

HUMAN HEALTH RISK ASSESSMENT SCREENING APPROACH FOR EVALUATING  
CONTAMINANTS AT SOURCE CONTROL AND INTEGRATOR OPERABLE UNITS

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## Human Health Risk Assessment Screening Approach for Evaluating Contaminants at Source Control and Integrator Operable Units

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### EXECUTIVE SUMMARY

The difficulties associated with obtaining quality site characterization data and the need to streamline the Remedial Investigation/Feasibility Study process at Department of Energy-Oak Ridge/Environmental Restoration Division (DOE-OR/ERD) sites has prompted the proposition that at certain DOE-OR/ERD sites it is appropriate to perform human health screening risk assessments but not full baseline risk assessments. These screening risk assessments would then be used to support an Interim Record of Decision. Interim remedial actions would be used to clean up the sites in a timely and expeditious manner. This report describes proposed approaches and strategies for performing these screening risk assessments at DOE-OR/ERD sites, and details the major components of a screening risk assessment.

On-site waste areas that are not accessible to the general public and that release contaminants into the environment are defined as Source Control Operable Units. Screening risk assessments will be performed at Source Control Operable Units in order to support Interim Records of Decisions and Interim Remedial Actions that mitigate immediate potential risks to on-site human receptors and control releases of contaminants to the environment.

Off-site Operable Units and on-site watersheds that may receive contaminants from any number of on-site Operable Units are known as Integrator Operable Units. Full scale baseline risk assessments will be performed at all Integrator Operable Units in order to estimate risks to on-site and off-site receptors and to support the final Record of Decision.

The two approaches used in the screening risk assessments provide the assessor with an upper-bound and lower-bound risk estimation. Actual risks to a potential maximally exposed individual are believed to lie somewhere between the risk estimates provided by the upper- and the lower-bound screening approaches.

The upper-bound screening approach is highly unlikely to underestimate the potential maximum exposure of an individual, but may substantially overestimate the actual exposure to an individual. The upper-bound approach is used, therefore, to identify sites that definitely **do not** pose a threat to human health or the environment because the conservatively biased risk estimates are sufficiently low.

The lower-bound screening approach provides a more realistic estimate of exposure and should not substantially overestimate the maximum exposure to an individual. However, under some circumstances, lower-bound screening could underestimate maximum exposure. Thus, the lower-bound approach is used to identify sites that definitely or potentially **do pose** a threat because the risk estimates are sufficiently high. Such sites, therefore, may require interim remedial actions. For Source Control Operable Units, the lower-bound screening approach should be performed before the upper-bound approach. If the lower-bound approach identifies unacceptable risks, then there is no point in performing the upper-bound risk estimation.

Screening risk assessments consider three exposure scenarios under current conditions: two lower-bound scenarios and one upper-bound scenario. Lower-bound exposure Scenario I is analogous to an intruder scenario and is created to represent a realistic, though improbable, situation that could occur. The intruder scenario selected is for an individual who is a hunter and fisherman and who illegally enters the operable unit boundary for this purpose. Lower-bound exposure Scenario II is analogous to an occupational

scenario and represents the exposure of a general plant employee to site related contaminants and not the exposure of a worker involved in remedial action. The upper-bound scenario is analogous to a potential residential scenario and is created for upper-bound screening purposes only.

The proposed approach recognizes the uncertainties associated with the cleanup process, particularly regarding the derivation of human health risk estimates. The approach is tailored for early identification of sites of immediate concern, early remediation of such sites, and the early identification of low risk sites that can be eliminated from further investigations. The purpose of the screening risk assessment is to hasten the clean-up process and to do so in a cost-effective manner.

## 1.0 PURPOSE

The clean-up of hazardous waste sites under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) is a complicated and painstaking process, particularly at facilities with a multitude of individual hazardous waste sites, each of which with a multitude of chemicals and radionuclides (EPA 1988). The Department of Energy Field Office, Oak Ridge, Environmental Restoration Division (DOE-OR/ERD) administers five such facilities which are undergoing environmental clean-up under the CERCLA Remedial Investigation and Feasibility Study (RI/FS) process or the Resource Conservation and Recovery Act (RCRA) investigation process. The nature of the wastes which have been treated, stored or disposed of at the DOE-OR/ERD sites is heterogeneous and often unknown. The amount of environmental sampling, chemical analysis, document preparation and review required to support a baseline risk assessment at each facility, often requires many years to arrive at a final Record of Decision (ROD) (EPA 1989, 1990a). Thus, there is clearly a need to streamline the investigative and decision processes in order to realize the Environmental Protection Agency's (EPA's) goal of reducing contaminant levels to those that are protective of human health and the environment in a timely and cost-effective manner (EPA 1990b). Furthermore, it may not be practicable to characterize the waste with sufficient certainty to justify performing a detailed RI/FS.

