Nevada
Environmental
Restoration
Project

DOE/NV--1107

National Nuclear Security Administration

Industrial Sites Project Establishment of Final Action Levels

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Environmental Restoration
Division

U.S. Department of Energy
National Nuclear Security Administration
Nevada Site Office

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INDUSTRIAL SITES PROJECT
ESTABLISHMENT OF FINAL ACTION LEVELS

U.S. Department of Energy
National Nuclear Security Administration
Nevada Site Office
Las Vegas, Nevada

Controlled Copy No.: ___

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INDUSTRIAL SITES PROJECT

ESTABLISHMENT OF FINAL ACTION LEVELS

Approved by: APPROVED SIGNATURE Date: 2/22/2006

Sabine Curtis, Acting Sub-Project Director,
Industrial Sites Project

Approved by: APPROVED SIGNATURE Date: 2/22/2006

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Federal Project Director,
Environmental Restoration Division

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List of Acronyms and Abbreviations

ASTM	American Society for Testing and Materials
Atm-m^3/mol	Atmospheric cubic meters per mole
CAI	Corrective Action Investigation
CAU	Corrective Action Unit
cm^2/sec	Square centimeters per second
cm^3/cm^3	Cubic centimeters per cubic centimeter
CZ	Contaminated zone
day/yr	Days per year
DOE	U.S. Department of Energy
DQO	Data quality objective
EPA	U.S. Environmental Protection Agency
FAL	Final action level
FFACO	*Federal Facility Agreement and Consent Order*
ft	Foot
g/cm^3	Grams per cubic centimeter
g/g	Grams per gram
g/m^3	Grams per cubic meter
g/yr	Grams per year
HEAST	Health Effects Assessment Summary Tables
hr/day	Hours per day
kg/day	Kilograms per day
kg/yr	Kilograms per year
L/kg	Liters per kilogram
L/yr	Liters per year

List of Acronyms and Abbreviations (Continued)

m	Meter
m/sec	Meters per second
m/yr	Meters per year
m^2	Square meter
m^2/day	Square meters per day
m^3/hr	Cubic meters per hour
m^3/yr	Cubic meters per year
mg/day	Milligrams per day
mg/kg	Milligrams per kilogram
mg/kg-day	Milligrams per kilogram per day
mg/L	Milligrams per liter
mg/m^3	Milligrams cubic meter
mrem	Millirem
mrem/yr	Millirem per year
m/yr	Meters per year
NAC	*Nevada Administrative Code*
NCRP	National Council on Radiation Protection
NDEP	Nevada Division of Environmental Protection
NNSA/NSO	U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
NTS	Nevada Test Site
PAL	Preliminary action level
pCi/g	Picocuries per gram
PRG	Preliminary Remediation Goal
RAGS	*Risk Assessment Guidance for Superfund*

List of Acronyms and Abbreviations (Continued)

RAIS	*Risk Assessment Information System*
RESRAD	Residual Radioactive Material computer code
RBCA	Risk-based corrective action
RBSL	Risk-based screening level
RfC	Reference concentration
RfD	Reference dose
SSTL	Site-specific target level
TPH	Total petroleum hydrocarbons
UCL	Upper confidence limit
VSP	Visual Sample Plan
yr	Year

Introduction

The U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) oversees numerous sites on the Nevada Test Site (NTS) and other locations in the State of Nevada that have been impacted by activities related to the development and testing of nuclear devices and by other activities. NNSA/NSO is responsible for protecting members of the public, including site workers, from harmful exposure to both chemical and radiological contaminants at these sites as they remediate these sites.

The Nevada Division of Environmental Protection (NDEP) is the primary state agency responsible for protection of human health and the environment with respect to chemical and radiological wastes. In 1996 the DOE, U.S. Department of Defense, and the State of Nevada entered into an agreement known as the *Federal Facility Agreement and Consent Order* (FFACO) (1996). Appendix VI to the FFACO describes the strategy employed to plan, implement, and complete environmental corrective action activities at NTS and other locations in the state of Nevada. One of the categories of corrective action units (CAUs) is Industrial Sites, which consists of approximately 1,150 locations that may require some level of investigation and corrective action.

To evaluate the need for the extent of corrective action at a particular site, NNSA/NSO assesses the potential impacts to receptors by comparing measurements of contaminant concentrations to risk-based (chemical) and dose-based (radionuclide) standards (action levels). Preliminary action levels (PALs) are established as part of the data quality objective (DQO) process, and are presented in one or more FFACO documents generated as part of the corrective action process.

This document formally defines and clarifies the NDEP-approved process NNSA/NSO Industrial Sites Project uses to fulfill the requirements of the FFACO and state regulations. This process establishes final action levels (FALs) based on the risk-based corrective action (RBCA) process stipulated in Chapter 445 of the *Nevada Administrative Code* (NAC) as described in the American Society for Testing and Materials (ASTM) Method E1739-95 (ASTM, 1995). It is designed to provide a set of consistent standards for chemical and radiological cleanup, and describes the procedure the State of Nevada will use in evaluating and approving the levels of residual chemical and radioactive contamination following those cleanup activities.

1.0 Regulatory Basis

The FFACO Part III, Section III.3 (FFACO, 1996) stipulates conformance with Chapter 445 of the NAC (NAC, 2000). Section NAC 445A.227 lists requirements for sites with soil contamination and stipulates a process to determine the necessary remediation standards (or FALs) based on an evaluation of the risk the site poses to public health and the environment.

Section NAC 445A.22705 states:

1. Except as otherwise provided in NAC 445A.22715, if an owner or operator is required to take corrective action pursuant to NAC 445A.227, the owner or operator may conduct an evaluation of the site, based on the risk it poses to public health and the environment, to determine the necessary remediation standards or to establish that corrective action is not necessary. Such an evaluation must be conducted using Method E1739-95, adopted by the American Society for Testing and Materials, as it exists on October 3, 1996, or an equivalent method approved by the Division.
2. The Division shall determine whether an evaluation complies with the requirements of Method E1739-95, or an equivalent method of testing approved by the Division. The Division may reject, require revisions be made to, or withdraw its concurrence with the evaluation at any time after the completion of the evaluation for the following reasons:
    - (a) The evaluation does not comply with the applicable requirements for conducting the evaluation;
    - (b) Conditions at the site have changed; or
    - (c) New information or previously unidentified information which would alter the results of the evaluation becomes available and demonstrates that the release may have a detrimental impact on public health or the environment.

Therefore, in compliance with Section NAC 445A.22705, NNSA/NSO will "conduct an evaluation of the site, based on the risk it poses to public health and the environment, to determine the necessary remediation standards or to establish that corrective action is not necessary" using ASTM Method E1739-95. Based on Section NAC 445A.2272, PALs are used for site screening purposes. They are not intended for use as remediation standards (as defined in Section NAC 445A.22675). The process to establish the remediation standards (i.e., FALs) is to conduct an evaluation of the site as stipulated in Section NAC 445A.22705. This section requires the use of ASTM Method E1739-95 to "conduct an evaluation of the site, based on the risk it poses to public health and the environment, to determine the necessary remediation standards or to establish that corrective action is not "necessary" (ASTM, 1995).

