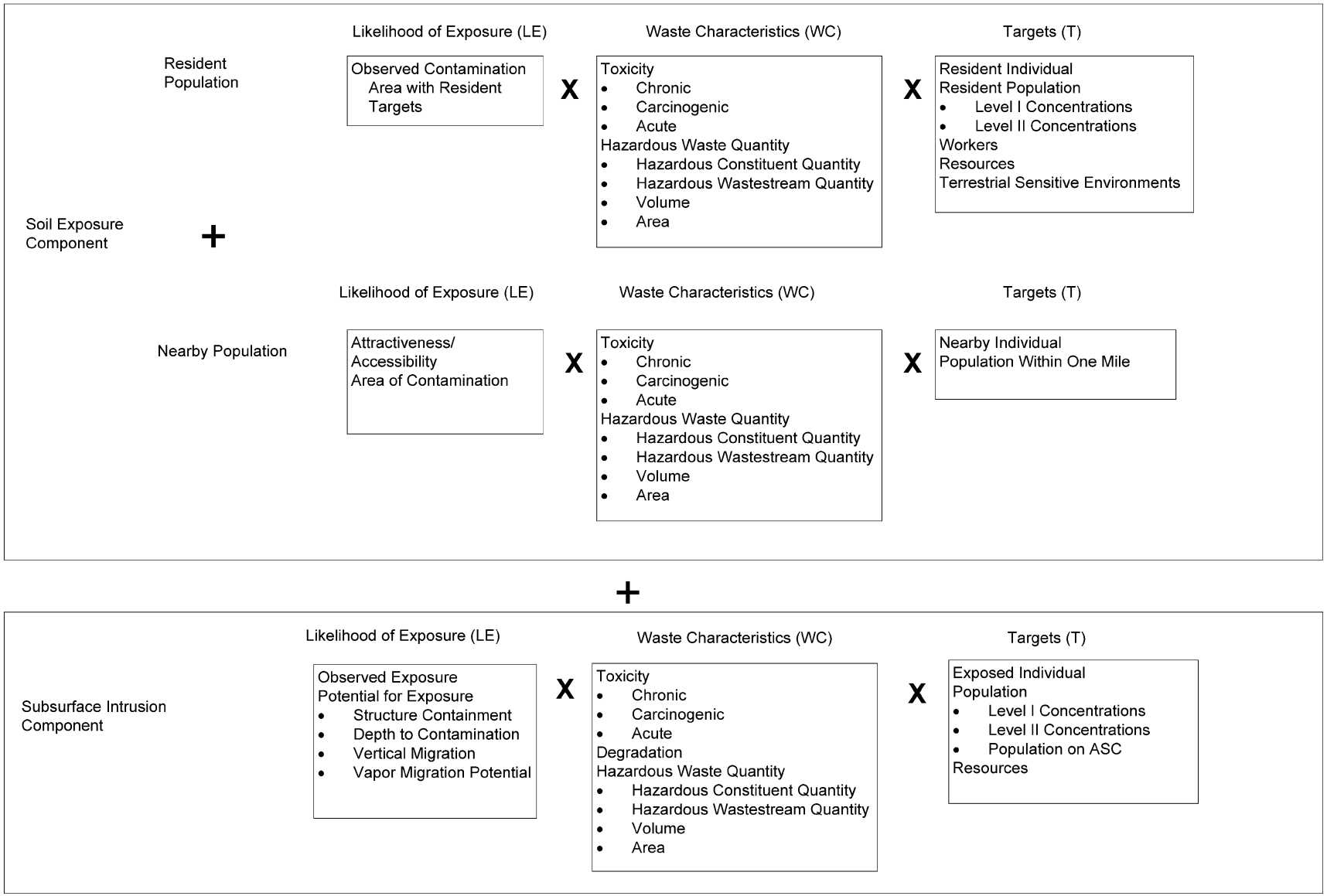
5.0.1 *Exposure components.* Evaluate the soil exposure and subsurface intrusion pathway based on two exposure components:

• Soil exposure component (see section 5.1).

• Subsurface intrusion component (see section 5.2).

Score one or both components considering their relative importance. If only one component is scored, assign its score as the soil exposure and subsurface intrusion pathway score. If both components are scored, sum the two scores and assign it as the soil exposure and subsurface intrusion pathway score, subject to a maximum of 100.

**Figure 5-1 Overview of the Soil Exposure and Subsurface Intrusion Pathway**




5.1 *Soil exposure component.* Evaluate the soil exposure component based on two threats: Resident population threat and nearby population threat. Evaluate both threats based on three factor categories: Likelihood of exposure, waste characteristics,

and targets. Figure 5–1 indicates the factors included within each factor category for each type of threat.

Determine the soil exposure component score ($S_{se}$) in terms of the factor category values as follows:

$$S_{se} = \frac{\sum_{i=1}^{2}(LE_i)(WC_i)(T_i)}{SF}$$

Where:

$LE_i$ = Likelihood of exposure factor category value for threat i (that is, resident population threat or nearby population threat).

$WC_i$ = Waste characteristics factor category value for threat i.

$T_i$ = Targets factor category value for threat i.

SF = Scaling factor.

Table 5–1 outlines the specific calculation procedure.

TABLE 5–1—SOIL EXPOSURE COMPONENT SCORESHEET

| Factor categories and factors | Maximum value | Value assigned |
|---|---|---|
| **Resident Population Threat** | | |
| Likelihood of Exposure: | | |
| 1. Likelihood of Exposure | 550 | |
| Waste Characteristics: | | |
| 2. Toxicity | ([a]) | |
| 3. Hazardous Waste Quantity | ([a]) | |
| 4. Waste Characteristics | 100 | |
| Targets: | | |
| 5. Resident Individual | 50 | |
| 6. Resident Population:. | | |
| 6a. Level I Concentrations | ([b]) | |
| 6b. Level II Concentrations | ([b]) | |
| 6c. Resident Population (lines 6a + 6b) | ([b]) | |
| 7. Workers | 15 | |
| 8. Resources | 5 | |
| 9. Terrestrial Sensitive Environments | ([c]) | |
| 10. Targets (lines 5 + 6c + 7 + 8 + 9) | ([b]) | |
| Resident Population Threat Score: | | |
| 11. Resident Population Threat (lines 1 × 4 × 10) | ([b]) | |
| **Nearby Population Threat** | | |
| Likelihood of Exposure: | | |
| 12. Attractiveness/Accessibility | 100 | |
| 13. Area of Contamination | 100 | |
| 14. Likelihood of Exposure | 500 | |
| Waste Characteristics: | | |
| 15. Toxicity | ([a]) | |
| 16. Hazardous Waste Quantity | ([a]) | |
| 17. Waste Characteristics | 100 | |
| Targets: | | |
| 18. Nearby Individual | 1 | |
| 19. Population Within 1 Mile | ([b]) | |
| 20. Targets (lines 18 + 19) | ([b]) | |
| Nearby Population Threat Score: | | |
| 21. Nearby Population Threat (lines 14 × 17 × 20) | ([b]) | |
| Soil Exposure Component Score: | | |
| 22. Soil Exposure Component Score[d] ($S_{se}$), (lines [11 + 21]/82,500, subject to a maximum of 100) | 100 | |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] No specific maximum value applies to factor. However, pathway score based solely on terrestrial sensitive environments is limited to maximum of 60.
[d] Do not round to nearest integer.

5.1.0 *General considerations.* Evaluate the soil exposure component based on areas of observed contamination:

- Consider observed contamination to be present at sampling locations where analytic evidence indicates that:
  - —A hazardous substance attributable to the site is present at a concentration significantly above background levels for the site (see Table 2–3 in section 2.3 for the criteria for determining analytical significance), *and*
  - —This hazardous substance, if not present at the surface, is covered by 2 feet or less of cover material (for example, soil).
- Establish areas of observed contamination based on sampling locations at which there is observed contamination as follows:
  - —For all sources except contaminated soil, if observed contamination from the site is present at any sampling location within the source, consider that entire source to be an area of observed contamination.
  - —For contaminated soil, consider both the sampling location(s) with observed contamination from the site and the area lying between such locations to be an area of observed contamination, unless available information indicates otherwise.
- If an area of observed contamination (or portion of such an area) is covered by a permanent, or otherwise maintained, essentially impenetrable material (for example, asphalt) that is not more than 2 feet thick, exclude that area (or portion of the area) in evaluating the soil exposure component.
- For an area of observed contamination, consider only those hazardous substances that meet the criteria for observed contamination for that area to be associated with that area in evaluating the soil exposure component (see section 2.2.2).

If there is observed contamination, assign scores for the resident population threat and the nearby population threat, as specified in sections 5.1.1 and 5.1.2. If there is no observed contamination, assign the soil exposure component of the soil exposure and subsurface intrusion pathway a score of 0.

5.1.1 *Resident population threat.* Evaluate the resident population threat only if there is an area of observed contamination in one or more of the following locations:

- Within the property boundary of a residence, school, or day care center *and* within 200 feet of the respective residence, school, or day care center, or
- Within a workplace property boundary *and* within 200 feet of a workplace area, or
- Within the boundaries of a resource specified in section 5.1.1.3.4, or
- Within the boundaries of a terrestrial sensitive environment specified in section 5.1.1.3.5.

If not, assign the resident population threat a value of 0, enter this value in Table 5–1, and proceed to the nearby population threat (section 5.1.2).

5.1.1.1 *Likelihood of exposure.* Assign a value of 550 to the likelihood of exposure factor category for the resident population threat if there is an area of observed contamination in one or more locations listed in section 5.1.1. Enter this value in Table 5–1.

5.1.1.2 *Waste characteristics.* Evaluate waste characteristics based on two factors: toxicity and hazardous waste quantity. Evaluate only those hazardous substances that meet the criteria for observed contamination at the site (see section 5.1.0).

5.1.1.2.1 *Toxicity.* Assign a toxicity factor value to each hazardous substance as specified in section 2.4.1.1. Use the hazardous substance with the highest toxicity factor value to assign the value to the toxicity factor for the resident population threat. Enter this value in Table 5–1.

5.1.1.2.2 *Hazardous waste quantity.* Assign a hazardous waste quantity factor value as specified in section 2.4.2. In estimating the hazardous waste quantity, use Table 5–2 and:

- Consider only the first 2 feet of depth of an area of observed contamination, except as specified for the volume measure.
- Use the volume measure (see section 2.4.2.1.3) only for those types of areas of observed contamination listed in Tier C of Table 5–2. In evaluating the volume measure for these listed areas of observed contamination, use the full volume, not just the volume within the top 2 feet.
- Use the area measure (see section 2.4.2.1.4), not the volume measure, for all other types of areas of observed contamination, even if their volume is known.

Enter the value assigned in Table 5–1.

TABLE 5–2—HAZARDOUS WASTE QUANTITY EVALUATION EQUATIONS FOR SOIL EXPOSURE COMPONENT

| Tier | Measure | Units | Equation for assigning value [a] |
|---|---|---|---|
| A | Hazardous Constituent Quantity (C) | lb | C. |
| B [b] | Hazardous Wastestream Quantity (W) | lb | W/5,000. |
| C [b] | Volume (V). | | |
| | Surface Impoundment [c] | $yd^3$ | V/2.5. |
| | Drums [d] | gallon | V/500. |
| | Tanks and Containers Other Than Drums | $yd^3$ | V/2.5. |
| D [b] | Area (A). | | |
| | Landfill | $ft^2$ | A/34,000. |
| | Surface Impoundment | $ft^2$ | A/13. |
| | Surface Impoundment (Buried/backfilled) | $ft^2$ | A/13. |
| | Land treatment | $ft^2$ | A/270. |
| | Pile [e] | $ft^2$ | A/34. |
| | Contaminated Soil | $ft^2$ | A/34,000. |

[a] Do not round nearest integer.
[b] Convert volume to mass when necessary: 1 ton = 2,000 pounds = 1 cubic yard = 4 drums = 200 gallons.
[c] Use volume measure only for surface impoundments containing hazardous substances present as liquids. Use area measures in Tier D for dry surface impoundments and for buried/backfilled surface impoundments.
[d] If actual volume of drums is unavailable, assume 1 drum = 50 gallons.
[e] Use land surface area under pile, not surface area of pile.

5.1.1.2.3 *Calculation of waste characteristics factor category value.* Multiply the toxicity and hazardous waste quantity factor values, subject to a maximum product of $1 \times 10^8$. Based on this product, assign a value from Table 2–7 (section 2.4.3.1) to the waste characteristics factor category. Enter this value in Table 5–1.

5.1.1.3 *Targets.* Evaluate the targets factor category for the resident population threat based on five factors: Resident individual, resident population, workers, resources, and terrestrial sensitive environments.