The difficulties associated with obtaining quality site characterization data and the need to streamline the cleanup process has prompted the recommendation that at certain DOE-OR/ERD sites it is appropriate to perform screening risk assessments and not baseline risk assessments. These screening risk assessments would then be used to support an interim ROD (IROD) (EPA 1991a). Interim Response Actions would then be used to clean up the sites in a timely and expeditious manner. The purpose of this report is to describe the proposed approaches and strategies for performing these screening risk assessments at DOE-OR/ERD sites and to detail the major components of a screening risk assessment.

## 2.0 SCOPE

The screening approaches proposed in this report apply to all hazardous waste sites under the auspices of the DOE-OR/ERD and are described for human health risk assessment only. Screening ecological risk assessment approaches are not within the scope of this report. It is expected that the approaches discussed here will be compatible with ecological risk assessment strategies already developed for DOE-OR/ERD sites (Suter et al. 1992). The scope of this report is confined to descriptions of general approaches and components of screening risk assessments. Specific issues regarding implementation of screening risk assessments at individual DOE-OR/ERD sites must be addressed on a case by case basis.

## 3.0 APPROACH

Operable Units or their equivalents have been defined in both on-site and off-site areas at the five DOE-OR/ERD facilities. Currently, access by the public is prohibited at the majority of hazardous waste sites under the auspices of the DOE-OR/ERD. Fences, armed security guards, and patrols exclude the public from on-site areas (on-site refers to any of the property currently owned and operated by the DOE-OR). However, many of these fenced areas are sources of contaminants known to have been released or known to have migrated into off-site areas that are accessible to the general public. As such, the operable units have been separated into two categories: Integrator Operable Units and Source Control Operable Units.

Integrator Operable Units are defined as off-site (and the on-site watershed) Operable Units which receive contaminants from any number of on-site Operable Units via groundwater and surface water pathways. Baseline risk assessments will be performed at all Integrator Operable Units (and other sites that are accessible to the general public) in order to estimate risks to on-site and off-site receptors and to support the final Record of Decision.

Source Control Operable Units are defined as On-site waste areas that are not accessible to the general public and that release contaminants into specific groundwater and surface water regimes. Screening risk assessments will be performed at Source Control Operable Units in order to support Interim Records of Decisions (IRODs) and Interim Response Actions to mitigate immediate potential risks to on-site human receptors, and control releases of contaminants to the environment.

It is important to note that screening risk assessments will be performed at both Integrator and Source Control Operable Units. Although the general approaches and components of the screening risk assessments will be similar for the two types of Operable Units, the objectives are different. Screening approaches have already been developed for Integrator Operable Units (Blaylock et al. 1991, Hoffman et al. 1991) and have been adapted by the authors and presented in this document so that they can be applied to on-site Source Control Operable Units.

For Integrator Operable Units the primary purpose of the screening risk assessment is to use existing data to identify and prioritize potential contaminants of concern for further evaluation and investigation. Thus, the screening risk assessment aids in focusing the sampling efforts on areas and contaminants that are the primary drivers of total potential risks (Blaylock et al. 1991, Hoffman et al. 1991). Full baseline risk assessments are subsequently performed for those areas and contaminants.

For Source Control Operable Units, the primary purpose of the screening risk assessment is to identify sites that do and sites that do not represent an immediate threat to human health, and to support IRODs and any immediate remedial actions that are required. The screening risk assessments for Source Control Operable Units also identify sites that are potential sources of contaminants to be evaluated in the Integrator Operable Units. Full baseline risk assessments will not generally be performed at Source Control Operable Units.

#### **4.0 UPPER-BOUND VERSUS LOWER-BOUND SCREENING APPROACHES**

The approach used in the screening risk assessments provides the assessor with two estimates: an upper-bound and a lower-bound risk estimation. The upper-bound screening approach is highly unlikely to underestimate the potential maximum exposure of an individual, but may substantially overestimate the actual exposure to an individual. The upper-bound approach is used, therefore, to identify sites that definitely do not pose a threat to human health or the environment because the conservatively biased risk estimates are sufficiently low. The lower-bound screening approach provides a more realistic estimate of exposure and should not substantially overestimate the maximum exposure of an individual. However, under some circumstances, lower-bound screening could underestimate maximum exposure. Thus, actual risks to a potential maximally exposed individual are believed to lie somewhere between the risk estimates provided by the upper- and the lower-bound screening approaches.

The lower-bound approach is used to identify sites that definitely or potentially **do pose** a threat because the risk estimates are sufficiently high. Such sites, therefore, may require interim remedial actions. For Source Control Operable Units, the lower-bound screening approach should be performed before the upper-bound approach. If the lower-bound approach identifies unacceptable risks, then there is no point in proceeding with the upper-bound estimate (other than to address potential bias in the exposure and/or toxicity assumptions and to begin to investigate interim remedial alternatives).