2.0 Process Overview

The RBCA decision process stipulated in Method E1739-95 (hereafter referred to as the RBCA process) is summarized in Figure 2-1. This process uses a three-tiered approach in evaluating the DQO decisions. Each tier establishes an action level using increasingly sophisticated (and site-specific) calculations. The action level established for Tier 1 is referred to as a risk-based screening level (RBSL), while action levels calculated for Tier 2 and Tier 3 are referred to as site-specific target levels (SSTLs). The result of the RBCA process will be to define each FAL as a Tier 1 RBSL, a Tier 2 SSTL, or a Tier 3 SSTL. The site-specific implementation of this process will be described in the FFACO plans and reported in the FFACO report. This process includes a provision for conducting an interim remedial action if necessary and appropriate. The decision to conduct an interim action may be made at any time during the investigation. Concurrence of the DQO decision-makers will be obtained before any interim action is implemented. Evaluation of DQO decisions will be based on conditions at the site following completion of any interim actions. Any interim actions conducted will be reported in the subsequent FFACO report.

The three tiers that may be used for evaluating DQO decisions are:

Tier 1 – Sample results from the source area are compared to Tier 1 RBSLs. These are defined to be the generic (non-site-specific) PALs defined in the DQO process and listed in the FFACO plans.

Tier 2 – Sample results from exposure points are compared to Tier 2 SSTLs calculated using site-specific inputs to standard risk equations.

Tier 3 – Sample results from points of compliance are compared to Tier 3 SSTLs calculated using site-specific inputs to more sophisticated chemical fate/transport and probabilistic models.

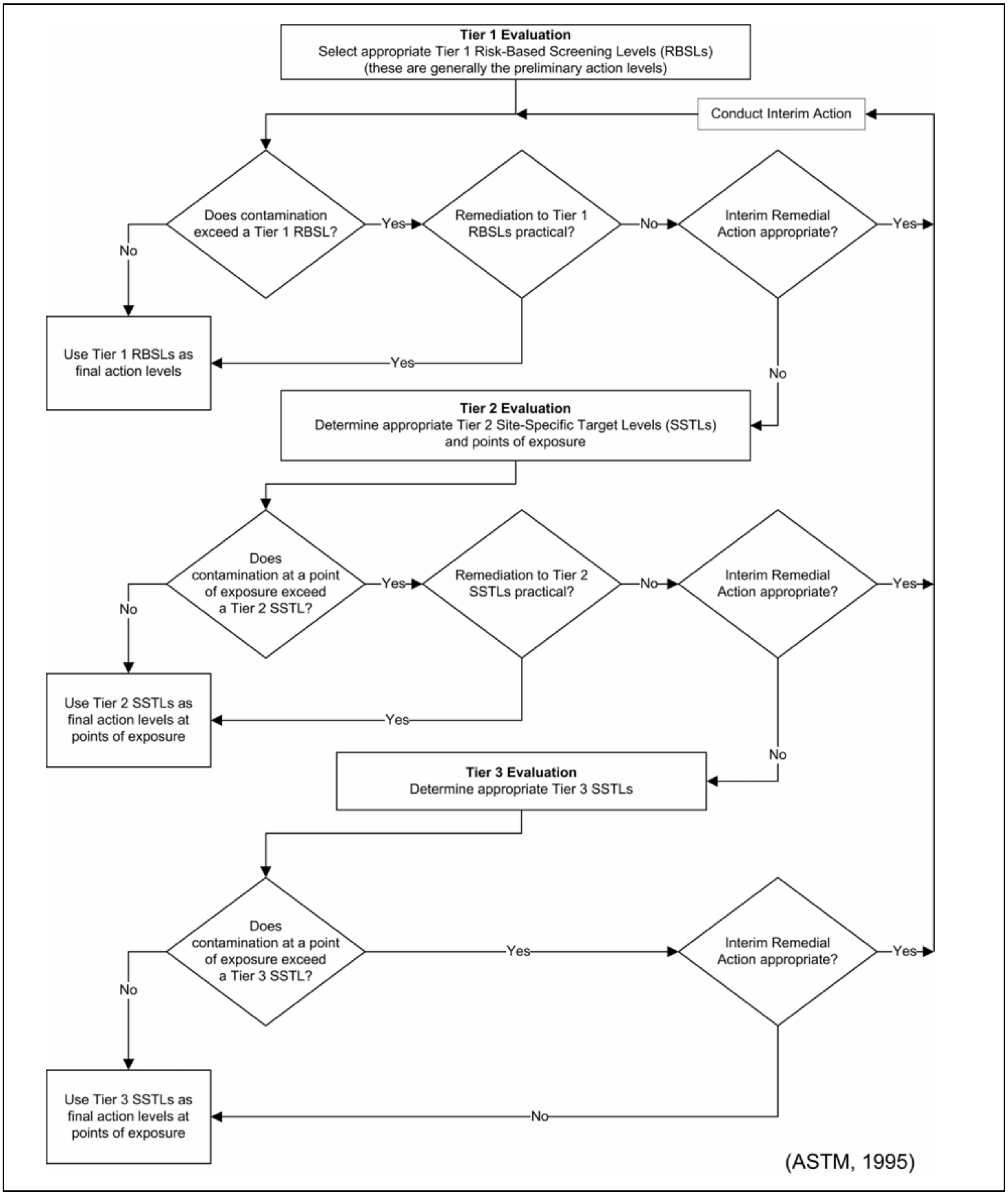

Figure 2-1
ASTM Method E1739-95 Risk-Based Corrective Action Decision Process

2.1 Tier 1 Evaluation

A Tier 1 evaluation will be conducted to determine whether contaminant levels satisfy the criteria for a quick regulatory closure or warrant a more site-specific assessment. This is accomplished by comparing individual sample results of source area contaminant concentrations or activities (or the 95 percent upper confidence limit [UCL] of the mean concentrations or activities of sample results collected from random sample locations representative of the source area) to Tier 1 RBSLs. Source areas are defined as the locations containing the highest concentrations or activities of contaminants. The Tier 1 RBSLs are defined to be the PALs established during the DQO process and documented in the FFACO plans.

The PALs for chemical constituents are generally based on U.S. Environmental Protection Agency (EPA) *Region 9 Preliminary Remediation Goals (PRGs)* (EPA, 2004a). The PALs for RCRA metals and zinc are established as the concentrations found in background soil when natural background concentrations exceed the PRG (as is often the case with arsenic on the NTS). For detected chemicals without established PRGs, PALs will be established and proposed in the FFACO reports. The PAL for total petroleum hydrocarbons (TPH) is 100 milligrams per kilogram (mg/kg), as listed in NAC 445A.2272 (NAC, 2000). As discussed in *Risk Assessment Guidance for Superfund* (RAGS)*: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)* (EPA, 1991a), PRGs are concentration goals for individual chemicals in specific medium and land use combinations. They are based on established current human health toxicity values with standard exposure factors to estimate contaminant concentrations in environmental media (soil, air, and water) that are considered by EPA to be protective of human health exposures (including sensitive groups), over a lifetime (EPA, 1991b).

The PALs for radiological constituents are taken from the National Council on Radiation Protection (NCRP) Report No. 129, Table 2.1, “Construction, Commercial, Industrial” land use scenario column for a 25 millirem (mrem) dose constraint (NCRP, 1999). The generic guidelines for residual concentrations of radium-226, radium-228, thorium-230, and thorium-232 are found in Chapter IV of DOE Order 5400.5, *Radiation Protection of the Public and Environment* (DOE, 1993).