In evaluating the targets factor category for the resident population threat, count only the following as targets:

- Resident individual—a person living or attending school or day care on a property with an area of observed contamination *and* whose residence, school, or day care center, respectively, is on or within 200 feet of the area of observed contamination.
- Worker—a person working on a property with an area of observed contamination *and* whose workplace area is on or within 200 feet of the area of observed contamination.
- Resources located on an area of observed contamination, as specified in section 5.1.1.
- Terrestrial sensitive environments located on an area of observed contamination, as specified in section 5.1.1.

5.1.1.3.1 *Resident individual.* Evaluate this factor based on whether there is a resident individual, as specified in section 5.1.1.3, who is subject to Level I or Level II concentrations.

First, determine those areas of observed contamination subject to Level I concentrations and those subject to Level II concentrations as specified in sections 2.5.1 and 2.5.2. Use the health-based benchmarks from Table 5–3 in determining the level of contamination. Then assign a value to the resident individual factor as follows:

- Assign a value of 50 if there is at least one resident individual for one or more areas subject to Level I concentrations.
- Assign a value of 45 if there is no such resident individuals, but there is at least one resident individual for one or more areas subject to Level II concentrations.
- Assign a value of 0 if there is no resident individual.

Enter the value assigned in Table 5–1.

5.1.1.3.2 *Resident population.* Evaluate resident population based on two factors: Level I concentrations and Level II concentrations. Determine which factor applies as specified in sections 2.5.1 and 2.5.2, using the health-based benchmarks from Table 5–3. Evaluate populations subject to Level I concentrations as specified in section 5.1.1.3.2.1 and populations subject to Level II concentrations as specified in section 5.1.1.3.2.2.

TABLE 5–3—HEALTH-BASED BENCHMARKS FOR HAZARDOUS SUBSTANCES IN SOILS

| |
|---|
| Screening concentration for cancer corresponding to that concentration that corresponds to the $10^{-6}$ individual cancer risk for oral exposures. |
| Screening concentration for noncancer toxicological responses corresponding to the Reference Dose (RfD) for oral exposures. |

Count only those persons meeting the criteria for resident individual as specified in section 5.1.1.3. In estimating the number of people living on property with an area of observed contamination, when the estimate is based on the number of residences, multiply each residence by the average number of persons per residence for the county in which the residence is located.

5.1.1.3.2.1 *Level I concentrations.* Sum the number of resident individuals subject to Level I concentrations and multiply this sum by 10. Assign the resulting product as the value for this factor. Enter this value in Table 5–1.

5.1.1.3.2.2 *Level II concentrations.* Sum the number of resident individuals subject to Level II concentrations. Do not include those people already counted under the Level I concentrations factor. Assign this sum as the value for this factor. Enter this value in Table 5–1.

5.1.1.3.2.3 *Calculation of resident population factor value.* Sum the factor values for Level I concentrations and Level II concentrations. Assign this sum as the resident population factor value. Enter this value in Table 5–1.

5.1.1.3.3 *Workers.* Evaluate this factor based on the number of workers that meet the section 5.1.1.3 criteria. Assign a value for these workers using Table 5–4. Enter this value in Table 5–1.

TABLE 5–4—FACTOR VALUES FOR WORKERS

| Number of workers | Assigned value |
|---|---|
| 0 | 0 |
| 1 to 100 | 5 |
| 101 to 1,000 | 10 |
| Greater than 1,000 | 15 |

5.1.1.3.4 *Resources.* Evaluate the resources factor as follows:

- Assign a value of 5 to the resources factor if one or more of the following is present on an area of observed contamination at the site:
  —Commercial agriculture.
  —Commercial silviculture.
  —Commercial livestock production or commercial livestock grazing.
- Assign a value of 0 if none of the above are present.

Enter the value assigned in Table 5–1.

5.1.1.3.5 *Terrestrial sensitive environments.* Assign value(s) from Table 5–5 to each terrestrial sensitive environment that meets the eligibility criteria of section 5.1.1.3.

Calculate a value (ES) for terrestrial sensitive environments as follows:

$$ES = \sum_{i=1}^{n} S_i$$

Where:

$S_i$ = Value(s) assigned from Table 5–5 to terrestrial sensitive environment i.

n = Number of terrestrial sensitive environments meeting section 5.1.1.3 criteria.

Because the pathway score based solely on terrestrial sensitive environments is limited to a maximum of 60, determine the value for the terrestrial sensitive environments factor as follows:

TABLE 5–5—TERRESTRIAL SENSITIVE ENVIRONMENTS RATING VALUES

| Terrestrial sensitive environments | Assigned value |
|---|---|
| Terrestrial critical habitat [a] for Federal designated endangered or threatened species | 100 |
| National Park | |
| Designated Federal Wilderness Area | |
| National Monument. | |
| Terrestrial habitat known to be used by Federal designated or proposed threatened or endangered species | 75 |
| National Preserve (terrestrial) | |
| National or State Terrestrial Wildlife Refuge | |
| Federal land designated for protection of natural ecosystems | |
| Administratively proposed Federal Wilderness Area | |
| Terrestrial areas utilized for breeding by large or dense aggregations of animals [b]. | |
| Terrestrial habitat known to be used by State designated endangered or threatened species | 50 |
| Terrestrial habitat known to be used by species under review as to its Federal designated endangered or threatened status | |
| State lands designated for wildlife or game management | 25 |
| State designated Natural Areas | |
| Particular areas, relatively small in size, important to maintenance of unique biotic communities. | |

[a] Critical habitat as defined in 50 CFR 424.02.
[b] Limit to vertebrate species.

- Multiply the values assigned to the resident population threat for likelihood of exposure (LE), waste characteristics (WC), and ES. Divide the product by 82,500.
  —If the result is 60 or less, assign the value ES as the terrestrial sensitive environments factor value.
  —If the result exceeds 60, calculate a value EC as follows:

$$EC = \frac{(60)(82{,}500)}{(LE)(WC)}$$

Assign the value EC as the terrestrial sensitive environments factor value. Do not round this value to the nearest integer.

Enter the value assigned for the terrestrial sensitive environments factor in Table 5–1.

5.1.1.3.6 *Calculation of resident population targets factor category value.* Sum the values for the resident individual, resident population, workers, resources, and terrestrial sensitive environments factors. Do not round to the nearest integer. Assign this sum as the targets factor category value for the resident population threat. Enter this value in Table 5–1.

5.1.1.4 *Calculation of resident population threat score.* Multiply the values for likelihood of exposure, waste characteristics, and targets for the resident population threat, and round the product to the nearest integer. Assign this product as the resident population threat score. Enter this score in Table 5–1.

5.1.2 *Nearby population threat.* Include in the nearby population only those individuals who live or attend school within a 1-mile travel distance of an area of observed contamination at the site and who do not meet the criteria for resident individual as specified in section 5.1.1.3.

Do not consider areas of observed contamination that have an attractiveness/accessibility factor value of 0 (see section

5.1.2.1.1) in evaluating the nearby population threat.

5.1.2.1 *Likelihood of exposure.* Evaluate two factors for the likelihood of exposure factor category for the nearby population threat: attractiveness/accessibility and area of contamination.

5.1.2.1.1 *Attractiveness/accessibility.* Assign a value for attractiveness/accessibility from Table 5–6 to each area of observed contamination, excluding any land used for residences. Select the highest value assigned to the areas evaluated and use it as the value for the attractiveness/accessibility factor. Enter this value in Table 5–1.

5.1.2.1.2 *Area of contamination.* Evaluate area of contamination based on the total area of the areas of observed contamination at the site. Count only the area(s) that meet the criteria in section 5.1.0 and that receive an attractiveness/accessibility value greater than 0. Assign a value to this factor from Table 5–7. Enter this value in Table 5–1.

TABLE 5–6—ATTRACTIVENESS/ACCESSIBILITY VALUES

| Area of observed contamination | Assigned value |
|---|---|
| Designated recreational area | 100 |
| Regularly used for public recreation (for example, fishing, hiking, softball) | 75 |
| Accessible and unique recreational area (for example, vacant lots in urban area) | 75 |
| Moderately accessible (may have some access improvements, for example, gravel road), with some public recreation use | 50 |
| Slightly accessible (for example, extremely rural area with no road improvement), with some public recreation use | 25 |
| Accessible, with no public recreation use | 10 |
| Surrounded by maintained fence or combination of maintained fence and natural barriers | 5 |
| Physically inaccessible to public, with no evidence of public recreation use | 0 |

TABLE 5–7—AREA OF CONTAMINATION FACTOR VALUES

| Total area of the areas of observed contamination (square feet) | Assigned value |
|---|---|
| Less than or equal to 5,000 | 5 |
| Greater than 5,000 to 125,000 | 20 |
| Greater than 125,000 to 250,000 | 40 |
| Greater than 250,000 to 375,000 | 60 |
| Greater than 375,000 to 500,000 | 80 |
| Greater than 500,000 | 100 |

5.1.2.1.3 *Likelihood of exposure factor category value.* Assign a value from Table 5–8 to the likelihood of exposure factor category, based on the values assigned to the attractiveness/accessibility and area of contamination factors. Enter this value in Table 5–1.

TABLE 5–8—NEARBY POPULATION LIKELIHOOD OF EXPOSURE FACTOR VALUES

| Area of contamination factor value | Attractiveness/accessibility factor value | | | | | | |
|---|---|---|---|---|---|---|---|
| | 100 | 75 | 50 | 25 | 10 | 5 | 0 |
| 100 | 500 | 500 | 375 | 250 | 125 | 50 | 0 |
| 80 | 500 | 375 | 250 | 125 | 50 | 25 | 0 |
| 60 | 375 | 250 | 125 | 50 | 25 | 5 | 0 |
| 40 | 250 | 125 | 50 | 25 | 5 | 5 | 0 |
| 20 | 125 | 50 | 25 | 5 | 5 | 5 | 0 |
| 5 | 50 | 25 | 5 | 5 | 5 | 5 | 0 |

5.1.2.2 *Waste characteristics.* Evaluate waste characteristics based on two factors: toxicity and hazardous waste quantity. Evaluate only those hazardous substances that meet the criteria for observed contamination (see section 5.1.0) at areas that can be assigned an attractiveness/accessibility factor value greater than 0.

5.1.2.2.1 *Toxicity.* Assign a toxicity factor value as specified in section 2.4.1.1 to each hazardous substance meeting the criteria in section 5.1.2.2. Use the hazardous substance with the highest toxicity factor value to assign the value to the toxicity factor for the nearby population threat. Enter this value in Table 5–1.

5.1.2.2.2 *Hazardous waste quantity.* Assign a value to the hazardous waste quantity factor as specified in section 5.1.1.2.2, except: consider only those areas of observed contamination that can be assigned an attractiveness/accessibility factor value greater than 0. Enter the value assigned in Table 5–1.

5.1.2.2.3 *Calculation of waste characteristics factor category value.* Multiply the toxicity and hazardous waste quantity factor values, subject to a maximum product of $1 \times 10^8$. Based on this product, assign a value from Table 2–7 (section 2.4.3.1) to the waste characteristics factor category. Enter this value in Table 5–1.

5.1.2.3 *Targets.* Evaluate the targets factory category for the nearby population threat based on two factors: nearby individual and population within a 1-mile travel distance from the site.

5.1.2.3.1 *Nearby individual.* If one or more persons meet the section 5.1.1.3 criteria for a resident individual, assign this factor a value of 0. Enter this value in Table 5–1.

If no person meets the criteria for a resident individual, determine the shortest travel distance from the site to any residence or school. In determining the travel distance, measure the shortest overland distance an individual would travel from a residence or school to the nearest area of observed contamination for the site with an attractiveness/accessibility factor value greater than 0. If there are no natural barriers to travel, measure the travel distance as the shortest straight-line distance from the residence or school to the area of observed contamination. If natural barriers exist (for example, a river), measure the travel distance as the shortest straight-line distance from the residence or school to the nearest crossing point and from there as the shortest straight-

line distance to the area of observed contamination. Based on the shortest travel distance, assign a value from Table 5–9 to the nearest individual factor. Enter this value in Table 5–1.

TABLE 5–9—NEARBY INDIVIDUAL FACTOR VALUES

| Travel distance for nearby individual (miles) | Assigned value |
|---|---|
| Greater than 0 to ¼ | [a] 1 |
| Greater than ¼ to 1 | 0 |

[a] Assign a value of 0 if one or more persons meet the section 5.1.1.3 criteria for resident individual.

5.1.2.3.2 *Population within 1 mile.* Determine the population within each travel distance category of Table 5–10. Count residents and students who attend school within this travel distance. Do not include those people already counted in the resident population threat. Determine travel distances as specified in section 5.1.2.3.1.

In estimating residential population, when the estimate is based on the number of residences, multiply each residence by the average number of persons per residence for the county in which the residence is located.

Based on the number of people included within a travel distance category, assign a distance-weighted population value for that travel distance from Table 5–10.