#### **5.0 SCREENING INDICES**

The screening index for a carcinogen is an estimate of the lifetime risk of excess cancer. The index is calculated by multiplying the exposure dose of the contaminant (where exposure occurs via external exposure, ingestion, dermal contact or inhalation) by the EPA-approved slope factor for radioactive and non-

radioactive substances. (EPA 1989). In general, the EPA slope factors are the upper 95th percent confidence limit of the slopes of the dose-response curves generated by laboratory studies. These will be used in the upper-bound screening risk assessments. The lower-bound approach will use the geometric mean of the slopes of the dose-response curves to generate a less conservative slope factor for each contaminant. The Martin Marietta Energy Systems, Inc., Environmental Restoration Program's Central Risk Assessment Council (CRAC) should be consulted when deriving these geometric mean slope factors.

The screening index for non-carcinogens is an estimate of the daily ingestion or inhalation dose of the contaminant divided by an EPA-approved Reference Dose (oral exposure) or Reference Concentration (inhalation exposure), the daily exposure level below which adverse effects should not occur (EPA 1989). In general, the EPA derives Reference Doses and Reference Concentrations by adjusting a No-Observed-Adverse-Effects-Level by an uncertainty factor (ranging from 1 to 10,000). The value of the uncertainty factor depends on the degree of uncertainty inherent in extrapolating from species to species, from short-term exposures to chronic exposures, and from Lowest-Observed-Adverse-Effects-Levels to No-Observed-Adverse-Effects-Levels, and to account for the possible existence of sensitive individuals and for the lack of certain kinds of toxicological data. The EPA-derived RfD will be used for the upper-bound screening. For screening assessment purposes, the lower-bound approach will use an alternative method (e.g., the square root of the uncertainty factor) to generate a less conservative Reference Dose for a given contaminant. CRAC should be consulted when deriving these lower-bound Reference Doses.

To estimate the potential risks from all contaminants in a particular exposure pathway, the screening indices are summed for all contaminants in the pathway. Summation is conducted separately for carcinogens and non-carcinogens. For the upper-bound screen, in order to estimate the potential risk from exposure to multiple pathways, the screening indices are summed across all pathways. Multiple pathways are not considered in the lower-bound screen.

## 6.0 ENVIRONMENTAL DATA

For screening risk assessments, exposure concentrations will generally be based on the available on-site sampling or inventory data. No fate and transport modeling will be necessary because the baseline risk assessment for the Integrator Operable Unit receiving contaminants from the Source Control Operable Units will evaluate the relevant monitoring data in the media of concern. Multiple data sets (e.g., from different years) will be used where possible, and statistical differences associated with comparisons of the data sets will be addressed on a case-by-case basis, as will the need for additional data. All decisions regarding data needs require consultation with and approval by CRAC.

Should additional samples be required, screening risk assessments demand Level II quality analytical data or their equivalent (EPA 1987). However, if preliminary investigations during project scoping indicate an eventual decision of no further action, then at least 10% of the samples must be analyzed with Level III quality analytical methods or their equivalent. If a no further action is not initially suspected, but the results of the screening risk assessment subsequently point to a decision of no further action, then a limited set of additional samples must be analyzed with Level III quality analytical methods or their equivalent in order to verify the results of the screening risk assessment.

Groundwater data are used only if they can be linked to the individual site under investigation. Such a link can only be made if contaminant concentrations in the groundwater from immediately down-gradient or on-site wells are significantly higher than in upgradient wells. Additional wells will not be constructed solely to support a screening risk assessment unless preliminary information suggests that groundwater is a significant exposure pathway of concern. If groundwater is not determined to be a significant exposure pathway for a Source Control Operable Unit, and if groundwater contaminants cannot be linked to releases from the individual unit, then the assessment of potential exposures to releases to the groundwater will be deferred to the appropriate Integrator Operable Unit.

Surface water data are only collected and evaluated for naturally occurring water bodies. Storm water runoff and waste stream discharges will only be evaluated to the extent that they contribute to elevated concentrations in the standing water body.

Comparable and representative reference/background data for media of potential concern will be addressed in the screening risk assessment. Naturally occurring metals (including radionuclides) may be eliminated from consideration in the screening risk assessment if on-site concentrations are not significantly greater than reference/background (provided reference/background concentrations do not themselves represent risks to human health) and there is no reason to suspect that on-site concentrations are associated with past or present activities at the site.

Exposure concentrations used in the screening risk assessment are estimated by the upper 95% confidence limit of the arithmetic mean of the site data for the upper-bound approach, and by the geometric mean for the lower-bound approach. The geometric mean is used as a lower-bound estimate of the exposure concentration because it is more indicative of the midpoint or median of a distribution and is often less conservative than the arithmetic mean (which is usually driven by the highest values in a distribution).