Although the PALs are radionuclide-specific or chemical-specific, they are not site-specific. Concentrations or activities above PALs would not automatically trigger a response action but may suggest that a site-specific evaluation of the potential radiological dose or chemical risk is appropriate.

If it were determined by NNSA/NSO that further evaluation of potential dose or risk is not appropriate, or that further evaluation would not affect the final decision for a particular contaminant at a particular site, the FAL would be established as the Tier 1 RBSL. Otherwise, a Tier 2 evaluation may be conducted. Rationale and justification for using a Tier 2 evaluation will be presented in the Corrective Action Decision Document, Corrective Action Decision Document/Corrective Action Plan, Corrective Action Plan, or Corrective Action Decision Document/Closure Report, (hereafter referred to as FFACO reports).

2.2 Tier 2 Evaluation

The Tier 2 evaluation starts by calculating Tier 2 SSTLs using site-specific inputs to standard risk equations (for chemical contaminants) or using the Residual Radioactive Material computer code (RESRAD) (for radiological contaminants). The calculation of these SSTLs is described in Section 3.0. The Tier 2 SSTLs are then compared to individual sample results from reasonable points of exposure (as opposed to the source areas as is done in Tier 1), or to the 95 percent UCL of the mean concentration or activity of sample results collected from random sample locations representative of the exposure area. Points of exposure or exposure areas are defined as those locations or areas at which an individual or population may come in contact with a contaminant of concern originating from a release site.

If a Tier 2 evaluation is conducted, the calculations used to derive the SSTLs will be provided as an appendix to the FFACO report. If it were determined by NNSA/NSO that further evaluation of potential risk would not affect the final decision for a particular contaminant at a particular site, the FAL would be established as the Tier 2 SSTL. Otherwise, a Tier 3 evaluation may be conducted. Rationale and justification for using a Tier 3 evaluation will be presented in the FFACO report.

2.3 Tier 3 Evaluation

If appropriate, a Tier 3 evaluation may be conducted by calculating Tier 3 SSTLs on the basis of more sophisticated risk analyses using methodologies described in Method E1739-95, such as Groundwater Modeling System software (Brigham Young University, 1999), that consider site-, pathway-, and receptor-specific parameters. Tier 3 evaluation is much more complex than Tier 1 and 2 evaluations because it may include additional site characterization, probabilistic evaluations, and sophisticated chemical fate/transport models. The Tier 3 SSTLs are then compared to the 95 percent UCL of the mean of sample results from the points of compliance. Contaminant concentrations or activities exceeding Tier 3 SSTLs require corrective action. If a Tier 3 evaluation is conducted, the calculations used to derive the SSTLs and the UCL of the means will be provided as an appendix to the FFACO report.

3.0 Process for Calculating Tier 2 SSTLs

Contaminant Tier 2 SSTLs can be based on carcinogenicity, systemic toxicity, or radiological dose depending upon the type of health hazard posed by a specific constituent. The calculation of carcinogenic or systemic toxicity risk-based Tier 2 SSTLs is described in Section 3.1, and the calculation of radiological dose-based Tier 2 SSTLs is described in Section 3.2.

3.1 Chemical Constituents

Tier 2 SSTLs based on carcinogenicity or systemic toxicity are calculated using site-specific inputs to standard risk equations such as those listed in RAGS, Part B (EPA, 1991a). The RAGS, Part B, was prepared for risk assessors, remedial project managers, and others to assist in developing PRGs for National Priorities List sites. Specifically, RAGS, Part B, provides guidance on using EPA toxicity values and exposure information to derive site- and constituent-specific, risk-based PRGs that are protective of human health.

The specific risk equations proposed for use in calculating Tier 2 SSTLs (listed in Appendices A and B) are compliant with RAGS Part B procedures and were extracted from the *Risk Assessment Information System* (RAIS) (ORNL, 2004) located online at: http://risk.lsd.ornl.gov/cgi-bin/prg/PRG_search. This website provides a convenient online menu-driven environmental risk assessment system that provides tools essential for performing basic risk assessment activities, such as toxicity values and profiles, federal and state guidelines, human health risk models, and the calculation of PRGs. The RAIS is used by the DOE, its laboratories, its subcontractors, commercial businesses, other countries, state governments, and colleges and universities. Information about this system was extracted from documents contained in the RAIS website.

3.1.1 Total Petroleum Hydrocarbons

For the specific case of TPH results exceeding the Tier 1 RBSL of 100 mg/kg, the Tier 2 risk-based SSTL evaluation for TPH contamination will be conducted by individually evaluating the risk posed by the specific hazardous constituents of TPH. The ASTM procedure (Section 6.4.3, "Use of Total Petroleum Hydrocarbon Measurements) states: "The TPHs should not be used for risk assessment because the general measure of TPH provides insufficient information about the amounts of individual chemical(s) of concern present" (see also Sections X1.5.4 and X1.42 of the ASTM procedure). Therefore, SSTLs will be established for the individual hazardous constituents of TPH for risk-based decisions under either Tier 2 or

Tier 3 evaluations. The individual hazardous constituents of TPH will depend on the petroleum product that was the source of the contamination. These constituents will be defined and justified in the FFACO report.

3.1.2 Use of Standard Risk Equations

The standard risk equations can be solved manually, or the RAIS system (which uses standard risk equations) can be used to automate the calculation of SSTLs. Both techniques will produce comparable risk-based SSTLs when using the same site-specific input parameters. The risk-based SSTLs developed using these methods are applicable to all sites and result in residual risks from direct contact with a contaminated medium that comply with the *National Oil and Hazardous Substances Pollution Contingency Plan* (EPA, 2004c) requirements for protection of human health.

To use the automated RAIS risk-based calculator, the user selects:

- The applicable land uses and media (generally, this will be outdoor industrial soil)
- Chemicals for which SSTLs are needed
- "Prompt for Parameters" (to modify generic input parameters)

For the purposes of calculating SSTLs using RAIS or the standard risk equations, adult workers are assumed to be routinely exposed to contaminated media within a commercial area or industrial site. For the industrial worker, routes of exposure included for soil and sediment are:

- Incidental ingestion of soil (or sediment)
- Inhalation of particulates and vapors emitted from soil (or sediment)
- Dermal contact with soil (or sediment)

For the soil pathway, it is assumed that there is an unlimited potential for surface erosion and production of particulates and vapor emissions. The RAIS will calculate a PRG for each route of exposure, and each type of chemical risk (carcinogenicity and toxicity). A combined PRG will be calculated using all of the routes of exposure (i.e., a combined PRG) for each type of chemical risk.

