744 Heartland Trail (53717-1934)
PO Box 8923 (53708-8923)
Madison, WI
Telephone (608) 831-4444
Fax (608) 831-3334

# Decommissioning Plan

*SCA Hartley & Hartley Landfill Site*
*Kawkawlin Township, Michigan*

**November 2003**

*Prepared for*
*S.C. Holdings, Inc.*



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# Annotated Acceptance Review Checklist

# Annotated Acceptance Review Checklist

Licensee Name: SCA Services (Hartley & Hartley Landfill) Site
License Number: SUC-1565; Docket Number: 040-09022
Facility: Kawkawlin, Bay County, Michigan
Decommissioning Plan Dated November 2003

## 1.0 Executive Summary

| | |
|---|---|
| 1.0 | The name and address of the licensee or owner of the site. |
| 1.0 | The location and address of the site. |
| 1.0 | A brief description of the site and immediate environs. |
| 1.0 | A summary of the licensed activities that occurred at the site. |
| 1.0 | The nature and extent of contamination at the site. |
| 1.0 | The decommissioning objective proposed by the licensee (*i.e.*, restricted or unrestricted use). |
| 1.0 | The DCGLs for the site, the corresponding doses from these DCGLs and the method that was use to determine the DCGLs. |
| 1.0 | A summary of the ALARA evaluations performed to support the decommissioning. |
| NA | If the licensee or responsible party requests license termination under restricted conditions, the restrictions the licensee intends to use to limit doses as required in 10 CFR Part 20.1403 or 20.1404 and a summary of institutional controls, financial assurance. |
| NA | If the licensee requests license termination under restricted conditions or using alternate criteria a summary of the public participation activities undertaken by the licensee to comply with 10 CFR Part 20.1403(d) or 20.1404(a)(4). |
| 1.0 | The proposed initiation and completion dates of decommissioning. |
| 1.0 | Any post-remediation activities (such as groundwater monitoring) that the licensee proposes to undertake prior to requesting license termination. |
| 1.0 | A statement that the licensee is requesting that its license be amended to incorporate the decommissioning plan |

## 2.0 Facility Operating History

### 2.1 License Number/Status/Authorized Activities

| | |
|---|---|
| 2.1 | The radionuclides and maximum activities of radionuclides authorized under the current *(possession only)* license. |
| 2.1 | The chemical forms of the radionuclides authorized under the current *(possession only)* license. |
| 2.1 | A detailed description of how the radionuclides are currently being *monitored* at the site. |
| 2.1 | The location(s) of *disposal* of the various radionuclides authorized under current *(possession only)* licenses. |
| 2.1 | A scale drawing or map of the building or site and environs showing the current locations of radionuclide at the site. |
| 2.1 | A list of amendments to the license. |

## 2.2 License History

2.2 The radionuclides and maximum activities of radionuclides authorized under all previous and *current* licenses and activities conducted by prior site owner/operators.

2.2 The chemical forms of the radionuclides authorized and used under all previous licenses.

2.2 A detailed description of how the radionuclides were used at the site.

2.2 The location(s) of use and storage of the various radionuclides authorized under all previous licenses.

2.2 A scale drawing or map of the site, facilities, and environs, showing previous locations of radionuclide use at the site.

## 2.3 Previous Decommissioning Activities

2.3 A list or summary of areas at the site that were remediated in the past, *including slurry wall, etc. for containment.*

2.3 A summary of the types, forms, activities and concentrations of radionuclides that were present in previously remediated areas.

2.3 The activities that caused the areas to become contaminated.

2.3 The procedures used to remediate the areas and the disposition of radioactive material generated during the remediation.

2.6 A summary of the results of the final radiological evaluation of the previously remediated area

2.3 A scale drawing or map of the site, facilities and environs showing the locations of previous remedial activity.

## 2.4 Spills

2.4 A summary of areas at the site where spills (or uncontrolled releases) of radioactive material occurred in the past *and material located in areas other than disposal cells.*

2.4 The types, forms, activities, and concentrations of radionuclides involved in the spill or uncontrolled release.

2.4 A scale drawing or map of the site, facilities, and environs showing the locations of *and material located in areas other than disposal cells.*