## **7.0 EXPOSURE SCENARIOS AND EXPOSURE PATHWAYS**

Screening risk assessments will consider three exposure scenarios under current conditions: two lower-bound scenarios and one upper-bound scenario. Lower-bound exposure Scenario I is analogous to an intruder scenario and is created to represent a realistic, though highly improbable, situation that could occur. The intruder scenario selected is for an individual who is a hunter and fisherman and who inadvertently enters the operable unit boundary for this purpose. Lower-bound exposure Scenario II is analogous to an occupational scenario and is created to represent a general plant employee who is not a worker involved in remedial action. The upper-bound scenario is analogous to a potential residential scenario and is created for upper-bound screening purposes only.

### **7.1 Exposure Pathways for the Lower-bound Scenario I**

Six exposure pathways are considered for this scenario: (1) external exposure to radiation in soil/sediment, (2) ingestion of soil/sediment, (3) inhalation of wind-generated dust, (4) dermal contact with soil, (5) ingestion of deer meat, and (6) ingestion of fish. Lower-bound approaches only evaluate contaminant concentration data that are obtained from direct measurements in the media of concern. Therefore, ingestion of deer meat and of fish is only considered if tissue concentration data are available and if contamination can be attributed to releases from the site and uptake through the food chain. Due to the movement of deer and fish across Operable Unit boundaries, it will be possible to assess these pathways only at Integrator Operable Units and at the larger Source Control Operable Units. Also, ingestion of fish is only considered if there is a surface water body on the site that supports viable populations of fish.

Intake and exposure parameters for the six exposure pathways are provided in Table 1. The parameters were derived on the assumption that an adult enters the Operable Unit boundaries to fish 10 days per year for 25 years and remains in the area for four hours each day. He or she catches an average of 10 kg of fish per year of which 33% is edible tissue (Blaylock et al. 1991). The same adult enters the unit boundary an additional 10 days per year over the same 25 years to hunt deer and remains in the area for six hours each day. He or she kills an average of one deer per year weighing 54 kg, of which 33% is edible tissue (Blaylock et al. 1991). The intruder is assumed to eat all the game that is killed.

Table 1. Intake and Exposure Parameters for all scenarios

| Exposure Pathway                                    | Lower-bound Scenario I Exposure Parameters <sup>a</sup>   | Lower-bound Scenario II Exposure Parameters <sup>a</sup>  | Upper-bound Exposure Parameters <sup>a</sup>  |
|---|---|---|---|
| External exposure                                   | 100 hours/year <sup>b</sup>   | 200 hours/year  | 8400 hours/year <sup>c</sup>  |
| Soil/sediment ingestion                             | 0.05 g/day <sup>d</sup><br>20 days/year   | 0.005 g/day   | Carcinogens <sup>e</sup><br>0.2 g/day (6 years)<br>0.1 g/day (24 years)<br>Non-carcinogens <sup>f</sup><br>0.2 g/day  |
| Dust inhalation                                     | 10 m <sup>3</sup> /day<br>20 days/year  | 2 m <sup>3</sup> air/day  | 20 m <sup>3</sup> air/day   |
| Dermal contact with soil/sediment                   | Surface area <sup>g</sup><br>Hands: 0.082 m <sup>2</sup><br>Arms: 0.23 m <sup>2</sup><br>Adherence Factor: <sup>h</sup><br>1.0 mg/cm <sup>2</sup><br>Absorption Factor <sup>h</sup><br>Organics: 1%<br>Inorganics: 0.1%<br>1 hour/day<br>20 days/year | Surface area <sup>g</sup><br>Hands: 0.082 m <sup>2</sup><br>Arms: 0.23 m <sup>2</sup><br>Adherence Factor: <sup>h</sup><br>1.0 mg/cm <sup>2</sup><br>Absorption Factor <sup>h</sup><br>Organics: 1%<br>Inorganics: 0.1%<br>1 hour/day | Surface area <sup>g</sup><br>Hands: 0.082 m <sup>2</sup><br>Arms: 0.23 m <sup>2</sup><br>Adherence Factor: <sup>h</sup><br>1.0 mg/cm <sup>2</sup><br>Absorption Factor: <sup>h</sup><br>Organics: 1%<br>Inorganics: 0.1%<br>8 hours/day |
| Surface water &/or groundwater ingestion            | NA  | 0.1 liter/day   | 2 liters/day  |
| Inhalation of volatiles from soil                   | NA  | NA  | 20 m <sup>3</sup> air/day   |
| Inhalation of vapor phase chemicals while showering | NA  | NA  | 15 m <sup>3</sup> /day (indoor inhalation rate)<br>12 minutes/day showering   |

| Exposure Pathway    | Lower-bound Scenario I Exposure Parameters <sup>a</sup> | Lower-bound Scenario II Exposure Parameters <sup>a</sup>      | Upper-bound Exposure Parameters <sup>a</sup>   |
|---------------------|---|---|--|
| Deer meat ingestion | 18 kg/year <sup>i</sup>                                 | NA  | NA   |
| Fish ingestion      | 3 kg/year <sup>j</sup>                                  | NA  | 54 g/day                                       |
| All pathways        | 25 years<br>70 kg body weight                           | 8 hours/day<br>250 days/year<br>25 years<br>70 kg body weight | 350 days/year<br>30 years<br>70 kg body weight |