3.1.3 Standard Risk Equation Input Parameters

The input parameters used to calculate Tier 2 SSTLs are categorized into the following groups:

1. Chemical-specific
2. Site-specific
3. Exposure scenario-specific
4. Generic

The chemical-specific input parameters of the selected chemicals listed in Table 3-1 will be used to calculate Tier 2 SSTLs. The human health toxicity values known as cancer slope factors or non-cancer reference doses (RfDs) form the basis of the values used to define the SSTLs. This information is contained in the RAIS chemical database for the chemicals listed on the website. If the chemical is not listed in the RAIS database or the risk equations are solved manually, toxicity values will be used from published databases following the toxicity value hierarchy below (EPA, 2004a):

1. Integrated Risk Information System (EPA, 2004b)
2. EPA Provisional Peer Reviewed Toxicity Values (EPA, 2004d)
3. Health Effects Assessment Summary Tables (HEAST) (EPA, 1997)
4. Agency for Toxic Substances and Disease Registry (HHS, 2004) minimal risk levels
5. California Environmental Protection Agency (CalEPA, 2004)

Table 3-1
Chemical-Specific Input Parameters

Parameter	Definition	Units
ABS	Absorption factor	unitless
D_i	Diffusivity in air	cm^2/sec
D_w	Diffusivity in water	cm^2/sec
H	Henry's Law constant	$atm\text{-}m^3/mol$
K_{oc}	Soil organic carbon partition coefficient	L/kg
RfC_i	Inhalation chronic reference concentration	mg/m^3
RfD_{ad}	Absorbed chronic reference dose	mg/kg-day
RfD_o	Oral chronic reference dose	mg/kg-day
S	Solubility in water	mg/L-water
SF_{ad}	Absorbed dose slope factor	$(mg/kg\text{-}day)^{-1}$
SF_o	Oral slope factor	$(mg/kg\text{-}day)^{-1}$
URF	Inhalation unit risk factor	$(mg/m^3)^{-1}$

If the toxicity information is not available from these sources, other sources of toxicity information may be used and documented in the risk assessment section of the report.

Site-specific, exposure scenario-specific, and generic input parameters are common to the calculation of both chemical and radiological Tier 2 SSTLs. Therefore, the selection of these types of input parameters is described in Section 3.3.

3.2 Radiological Constituents

Tier 2 SSTLs based on radiological dose are calculated using the RESRAD computer code to model expected doses to a critical group based on proposed land uses and site-specific physical parameters. The primary dose limit for any member of the public is 100 mrem total effective dose equivalent in a year. This limit applies to the sum of internal and external doses resulting from all modes of exposure to all radiation sources other than background radiation and doses received as a patient from medical sources, as defined in DOE Order 5400.5, II.1.a.(3)(a) (DOE, 1993). The dose constraint is defined as one-quarter of the dose limit (i.e., 25 millirem per year [mrem/yr]) and will be applied to ensure that in a 1,000-year period, the maximally exposed individual does not exceed the dose limit in any single year. In addition, the 25 mrem/yr dose constraint is commensurate with the requirements listed in *Code of Federal Regulations* Title 10, Part 20 (CFR, 2004) and NAC 459.316 to 459.3184 (NAC, 2003).

Due to the impact from the testing of nuclear weapons at these sites, determination of a “true” background at the NTS is not practical. Therefore, no background subtraction will be used and the “above background criterion” will be defined as the concentration of a specific radionuclide in soil that equals or exceeds the corresponding PAL.

This use of the dose constraint with no background subtraction is a more conservative and sensitive approach because it does not deal with the uncertainty of natural background.

3.2.1 Pathway Modeling Implementation for FFACO Corrective Actions

The RESRAD computer code will be used to perform the exposure scenario-specific modeling for the following pathways:

- External exposure
- Particulate inhalation
- Ingestion of soil

The most recent version of the code will be used to account for revision updates. The version used will be documented in the FFACO reports.

To ensure consistency in calculating doses and for ease in performing verifications, the "NTS standard" parameter values listed in Section 3.3 and the RESRAD-specific input parameters listed in Table 3-2 will be used for all remediation dose calculations. All of the input parameters needed for RESRAD SSTL calculations are listed in Appendix B.

Table 3-2
RESRAD-Specific Input Parameters

Parameter	Units	RESRAD Input Value	RESRAD Default Value	Reference/Rationale
Shape Factor	-	1	1	RESRAD Default
Contaminated Zone Hydraulic Conductivity	m/yr	10	10	RESRAD Default unless site data significantly different
Cover Depth Erosion Rate	m/yr	0.001	0.001	RESRAD Default unless site data significantly different
Contamination Zone Erosion Rate	m/yr	0.001	0.001	RESRAD Default unless site data significantly different
Contaminated Zone Field Capacity	-	0.2	0.2	RESRAD Default unless site data significantly different
Runoff Coefficient	-	0.4	0.2	Open Sandy Loam 30% impervious Table 10.1 (Yu, et al., 1993)
Evapotranspiration Coefficient	-	0.5	0.5	RESRAD Default not significant due to lack of groundwater pathway
Contaminated Zone b Parameter	-	5.3	5.3	RESRAD Default unless site data significantly different
Mass Loading for Inhalation	g/m^3	0.0006	1E-04	The estimated mass loading for construction activities (Yu, et al., 1993)
Area of CZ	m^2	Site Specific	10,000	Maximum area of contamination out to two successive sample intervals below PALs (~15 ft intervals laterally)
Thickness of CZ	m	Site Specific	2	Maximum identified depth plus two successive intervals below PALs as identified during the site characterization (~5 ft intervals vertically)
Site Specific Parent Radionuclide[a]	pCi/g	Site Specific	0	The highest detected activity or the 95% UCL of the mean
Cover Depth	m	Site Specific	0	The minimum depth as identified during the site characterization
Precipitation	m/yr	Site Specific	1	Data from Air Resources Laboratory (ARL/SORD, 2004)

[a] Only those with half-lives greater than 180 days (does not include naturally occurring and primordial radionuclides)

3.3 Standardized Exposure Scenarios and Input Parameters

Some of the input parameters used in calculating Tier 2 SSTLs are dependent upon the exposure of NTS workers or visitors to the contaminants present at a particular site. To facilitate calculation of Tier 2 SSTLs, three exposure scenarios were developed to represent potential exposures to soil contamination at the NTS based on the type of site, the time workers are present at the site, and the projected future use of the site. The exposure scenarios are presented in Section 3.3.1. The exposure scenario-specific and site-specific default input parameters are presented in Section 3.3.2. The generic default input parameters are presented in Section 3.3.3.

3.3.1 Exposure Scenarios

The exposure of workers and visitors to site contaminants is dependent upon activities of the exposed individuals at each contaminated site. Based on the future land use as identified in DOE/NV-525, *Nevada Test Site Resource Management Plan* (DOE/NV, 1998), each contaminated site will be categorized into one of three types: Industrial Area, Remote Work Area, and Occasional Use Area. The appropriate scenario for each site will be selected by NNSA/NSO during development of the DQOs using the criteria presented for each of the scenarios below. The selected scenarios will be documented in the FFACO plans and FFACO reports.

Industrial Area – Assumes continuous industrial use of a site. This scenario addresses exposure to industrial workers exposed daily to contaminants in soil during an average workday. This scenario assumes that this is the regular assigned work area for the worker who will be on the site for an entire career (225 days per year, 10 hours per day for 25 years). The criteria for this exposure scenario are that active powered buildings with toilets are present at the site for the shelter and comfort of the worker. Due to the type of work done at the NTS, and the harsh climate, site workers spend most of their time in air-conditioned indoor facilities. However, for the purposes of calculating risk and dose, it will be conservatively assumed that workers under this scenario will spend one-third of their workday outdoors (outdoor time fraction of 0.333 and indoor time fraction of 0.666). Because the RESRAD input for outdoor time fraction is in terms of the fraction of a year spent outdoors, this is calculated as the daily time fraction (0.333) times the number of hours spend on site per year (10 hours per day times 225 days) divided by the total number of hours per year (8,760 hours). This equates to a RESRAD outdoor time fraction of $8.55E^{-2}$.