## 2.5 Prior On-site Burials

2.5 A summary of areas at the site where radioactive material has been buried in the past.

2.4 The types, forms, activities, and concentrations of waste and radionuclides in the former burial.

2.5 A scale drawing or map of the site, facilities, and environs showing the locations of former burials.

## 3.0 Facility Description

## 3.1 Site Location and Description

3.1 The size of the site in acres or square meters.

3.1 The State and county in which the site is located.

3.1 The names and distances to nearby communities, towns and cities.

3.1 A description of the contours and features of the site.

3.1 The elevation of the site.

3.1 A description of property surrounding the site; including the location of all off-site wells used by nearby communities or individuals *(about one mile radius).*

3.1 The location of the site relative to prominent features such as rivers and lakes.

3.1 A map that shows the detailed topography of the site using a contour interval.

3.1 The location of the nearest residences and all significant facilities or activities near the site.

3.1 A description of the facilities (buildings, parking lots, fixed equipment, etc.) at the site.

## 3.2 Population Distribution

3.2 A summary of the current population in and around the site, by compass vectors.

3.2 A summary of the projected population in and around the site by compass vectors.

3.2 A list of minority populations by compass vectors.

3.2 Demographic data by census block group to identify minority or low-income populations.

## 3.3 Current/Future Land Use

3.3 A description of the current land uses in and around the site.

3.3 A summary of anticipated land uses.

## 3.4 Metrology and Climatology

3.4 A description of the general climate of the region.

3.4 Seasonal and annual frequencies of severe weather phenomena.

3.4 Weather-related radionuclide transmission parameters.

3.4 Routine weather-related site deterioration parameters.

3.4 Extreme weather-related site deterioration parameters.

3.4 A description of the local (site) meteorology.

3.4 The National Ambient Air Quality Standards Category of the area in which the facility is located and, if the facility is not in a Category 1 zone, the closest and first downwind Category 1 zone.

## 3.5 Geology and Seismology

3.5 A detailed description of the geologic characteristics of the site and the region around the site.

3.5 A discussion of the tectonic history of the region, regional geomorphology, physiography, stratigraphy, and geochronology.

3.5 A regional tectonic map showing the site location and its proximity to tectonic structures.

3.5 A description of the structural geology of the region and its relationship to the site geologic structure.

3.5 A description of any crustal tilting, subsidence, karst terrain, landsliding, and erosion.

3.5 A description of the surface and subsurface geologic characteristics of the site and its vicinity.

3.5 A description of the geomorphology of the site.

| | |
|---|---|
| 3.5 | A description of the location, attitude, and geometry of all known or inferred faults in the site and vicinity. |
| 3.5 | A discussion of the nature and rates of deformation. |
| 3.5 | A description of any man-made geologic features such as mines or quarries. |
| 3.5 | A description of the seismicity of the site and region. |
| 3.5 | A complete list of all historical earthquakes that have a magnitude of 3 or more or a modified Mercalli intensity of IV or more within 200 miles of the site. |

## 3.6 Surface Water Hydrology

| | |
|---|---|
| 3.6 | A description of site drainage and surrounding watershed fluvial features. |
| 3.6 | Water resource data including maps, hydrographs, and stream records from other agencies (*e.g.*, U.S. Geological Survey and U.S. Army Corps of Engineers). |
| 3.6 | Topographic maps of the site that show natural drainages and man-made features. |
| 3.6 | A description of the surface water bodies at the site and surrounding areas. |
| 3.6 | A description of existing and proposed water control structures and diversions (both upstream and downstream that may influence the site). |
| 3.6 | Flow-duration data that indicate minimum, maximum, and average historical observations for surface water bodies in the site areas. |
| 3.6 | Aerial photography and maps of the site and adjacent drainage areas identifying features such as drainage areas, surface gradients, and areas of flooding. |
| 3.6 | An inventory of all existing and planned surface water users, whose intakes could be adversely affected by migration of radionuclides from the site. |
| 3.6 | Topographic and/or aerial photographs that delineate the 100-year floodplain at the site. |
| 3.6 | A description of any man-made changes to the surface water hydrologic system that may influence the potential for flooding at the site. |