Calculate the value for the population within 1 mile factor (PN) as follows:

$$PN = \frac{1}{10}\sum_{i=1}^{3} W_i$$

Where:

$W_i$=Distance-weighted population value from Table 5–10 for travel distance category i.

If PN is less than 1, do not round it to the nearest integer; if PN is 1 or more, round to the nearest integer. Enter this value in Table 5–1.

5.1.2.3.3 *Calculation of nearby population targets factor category value.* Sum the values for the nearby individual factor and the population within 1 mile factor. Do not round this sum to the nearest integer. Assign this sum as the targets factor category value for the nearby population threat. Enter this value in Table 5–1.

TABLE 5–10—DISTANCE WEIGHTED POPULATION VALUES FOR NEARBY POPULATION THREAT [a]

| Travel distance category (miles) | Number of people within the travel distance category | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 to 10 | 11 to 30 | 31 to 100 | 101 to 300 | 301 to 1,000 | 1,001 to 3,000 | 3,001 to 10,000 | 10,001 to 30,000 | 30,001 to 100,000 | 100,001 to 300,000 | 300,001 to 1,000,000 |
| Greater than 0 to ¼ | 0 | 0.1 | 0.4 | 1.0 | 4 | 13 | 41 | 130 | 408 | 1,303 | 4,081 | 13,034 |
| Greater than ¼ to ½ | 0 | 0.05 | 0.2 | 0.7 | 2 | 7 | 20 | 65 | 204 | 652 | 2,041 | 6,517 |
| Greater than ½ to 1 | 0 | 0.02 | 0.1 | 0.3 | 1 | 3 | 10 | 33 | 102 | 326 | 1,020 | 3,258 |

[a] Round the number of people present within a travel distance category to nearest integer. Do not round the assigned distance-weighted population value to nearest integer.

5.1.2.4 *Calculation of nearby population threat score.* Multiply the values for likelihood of exposure, waste characteristics, and targets for the nearby population threat, and round the product to the nearest integer. Assign this product as the nearby population threat score. Enter this score in Table 5–1.

5.1.3 *Calculation of soil exposure component score.* Sum the resident population threat score and the nearby population threat score, and divide the sum by 82,500. Assign the resulting value, subject to a maximum of 100, as the soil exposure component score ($S_{se}$). Enter this score in Table 5–1.

5.2 *Subsurface intrusion component.* Evaluate the subsurface intrusion component based on three factor categories: likelihood of exposure, waste characteristics, and targets. Figure 5–1 indicates the factors included within each factor category for the subsurface intrusion component.

Determine the component score ($S_{ssi}$) in terms of the factor category values as follows:

$$S_{ssi} = \frac{(LE)(WC)(T)}{SF}$$

Where:

LE=Likelihood of exposure factor category value.

WC=Waste characteristics factor category value.

T=Targets factor category value.

SF=Scaling factor.

Table 5–11 outlines the specific calculation procedure.

TABLE 5–11—SUBSURFACE INTRUSION COMPONENT SCORESHEET

| Factor categories and factors | Maximum value | Value assigned |
|---|---|---|
| Subsurface Intrusion Component: | | |
| Likelihood of Exposure: | | |
| 1. Observed Exposure | 550 | |
| 2. Potential for Exposure. | | |
| 2a. Structure Containment | 10 | |
| 2b. Depth to contamination | 10 | |
| 2c. Vertical Migration | 15 | |
| 2d. Vapor Migration Potential | 25 | |
| 3. Potential for Exposure (lines 2a * (2b + 2c + 2d), subject to a maximum of 500) | 500 | |
| 4. Likelihood of Exposure (higher of lines 1 or 3) | 550 | |
| Waste Characteristics: | | |
| 5. Toxicity/Degradation | ([a]) | |
| 6. Hazardous Waste Quantity | ([a]) | |
| 7. Waste Characteristics (subject to a maximum of 100) | 100 | |
| Targets: | | |
| 8. Exposed Individual | 50 | |
| 9. Population:. | | |
| 9a. Level I Concentrations | ([b]) | |
| 9b. Level II Concentrations | ([b]) | |
| 9c. Population within an Area of Subsurface Contamination | ([b]) | |
| 9d. Total Population (lines 9a + 9b + 9c) | ([b]) | |

TABLE 5–11—SUBSURFACE INTRUSION COMPONENT SCORESHEET—Continued

| Factor categories and factors | Maximum value | Value assigned |
|---|---|---|
| 10. Resources | 5 | |
| 11. Targets (lines 8 + 9d + 10) | ([b]) | |
| Subsurface Intrusion Component Score: | | |
| 12. Subsurface Intrusion Component (lines 4 × 7 × 11)/82,500 [c] (subject to a maximum of 100) | 100 | |
| Soil Exposure and Subsurface Intrusion Pathway Score: | | |
| 13. Soil Exposure Component + Subsurface Intrusion Component (subject to a maximum of 100) | 100 | |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] Do not round to the nearest integer.

5.2.0 *General considerations.* The subsurface intrusion component evaluates the threats from hazardous substances that have or could intrude into regularly occupied structures from the subsurface. Evaluate the subsurface intrusion component based on the actual or potential intrusion of hazardous substances into all regularly occupied structures that have structure containment values greater than zero and meet the criteria identified in the section below as being either in an area of observed exposure or in an area of subsurface contamination. These structures may or may not have subunits. Subunits are partitioned areas within a structure with separate heating, ventilating, and air conditioning (HVAC) systems or distinctly different air exchange rates. Subunits include regularly occupied partitioned tenant spaces such as office suites, apartments, condos, common or shared areas, and portions of residential, commercial or industrial structures with separate heating, ventilating, and air conditioning (HVAC) systems.

In evaluating the subsurface intrusion component, consider the following:

• Area(s) of observed exposure: An area of observed exposure is delineated by regularly occupied structures with documented contamination meeting observed exposure criteria; an area of observed exposure includes regularly occupied structures with samples meeting observed exposure criteria or inferred to be within an area of observed exposure based on samples meeting observed exposure criteria (see section 5.2.1.1.1 *Observed exposure*). Establish areas of observed exposure as follows:

—For regularly occupied structures that have no subunits, consider both the regularly occupied structures containing sampling location(s) meeting observed exposure criteria for the site and the regularly occupied structure(s) in the area lying between such locations to be an area of observed exposure (*i.e.,* inferred to be in an area of observed exposure), unless available information indicates otherwise.

—In multi-story, multi-subunit, regularly occupied structures, consider all subunits on a level with sampling locations meeting observed exposure criteria from the site and all levels below, if any, to be within an area of observed exposure, unless available information indicates otherwise.

—In multi-tenant structures, that do not have a documented observed exposure, but are located in an area lying between locations where observed exposures have been documented, consider only those regularly occupied subunits, if any, on the lowest level of the structure, to be within an area of observed exposure (*i.e.,* inferred to be in an area of observed exposure, unless available information indicates otherwise.

• Area(s) of subsurface contamination: An area of subsurface contamination is delineated by sampling locations meeting observed release criteria for subsurface intrusion, excluding areas of observed exposure (see Table 2–3 in section 2.3). The area within an area of subsurface contamination includes potentially exposed populations. If the significant increase in hazardous substance levels cannot be attributed at least in part to the site, and cannot be attributed to other sites, attribution can be established based on the presence of hazardous substances in the area of subsurface contamination. Establish areas of subsurface contamination as follows:

—Exclude those areas that contain structures meeting the criteria defined as an area of observed exposure.

—Consider both the sampling location(s) with subsurface contamination meeting observed release criteria from the site and the area lying between such locations to be an area of subsurface contamination (*i.e.,* inferred to be in an area of subsurface contamination). If sufficient data is available and state of the science shows there is no unacceptable risk due to subsurface intrusion into a regularly occupied structure located within an area of subsurface contamination, that structure can be excluded from the area of subsurface contamination.

Evaluate an area of subsurface contamination based on hazardous substances that:

▪ Meet the criteria for observed exposure of a chemical that has a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to $10^{-5}$ atm-m$^3$/mol, or

▪ Meet the criteria for observed release in an area of subsurface contamination and have a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to $10^{-5}$ atm-m$^3$/mol, or

▪ Meet the criteria for an observed release in a structure within, or in a sample from below, an area of observed exposure and have a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to $10^{-5}$ atm-m$^3$/mol.

—Evaluate all structures with no subunits that have containment factor values greater than zero, and not documented to meet observed exposure criteria to be in an area of subsurface contamination if they are lying between locations of subsurface intrusion samples meeting observed release criteria.

—Evaluate multi-subunit structures as follows:

▪ If an observed exposure has been documented based on a gaseous indoor air sample, consider all regularly occupied subunit(s), if any, on the level immediately above the level where an observed exposure has been documented (or has been inferred to be within an area of observed exposure), to be within an area of subsurface contamination. If sufficient data is available and state of the science shows there is no unacceptable risk due to subsurface intrusion on the level immediately above the level where an observed exposure has been documented (or has been inferred to be within an area of observed exposure) that level can be excluded from the area of subsurface contamination.

▪ If observed release criteria have been met based on a gaseous indoor air sample collected from a level not regularly occupied, consider all regularly occupied subunit(s), if any, on the level immediately above the level where the observed release criteria has been documented, to be within an area of subsurface contamination. If sufficient data is available and state of the science shows there is no unacceptable risk due to subsurface intrusion on the level immediately above the level where the observed release criteria has been documented that level can be excluded from the area of subsurface contamination.

▪ If any regularly occupied multi-subunit structure is inferred to be in an area of subsurface contamination, consider only those regularly occupied subunit(s), if any, on the lowest level, to be within an area of subsurface contamination. If sufficient data is available and state of the science shows there is no unacceptable risk due to subsurface intrusion on the lowest level, that structure can be excluded from the area of subsurface contamination.

See Section 7.0 for establishing an area of subsurface contamination based on the

presence of radioactive hazardous substances.

If there is no area of observed exposure and no area of subsurface contamination, assign a score of 0 for the subsurface intrusion component.

5.2.1 *Subsurface intrusion component.* Evaluate this component only if there is an area of observed exposure or area of subsurface contamination:

• Within or underlying a residence, school, day care center, workplace, or

• Within or underlying a resource specified in section 5.2.1.3.3.

5.2.1.1 *Likelihood of exposure.* Assign a value of 550 to the likelihood of exposure factor category for the subsurface intrusion component if there is an area of observed exposure in one or more locations listed in section 5.2.1. Enter this value in Table 5–11.

5.2.1.1.1 *Observed exposure.* Establish observed exposure in a regularly occupied structure by demonstrating that a hazardous substance has been released into a regularly occupied structure via the subsurface. Base this demonstration on either of the following criteria:

• Direct observation:

—A solid, liquid, or gaseous material that contains one or more hazardous substances attributable to the site has been observed entering a regularly occupied structure through migration via the subsurface or is known to have entered a regularly occupied structure via the subsurface, or

—When evidence supports the inference of subsurface intrusion of a material that contains one or more hazardous substances associated with the site into a regularly occupied structure, demonstrated adverse effects associated with that release may be used to establish observed exposure.

• Chemical analysis:

—Analysis of indoor samples indicates that the concentration of hazardous substance(s) is significantly above the background concentration for the site for that type of sample (see section 2.3).

—Some portion of the significant increase above background must be attributable to the site to establish the observed exposure. Documentation of this attribution should account for possible concentrations of the hazardous substance(s) in outdoor air or from materials found in the regularly occupied structure, and should provide a rationale for the increase being from subsurface intrusion.

If observed exposure can be established in a regularly occupied structure, assign an observed exposure factor value of 550, enter this value in Table 5–11, and proceed to section 5.2.1.1.3. If no observed exposure can be established, assign an observed exposure factor value of 0, enter this value in Table 5–11, and proceed to section 5.2.1.1.2.

5.2.1.1.2 *Potential for exposure.* Evaluate potential for exposure only if an observed exposure cannot be established, but an area of subsurface contamination has been delineated. Evaluate potential for exposure based only on the presence of hazardous substances with a vapor pressure greater than or equal to one torr or a Henry's constant greater than or equal to $10^{-5}$ atm-m$^3$/mol. Evaluate potential for exposure for each area of subsurface contamination based on four factors: Structure containment (see section 5.2.1.1.2.1), depth to contamination (see section 5.2.1.1.2.2), vertical migration (see section 5.2.1.1.2.3) and vapor migration potential (see section 5.2.1.1.2.4). For each area of subsurface contamination, assign the highest value for each factor. If information is insufficient to calculate any single factor value used to calculate the potential for exposure factor values at an identified area of subsurface contamination, information collected for another area of subsurface contamination at the site may be used when evaluating potential for exposure. Calculate the potential for exposure value for the site as specified in section 5.2.1.1.2.5.