As presented in Equation 1, because the indoor soil ingestion rate is 50 milligrams per day (mg/day) and the outdoor soils ingestion rate is 480 mg/day, this results in a total soil ingestion rate of 194 mg/day.

$$\begin{array}{lr} \textit{indoor soil ingestion rate x indoor fraction} & (50 \text{ mg/day} \times 0.666) \\ + \underline{\textit{outdoor soil ingestion rate x outdoor fraction}} & \underline{+ (480 \text{ mg/day} \times 0.333)} \\ = \textit{total daily soil ingestion rate} & = 193 \text{ mg/day} \end{array} \qquad \text{(Eq. 1)}$$

Because RESRAD considers outdoor time fractions as a separate input parameter, the higher soil ingestion rate of 480 mg/day will be used for the RESRAD soil ingestion rate input parameter. As the RESRAD input parameter is in terms of grams per day, this is calculated as 0.48 grams per day times 225 days for an equivalent soil ingestion rate of 108 grams per year.

Remote Work Area – Assumes non-continuous work activities at a site. This scenario addresses exposure to industrial workers exposed to contaminants in soil during a portion of an average workday. This scenario assumes that this is an area where the worker regularly visits but is not an assigned work area where the worker spends an entire workday. The criteria for this exposure scenario is that site structures are present for shelter and comfort of the worker but not sufficient to support full-time work assignments (e.g., Test Cell C, Area 12 Camp) nor are any such facilities anticipated to be built based on NTS future land use specifications. A site worker under this scenario is assumed to be on the site for an equivalent of 336 hours (or 42 days) per year, for an entire career (25 years). Because this scenario assumes the presence of sheltered workspace, the indoor/outdoor time fractions and the soil ingestion rates are calculated in the same manner as for the Industrial Area Scenario.

The RESRAD input for outdoor time fraction in terms of the fraction of a year spent outdoors for the remote work area scenario is calculated as the daily time fraction (0.333) times the number of hours spend on site per year (8 hours per day times 42 days) divided by the total number of hours per year (8,760 hours). This equates to a RESRAD outdoor time fraction of $1.28E^{-2}$.

The RESRAD soil ingestion rate input parameter for the remote work area scenario is calculated as 0.48 grams per day times 42 days for an equivalent of 20.2 grams per year.

Occasional Use Area – Assumes occasional work activities at a site. This scenario addresses exposure to industrial workers who are not assigned to the area as a regular worksite but may occasionally use the site. This scenario assumes that this is an area where the worker does not regularly visit but may occasionally use for short-term activities. The criteria for this exposure scenario are that it is a remote area with no active improvements and the future land use designation is for outdoor tests and/or military training exercises. A site worker under this scenario is assumed to be on the site for an equivalent of 80 hours (or 10 days) per year, for 5 years. The indoor time is zero because there are no buildings on the site.

The RESRAD input for outdoor time fraction in terms of the fraction of a year spent outdoors for the occasional use area scenario is calculated as the daily time fraction (1.0) times the number of hours spend on site per year (8 hours per day times 10 days) divided by the total number of hours per year (8,760 hours). This equates to a RESRAD outdoor time fraction of $9.13E^{-3}$.

The RESRAD soil ingestion rate input parameter for the occasional use area scenario is calculated as 0.48 grams per day times 10 days for an equivalent of 4.8 grams per year.

3.3.2 Site-Specific Input Parameters

The "NTS standard" site-specific input parameter values for each of the exposure scenarios are presented in Table 3-3. Other non-specific default input parameter values are presented in Table 3-4. These parameters will be used unless site-specific information is available. The FFACO reports will document the use of the input parameter values specified herein by referencing this document. If parameter values are used that deviate from the "NTS standard" parameter values, the values will be documented and justified in the FFACO report (see Section 7.0).

Table 3-3
Site-Specific Input Parameters with Proposed NTS Standard Values

Parameter	Method	Units	Exposure Scenarios		
			Industrial Area	Remote Work Area	Occasional Use Area
Exposure Duration	Risk	yr	25[a]	25[a]	5[b]
	Dose				
Exposure Frequency	Risk	day/yr	225[a]	42[b]	10[b]
	Dose				
Exposure Time Outdoor	Dose	unitless	8.55E-2	1.28E-2	9.13E-3
Soil Ingestion Rate	Risk	kg/day	0.0002[c]	0.0002[c]	0.00048[c]
	Dose		0.00048[c]	0.00048[c]	0.00048[c]
Organic Carbon in Soil	Risk	g/g	0.001[d]	0.001[d]	0.001[d]
Water-filled Soil Porosity	Risk	cm^3/cm^3	0.1[e]	0.1[e]	0.1[e]
Vegetative Cover	Risk	unitless	0.2-.06[f]	0.2-.06[f]	0.2-.06[f]
Target Hazard Index	Risk	unitless	1	1	1
Target Cancer Risk	Risk	unitless	1E-06	1E-05[g]	1E-05[g]

Rationale for input values:
[a] RAGS Part B (EPA, 1991a)
[b] Based on scenarios defined in Section 3.3.1
[c] Scaled based on ratio of time spent outdoors defined in Section 3.3.1 scenarios - indoor ingestion rate 50 mg/day, outdoor soil ingestion rate 480 mg/day (Yu, et al., 1993)
[d] Value reflects a conservative estimate of organic content for desert soils
[e] Value reflects a conservative estimate of water content for desert soils
[f] Estimated range, NTS-specific value will be extracted from U.S. Geological Survey Water-Resources Investigations Report 03-4090 (Hevesi et al., 2003)
[g] Lower target cancer risk more appropriate for limited populations and short-term exposures (ASTM, 1995)

3.3.3 Generic Input Parameters

Other input parameters used in the risk- or dose-based calculations will use the default values listed in RAIS as presented in Table 3-4. These are commonly used values for risk equations and are appropriate for the purposes of calculating Tier 2 SSTLs.

Table 3-4
Generic Default Input Parameter Values

Parameter	Definition	Units	Default Value
Size	Surface Area of Concern	acres	0.5[a]
T	Exposure Interval	seconds	9.50E+08[b]
P_b	Dry Soil Bulk Density	g/cm^3	1.5[b]
P_s	Soil Particle Density	g/cm^3	2.65[b]
AF	Adult Adherence Factor	mg/cm^2	0.2[c]
BW	Adult Body Weight	kg	70[d]
SA	Adult Surface Area	m^2/day	0.33[c]
AT	Averaging Time (carcinogen) (yr x day/yr)	days	70 x 365
AT	Averaging Time (non-carcinogen) (yr x day/yr)	days	ED[e] x 365
Um	Average Wind Speed	m/sec	4.07[b]

Rationale for input values:
[a] Default minimum surface area – if surface area is larger, use actual surface area
[b] EPA, 1996
[c] EPA, 2004e
[d] EPA, 1991a
[e] Exposure duration

3.3.4 RAIS Input Parameter Sensitivity Analysis

A sensitivity analysis was conducted on selected input parameters for the calculation of RAIS PRGs and is presented in Appendix A. The analysis demonstrates that:

- All results (both carcinogenic and toxic) are very sensitive to changes in exposure frequency.
- The carcinogen results are sensitive to changes in exposure duration.
- The ingestion exposure route (both carcinogenic and toxic) and dermal contact with carcinogen results are sensitive to changes in soil ingestion rate.
- The inhalation exposure route results (both carcinogenic and toxic) are sensitive to changes in water-filled soil porosity.
- The inhalation of carcinogen results are moderately sensitive to changes in fraction soil organic carbon.