## 3.7 Groundwater Hydrology

| | |
|---|---|
| 3.7 | A description of the saturated zone. |
| 3.7 | Descriptions of monitoring wells. |
| 3.7 | Physical parameters. |
| 3.7 | A description of groundwater flow directions and velocities. |
| 3.7 | A description of the unsaturated zone. |
| 3.7 | Information on all monitor stations, including location and depth. |
| 3.7 | A description of physical parameters. |
| NA | A description of the numerical analyses techniques used to characterize the unsaturated and saturated zones. |
| 3.7 | The distribution coefficients of the radionuclides of interest at the site. |
| 3.7 | *Typical geologic cross-sections showing groundwater elevations and flow direction(s).* |

## 3.8 Natural Resources

3.8 A description of the natural resources occurring at or near the site.

3.8 A description of potable, agricultural, or industrial ground or surface waters.

3.8 A description of economic, marginally economic, or subeconomic known or identified natural resources as defined in U.S. Geological Survey Circular 831.

3.8 Mineral, fuel, and hydrocarbon resources near and surrounding the site which, if exploited, would effect the licensee' or responsible party's dose estimates.

## 3.9 Ecology/Endangered Species

3.9.0 A list of commercially or recreationally important invertebrate species known to occur within 5 km of the site.

3.9.2 A list of all commercially important floral species known to occur within 5 km of the site.

3.9.3 A list of commercially or recreationally important vertebrate animals known to occur within 5 km of the site.

3.9 Estimates of the relative abundance of both commercially and recreationally important game and nongame vertebrates.

3.9.4 A list of all endangered species at or within 5 km of the site.

## 4.0 Radiological Status of Facility

## 4.1 Contaminated Structures

NA A list or description of all structures at the facility where licensed activities occurred that contain residual radioactive material in excess of site background levels.

NA A summary of the structures and locations at the facility that the licensee or responsible party has concluded have not been *(radiologically)* impacted and the rationale for the conclusion.

NA A list or description of each room or work area within each of these structures.

4.3 A summary of the background levels used during scoping or characterization surveys.

NA A summary of the locations of contamination in each room or work area.

NA A summary of the radionuclides present at each location, the maximum and average radionulide activities in dpm/100cm2, and, if multiple radionuclides are present, the radionuclide ratios.

NA The mode of contamination for each surface (*i.e.*, whether the radioactive material is present only on the surface of the material or if it has penetrated the material).

NA The maximum and average radiation levels in mrem/hr in each room or work area.

NA A scale drawing or map of the rooms or work areas showing the locations of radionuclide material contamination.

## 4.2 Contaminated Systems and Equipment

| | |
|---|---|
| NA | A list or description and the location of all systems or equipment *including leachate system* at the facility that contain residual radioactive material in excess of site background levels. |
| NA | A summary of the radionuclides present in each systems or on the equipment at each location, the maximum and average radionulide activities in dpm/100cm2, and, if multiple radionuclides are present, the radionuclide ratios. |
| NA | The maximum and average radiation levels in mrem/hr at the surface of each piece of equipment. |
| NA | A summary of the background levels used during scoping or characterization surveys. |
| NA | A scale drawing or map of the rooms or work areas showing the locations of the contaminated systems or equipment. |

## 4.3-4.7 Surface Soil Contamination

| | |
|---|---|
| 4.3 – 4.7 | A list or description of all locations at the facility where surface soil contains residual radioactive material in excess of site background levels. |
| 4.3 – 4.7 | A summary of the background levels used during scoping or characterization surveys. |
| 4.3 – 4.7 | A summary of the radionuclides present at each location, the maximum and average radionuclide activities in pCi/gm, and, if multiple radionuclides are present, the radionuclide ratios. |
| 4.3 – 4.7 | The maximum and average radiation levels in mrem/hr at each location. |
| 4.3 – 4.7 | A scale drawing or map of the site showing the locations of radionuclide material contamination in surface soil. |

## 4.3-4.7 Subsurface Soil Contamination

| | |
|---|---|
| 4.3 – 4.7 | A list or description of all locations at the facility where subsurface soil contains residual radioactive material in excess of site background levels. |
| 4.3 – 4.7 | A summary of the background levels used during scoping or characterization surveys. |
| 4.3 – 4.7 | A summary of the radionuclides present at each location, the maximum and average radionulide activities in pCi/gm, and, if multiple radionuclides are present, the radionuclide ratios. |
| App. B-3 | The depth of the subsurface soil contamination at each location; and *in a cross section.* |
| 4.3 – 4.7 | A scale drawing or map of the site showing the locations of subsurface soil contamination. |