5.2.1.1.2.1 *Structure containment.* Calculate containment for eligible hazardous substances within this component as directed in Table 5–12 and enter this value into Table 5–11. Assign each regularly occupied structure within an area of subsurface contamination the highest appropriate structure containment value from Table 5–12 and use the regularly occupied structure at the site with the highest structure containment value in performing the potential for exposure calculation. For all regularly occupied structures with unknown containment features assign a structure containment value of greater than zero for the purposes of evaluating targets (see section 5.2.1.3).

TABLE 5–12—STRUCTURE CONTAINMENT

| No. | Evidence of structure containment | Assigned value |
|---|---|---|
| 1. | Regularly occupied structure with evidence of subsurface intrusion, including documented observed exposure or sampling of bio or inert gases, such as methane and radon. | 10 |
| 2. | Regularly occupied structure with open preferential subsurface intrusion pathways (*e.g.,* sumps, foundation cracks, unsealed utility lines). | 10 |
| 3. | Regularly occupied structure with an engineered vapor migration barrier system that does not address all preferential subsurface intrusion pathways. | 7 |
| 4. | Regularly occupied structure with an engineered passive vapor mitigation system *without* documented institutional controls (*e.g.,* deed restrictions) or evidence of regular maintenance and inspection. | 6 |
| 5. | Regularly occupied structure with no visible open preferential subsurface intrusion pathways from the subsurface (*e.g.,* sumps, foundation cracks, unsealed utility lines). | 4 |
| 6. | Regularly occupied structure with an engineered passive vapor mitigation system (*e.g.,* passive venting) *with* documented institutional controls (*e.g.,* deed restrictions) or evidence of regular maintenance and inspection. | 3 |
| 7. | Regularly occupied structure with an engineered, active vapor mitigation system (*e.g.,* active venting) *without* documented institutional controls (*e.g.,* deed restrictions) and funding in place for on-going operation, inspection and maintenance. | 2 |
| 8. | Regularly occupied structure with a permanent engineered, active vapor mitigation system (*e.g.,* active venting) *with* documented institutional controls (*e.g.,* deed restrictions) and funding in place for on-going operation, inspection and maintenance. | 1 |
| 9. | Regularly occupied structure with a foundation raised greater than 6 feet above ground surface (*e.g.,* structure on stilts) or structure that has been built, and maintained, in a manner to prevent subsurface intrusion. | 0 |

5.2.1.1.2.2 *Depth to contamination.* Assign each area of subsurface contamination a depth to contamination based on the least depth to either contaminated crawl space or subsurface media underlying a regularly occupied structure. Measure this depth to contamination based on the distance between the lowest point of a regularly occupied structure to the highest known point of hazardous substances eligible to be evaluated. Use any regularly occupied structure within an area of subsurface contamination with a structure containment factor value greater than zero. Subtract from the depth to contamination the thickness of any subsurface layer composed of features that would allow channelized flow (*e.g.,* karst, lava tubes, open fractures, as well as manmade preferential pathways such as utility conduits or drainage systems).

Based on this calculated depth, assign a factor value from Table 5–13. If the necessary information is available at multiple locations, calculate the depth to contamination at each location. Use the location having the least depth to contamination to assign the factor value. Enter this value in Table 5–11.

TABLE 5–13—DEPTH TO CONTAMINATION

| Depth range [1] [2] | Depth to contamination assigned value |
|---|---|
| 0 to <10 ft (Including subslab and semi-enclosed or enclosed crawl space contamination) | 10 |
| >10 to 20 ft | 8 |
| >20 to 50 ft | 6 |
| >50 to 100 ft | 4 |
| >100 to 150 ft | 2 |
| >150 ft | 0 |

[1] If any part of the subsurface profile has channelized flow features, assign that portion of the subsurface profile a depth of 0.

[2] Measure elevation below any regularly occupied structure within an area of subsurface contamination at a site. Select the regularly occupied structure with the least depth to contamination below a structure.

5.2.1.1.2.3 *Vertical migration.* Evaluate the vertical migration factor for each area of subsurface contamination based on the geologic materials in the interval between the lowest point of a regularly occupied structure and the highest known point of hazardous substances in the subsurface. Use any regularly occupied structure either within an area of subsurface contamination or overlying subsurface soil gas or ground water contamination. Assign a value to the vertical migration factor as follows:

• If the depth to contamination (see section 5.2.1.1.2.2) is 10 feet or less, assign a value of 15.

• If the depth to contamination is greater than 10 feet, do not consider layers or portions of layers within the first 10 feet of the depth to contamination (as assigned in section 5.2.1.1.2.2).

• If, for the interval between the lowest point of a regularly occupied structure and the highest point of hazardous substances in the subsurface, all layers that underlie a portion of a regularly occupied structure at the site are karst or otherwise allow channelized flow, assign a value of 15.

• Otherwise:

—Select the lowest effective porosity/permeability layer(s) from within the interval identified above. Consider only layers at least 1 foot thick.—Assign a value for individual layers from Table 5–14 using the hydraulic conductivity of the layer, if available. If the hydraulic conductivity is not available, assign a value based on the type of material in the selected layer.

—If more than one layer has the same assigned porosity/permeability value, include all such layers and sum their thicknesses. Assign a thickness of 0 feet to a layer with channelized flow features found within any area of subsurface contamination at the site.

—Assign a value from Table 5–15 to the vertical migration factor, based on the thickness and assigned porosity/permeability value of the lowest effective porosity/permeability layer(s).

Determine vertical migration only at locations within an area of subsurface contamination at the site. If the necessary subsurface geologic information is available at multiple locations, evaluate the vertical migration factor at each location. Use the location having the highest vertical migration factor value to assign the factor value. Enter this value in Table 5–11.

TABLE 5–14—EFFECTIVE POROSITY/PERMEABILITY OF GEOLOGIC MATERIALS

| Type of material | Hydraulic conductivity (cm/sec) | Assigned porosity/permeability value |
|---|---|---|
| Gravel; clean sand; highly permeable fractured igneous and metamorphic rocks; permeable basalt; karst limestones and dolomites. | Greater than or equal to $1 \times 10^{-3}$. | 1 |
| Sand; sandy clays; sandy loams; loamy sands; sandy silts; sediments that are predominantly sand; highly permeable till (coarse-grained, unconsolidated or compact and highly fractured); peat; moderately permeable limestones and dolomites (no karst); moderately permeable sandstone; moderately permeable fractured igneous and metamorphic rocks. | Less than $1 \times 10^{-3}$ | 2 |
| Silt; loams; silty loams; loesses; silty clays; sediments that are predominantly silts; moderately permeable till (fine-grained, unconsolidated till, or compact till with some fractures); low permeability limestones and dolomites (no karst); low permeability sandstone; low permeability fractured igneous and metamorphic rocks. | Less than $1 \times 10^{-5}$ | 3 |
| Clay; low permeability till (compact unfractured till); shale; unfractured metamorphic and igneous rocks. | Less than $1 \times 10^{-7}$ | 4 |

TABLE 5–15—VERTICAL MIGRATION FACTOR VALUES [a]

| Assigned porosity/permeability value | Thickness of lowest porosity layer(s) [b] (feet) | | | | | |
|---|---|---|---|---|---|---|
| | 0 to 5 | Greater than 5 to 10 | Greater than 10 to 20 | Greater than 20 to 50 | Greater than 50 to 100 | Greater than 100 to 150 |
| 1 | 15 | 15 | 14 | 11 | 8 | 6 |
| 2 | 15 | 14 | 12 | 9 | 6 | 4 |
| 3 | 15 | 13 | 10 | 7 | 5 | 2 |
| 4 | 15 | 12 | 9 | 6 | 3 | 1 |

[a] If depth to contamination is 10 feet or less or if, for the interval being evaluated, all layers that underlie a portion of the structure at the site are karst or have other channelized flow features, assign a value of 15.

[b] Consider only layers at least 1 foot thick.

5.2.1.1.2.4 *Vapor migration potential.* Evaluate this factor for each area of subsurface contamination as follows:

• If the depth to contamination (see section 5.2.1.1.2.2) is 10 feet or less, assign a value of 25.

• Assign a value for vapor migration potential to each of the gaseous hazardous substances associated with the area of subsurface contamination (see section 2.2.2) as follows:

—Assign values from Table 5–16 for both vapor pressure and Henry's constant to each hazardous substance. If Henry's constant cannot be determined for a hazardous substance, assign that hazardous substance a value of 2 for the Henry's constant component.

—Sum the two values assigned to each hazardous substance.

—Based on this sum, assign each hazardous substance a value from Table 5–17 for vapor migration potential.

• Assign a value for vapor migration potential to each area of subsurface contamination as follows:

—Select the hazardous substance associated with the area of subsurface contamination

with the highest vapor migration potential value and assign this value as the vapor migration potential factor value for the area of subsurface contamination.

Enter this value in Table 5–11.

TABLE 5–16—VALUES FOR VAPOR PRESSURE AND HENRY'S CONSTANT

| Vapor pressure (torr) | Assigned value |
|---|---|
| Greater than 10 | 3 |
| 1 to 10 | 2 |
| Less than 1 | 0 |
| **Henry's constant (atm-m$^3$/mol)** | **Assigned value** |
| Greater than $10^{-3}$ | 3 |
| Greater than $10^4$ to $10^{-3}$ | 2 |
| $10^{-5}$ to $10^{-4}$ | 1 |
| Less than $10^{-5}$ | 0 |

TABLE 5–17—VAPOR MIGRATION POTENTIAL FACTOR VALUES FOR A HAZARDOUS SUBSTANCE

| Sum of values for vapor pressure and Henry's constant | Assigned value |
|---|---|
| 0 | 0 |
| 1 or 2 | 5 |
| 3 or 4 | 15 |
| 5 or 6 | 25 |

5.2.1.1.2.5 *Calculation of potential for exposure factor value.* For each identified area of subsurface contamination, sum the factor values for depth to contamination, vertical migration, and vapor migration potential, and multiply this sum by the factor value for structure containment. Select the highest product for any area of subsurface contamination and assign this value as the potential for exposure factor value for the component. Enter this value in Table 5–11.

5.2.1.1.3 *Calculation of likelihood of exposure factor category value.* If observed exposure is established for the site, assign the observed exposure factor value of 550 as the likelihood of exposure factor category value for the site. Otherwise, assign the potential for exposure factor value for the component as the likelihood of exposure value. Enter the value assigned in Table 5–11.

5.2.1.2 *Waste characteristics.* Evaluate waste characteristics based on two factors: toxicity/degradation and hazardous waste quantity.

5.2.1.2.1 *Toxicity/degradation.* For each hazardous substance, assign a toxicity factor value, a degradation factor value and a combined toxicity/degradation factor value as specified in sections 2.2.3, 2.4.1.2 and 5.2.1.2.1.1 through 5.2.1.2.1.3.

5.2.1.2.1.1 *Toxicity.* Assign a toxicity factor value to each hazardous substance as specified in sections 2.2.2 and 2.4.1.1.

5.2.1.2.1.2 *Degradation.* Assign a degradation factor value to each hazardous substance as follows:

- For any hazardous substance that meets the criteria for an observed exposure, or if a NAPL is present in the subsurface below an area of observed exposure or area of subsurface contamination at a depth less than or equal to 30 feet, assign that substance a degradation factor value of 1.
- For all other situations, assign a degradation factor value using Table 5–18. Assign the depth to contamination as directed in section 5.2.1.1.2.2, except if evidence indicates that biologically active soil is not present throughout the depth beneath any regularly occupied structure. In this situation, subtract any thickness of non-biologically active soil from the estimated depth to contamination.

TABLE 5–18—DEGRADATION FACTOR VALUE TABLE

| Depth to contamination (feet) [a] | Half-life | | |
|---|---|---|---|
| | >100 Days | >30 days and ≤100 days | ≤30 days |
| <10 | 1 | 1 | 1 |
| 10 to ≤30 | 1 | 1 | 0.1 |
| >30 | 1 | 0.5 | 0.1 |

[a] When determining the depth to contamination do not include layers of non-biologically-active soil, nor subsurface intervals with channelized flow (*e.g.,* karst, lava tubes, open fractures, and manmade preferential pathways as directed in section 5.2.1.1.2.2).

Calculate the half-life for each hazardous substance that meets subsurface intrusion observed release criteria as follows:

The half-life of a substance in the subsurface is defined for HRS purposes as the time required to reduce the initial concentration of the substance in the subsurface by one-half as a result of the combined decay processes of two components: Biodegradation and hydrolysis.

Estimate the half-life ($t_{1/2}$) of a hazardous substance as follows:

$$t_{1/2} = \frac{1}{1/h + 1/b}$$

Where:

h=Hydrolysis half-life.

b=Biodegradation half-life.

If either of these component half-lives cannot be estimated for the hazardous substance from available data, delete that component half-life from the above equation.

If no half-life information is available for a hazardous substance and the substance is not already assigned a value of 1, unless information indicates otherwise, assign a value of 1.