<sup>a</sup> Parameter values are the default values provided as EPA guidance (EPA 1989, 1991b, 1991c)

<sup>b</sup> External exposure based on hunting 6 hours/day, 10 days/year and fishing 4 hours/day

<sup>c</sup> External exposure based on 24 hours/day, 7 days/week, and 50 weeks/year

<sup>d</sup> Soil ingestion and inhalation rates are 50% of the adult daily values provided by the EPA (1989, 1991b, 1991c) due to the limited amount of time spent on the site.

<sup>e</sup> For ingestion of soil/sediment, total exposures to carcinogens are based on a 15 kg child ingesting 0.2 g/day for 6 years and a 70 kg adult ingesting 0.1 g/day for 24 years.

<sup>f</sup> For ingestion of soil/sediment, exposures to non-carcinogens are based on a 15 kg child consuming 0.2 g/day.

<sup>g</sup> 50th percentile adult body-part surface area (EPA 1989)

<sup>h</sup> Adherence factor and absorption factor based on EPA Region IV guidance

<sup>i</sup> Deer meat ingestion rate based on one 54 kg deer per year, of which 33% is edible.

<sup>j</sup> Fish ingestion rate based on 10 kg fish per year, of which 33% is edible.



## 7.2 Exposure Pathways for the Lower-Bound Scenario II

Five exposure pathways are considered for this scenario: (1) external exposure to radiation in soil/sediment, (2) ingestion of soil/sediment, (3) inhalation of wind-generated dust, (4) dermal contact with soil/sediment, and (5) ingestion of surface water and/or groundwater. The surface water pathway is only considered if there are data available for a naturally occurring water body on the site. The groundwater pathway is only considered if there are groundwater data available that can be related to releases from the site itself.

Intake and exposure parameters for the five exposure pathways are provided in Table 1. The parameters were derived based on the assumption that an adult enters the facility to work five days per week, 50 weeks per year for 25 years. Parameter values are generally the default occupational values provided as EPA guidance (EPA 1991b, 1991c) but are adjusted on the assumption that the subject spends only 10% of his or her working day within the boundaries of the individual Operable Unit under investigation.

## 7.3 Exposure Pathways for the Upper-bound Scenario

Eight exposure pathways are considered for the upper-bound scenario: (1) external exposure to radiation in soil/sediment, (2) ingestion of soil/sediment, (3) inhalation of wind-generated dust, (4) dermal contact with soil/sediment, (5) inhalation of volatiles from the soil, (6) ingestion of surface water and/or groundwater, (7) inhalation of vapor-phase chemicals while showering, and (8) ingestion of fish. The surface water pathways are only considered if there are contaminant concentration data available for a naturally occurring water body on the site. The groundwater pathways are only considered if there are groundwater data available that can be related to releases from the site itself. Ingestion of fish is only considered if there is a surface water body on the site that supports viable populations of fish.

Intake and exposure parameters for each of the upper-bound exposure pathways are provided in Table 1. Parameter values are the default values provided as EPA guidance (EPA 1989, 1991b, 1991c). Terrestrial food chain pathways (ingestion of crops, milk, and meat) are not included in Table 1. The purpose of an upper-bound screen is to identify sites (or contaminants) that are definitely not a threat to human health or the environment. The upper-bound screen would thus be used to support a no further action alternative if this were appropriate. If the eight pathways in Table 1 alone represent a threat (according to the screening criteria described in Section 8) then it is not necessary to evaluate food chain pathways. In this case, a no further action alternative would already be inappropriate, and the inclusion of the food chain pathways would simply add to the already unacceptable risks. However if the eight pathways alone do not represent a threat, then food chain pathways would have to be considered. Separate documentation on evaluating the food chain pathway is available upon request.

## 8.0 SCREENING CRITERIA

### 8.1 Lower-bound Screening Criteria

Lower-bound screening criteria for this report are summarized in Table 2. For each exposure scenario, a total cumulative screening index is calculated by summing the individual screening indices across all chemicals for a given pathway. Screening indices are not summed across pathways for the lower-bound scenarios.