3.4 Selection of Tier 2 SSTLs

Constituent Tier 2 SSTLs can be based on carcinogenicity, systemic toxicity, or radiological dose depending upon the type of health hazard posed by a specific constituent.

A chemical-specific SSTL based on carcinogenic toxicity will be derived using a carcinogenic risk slope factor. In this derivation, the slope factors are specific to the route of exposure (i.e., ingestion, inhalation, dermal contact, and external exposure). Slope factors for dermal contact (i.e., absorbed chemical dose) are derived using a chemical-specific gastrointestinal absorption factor to adjust the oral slope factor (EPA, 1992).

A chemical-specific SSTL based on non-carcinogenic toxicity will be derived using an oral reference dose (RfD). Inhalation reference concentration (RfC) will not be used directly because chronic RfDs are available for more chemicals and are more conservative relative to human health. Also, before incorporation of the inhalation RfC into the derivation equations, the inhalation RfCs are converted to an RfD by the units conversion factor recommended in HEAST (EPA, 1997). Finally, RfDs for dermal exposure (absorbed dose) are derived from the oral chronic RfD using a gastrointestinal absorption factor (EPA, 1992).

A Tier 2 chemical-specific SSTL will be defined as the more conservative (lower) of the calculated action levels described above. The Tier 2 radioisotope-specific dose-based SSTL will be derived using RESRAD.

4.0 Process for Calculating Tier 3 SSTLs

If appropriate, a Tier 3 evaluation may be conducted by calculating Tier 3 SSTLs on the basis of more sophisticated risk analyses using methodologies described in Method E1739-95 that consider site-, pathway-, and receptor-specific parameters (i.e., a site-specific risk assessment) (ASTM, 1995). The site-specific risk assessment is an analysis of the potential adverse health effects (current or future) caused by contaminant releases from a site in the absence of any actions to control or mitigate these releases (i.e., under an assumption of no further action). The site-specific risk assessment contributes to the subsequent development, evaluation, and selection of corrective action alternatives. The results of the site-specific risk assessment will document the magnitude of risk at a site, and the primary causes of that risk.

Site-specific risk assessments vary in both detail and the extent to which qualitative and quantitative analyses are used, depending on the complexity and particular circumstances of the site. Therefore, specific methodologies must be developed based on site conditions, contaminants present, potential receptors, and future land use scenarios. The calculation of Tier 3 SSTLs using site-specific risk assessments will be accomplished according to the provisions of RAGS Part A (EPA, 1989).

5.0 Selection of Sampling Design

The selection of a judgmental or probabilistic sampling design for evaluating site data must be appropriate to the site being evaluated. The basis and assumptions used to select the sampling design will be discussed and agreed to during the DQO process. The criteria for selecting a judgmental or probabilistic sampling design are listed below.

Judgmental Sampling Design Criteria:

1. The location(s) of the highest concentrations of contamination within an area can be identified.

2. Contamination was released from a known point source location(s) that can be identified.

Probabilistic Sampling Design Criteria:

1. Contamination was released over a defined area.
2. Multiple releases are present within a well-defined area.
3. Point source release(s) is/are suspected but location(s) cannot be confidently identified.

Conditions at a particular site may warrant the use of both designs for distinct areas. If this is implemented, the DQO decisions for those areas will be evaluated separately.

5.1 Judgmental Sampling Design

This design will be used when there is sufficient information on the contamination sources and site history to select specific sampling locations. This design is used to confirm the existence of contamination at specific locations and provide information (such as extent of contamination) about specific releases at the site.

The statistic of this sampling design to be compared to the FAL is the individual sample result. Justification for the use of this sampling design will be that samples were collected from locations where there is a high confidence that contaminants of concern would be located if they existed anywhere within the site being evaluated. The number and location of samples chosen to meet this criterion will be discussed and agreed to during the DQO process.

5.2 Probabilistic Sampling Design

This design will be used when there is insufficient information on the contamination sources and history to select specific sampling locations. This design is used to establish contaminant concentrations that represent the site as a whole (i.e., a site characteristic contaminant concentration). Justification for the use of this sampling design will be that the areas to be characterized encompass (and are limited to) a distinct contaminant population. The areas chosen for characterization will be discussed and agreed to during the DQO process.

The objective of the probabilistic sampling design is to determine, with a specified degree of confidence, whether the true average contaminant concentrations at the site in question represent an unacceptable risk to human health and the environment (EPA, 2002a). The true average concentration for each contaminant at the site is estimated from the average of sample analytical results. An unacceptable risk to human health and the environment is deemed to be any average site contaminant concentrations exceeding FALs.

Because the average contaminant concentrations from samples are only an estimate of the true (unknown) average contaminant concentrations, it is uncertain how well the sample averages represent the true averages. If a sample average was directly compared to the FAL, any error in estimating the true average could lead to making a decision error. To reduce the probability of making a false negative decision error, a conservative estimate of the true average is used to compare to the FAL. This conservative estimate of the true average contaminant concentration will be calculated as the 95 percent UCL of the average sample contaminant concentration. By definition, there will be a 95 percent probability that the true average concentration is less than the 95 percent UCL of the sample average.

5.2.1 Computation of the Upper Confidence Limit

The computation of appropriate UCLs depends upon the data distribution, the number of samples, the variability of the dataset, and the skewness associated with the dataset. The statistical package ProUCL (or similar) will be used to determine the appropriate probability distribution (e.g., normal, lognormal, gamma) and/or a suitable non-parametric distribution-free method and then to compute appropriate UCLs. To ensure that the appropriate UCL computational method is used, the sample data will be tested for goodness-of-fit to all of the parametric and non-parametric UCL computation methods described in the EPA guidance document *Calculating the Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (OSWER 9285.6-10) (EPA, 2002b).

A UCL will be calculated for each contaminant that is detected in any sample at a concentration greater than the PAL. This computation requires that a minimum number of samples be collected from random locations at each site and a basic assumption that:

- The data originate from a symmetric, but not necessarily normally distributed, population.
- The estimation of the variability is representative of the population being sampled.
- The population values are not temporally or spatially correlated.

5.2.2 Sample Size

A minimum number of samples are required to compute a UCL for each site being evaluated. This number will be calculated from the actual investigation results for the major site contaminant constituent as well as any site contaminant with a single result exceeding one-half of the FAL concentration. This will verify that a sufficient number of samples were collected to adequately evaluate the site. The Visual Sample Plan (VSP) software (or equivalent software) will be used to calculate minimum sample sizes (PNNL, 2005).

The VSP software was developed by Pacific Northwest National Laboratory for the DOE and the EPA to determine the minimum number of samples needed to characterize a site based on the type of test to be performed, the distribution of the data, the variability of the data, and the acceptable false positive and false negative error rates.

Because the minimum number of samples needed to perform the UCL comparison tests cannot be determined until after investigation results are obtained, the planned number of samples to be collected during a corrective action investigation (CAI) must be estimated. The VSP software will be used to estimate the minimum number of samples needed before the CAI based on estimates and assumptions about the characteristics of the data that will be generated as a result of the CAI. The bases for establishing sample sizes will be discussed and agreed to during the DQO process.