5.2.1.2.1.3 *Calculation of toxicity/degradation factor value.* Assign each substance a toxicity/degradation value by multiplying the toxicity factor value by the degradation factor value. Use the hazardous substance with the highest combined toxicity/degradation value to assign the factor value to the toxicity/degradation factor for the subsurface intrusion threat. Enter this value in Table 5–11.

5.2.1.2.2 *Hazardous waste quantity.* Assign a hazardous waste quantity factor value as specified in section 2.4.2. Consider only those regularly occupied structures or subunits with a non-zero structure containment value. Also include all regularly occupied structures or subunits that have had mitigation systems installed as part of a removal or other temporary response action. If sufficient structure-specific concentration data is available and state of the science shows there is no unacceptable risk of exposure to populations in a regularly occupied structure or subunit in an area of subsurface contamination, that structure or subunit is not included in the hazardous waste quantity evaluation. In estimating the hazardous waste quantity, use Tables 2–5 and 5–19 and:

- For Tier A, hazardous constituent quantity, use the mass of constituents found in the regularly occupied structure(s) where the observed exposure has been identified.
  - —For multi-subunit structures, when calculating Tier A, use the mass of constituents found in the regularly occupied subunit space(s) where the observed exposure has been identified.
- For Tier B, hazardous wastestream quantity, use the flow-through volume of the regularly occupied structures where the observed exposure has been identified.
  - —For multi-subunit structures, when calculating Tier B, use the flow-through volume of the regularly occupied subunit spaces where the observed exposure has been identified.
- For Tier C, volume, use the volume divisor listed in Tier C of Table 5–19. Volume is calculated for those regularly occupied structures located within areas of observed exposure with observed or inferred

intrusion and within areas of subsurface contamination.

—In evaluating the volume measure for these listed areas of observed exposure and areas of subsurface contamination based on a gaseous/vapor intrusion or the potential for gaseous/vapor intrusion, consider the following:

- Calculate the volume of each regularly occupied structure based on actual data. If unknown, use a ceiling height of 8 feet.
- For multi-subunit structures, when calculating Tier C, calculate volume for those subunit spaces with observed or inferred exposure and all other regularly occupied subunit spaces on that level, unless available information indicates otherwise. If the structure has multiple stories, also include the volume of all regularly occupied subunit spaces below the floor with an observed exposure and one story above, unless evidence indicates otherwise.
- For multi-subunit structures within an area of subsurface contamination and no observed or inferred exposure, consider only the volume of the regularly occupied subunit spaces on the lowest story, unless available information indicates otherwise.

• For Tier D, area, if volume is unknown, use the area divisor listed in Tier D of Table 5–19 for those regularly occupied structures within areas of observed exposure with observed or inferred intrusion and within areas of subsurface contamination.

—In evaluating the area measure for these listed areas of observed exposure and areas of subsurface contamination, calculate the area of each regularly occupied structure (including multi-subunit structures) or subunit based on actual footprint area data.

- If the actual footprint area of the structure(s) is unknown, use an area of 1,740 square feet for each structure (or subunit space).
- For multi-subunit structures, when calculating Tier D, calculate area for those subunit spaces with observed or inferred exposure and all other regularly occupied subunit spaces on that level, unless available information indicates otherwise. If the structure has multiple stories, also include the area of all regularly occupied subunit spaces below the floor with an observed exposure and one story above, unless evidence indicates otherwise.
- For multi-subunit structures within an area of subsurface contamination and no observed or inferred exposure, consider only the area of the regularly occupied subunit spaces on the lowest story, unless available information indicates otherwise.

TABLE 5–19—HAZARDOUS WASTE QUANTITY EVALUATION EQUATIONS FOR SUBSURFACE INTRUSION COMPONENT

| Tier | Measure | Units | Equation for assigning value [a] |
|---|---|---|---|
| A | Hazardous Constituent Quantity (C) | Lb | C |
| B[b] | Hazardous Wastestream Quantity (W) | Lb | W/5,000 |
| C[b,c] | Volume (V). Regularly occupied structure(s) in areas of observed exposure or subsurface contamination | $yd^3$ | V/2.5 |
| D[b,d] | Area (A). Regularly occupied structure(s) in areas of observed exposure or subsurface contamination | $ft^2$ | A/13 |

[a] Do not round to the nearest integer.
[b] Convert volume to mass when necessary: 1 ton=2,000 pounds=1 cubic yard=4 drums=200 gallons.
[c] Calculate volume of each regularly occupied structure or subunit space in areas of observed exposure and areas of subsurface contamination—Assume 8-foot ceiling height unless actual value is known.
[d] Calculate area of the footprint of each regularly occupied structure in areas of observed exposure and areas of subsurface contamination. If the footprint area of a regularly occupied structure is unknown, use 1,740 square feet as the footprint area of the structure or subunit space.

For the subsurface intrusion component, if the hazardous constituent quantity is adequately determined for all areas of observed exposure, assign the value from Table 2–6 as the hazardous waste quantity factor value. If the hazardous constituent quantity is not adequately determined for one or more areas of observed exposure or if one or more areas of subsurface contamination are present, assign either the value from Table 2–6 or assign a factor value as follows:

• If any target for the subsurface intrusion component is subject to Level I or Level II concentrations (see section 2.5), assign either the value from Table 2–6 or a value of 100, whichever is greater, as the hazardous waste quantity factor value for this component.

• If none of the targets for the subsurface intrusion component is subject to Level I or Level II concentrations and if there has been a removal action that does not permanently interrupt target exposure from subsurface intrusion, and if an area of subsurface contamination exists, assign a factor value as follows:

—Determine the values from Table 2–6 with and without consideration of the removal action.

—If the value that would be assigned from Table 2–6 without consideration of the removal action would be 100 or greater, assign either the value from Table 2–6 with consideration of the removal action or a value of 100, whichever is greater, as the hazardous waste quantity factor value for the component.

—If the value that would be assigned from Table 2–6 without consideration of the removal action would be less than 100, assign a value of 10 as the hazardous waste quantity factor value for the component.

• Otherwise, if none of the targets for the subsurface intrusion component is subject to Level I or Level II concentrations and there has not been a removal action, assign a value from Table 2–6 or a value of 10, whichever is greater.

Enter the value assigned in Table 5–11.

5.2.1.2.3 *Calculation of waste characteristics factor category value.* Multiply the toxicity/degradation and hazardous waste quantity factor values, subject to a maximum product of $1 \times 10^8$. Based on this product, assign a value from Table 2–7 (section 2.4.3.1) to the waste characteristics factor category. Enter this value in Table 5–11.

5.2.1.3 *Targets.* Evaluate the targets factor category for the subsurface intrusion threat based on three factors: Exposed individual, population, and resources in regularly occupied structures with structure containment factors greater than 0. Evaluate only those targets within areas of observed exposure and areas of subsurface contamination (see section 5.2.0).

In evaluating the targets factor category for the subsurface intrusion threat, count only the following as targets:

• Exposed individual—a person living, attending school or day care, or working in a regularly occupied structure with observed exposure or in a structure within an area of observed exposure or within an area of subsurface contamination.

• Population—exposed individuals in a regularly occupied structure within an area of observed exposure or within an area of subsurface contamination.

• Resources—located within an area of observed exposure or within an area of subsurface contamination as specified in section 5.2.1.3.3.

If a formerly occupied structure has been vacated due to subsurface intrusion attributable to the site, count the initial targets as if they were still residing in the structure. In addition, if a removal or temporary response action has occurred that has not completely mitigated the release, count the initial targets as if the removal or temporary response action has not permanently interrupted target exposure from subsurface intrusion. Evaluate those targets based on conditions at the time of removal of temporary response action.

For populations residing in or working in a multi-subunit structure with multiple stories in an area of observed exposure or area of subsurface contamination, count these targets as follows:

• If there is no observed exposure within the structure, include in the evaluation only those targets, if any, in the lowest occupied level. If sufficient structure-specific concentration data is available and state of the science shows there is no unacceptable risk of exposure to targets in the lowest level, those targets are not included in the evaluation.

• If there is an observed exposure in any level, include in the evaluation those targets in that level, the level above and all levels below. (The weighting of these targets is specified in Section 5.2.1.3.2.) If sufficient structure-specific concentration data is available and state of the science shows there is no unacceptable risk of exposure to targets in the level above where the observed exposure has been documented, those targets are not included in the evaluation.

5.2.1.3.1 *Exposed individual.* Evaluate this factor based on whether there is an exposed individual, as specified in sections 2.5.1, 2.5.2 and 5.2.1.3, who is subject to Level I or Level II concentrations.

First, determine those regularly occupied structures or partitioned subunit(s) within structures in an area of observed exposure subject to Level I concentrations and those subject to Level II concentrations as specified as follows (see section 5.2.0):

• Level I Concentrations: For contamination resulting from subsurface intrusion, compare the hazardous substance concentrations in any sample meeting the observed exposure by chemical analysis criteria to the appropriate benchmark. Use the health-based benchmarks from Table 5–20 to determine the level of contamination.

—If the sample is from a structure with no subunits and the concentration equals or exceeds the appropriate benchmark, assign Level I concentrations to the entire structure.

—If the sample is from a subunit within a structure and the concentration from that subunit equals or exceeds the appropriate benchmark, assign Level I concentrations to that subunit.

• Level II Concentrations: Structures, or subunits within structures, with one or more samples that meet observed exposure by chemical analysis criteria but do not equal or exceed the appropriate benchmark; structures, or subunits, that have an observed exposure by direct observation; and structures inferred to be in an area of observed exposure based on samples meeting observed exposure, are assigned Level II concentrations.

—For all regularly occupied structures, or subunits in such structures, in an area of observed exposure that are not assigned Level I concentrations, assign Level II concentrations.

Then assign a value to the exposed individual factor as follows:

• Assign a value of 50 if there is at least one exposed individual in one or more regularly occupied structures subject to Level I concentrations.

• Assign a value of 45 if there are no Level I exposed individuals, but there is at least one exposed individual in one or more regularly occupied structures subject to Level II concentrations.

• Assign a value of 20 if there is no Level I or Level II exposed individual but there is at least one individual in a regularly occupied structure within an area of subsurface contamination. Enter the value assigned in Table 5–11.

5.2.1.3.2 *Population.* Evaluate population based on three factors: Level I concentrations, Level II concentrations, and population within an area of subsurface contamination. Determine which factors apply as specified in section 5.2.1.3.1, using the health-based benchmarks from Table 5–20. Evaluate populations subject to Level I and Level II concentrations as specified in section 2.5.

TABLE 5–20—HEALTH-BASED BENCHMARKS FOR HAZARDOUS SUBSTANCES IN THE SUBSURFACE INTRUSION COMPONENT

| |
|---|
| Screening concentration for cancer corresponding to that concentration that corresponds to the $10^{-6}$ individual cancer risk using the inhalation unit risk. For oral exposures use the oral cancer slope factor. |
| Screening concentration for noncancer toxicological responses corresponding to the reference dose (RfD) for oral exposure and the reference concentration (RfC) for inhalation exposures. |

Count only those persons meeting the criteria for population as specified in section 5.2.1.3. In estimating the number of individuals in structures in an area of observed exposure or area of subsurface contamination if the actual number of residents is not known, multiply each residence by the average number of persons per residence for the county in which the residence is located.

5.2.1.3.2.1 *Level I concentrations.* Assign the population subject to Level I concentrations as follows:

1. Identify all exposed individuals regularly present in an eligible structure with a structure containment value greater than zero, or if the structure has subunits, identify those regularly present in each subunit, located in an area of observed exposure subject to Level I concentrations as described in sections 5.2.0 and 5.2.1.3.1. Identify only once per structure those exposed individuals that are using more than one eligible subunit of the same structure (*e.g.,* using a common or shared area and other parts of the same structure).

2. For each structure or subunit count the number of individuals residing in or attending school or day care in the structure or subunit.

3. Count the number of full-time and part-time workers in the structure or subunit(s) subject to Level I concentrations. If information is unavailable to classify a worker as full- or part-time, evaluate that worker as being full-time. Divide the number of full-time workers by 3 and the number of part-time workers by 6, and then sum these products with the number of other individuals for each structure or subunit.

4. Sum this combined value for all structures, or subunits, within areas of observed exposure and multiply this sum by 10.

Assign the resulting product as the combined population factor value subject to Level I concentrations for the site. Enter this value in line 9a of Table 5–11.

5.2.1.3.2.2 *Level II concentrations.* Assign the population subject to Level II concentrations as follows:

1. Identify all exposed individuals regularly present in an eligible structure with a structure containment value greater than zero, or if the structure has subunits, identify those regularly present in each subunit, located in an area of observed exposure subject to Level II concentrations as described in sections 5.2.0 and 5.2.1.3.1. Identify only once per structure those exposed individuals that are using more than one eligible subunit of the same structure (*e.g.,* using a common or shared area and other parts of the same structure).