For lower-bound screening of carcinogenic effects, Operable Units whose lifetime cancer risk levels (exposure multiplied by cancer slope factor) exceed  $10^{-4}$  are of immediate concern. The Focussed Feasibility Study process will be initiated in order to evaluate a limited range of remedial alternatives for the IROD. Operable Units whose risk levels lie between  $10^{-4}$  and  $10^{-6}$  are of potential concern. The need for Interim Remedial Measures or further remedial investigations will be negotiated with the regulators. All Source Control Operable Units identified as being of potential or immediate concern by lower-bound screening require monitoring and are given high priority in the Integrator Operable Units as sources of contaminants in the environment. Because lower-bound screening employs parameter values that should not overestimate maximum exposures, lower-bound screening is not used to identify Operable Units with low priority for

**Table 2. Criteria for lower-bound screening of carcinogenic and non-carcinogenic effects at Source Control Operable Units.**

| Screening Index  | Implications  |
|--|---|
| Risk < 10 <sup>-6a</sup><br>or<br>HI < 1 <sup>b</sup>      | <ul style="list-style-type: none"> <li>● Perform upper-bound screening assessment</li> </ul>  |
| 10 <sup>-6</sup> < Risk < 10 <sup>-4</sup><br>or<br>HI > 1 | <ul style="list-style-type: none"> <li>● Site of potential concern</li> <li>● Negotiate interim remedial actions</li> <li>● Include as source term in Integrator Operable Unit</li> <li>● Continued monitoring required</li> <li>● Further investigations considered</li> <li>● Uncertainty analysis</li> </ul> |
| Risk > 10 <sup>-4</sup>                                    | <ul style="list-style-type: none"> <li>● Risk levels are potentially of immediate concern</li> <li>● Initiate IROD/FFS and interim remedial measures</li> <li>● Include as source term in Integrator Operable Unit</li> <li>● Continued monitoring required</li> <li>● Uncertainty analysis</li> </ul>          |

<sup>a</sup> Risk - exposure multiplied by lifetime cancer slope factor

<sup>b</sup> HI - Hazard Index, exposure divided by Reference Dose

further consideration. Sites whose lower-bound risk levels are lower than 10<sup>-6</sup> will require an upper-bound screening assessment.

For lower-bound screening of non-carcinogenic effects, Operable Units whose Hazard Indices (exposure divided by Reference Dose or Reference Concentration) exceed unity are of potential or immediate concern. The need to implement immediate Interim Remedial Measures will depend on a number of factors, including (1) the lifetime cancer risk estimates associated with the site, (2) the magnitude of the Hazard Index - there may be reason to expect that sites with extremely high Hazard Indices (exposures greatly exceed Reference Doses) to be particularly hazardous, even though EPA methodology assumes a threshold of non-carcinogenic effects, and (3) negotiations with the regulators. Sites whose lower-bound Hazard Indices are less than unity will require an upper-bound screening risk assessment.

## 8.2 Upper-bound Screening

Upper-bound screening criteria for this report are summarized in Table 3. For each exposure scenario, a total cumulative screening index is calculated by summing the individual screening indices across all chemicals for a given pathway and then summing across all pathways included in the exposure scenario.

For upper-bound screening, Operable Units whose lifetime cancer risk levels are less than 10<sup>-6</sup> are considered not of potential concern. However, two stipulations must be met before a decision of no further action can be reached. First, potential future risks must be evaluated. If future risks are greater than 10<sup>-6</sup> then a decision of no further action cannot be made. Second, at the very least, a limited quantity of Level III quality or equivalent analytical data must be obtained (if this has not already been done) in order to verify the results and to support any decision of no further action.

Operable Units whose risk levels lie between  $10^{-4}$  and  $10^{-6}$  will require monitoring but are of low priority for further consideration. However, Source Control Operable Units whose risk levels lie within this range will need to be included as source terms for the relevant Integrator Operable Unit.

For upper-bound screening of non-carcinogenic effects, Operable Units whose Hazard Indices are less than unity are considered not of potential concern. However, fate and transport models will be used to determine whether future hazards are of concern. In addition, Level III quality analytical data will be evaluated in order to support any decision of no further action.

Operable Units whose upper-bound Hazard Indices exceed unity will require monitoring and will be included as source terms for the relevant Integrator Operable Unit. Upper-bound screening indices are not used as criteria to identify Operable Units that are of potential high priority.

Please note that the above discussion refers to how screening criteria are used to identify sites that are or are not of potential concern. Thus, it would appear that the discussion applies most directly to Source Control Operable Unit screening risk assessments (see Section 3). Integrator Operable Unit screening risk assessments focus on identifying contaminants or areas of study that are or are not of potential concern. The same screening criteria are used to identify contaminants or areas of potential concern. Therefore, the above discussion and Tables 2 and 3 can, in fact, be applied to Integrator Operable Units too.