6.0 Resolution of DQO Decisions

6.1 Multiple Constituent Analysis

The DQO decisions based on FALs will also be subject to an evaluation of additive risk to the receptor by multiple constituents at sites where contamination exceeds RBSLs but does not exceed FALs. This will address a potential situation where all constituents present at a site are below the individual FALs (and, therefore, the DQO decision may otherwise be that no further action is required), but the additive effect of multiple constituents may pose an unacceptable risk to the receptor. This assessment will be identified in the FFACO reports as a multiple constituent analysis.

When required, a multiple constituent analysis will be conducted for carcinogenic risk and/or toxicity using all of the constituents exceeding RBSLs that have either a slope factor or an RfD (i.e., that are either carcinogenic or toxic). A multiple constituent analysis will not be conducted for radioactive dose because RESRAD back-calculates SSTLs from total dose to the receptor based on the combination of radioactive constituents present at the site.

The multiple constituent analysis will be conducted by summing the ratios of each constituent concentration exceeding an RBSL to their corresponding Tier 2 or Tier 3 carcinogenic- or toxicity-based SSTL. If the sum of the ratios exceeds 1.0, then the DQO decision will be modified such that a corrective action other than no further action will be required.

6.2 Future Land Use

If the Remote Work Area or Occasional Use Area scenarios are used for any site to calculate a FAL, an administrative use restriction (no monitoring, fencing, or signage required) will be recorded to protect workers from future work activities that would cause an exposure exceeding that used in the calculation of the FAL. This administrative use restriction would establish the exposure assumptions used in the FAL calculation as the exposure limits of the use restriction. Any proposed activity within this use restricted area that would potentially cause an exposure exceeding the exposure limits would require NDEP approval.

6.3 Evaluation Process Overview

A summary of the evaluation levels discussed in Sections 3.0, 4.0, and 5.0 is presented in Table 6-1. The potential actions to be taken based on exceedance or non-exceedance of the RBSL or SSTL at each evaluation level are presented in Table 6-2.

Table 6-1
Evaluation Levels

Evaluation Level	Tier	Exposure Scenario	Exposure Assumptions	Environmental Dataset	Comments
1	Tier 1 RBSL	Industrial Area	Continuous direct exposure to contaminated soil for entire career (8 hrs/day, 225 days/yr, 25 years)	Evaluate all results.	These are the PALs.
2	Tier 2 SSTL	Industrial Area	Continuous direct exposure to contaminated soil for entire career (8 hrs/day, 225 days/yr, 25 years)	Evaluate results from exposure points.	SSTL is roughly equivalent to the Tier 1 RBSL.
3	Tier 2 SSTL	Remote Work Area	The direct exposure to contaminated soil for over 1.5 hrs/day for each day of entire work life (8 hrs/day, 43 days/yr, 25 years)	Evaluate results from exposure points.	Use carcinogenic risk of 1E-5.
4	Tier 2 SSTL	Occasional Use Area	The direct exposure to contaminated soil during an entire workday for 50 days (8 hrs/day, 10 days/yr, 5 years)	Evaluate results from exposure points.	Use carcinogenic risk of 1E-5.
5	Tier 3 SSTL	N/A	Specific to most exposed individual	Evaluate risk at exposure points.	Conduct risk assessment.

Table 6-2
Progression of Evaluations

Evaluation Level	Action Taken for Non-Exceedance	Potential Actions Taken for Exceedance
1	Establish FAL at RBSL concentration. No further action required.	• Conduct corrective action, or • Evaluate at Level 2.
2	Establish FAL at SSTL concentration. No further action required.	• Conduct corrective action, or • Evaluate at Level 3 if Remote Work Area scenario is appropriate, and record use restriction for activities where potential exposure to contaminated media exceeds the equivalent of 1,075 workdays, or • Evaluate at Level 5.
3	Establish FAL at SSTL concentration. No further action required.	• Conduct corrective action, or • Evaluate at Level 4 if Occasional Use Area scenario is appropriate, and record use restriction for activities where potential exposure to contaminated media exceeds the equivalent of 50 workdays, or • Evaluate at Level 5.
4	Establish FAL at SSTL concentration.	• Conduct corrective action, or • Evaluate at Level 5.
5	Establish FAL at SSTL concentration. No further action required.	• Conduct corrective action.

7.0 Process Documentation

Final action levels along with the basis for their selection (e.g., PALs, Tier 2 SSTL, or Tier 3 SSTL) will be documented in FFACO reports, where they will be compared to laboratory results in the evaluation or verification of corrective actions. If the FALS are established as Tier 2 or Tier 3 SSTLs, the equations and all input parameter values (including the documentation and justification of non-standard input values) will be provided in the risk assessment appendix of the FFACO report. This appendix will be consistent with the format and content of the example text contained in Section X.5 of Method E1739-95 (ASTM, 1995).

8.0 References

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Appendix A
RAIS Input Parameter Sensitivity Analysis

Appendix A - RAIS Input Parameter Sensitivity Analysis

A sensitivity analysis was conducted for the site-specific input parameters listed in Table 3-2. To better evaluate the effect of changing input values on the total soil SSTL (which combines the risk associated with inhalation, dermal, and ingestion), six chemical constituents were chosen that have a predominant risk associated with each of the exposure routes/effects listed in Table A.1-1. The numbers in Table A.1-1 relate to a percent change in the SSTL value corresponding to a 1 percent increase in the input parameter.

Table A.1-1
Percent Change in SSTL Due to a 1 Percent Increase in the Input Parameter

Chemical Constituents	Exposure Route/Effect	Exposure Duration	Exposure Frequency	Soil Ingestion Rate	Fraction Soil Organic Carbon	Water-Filled Soil Porosity	Fraction Vegetative Cover
Arsenic, Inorganic	Ingestion Carcinogen	-0.84	-0.88	-1.02	0	0	0
Benzene	Inhalation Carcinogen	-0.82	-0.89	-0.05	0.56	0.70	0
Chlordane	Dermal Carcinogen	-0.83	-0.90	-0.92	0.07	0.04	0
Demeton	Ingestion Toxic	0	-0.90	-1.59	0	0	0
Acrolein	Inhalation Toxic	0	-0.91	0	0.07	1.06	0
Endrin	Dermal Toxic	0	-0.90	-0.26	0	0	0

Appendix B
RESRAD Input Parameters

Table B.1-1
RESRAD Parameters
(Page 1 of 4)

Parameter	Units	Industrial Scenario Value	Remote Scenario Value	Occasional Scenario Value	RESRAD Default Value	Reference/Rationale
Dose Conversion Factors						FGR 13 Morbidity
R02 Exposure Pathways						
Pathway 1- External Gamma		Active	Active	Active		
Pathway 2- Inhalation		Active	Active	Active		
Pathway 3- Plant Ingestion		Suppressed	Suppressed	Suppressed		
Pathway 4- Meat Ingestion		Suppressed	Suppressed	Suppressed		
Pathway 5- Milk Ingestion		Suppressed	Suppressed	Suppressed		
Pathway 6- Aquatic Foods		Suppressed	Suppressed	Suppressed		
Pathway 7- Drinking Water		Suppressed	Suppressed	Suppressed		
Pathway 8- Soil Ingestion		Active	Active	Active		
Pathway 9- Radon		Suppressed	Suppressed	Suppressed		
R011 Contaminated Zone						
Area of CZ	m^2	Site Specific	Site Specific	Site Specific	1.00E+04	Maximum area of contamination out to two successive sample intervals below PALs. (~15 ft intervals laterally)
Thickness of CZ	m	Site Specific	Site Specific	Site Specific	2.00E+00	Maximum identified depth plus two successive intervals below PALs as identified during the site characterization. (~5 ft intervals vertically)
Length Parallel to Aquifer Flow	m	not used	not used	not used	1.00E+02	Not used with the above pathway selection
Radiation Dose Limit	mrem/yr	25	25	25	2.50E+01	RESRAD Default (DOE, 1993)
Elapsed Time Since Placement of Material	yr	0	0	0	0	RESRAD Default
R012 Initial Principle Radionuclide						
Site Specific Parent Radionuclide with half-life greater than 180 days, does not include naturally occurring and primordial radionuclides	pCi/g	Site Specific	Site Specific	Site Specific	0	The maximum detected activity or the 95% UCL of the mean.