2. Do not include exposed individuals already counted under the Level I concentrations factor.

3. For each structure or subunit(s), count the number of individuals residing in or attending school or day care in the structure, or subunit, subject to Level II concentrations.

4. Count the number of full-time and part-time workers in the structure or subunit(s) subject to Level II concentrations. If information is unavailable to classify a worker as full- or part-time, evaluate that worker as being full-time. Divide the number of full-time workers by 3 and the number of part-time workers by 6, and then sum these products with the number of other individuals for each structure or subunit.

5. Sum the combined population value for all structures within the areas of observed exposure for the site.

Assign this sum as the combined population factor value subject to Level II concentrations for this site. Enter this value in line 9b of Table 5–11.

5.2.1.3.2.3 *Population within area(s) of subsurface contamination.* Assign the population in area(s) of subsurface contamination factor value as follows. If sufficient structure-specific concentration data is available and state of the science shows there is no unacceptable risk of exposure to populations in a regularly occupied structure in an area of subsurface contamination, those populations are not included in the evaluation. (see sections 5.2.0 and 5.2.1.3.1):

1. Identify the regularly occupied structures with a structure containment value greater than zero and the eligible population associated with the structures or portions of structures in each area of subsurface contamination:

• For each regularly occupied structure or portion of a structure in an area of subsurface contamination, sum the number of all individuals residing in or attending school or day care, in the structure or portion of the structure in the area of subsurface contamination.

• Count the number of full-time and part-time workers regularly present in each

structure or portion of a structure in an area of subsurface contamination. If information is unavailable to classify a worker as full- or part-time, evaluate that worker as being full-time. Divide the number of full-time workers by 3 and the number of part-time workers by 6. Sum these products with the number of individuals residing in or attending school or day care in the structure.

• Use this sum as the population for the structure.

2. Estimate the depth or distance to contamination at each regularly occupied structure within an area of subsurface contamination based on available sampling data, and categorize each eligible structure based on the depth or distance to contamination and sample media as presented in Table 5–21. Weight the population in each structure using the appropriate weighting factors in Table 5–21. If samples from multiple media are available, use the sample that results in the highest weighting factor.

3. Sum the weighted population in all structures within the area(s) of subsurface contamination and assign this sum as the population within an area of subsurface contamination factor value. Enter this value in line 9c of Table 5–11.

TABLE 5–21—WEIGHTING FACTOR VALUES FOR POPULATIONS WITHIN AN AREA OF SUBSURFACE CONTAMINATION

| Eligible populations [a] in structures [b] within an area of subsurface contamination | Population weighting factor |
|---|---|
| **Samples From Within Structures or in Crawl Spaces** | |
| 1. Population in a structure with levels of contamination in a semi-enclosed or enclosed crawl space sample meeting observed release criteria or<br>Population in a subunit of a multi-story structure within an area of subsurface contamination located directly above a level in an area of observed exposure or a gaseous indoor air sample meeting observed release criteria or<br>Population within a structure where a mitigation system has been installed as part of a removal or other temporary response action. | 0.9 |
| 2. Population in a structure where levels of contaminants meeting observed release criteria are inferred based on semi-enclosed or enclosed crawl space samples in surrounding structures, and a NAPL is present in those samples | 0.8 |
| 3. Population in a structure where levels of contaminants meeting observed release criteria are inferred based on semi-enclosed or enclosed crawl space samples in surrounding structures, but no NAPL is present | 0.4 |
| **Subsurface Samples From Less Than or Equal to 5 Feet From a Foundation** | |
| 4. Population in a structure where levels of contaminants meeting observed release criteria are found or inferred based on any sampling media at or within five feet horizontally or vertically of the structure foundation, and a NAPL is present within that depth | 0.8 |
| 5. Population in a structure where levels of contaminants meeting observed release criteria are found or inferred based on any sampling media at or within five feet horizontally or vertically of the structure foundation, but no NAPL is present within that depth | 0.4 |
| **Subsurface Samples From Greater Than 5 Feet But Less Than or Equal to 30 Feet Depth** | |
| 6. Population in a structure where levels of contaminants meeting observed release criteria are found or inferred based on any underlying non-ground water subsurface sample at a depth greater than 5 feet but less than or equal to 30 feet from a structure foundation and a NAPL is present within that depth | 0.4 |
| 7. Population in a structure where levels of contaminants meeting observed release criteria are found or inferred based on any underlying non-ground water subsurface sample at a depth greater than 5 feet but less than or equal to 30 feet, but no NAPL is present within that depth | 0.2 |
| 8. Population in a structure where levels of contaminants meeting observed release criteria are found or inferred based on underlying ground water samples greater than 5 feet from the structure foundation but less than or equal to 30 feet, and a NAPL is present in those samples | 0.2 |
| 9. Population in a structure where levels of contaminants meeting observed release criteria are found or inferred based on underlying ground water samples greater than 5 feet from the structure foundation but less than or equal to 30 feet, but no NAPL is present in those samples | 0.1 |
| **Subsurface Samples From Greater Than 30 Feet Depth** | |
| 10. Population in a structure where levels of contaminants meeting observed release criteria are found or inferred based on any underlying sample at depths greater than 30 feet | 0.1 |

[a] Eligible populations include residents (including individuals living in, or attending school or day care in the structure), and workers in regularly occupied structures (see HRS Section 5.2.1.3).

[b] Eligible structures may include single- or multi-tenant structures where eligible populations reside, attend school or day care, or work. These structures may also be mixed use structures.

5.2.1.3.2.4 *Calculation of population factor value.* Sum the factor values for Level I concentrations, Level II concentrations, and population within the area(s) of subsurface contamination. Assign this sum as the population factor value. Enter this value in line 9d of Table 5–11.

5.2.1.3.3 *Resources.* Evaluate the resources factor as follows:

• Assign a value of 5 if a resource structure (*e.g.,* library, church, tribal facility) is present and regularly occupied within either an area of observed exposure or area of subsurface contamination.

• Assign a value of 0 if there is no resource structure within an area of observed exposure or area of subsurface contamination.

Enter the value assigned in Table 5–11.

5.2.1.3.4 *Calculation of targets factor category value.* Sum the values for the exposed individual, population, and resources factors. Do not round to the nearest integer. Assign this sum as the targets factor category value for the subsurface intrusion component. Enter this value in Table 5–11.

5.2.2 *Calculation of subsurface intrusion component score.* Multiply the factor category values for likelihood of exposure, waste characteristics, and targets and round the product to the nearest integer. Divide the product by 82,500. Assign the resulting value, subject to a maximum of 100, as the

subsurface intrusion component score and enter this score in Table 5–11.

5.3 *Calculation of the soil exposure and subsurface intrusion pathway score.* Sum the soil exposure component score and subsurface intrusion component score. Assign the resulting value, subject to a maximum of 100, as the soil exposure and subsurface intrusion pathway score ($S_{sessi}$). Enter this score in Table 5–11.

**6.0 Air Migration Pathway**

* * * * *

TABLE 6–14—HEALTH-BASED BENCHMARKS FOR HAZARDOUS SUBSTANCES IN AIR

- Concentration corresponding to National Ambient Air Quality Standard (NAAQS).
- Concentration corresponding to National Emission Standards for Hazardous Air Pollutants (NESHAPs).
- Screening concentration for cancer corresponding to that concentration that corresponds to the $10^{-6}$ individual cancer risk for inhalation exposures.
- Screening concentration for noncancer toxicological responses corresponding to the Reference Concentration (RfC) for inhalation exposures.

* * * * *

**7.0 Sites Containing Radioactive Substances**

* * * * *

TABLE 7–1—HRS FACTORS EVALUATED DIFFERENTLY FOR RADIONUCLIDES

| Ground water pathway | Status [a] | Surface water pathway | Status [a] | Soil exposure component of SESSI pathway | Status [a] | Subsurface intrusion component of SESSI pathway | Status [a] | Air pathway | Status [a] |
|---|---|---|---|---|---|---|---|---|---|
| *Likelihood of Release* | | *Likelihood of Release.* | | *Likelihood of Exposure.* | | *Likelihood of Exposure.* | | *Likelihood of Release.* | |
| Observed Release | Yes | Observed Release. | Yes | Observed Contamination. | Yes | Observed Exposure. | Yes | Observed Release. | Yes. |
| Potential to Release | No | Potential to Release. | No | Attractiveness/Accessibility to Nearby Residents. | No | Potential for Exposure. | Yes | Gas Potential to Release. | No. |
| Containment | No | Overland Flow Containment. | No | Area of Contamination. | No | Structure Containment. | No | Gas Containment. | No. |
| Net Precipitation | No | Runoff | No | Area of Observed Exposure. | No | Depth to Contamination. | Yes | Gas Source Type. | No. |
| Depth to Aquifer | No | Distance to Surface water. | No | Area of Subsurface Contamination. | No | Vertical migration. | No | Gas Migration Potential. | No. |
| Travel Time | No | Flood Frequency. | No | | | Vapor Migration Potential. | No | Particulate Potential to Release. | No. |
| | | Flood Containment. | No | | | | | Particulate Containment. | No. |
| | | | | | | | | Particulate Source Type. | No. |
| | | | | | | | | Particulate Migration Potential. | No. |
| *Waste Characteristics* | | *Waste Characteristics.* | | *Waste Characteristics.* | | *Waste Characteristics.* | | *Waste Characteristics.* | |
| Toxicity | Yes | Toxicity/Ecotoxicity. | Yes/Yes. | Toxicity | Yes | Toxicity/Degradation. | Yes/Yes. | Toxicity | Yes. |
| Mobility | No | Persistence/Mobility | Yes/No | Hazardous Waste Quantity. | Yes | Hazardous Waste Quantity. | Yes | Mobility | No. |
| Hazardous Waste Quantity | Yes | Bioaccumulation Potential. | No | | | | | Hazardous Waste Quantity. | Yes. |
| | | Hazardous Waste Quantity. | Yes | | | | | | |
| *Targets* | | *Targets* | | *Targets* | | *Targets* | | *Targets* | |
| Nearest Well | Yes.[b] | Nearest Intake. | Yes.[b] | Resident Individual. | Yes.[b] | Exposed Individual | Yes.[b] | Nearest Individual. | Yes.[b] |

TABLE 7–1—HRS FACTORS EVALUATED DIFFERENTLY FOR RADIONUCLIDES—Continued

| Ground water pathway | Status [a] | Surface water pathway | Status [a] | Soil exposure component of SESSI pathway | Status [a] | Subsurface intrusion component of SESSI pathway | Status [a] | Air pathway | Status [a] |
|---|---|---|---|---|---|---|---|---|---|
| Population | Yes.[b] | Drinking Water Population. | Yes.[b] | Resident Population. | Yes.[b] | Population | Yes.[b] | Population | Yes.[b] |
| Resources | No | Resources | No | Workers | No | Resources | No | Resources | No |
| Wellhead Protection Area | No | Sensitive Environments. | Yes.[b] | Resources | No | | | Sensitive Environments. | No |
| | | Human Food Chain Individual. | Yes.[b] | Terrestrial Sensitive Environments. | No | | | | |
| | | Human Food Chain Population. | Yes.[b] | Nearby Individual. | No | | | | |
| | | | | Population Within 1 Mile. | No | | | | |

[a] Factors evaluated differently are denoted by ''yes''; factors not evaluated differently are denoted by ''no''.
[b] Difference is in the determination of Level I and Level II concentrations.

* * * * *

* * * These differences apply largely to the soil exposure and subsurface intrusion pathway and to sites containing mixed radioactive and other hazardous substances. * * *

7.1 *Likelihood of release/likelihood of exposure.* Evaluate likelihood of release for the three migration pathways and likelihood of exposure for the soil exposure and subsurface intrusion pathway as specified in sections 2 through 6, except: establish an observed release, observed contamination, and/or observed exposure as specified in section 7.1.1. When an observed release or exposure cannot be established for a migration pathway or the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, evaluate potential to release as specified in section 7.1.2. When observed contamination cannot be established, do not evaluate the soil exposure component of the soil exposure and subsurface intrusion pathway.

7.1.1 *Observed release/observed contamination/observed exposure.* For radioactive substances, establish an observed release for each migration pathway by demonstrating that the site has released a radioactive substance to the pathway (or watershed or aquifer, as appropriate); establish observed contamination or observed exposure for the soil exposure and subsurface intrusion pathway as indicated below. Base these demonstrations on one or more of the following, as appropriate to the pathway being evaluated:

- Direct observation:

—For each migration pathway, a material that contains one or more radionuclides has been seen entering the atmosphere, surface water, or ground water, as appropriate, or is known to have entered ground water or surface water through direct deposition, or

—For the surface water migration pathway, a source area containing radioactive substances has been flooded at a time that radioactive substances were present and one or more radioactive substances were in contact with the flood waters.