**Table 3. Criteria for upper-bound screening of carcinogenic and non-carcinogenic effects at Source Control Operable Units.**

| Screening Index                              | Implications   |
|--|--|
| Risk < $10^{-6}$<br>or<br>HI < 1             | IF, <ul style="list-style-type: none"> <li>• The results of the screening risk assessment have been verified with Level III data, and</li> <li>• The evaluation of potential future risks indicates that future risks are &lt; <math>10^{-6}</math></li> </ul> THEN <ul style="list-style-type: none"> <li>• The site is not considered a significant source of contaminants, and</li> <li>• No further consideration is required</li> </ul> |
| $10^{-6}$ < Risk < $10^{-4}$<br>or<br>HI > 1 | <ul style="list-style-type: none"> <li>• The site is determined to be a low priority for further consideration, but</li> <li>• Will be included as a source term for the associated Integrator Operable Unit, and</li> <li>• Continued monitoring is required</li> </ul>   |

## 9.0 UNCERTAINTY ANALYSES

The screening risk methodology described above is itself a limited uncertainty analysis. Lower and upper bound risk estimates are derived so that the true risks are certain to lie somewhere between the two estimates. Full quantitative uncertainty analyses will not be included in the screening risk assessments. However, qualitative statements regarding the parameters and assumptions contributing to overall uncertainty should be made, along with the expected consequences of these uncertainties. After initial screening, the baseline risk assessment should include a quantitative uncertainty analysis for all contaminants designated as

warranting further investigation and continued monitoring. Guidelines for performing uncertainty analysis will be issued in the near future by CRAC.

## **10.0 IROD DEVELOPMENT**

Clearly, the development of the IROD and the types of interim remedial actions evaluated in the Focused Feasibility Study (FFS) will depend on the exposure scenario(s) of concern (Table 4). Lower-bound exposure scenario I is analogous to an intruder scenario and is created to represent a realistic, though highly improbable, situation that could occur under current conditions. If this scenario is of potential concern then continued monitoring, active response measures, and maintenance or enhancement of current institutional control practices would be a primary interim remedial alternative. Final remedial action alternatives will depend on the results of the relevant Integrator Unit risk assessment and the associated screening ecological assessment.

Lower-bound exposure scenario II is analogous to an occupational scenario and is created to represent risks to a general plant employee under current conditions. If this scenario is of potential concern, then this would indicate that current occupational health and safety measures need to be maintained or enhanced.

More active response measures would need to be addressed in the FFS and IROD for sites that are an immediate threat to human health. In such cases, remedial measures would be directed at the prime drivers of the risks. Remedial action goals would be set at Applicable or Relevant and Appropriate Requirements (Etnier and Weaver 1990) or at conservative health-based guideline values, but would not be set below background concentrations or lowest available detection limits. While active Interim Remedial Measures at Source Control Operable Units are triggered by lower-bound risk assessment values, they should be targeted toward conservative remediation goals. This is because interim measures must support the final Record of Decision made after the appropriate Integrator Operable Unit has been assessed. It is imperative that interim remediation measures will not have to be "redone" at a later date.

## **11.0 IMPLEMENTATION OF SOURCE CONTROL AND INTEGRATOR OPERABLE UNIT STRATEGY**

Figure 1 depicts how screening and full baseline risk assessments will be implemented at Source Control and Integrator Operable Units. Screening risk assessments for Source Control Operable Units will be performed in parallel with risk assessments for the Integrator Operable Unit that they potentially impact. For Source Control Operable Units, screening risk assessments will identify sites that require Interim Remedial Measures and that are potential sources of releases to an Integrator Operable Unit. For Integrator Operable Units, screening risk assessments and subsequent full baseline risk assessments will be used to identify contaminants that are of potential concern. For each contaminant of concern identified at the Integrator Operable Unit, the screening risk assessment for each Source Control Operable Unit will be addressed to determine which sites are potential sources. Fate and transport models will be used where necessary to determine the Source Control Operable Units that are the prime drivers of risks for the given contaminant in the Integrator Operable Unit. Feasibility Studies will then be initiated in order to support the Final Record of Decision.