Table B.1-1
RESRAD Parameters
(Page 2 of 4)

Parameter	Units	Industrial Scenario Value	Remote Scenario Value	Occasional Scenario Value	RESRAD Default Value	Reference/Rationale
R013 Cover and Contaminated Zone Hydrological Data						
Cover Depth	m	Site Specific	Site Specific	Site Specific	0	The minimum depth as identified during the site characterization
Density of Cover Material	g/cm^3	1.5	1.5	1.5	1.5	RESRAD Default unless site data significantly different
Cover Depth Erosion Rate	m/yr	1.00E-03	1.00E-03	1.00E-03	1.00E-03	RESRAD Default unless site data significantly different
Density of Contaminated Zone	g/cm^3	1.5	1.5	1.5	1.5	RESRAD Default unless site data significantly different
Contamination Zone Erosion Rate	m/yr	1.00E-03	1.00E-03	1.00E-03	1.00E-03	RESRAD Default unless site data significantly different
Contaminated Zone Total Porosity	-	4.00E-01	4.00E-01	4.00E-01	4.00E-01	RESRAD Default unless site data significantly different
Contaminated Zone Field Capacity	-	2.00E-01	2.00E-01	2.00E-01	2.00E-01	RESRAD Default unless site data significantly different
Contaminated Zone Hydraulic Conductivity	m/yr	1.00E+01	1.00E+01	1.00E+01	1.00E+01	RESRAD Default unless site data significantly different
Contaminated Zone b Parameter	-	5.30E+00	5.30E+00	5.30E+00	5.30E+00	RESRAD Default unless site data significantly different
Average Annual Wind Speed	m/sec	4.07	4.07	4.07	2.00E+00	RAIS Default for Las Vegas, NV
Humidity in Air	g/m^3	not used	not used	not used	8.00E+00	Not used with the above pathway selection
Evapotranspiration Coefficient	-	5.00E-01	5.00E-01	5.00E-01	5.00E-01	RESRAD Default not significant due to lack of groundwater pathway
Precipitation	m/yr	Site Specific	Site Specific	Site Specific	1.00E+00	Data from Air Resources Laboratory (http://www.sord.nv.doe.gov/arlsord-1.htm)
Irrigation	m/yr	0	0	0	2.00E-01	Assumes no artificial supply of water to soil
Irrigation Mode	-	overhead	overhead	overhead	overhead	RESRAD Default
Runoff Coefficient	-	4.00E-01	4.00E-01	4.00E-01	2.00E-01	Open Sandy Loam 30% impervious Table 10.1 (Yu, et al., 1993)
Watershed Area for Nearby Stream or Pond	m^2	not used	not used	not used	1.00E+06	Not used with the above pathway selection

Table B.1-1
RESRAD Parameters
(Page 3 of 4)

Parameter	Units	Industrial Scenario Value	Remote Scenario Value	Occasional Scenario Value	RESRAD Default Value	Reference/Rationale
Accuracy for Water/Soil Computations	-	not used	not used	not used	1.00E-03	Not used with the above pathway selection
R014 Saturated Zone Hydrological Data						
Parameters Not Used						
R015 Uncontaminated and Unsaturated Strata Hydrological Data						
Parameters Not Used						
R016 Distribution Coefficients and Leach Rates						
Parameters Not Used						
R017 Inhalation and External Gamma						
Inhalation Rate	m^3/yr	8.40E+03	12,300	12,300	8.40E+03	RESRAD Default and for an individual performing outdoor activities, a typical activity mix can consist of 37% at a moderate activity level, 28% at both resting and light activity levels, and 7% at a heavy activity level, which results in a 1.4 m^3/hr (12,300 m^3/yr) inhalation rate (Yu, et al., 1993)
Mass Loading for Inhalation	g/m^3	6.00E-04	6.00E-04	6.00E-04	1.00E-04	The estimated mass loading for construction activities (Yu, et al., 1993)
Exposure Duration	yr	25	25	5	30	Standard for Industrial/Commercial Scenario
Shielding Factor Inhalation	-	1	1	1	0.4	Assumes no indoor time fraction
Shielding Factor External Gamma	-	1	1	1	0.7	Assumes no indoor time fraction
Fraction of Time Spent Indoors	-	0	0	0	0.5	Based on use scenarios
Fraction of Time Spent Outdoors	-	$8.55E^{-2}$	$1.28E^{-2}$	$9.13E^{-3}$	0.25	Based on use scenarios
Shape Factor	-	1	1	1	1	RESRAD Default
R018 Ingestion Pathway Data, Dietary Parameters						
Fruits, Vegetables, and Grain Consumption	kg/yr	not used	not used	not used	1.60E+02	Not used with the above pathway selection
Leafy Vegetable Consumption	kg/yr	not used	not used	not used	1.40E+01	Not used with the above pathway selection
Milk Consumption	L/yr	not used	not used	not used	9.20E+01	Not used with the above pathway selection
Meat and Poultry Consumption	kg/yr	not used	not used	not used	6.30E+01	Not used with the above pathway selection

Table B.1-1
RESRAD Parameters
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Parameter	Units	Industrial Scenario Value	Remote Scenario Value	Occasional Scenario Value	RESRAD Default Value	Reference/Rationale
Fish Consumption	kg/yr	not used	not used	not used	5.40E+00	Not used with the above pathway selection
Other Seafood Consumption	kg/yr	not used	not used	not used	9.00E-01	Not used with the above pathway selection
Soil Ingestion Rate	g/yr	108	20.2	4.8	36.5	Based on exposure duration and soil ingestion rate of 480 mg/day (Yu, et al., 1993)
Drinking Water Intake	L/yr	not used	not used	not used	5.10E+02	Not used with the above pathway selection
Drinking Water Contaminated Fraction	-	not used	not used	not used	1.00E+00	Not used with the above pathway selection
Household Water Contaminated Fraction	-	not used	not used	not used	1.00E+00	Not used with the above pathway selection
Livestock Water Contaminated Fraction	-	not used	not used	not used	1.00E+00	Not used with the above pathway selection
Irrigation Water Contaminated Fraction	-	not used	not used	not used	1.00E+00	Not used with the above pathway selection
Aquatic Food Contamination Fraction	-	not used	not used	not used	5.00E-01	Not used with the above pathway selection
Plant Food Contamination Fraction	-	not used	not used	not used	-1	Not used with the above pathway selection
Meat Contamination Fraction	-	not used	not used	not used	-1	Not used with the above pathway selection
Milk Contamination Fraction	-	not used	not used	not used	-1	Not used with the above pathway selection
R019 Ingestion Pathway Data, Non-dietary						
Parameters Not Used						
R021 Radon						
Parameters Not Used						