—For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, a material that contains one or more radionuclides has been observed entering a regularly occupied structure via the subsurface or is known to have entered a regularly occupied structure via the subsurface. Also, when evidence supports the inference of subsurface intrusion of a material that contains one or more radionuclides by the site into a regularly occupied structure, demonstrated adverse effects associated with that release may also be used to establish observed exposure by direct observation.

- Analysis of radionuclide concentrations in samples appropriate to the pathway (that is, ground water, soil, air, indoor air, soil gas, surface water, benthic, or sediment samples):

—For radionuclides that occur naturally and for radionuclides that are ubiquitous in the environment:

- Measured concentration (in units of activity, for example, pCi per kilogram [pCi/kg], pCi per liter [pCi/L], pCi per cubic meter [pCi/m3]) of a given radionuclide in the sample are at a level that:
  - Equals or exceeds a value 2 standard deviations above the mean site-specific background concentration for that radionuclide in that type of sample, or
  - Exceeds the upper-limit value of the range of regional background concentration values for that specific radionuclide in that type of sample.
- Some portion of the increase must be attributable to the site to establish the observed release (or observed contamination or observed exposure), and
- For the soil exposure component of the soil exposure and subsurface intrusion pathway only, the radionuclide must also be present at the surface or covered by 2 feet or less of cover material (for example, soil) to establish observed contamination.

—For man-made radionuclides without ubiquitous background concentrations in the environment:

- Measured concentration (in units of activity) of a given radionuclide in a sample equals or exceeds the sample quantitation limit for that specific radionuclide in that type of media and is attributable to the site.
- However, if the radionuclide concentration equals or exceeds its sample quantitation limit, but its release can also be attributed to one or more neighboring sites, then the measured concentration of that radionuclide must also equal or exceed a value either 2 standard deviations above the mean concentration of that radionuclide contributed by those neighboring sites or 3 times its background concentration, whichever is lower.
- If the sample quantitation limit cannot be established:
  - If the sample analysis was performed under the EPA Contract Laboratory Program, use the EPA contract-required quantitation limit (CRQL) in place of the sample quantitation limit in establishing an observed release (or observed contamination or observed exposure).
  - If the sample analysis is not performed under the EPA Contract Laboratory Program, use the detection limit in place of the sample quantitation limit.
- For the soil exposure component of the soil exposure and subsurface intrusion pathway only, the radionuclide must also be present at the surface or covered by 2 feet or less of cover material (for example, soil) to establish observed contamination.

- Gamma radiation measurements (applies only to observed contamination or observed exposure in the soil exposure and subsurface intrusion pathway):

—The gamma radiation exposure rate, as measured in microroentgens per hour (μR/hr) using a survey instrument held 1 meter above the ground surface or floor or walls of a structure (or 1 meter away from an aboveground source for the soil exposure component), equals or exceeds 2 times the site-specific background gamma radiation exposure rate.

—Some portion of the increase must be attributable to the site to establish observed contamination or observed exposure. The gamma-emitting radionuclides do not have to be within 2 feet of the surface of the source.

For the three migration pathways and for the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, if an observed release or observed exposure can be established for the pathway (or component, threat, aquifer, or watershed, as appropriate), assign the pathway (or component, threat, aquifer, or watershed) an observed release or observed exposure factor value of 550 and proceed to section 7.2. If an observed release or observed exposure cannot be established, assign an observed release or observed exposure factor value of 0 and proceed to section 7.1.2.

For the soil exposure component of the soil exposure and subsurface intrusion pathway, if observed contamination can be established, assign the likelihood of exposure factor for resident population a value of 550 if there is an area of observed contamination in one or more locations listed in section 5.1.1; evaluate the likelihood of exposure factor for nearby population as specified in section 5.1.2.1; and proceed to section 7.2. If observed contamination cannot be established, do not evaluate the soil exposure component of the soil exposure and subsurface intrusion pathway.

At sites containing mixed radioactive and other hazardous substances, evaluate observed release (or component, observed contamination or observed exposure) separately for radionuclides as described in this section and for other hazardous substances as described in sections 2 through 6.

For the three migration pathways and the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, if an observed release or observed exposure can be established based on either radionuclides or other hazardous substances, or both, assign the pathway (or threat, aquifer, or watershed) an observed release or observed exposure factor value of 550 and proceed to section 7.2. If an observed release or observed exposure cannot be established based on either radionuclides or other hazardous substances, assign an observed release or observed exposure factor value of 0 and proceed to section 7.1.2.

For the soil exposure component of the soil exposure and subsurface intrusion pathway, if observed contamination can be established based on either radionuclides or other hazardous substances, or both, assign the likelihood of exposure factor for resident population a value of 550 if there is an area of observed contamination in one or more locations listed in section 5.1.1; evaluate the likelihood of exposure factor for nearby population as specified in section 5.1.2.1; and proceed to section 7.2. If observed contamination cannot be established based on either radionuclides or other hazardous substances, do not evaluate the soil exposure component of the soil exposure and subsurface intrusion pathway.

7.1.2 Potential to release/potential for exposure. For the three migration pathways and the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, evaluate potential to release or potential for exposure for sites containing radionuclides in the same manner as specified for sites containing other hazardous substances. Base the evaluation on the physical and chemical properties of the radionuclides, not on their level of radioactivity. For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, if the potential for exposure is based on the presence of gamma emitting radioactive substances, assign a potential for exposure factor value of 500 only if the contamination is found within 2 feet beneath a regularly occupied structure, otherwise assign a potential for exposure factor value of 0.

For sites containing mixed radioactive and other hazardous substances, evaluate potential to release or potential for exposure considering radionuclides and other hazardous substances together. Evaluate potential to release for each migration pathway and the potential for exposure for the subsurface intrusion component of the soil exposure and subsurface intrusion pathway as specified in sections 3 through 6, as appropriate.

* * * * *

7.2.1 Human Toxicity. For radioactive substances, evaluate the human toxicity factor as specified below, not as specified in section 2.4.1.1.

Assign human toxicity factor values to those radionuclides available to the pathway based on quantitative dose-response parameters for cancer risks as follows:

• Evaluate radionuclides only on the basis of carcinogenicity and assign all radionuclides to weight-of-evidence category A, or weight-of-evidence category ''Carcinogenic to Humans''.

• Assign a human toxicity factor value from Table 7–2 to each radionuclide based on its slope factor (also referred to as a cancer potency factor).

—For each radionuclide, use the higher of the slope factors for inhalation and ingestion to assign the factor value.

—If only one slope factor is available for the radionuclide use it to assign the toxicity factor value.

—If no slope factor is available for the radionuclide, assign that radionuclide a toxicity factor value of 0 and use other radionuclides for which a slope factor is available to evaluate the pathway.

• If all radionuclides available to a particular pathway are assigned a human toxicity factor value of 0 (that is, no slope factor is available for all the radionuclides), use a default human toxicity factor value of 1,000 as the human toxicity factor value for all radionuclides available to the pathway.

At sites containing mixed radioactive and other hazardous substances, evaluate the toxicity factor separately for the radioactive and other hazardous substances and assign each a separate toxicity factor value. This applies regardless of whether the radioactive and other hazardous substances are physically separated, combined chemically, or simply mixed together. Assign toxicity factor values to the radionuclides as specified above and to the other hazardous substances as specified in section 2.4.1.1.

At sites containing mixed radioactive and other hazardous substances, if all radionuclides available to a particular pathway are assigned a human toxicity factor value of 0, use a default human toxicity factor value of 1,000 for all those radionuclides even if nonradioactive hazardous substances available to the pathway are assigned human toxicity factor values greater than 0. Similarly, if all nonradioactive hazardous substances available to the pathway are assigned a human toxicity factor value of 0, use a default human toxicity factor value of 100 for all these nonradioactive hazardous substances even if radionuclides available to the pathway are assigned human toxicity factor values greater than 0.

* * * * *

7.2.3 *Persistence/Degradation.* In determining the surface water persistence factor for radionuclides, evaluate this factor based solely on half-life; do not include sorption to sediments in the evaluation as is done for nonradioactive hazardous substances. Assign a persistence factor value from Table 4–10 (section 4.1.2.2.1.2) to each radionuclide based on half-life ($t_{1/2}$) calculated as follows:

$$t_{1/2} = \frac{1}{\frac{1}{r}+\frac{1}{v}}$$

Where:

r = Radioactive half-life.

V = Volatilization half-life.

If the volatilization half-life cannot be estimated for a radionuclide from available data, delete it from the equation. Select the portion of Table 4–10 to use in assigning the persistence factor value as specified in section 4.1.2.2.1.2.

At sites containing mixed radioactive and other hazardous substances, evaluate the persistence factor separately for each radionuclide and for each nonradioactive hazardous substance, even if the available data indicate that they are combined chemically. Assign a persistence factor value to each radionuclide as specified in this section and to each nonradioactive hazardous substance as specified in section 4.1.2.2.1.2. When combined chemically, assign a single persistence factor value based on the higher of the two values assigned (individually) to the radioactive and nonradioactive components.

In determining the subsurface intrusion degradation factor for radionuclides, when evaluating this factor based solely on half-life, assign a degradation factor value from section 5.2.1.2.1.2 to each radionuclide based on half-life ($t_{1/2}$) calculated as follows:

$$t_{1/2} = \frac{1}{\frac{1}{r}}$$

Where:

r=Radioactive half-life.

If no radioactive half-life information is available for a radionuclide and the substance is not already assigned a value of 1, unless information indicates otherwise, assign a value of 1.

At sites containing mixed radioactive and other hazardous substances, evaluate the degradation factor separately for each radionuclide and for each nonradioactive hazardous substance, even if the available data indicate that they are combined chemically. Assign a degradation factor value to each radionuclide as specified in this section and to each nonradioactive hazardous substance as specified in section 5.2.1.2.1.2. If no radioactive half-life information is available for a radionuclide and the substance is not already assigned a value of 1, unless information indicates otherwise, assign a value of 1. Similarly, if no half-life information is available for a nonradioactive substance, and the substance is not already assigned a value of 1, unless information indicates otherwise, assign a value of 1. When combined chemically, assign a single persistence or degradation factor value based on the higher of the two values assigned (individually) to the radioactive and nonradioactive components.

7.2.4 *Selection of substance potentially posing greatest hazard.* For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway and each migration pathway (or threat, aquifer, or watershed, as appropriate), select the radioactive substance or nonradioactive hazardous substance that potentially poses the greatest hazard based on its toxicity factor value, combined with the applicable mobility, persistence, degradation and/or bioaccumulation (or ecosystem bioaccumulation) potential factor values. Combine these factor values as specified in sections 2 through 6. For the soil exposure component of the soil exposure and subsurface intrusion pathway, base the selection on the toxicity factor alone (see sections 2 and 5).

* * * * *

7.2.5.1 *Source hazardous waste quantity for radionuclides.* For each migration pathway, assign a source hazardous waste quantity value to each source having a containment factor value greater than 0 for the pathway being evaluated. For the soil exposure component of the soil exposure and subsurface intrusion pathway, assign a source hazardous waste quantity value to each area of observed contamination, as applicable to the threat being evaluated. For the subsurface intrusion component, assign a source hazardous waste quantity value to each regularly occupied structure located within areas of observed exposure or areas of subsurface contamination. Allocate hazardous substances and hazardous wastestreams to specific sources (or areas of observed contamination, areas of observed exposure or areas of subsurface contamination) as specified in sections 2.4.2 and 5.2.0.

7.2.5.1.1 *Radionuclide constituent quantity (Tier A).* Evaluate radionuclide constituent quantity for each source (or area of observed contamination or area of observed exposure) based on the activity content of the radionuclides allocated to the source (or area of observed contamination or area of observed exposure) as follows:

• Estimate the net activity content (in curies) for the source (or area of observed contamination or area of observed exposure) based on:

—Manifests, or

—Either of the following equations, as applicable:

$$N = 9.1x10^{-7}(V)\sum_{i=1}^{n} AC_i$$

Where:

N=Estimated net activity content (in curies) for the source (or area of observed contamination or area of observed exposure).

V=Total volume of material (in cubic yards) in a source (or area of observed contamination or area of observed exposure) containing radionuclides.

$AC_i$=Activity concentration above the respective background concentration (in pCi/g) for each radionuclide i allocated to the source (or area of observed contamination or area of observed exposure).

n=Number of radionuclides allocated to the source (or area of observed contamination or area of observed exposure) above the respective background concentrations.

or,

$$N = 3.8x10^{-12}(V)\sum_{i=1}^{n} AC_i$$

Where:

N=Estimated net activity content (in curies) for the source (or area of observed contamination or area of observed exposure).

V=Total volume of material (in gallons) in a source (or area of observed contamination or area of observed exposure) containing radionuclides.

$AC_i$=Activity concentration above the respective background concentration (in pCi/1) for each radionuclide i allocated to the source (or area of observed contamination or area of observed exposure).

n=Number of radionuclides allocated to the source (or area of observed contamination or area of observed exposure) above the respective background concentrations.