## **12.0 SUMMARY**

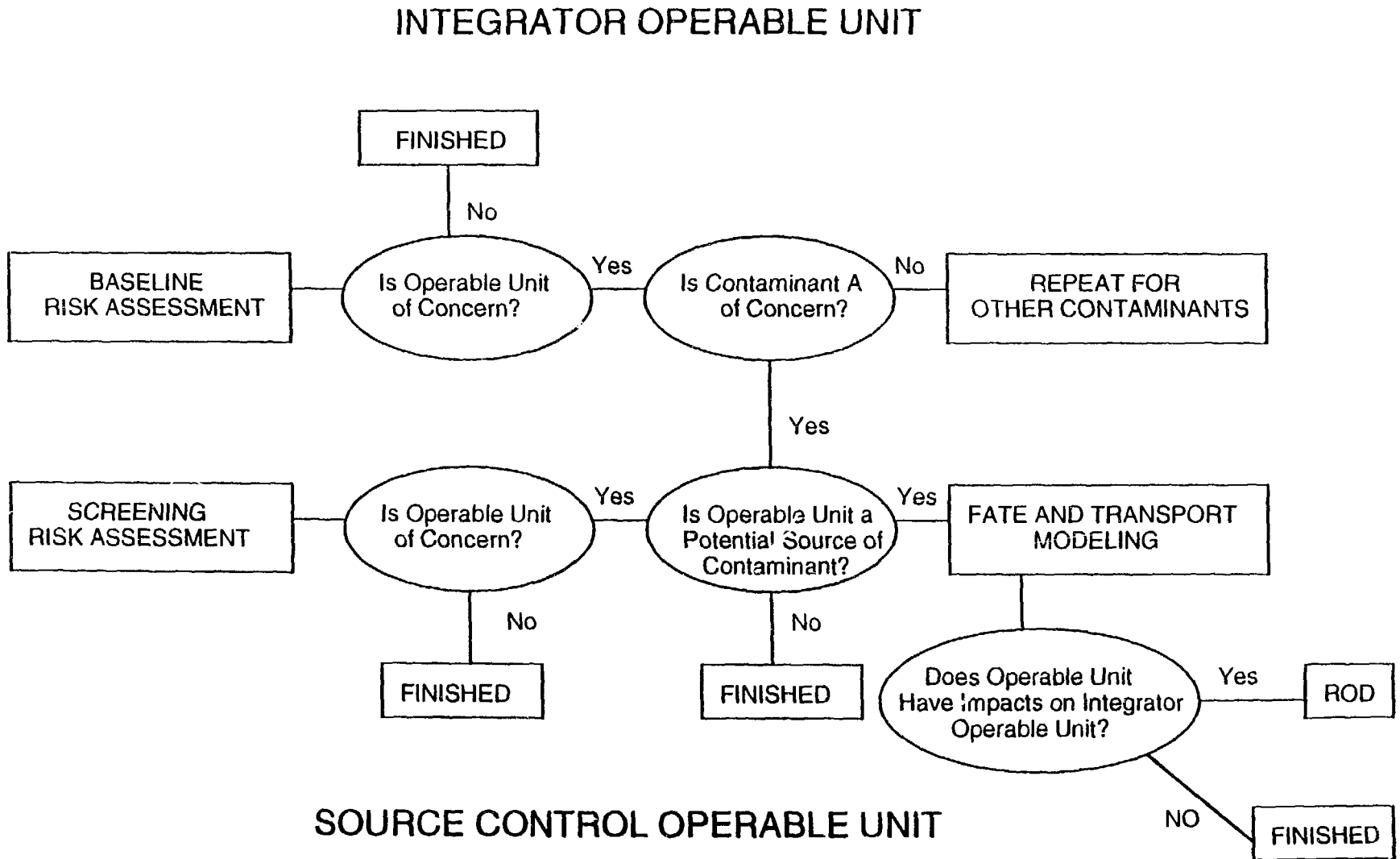
A more streamlined approach is proposed for executing the Remedial Investigation/Feasibility Study Process. This approach recognizes the uncertainties associated with the process, particularly regarding the derivation of human health risk estimates. The approach is tailored for early identification of sites and contaminants of immediate concern, early remediation of such sites, and early identification of low-risk sites that can be eliminated from further investigations. The purpose is to hasten the clean-up process and do so in a cost-effective manner.

**Table 4. Exposure scenarios and the development of Interim Records of Decisions for Source Control Operable Units**

| Exposure Scenario of Concern | Types of Interim Remedial Action*  |
|------------------------------|--|
| Residential only             | <ul style="list-style-type: none"> <li>● Continued Monitoring</li> <li>● Active Response Measures</li> <li>● Maintenance or Enhancement of Current Institutional Controls</li> </ul> |
| Intruder                     | <ul style="list-style-type: none"> <li>● Warning Signs</li> <li>● Maintenance or Enhancement of Current Institutional Controls</li> <li>● Active Response Measures</li> </ul>        |
| Occupational                 | <ul style="list-style-type: none"> <li>● Maintenance or Enhancement of Occupational Safety Measures</li> <li>● Active Response Measures</li> </ul>                                   |

\* Final remedial action alternatives depend on the results of the relevant Integrator Operable Unit baseline risk assessment

Figure 1. Implementation of Screening and Baseline Risk Assessments at Source Control and Integrator Operable Units.



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