—Estimate volume for the source (or volume for the area of observed contamination or area of observed exposure) based on records or measurements.

—For the soil exposure component of the soil exposure and subsurface intrusion pathway, in estimating the volume for areas of observed contamination, do not include more than the first 2 feet of depth, except: for those types of areas of observed contamination listed in Tier C of Table 5–2 (section 5.1.1.2.2), include the entire depth, not just that within 2 feet of the surface.

—For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, in estimating the volume for areas of observed exposure, only use the volume of air in the regularly occupied structures where observed exposure has been documented.

• Convert from curies of radionuclides to equivalent pounds of nonradioactive hazardous substances by multiplying the activity estimate for the source (or area of observed contamination or area of observed exposure) by 1,000.

• Assign this resulting product as the radionuclide constituent quantity value for the source (or area of observed contamination or area of observed exposure).

If the radionuclide constituent quantity for the source (or area of observed contamination or area of observed exposure) is adequately determined (that is, the total activity of all radionuclides in the source and releases from the source [or in the area of observed contamination or area of observed exposure] is known or is estimated with reasonable confidence), do not evaluate the radionuclide wastestream quantity measure in section 7.2.5.1.2. Instead, assign radionuclide wastestream quantity a value of 0 and proceed to section 7.2.5.1.3. If the radionuclide constituent quantity is not adequately determined, assign the source (or area of observed contamination or area of observed exposure) a value for radionuclide constituent quantity based on the available data and proceed to section 7.2.5.1.2.

7.2.5.1.2 Radionuclide wastestream quantity (Tier B). Evaluate radionuclide wastestream quantity for the source (or area of observed contamination, area of observed exposure, or area of subsurface contamination) based on the activity content of radionuclide wastestreams allocated to the source (or area of observed contamination, area of observed exposure, or area of subsurface contamination) as follows:

• Estimate the total volume (in cubic yards or in gallons) of wastestreams containing radionuclides allocated to the source (or area of observed contamination, area of observed exposure, or area of subsurface contamination).

• Divide the volume in cubic yards by 0.55 (or the volume in gallons by 110) to convert to the activity content expressed in terms of equivalent pounds of nonradioactive hazardous substances.

• Assign the resulting value as the radionuclide wastestream quantity value for the source (or area of observed contamination, area of observed exposure, or area of subsurface contamination).

• For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, estimate the total wastestream volume for all regularly occupied structures that have a containment value >0 and that are located within areas of observed exposure with observed or inferred intrusion, and

within areas of subsurface contamination. Calculate the volume of each regularly occupied structure based on actual data. If unknown, use a ceiling height of 8 feet.

7.2.5.1.3 Calculation of source hazardous waste quantity value for radionuclides. Select the higher of the values assigned to the source (or area of observed contamination, area of observed exposure, and/or area of subsurface contamination) for radionuclide constituent quantity and radionuclide wastestream quantity. Assign this value as the source hazardous waste quantity value for the source (or area of observed contamination, area of observed exposure, or area of subsurface contamination). Do not round to the nearest integer.

7.2.5.2 Calculation of hazardous waste quantity factor value for radionuclides. Sum the source hazardous waste quantity values assigned to all sources (or areas of observed contamination, areas of observed exposure, or areas of subsurface contamination) for the pathway being evaluated and round this sum to the nearest integer, except: if the sum is greater than 0, but less than 1, round it to 1. Based on this value, select a hazardous waste quantity factor value for this pathway from Table 2–6 (section 2.4.2.2).

For a migration pathway, if the radionuclide constituent quantity is adequately determined (see section 7.2.5.1.1) for all sources (or all portions of sources and releases remaining after a removal action), assign the value from Table 2–6 as the hazardous waste quantity factor value for the pathway. If the radionuclide constituent quantity is not adequately determined for one or more sources (or one or more portions of sources or releases remaining after a removal action), assign a factor value as follows:

• If any target for that migration pathway is subject to Level I or Level II concentrations (see section 7.3), assign either the value from Table 2–6 or a value of 100, whichever is greater, as the hazardous waste quantity factor value for that pathway.

• If none of the targets for that pathway is subject to Level I or Level II concentrations, assign a factor value as follows:

—If there has been no removal action, assign either the value from Table 2–6 or a value of 10, whichever is greater, as the hazardous waste quantity factor value for that pathway.

—If there has been a removal action:

▪ Determine values from Table 2–6 with and without consideration of the removal action.

▪ If the value that would be assigned from Table 2–6 without consideration of the removal action would be 100 or greater, assign either the value from Table 2–6 with consideration of the removal action or a value of 100, whichever is greater, as the hazardous waste quantity factor value for the pathway.

▪ If the value that would be assigned from Table 2–6 without consideration of the removal action would be less than 100, assign a value of 10 as the hazardous waste quantity factor value for the pathway.

For the soil exposure component of the soil exposure and subsurface intrusion pathway, if the radionuclide constituent quantity is adequately determined for all areas of observed contamination, assign the value from Table 2–6 as the hazardous waste quantity factor value. If the radionuclide constituent quantity is not adequately determined for one or more areas of observed contamination, assign either the value from Table 2–6 or a value of 10, whichever is greater, as the hazardous waste quantity factor value.

For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, if the radionuclide constituent quantity is adequately determined for all areas of observed exposure, assign the value from Table 2–6 as the hazardous waste quantity factor value. If the radionuclide constituent quantity is not adequately determined for one or more areas of observed exposure, assign either the value from Table 2–6 or a value of 10, whichever is greater, as the hazardous waste quantity factor value.

7.2.5.3 Calculation of hazardous waste quantity factor value for sites containing mixed radioactive and other hazardous substances. For each source (or area of observed contamination, area of observed exposure, or area of subsurface contamination) containing mixed radioactive and other hazardous substances, calculate two source hazardous waste quantity values—one based on radionuclides as specified in sections 7.2.5.1 through 7.2.5.1.3 and the other based on the nonradioactive hazardous substances as specified in sections 2.4.2.1 through 2.4.2.1.5, and sections 5.1.1.2.2, 5.1.2.2.2 and 5.2.1.2.2 (that is, determine each value as if the other type of substance was not present). Sum the two values to determine a combined source hazardous waste quantity value for the source (or area of observed contamination, area of observed exposure, or area of subsurface contamination). Do not round this value to the nearest integer.

Use this combined source hazardous waste quantity value to calculate the hazardous waste quantity factor value for the pathway as specified in section 2.4.2.2, except: if either the hazardous constituent quantity or the radionuclide constituent quantity, or both, are not adequately determined for one or more sources (or one or more portions of sources or releases remaining after a removal action) or for one or more areas of observed contamination or areas of observed exposure, as applicable, assign the value from Table 2–6 or the default value applicable for the pathway, whichever is greater, as the hazardous waste quantity factor value for the pathway.

7.3 Targets. For radioactive substances, evaluate the targets factor category as specified in section 2.5 and sections 3 through 6, except: Establish Level I and Level II concentrations at sampling locations as specified in sections 7.3.1 and 7.3.2 and establish weighting factors for populations associated with an area of subsurface contamination in the subsurface intrusion component of the soil exposure and subsurface intrusion pathway as specified in section 7.3.3.

For all pathways (components and threats), use the same target distance limits for sites containing radioactive substances as is specified in sections 3 through 6 for sites containing nonradioactive hazardous substances. At sites containing mixed radioactive and other hazardous substances, include all sources (or areas of observed contamination, areas of observed exposure, or areas of subsurface contamination) at the site in identifying the applicable targets for the pathway.

7.3.1 *Level of contamination at a sampling location.* Determine whether Level I or Level II concentrations apply at a sampling location (and thus to the associated targets) as follows:

• Select the benchmarks from section 7.3.2 applicable to the pathway (or component or threat) being evaluated.

• Compare the concentrations of radionuclides in the sample (or comparable samples) to their benchmark concentrations for the pathway (or component or threat) as specified in section 7.3.2. Treat comparable samples as specified in section 2.5.1.

• Determine which level applies based on this comparison.

• If none of the radionuclides eligible to be evaluated for the sampling location have an applicable benchmark, assign Level II to the actual contamination at that sampling location for the pathway (or component or threat).

• In making the comparison, consider only those samples, and only those radionuclides in the sample, that meet the criteria for an observed release (or observed contamination or observed exposure) for the pathway, except: Tissue samples from aquatic human food chain organisms may also be used for the human food chain threat of the surface water pathway as specified in sections 4.1.3.3 and 4.2.3.3.

7.3.2 *Comparison to benchmarks.* Use the following media specific benchmarks (expressed in activity units, for example, pCi/l for water, pCi/kg for soil and for aquatic human food chain organisms, and pCi/m3 for air) for making the comparisons for the indicated pathway (or threat):

• Maximum Contaminant Levels (MCLs)—ground water migration pathway and drinking water threat in surface water migration pathway.

• Uranium Mill Tailings Radiation Control Act (UMTRCA) standards—soil exposure component of the soil exposure and subsurface intrusion pathway only.

• Screening concentration for cancer corresponding to that concentration that corresponds to the $10^{-6}$ individual cancer risk for inhalation exposures (air migration pathway and subsurface intrusion component of the soil exposure and subsurface intrusion pathway) or for oral exposures (ground water migration pathway; drinking water or human food chain threats in surface water migration pathway; and soil exposure and subsurface intrusion pathway).

—For the soil exposure component of the soil exposure and subsurface intrusion pathway, include two screening concentrations for cancer—one for ingestion of surface materials and one for external radiation exposures from gamma-emitting radionuclides in surface materials.

Select the benchmark(s) applicable to the pathway (component or threat) being

evaluated. Compare the concentration of each radionuclide from the sampling location to its benchmark concentration(s) for that pathway (component or threat). Use only those samples and only those radionuclides in the sample that meet the criteria for an observed release (or observed contamination or observed exposure) for the pathway, except: Tissue samples from aquatic human food chain organisms may be used as specified in sections 4.1.3.3 and 4.2.3.3. If the concentration of any applicable radionuclide from any sample equals or exceeds its benchmark concentration, consider the sampling location to be subject to Level I concentrations for that pathway (component or threat). If more than one benchmark applies to the radionuclide, assign Level I if the radionuclide concentration equals or exceeds the lowest applicable benchmark concentration. In addition, for the soil exposure and subsurface intrusion pathway, assign Level I concentrations at the sampling location if measured gamma radiation exposure rates equal or exceed 2 times the background level (see section 7.1.1).

If no radionuclide individually equals or exceeds its benchmark concentration, but more than one radionuclide either meets the criteria for an observed release (or observed contamination or observed exposure) for the sample or is eligible to be evaluated for a tissue sample (see sections 4.1.3.3 and 4.2.3.3), calculate a value for index I for these radionuclides as specified in section 2.5.2. If I equals or exceeds 1, assign Level I to the sampling location. If I is less than 1, assign Level II.

At sites containing mixed radioactive and other hazardous substances, establish the level of contamination for each sampling location considering radioactive substances and nonradioactive hazardous substances separately. Compare the concentration of each radionuclide and each nonradioactive hazardous substance from the sampling location to its respective benchmark concentration(s). Use only those samples and only those substances in the sample that meet the criteria for an observed release (or observed contamination or observed exposure) for the pathway except: Tissue samples from aquatic human food chain organisms may be used as specified in sections 4.1.3.3 and 4.2.3.3. If the concentration of one or more applicable radionuclides or other hazardous substances from any sample equals or exceeds its benchmark concentration, consider the sampling location to be subject to Level I concentrations. If more than one benchmark applies to a radionuclide or other hazardous substance, assign Level I if the concentration of the radionuclide or other hazardous substance equals or exceeds its lowest applicable benchmark concentration.

If no radionuclide or other hazardous substance individually exceed a benchmark concentration, but more than one radionuclide or other hazardous substance either meets the criteria for an observed release (or observed contamination or observed exposure) for the sample or is eligible to be evaluated for a tissue sample, calculate an index I for both types of substances as specified in section 2.5.2. Sum the index I values for the two types of substances. If the value, individually or combined, equals or exceeds 1, assign Level I to the sample location. If it is less than 1, calculate an index J for the nonradioactive hazardous substances as specified in section 2.5.2. If J equals or exceeds 1, assign Level I to the sampling location. If J is less than 1, assign Level II.

7.3.3 Weighting of targets within an area of subsurface contamination. For the subsurface intrusion component of the soil exposure and subsurface intrusion pathway, assign a weighting factor as specified in section 5.2.1.3.2.3 except when a structure in an area of subsurface contamination is delineated or inferred to be delineated by gamma radiation exposure rates meeting observed release criteria with a depth to contamination of 2 feet or less. For those populations residing, working, or attending school or day care in a structure delineated or inferred to be delineated by gamma radiation exposure rates meeting observed release criteria with a depth to contamination of 2 feet or less, assign a weighting factor of 0.9.

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