## 4.3-4.7 Surface Water

| | |
|---|---|
| 4.3 – 4.7 | A list or description of all surface water bodies at the facility that contain residual radioactive material in excess of site background levels. |
| 4.3 – 4.7 | A summary of the background levels used during scoping or characterization surveys. |
| 4.3 – 4.7 | A summary of the radionuclides present in each surface water body and the maximum and average radionuclide activities in pCi/l. |

## 4.3-4.7 Groundwater/*Leachate*

| | |
|---|---|
| 4.3 – 4.7 | A summary of the aquifer(s) at the facility that contain residual radioactive material in excess of site background levels. |
| 4.3 – 4.7 | A summary of the background levels used during scoping or characterization surveys. |
| 4.3 – 4.7 | A summary of the radionuclides present in each aquifer and the maximum and average radionulide activities in pCi/l. |
| 4.3 – 4.7 | *A summary of radionuclides present in leachate in each disposal cell.* |

# 5.0 <u>Dose Modeling</u>

## Unrestricted Release Using Screening Criteria

### Unrestricted Release Using Screening Criteria For Building Surface Residual Radioactivity

| | |
|---|---|
| NA | The general conceptual model (for both the source term and the building environment) of the site. |
| NA | A summary of the screening method (*i.e.*, running DandD or using the look-up tables) used in the decommissioning plan. |

### Unrestricted Release Using Screening Criteria For Surface Soil Residual Radioactivity

| | |
|---|---|
| NA | Justification on the appropriateness of using the screening approach (for both the source term and the environment) at the site. |
| NA | A summary of the screening method (*i.e.*, running DandD or using the look-up tables) used in the decommissioning plan. |

## 5.2 Unrestricted Release Using Site-Specific Information

| | |
|---|---|
| 5.0 | Source term information including nuclides of interest, configuration of the source, areal variability of the source, etc. |
| 5.2 | Description of the exposure scenario including a description of the critical group. |
| 5.2 | Description of the conceptual model of the site including the source term, physical features important to modeling the transport pathways, and the critical group. |

| | |
|---|---|
| 5.2 | Identification/description of the mathematical model used (e.g., hand calculations, DandD Screen v1.0, RESRAD 6.0, etc.). |
| 5.2.3 | Description of the parameters used in the analysis. |
| 5.4 | Discussion about the effect of uncertainty on the results. |
| App. D | Input and output files or printouts, if a computer program was used. |

## Restricted Release Using Site-Specific Information

| | |
|---|---|
| NA | Source term information including nuclides of interest, configuration of the source, areal variability of the source, and chemical forms. |
| NA | A description of the exposure scenarios including a description of the critical group for |
| NA | each scenario. |
| NA | A description of the conceptual model(s) of the site that includes the source term, physical features important to modeling the transport pathways, and the critical group for each scenario. |
| NA | Identification/description of the mathematical model(s) used (*e.g.*, hand calculations, RESRAD v6.0, etc.); |
| NA | A summary of parameters used in the analysis. |
| NA | A discussion about the effect of uncertainty on the results. |
| NA | Input and output files or printouts, if a computer program was used. |

## Release Involving Alternate Criteria

| | |
|---|---|
| NA | Source term information including nuclides of interest, configuration of the source, areal variability of the source, and chemical forms. |
| NA | A description of the exposure scenarios including a description of the critical group for each scenario. |
| NA | A description of the conceptual model(s) of the site that includes the source term, physical features important to modeling the transport pathways, and the critical group for each scenario. |
| NA | Identification/description of the mathematical model(s) used (e.g., hand calculations, RESRAD v6.0, etc.). |
| NA | A summary of parameters used in the analysis. |
| NA | A discussion about the effect of uncertainty on the results. |
| NA | Input and output files or printouts, if a computer program was used. |

# 6.0 Alternatives Considered and Rationale for Chosen Alternative

## 6.1 Alternatives Considered

| | |
|---|---|
| 6.1 | A description of the facility if the alternative is employed. |
| 6.1 | A summary of the health effects to adjacent communities if the alternative is employed. |
| 6.1 | A summary of the impacts on community resources such as land use and property values. |

6.1 A summary of the impacts on the geology, hydrology, air quality and ecology in and around the site.

6.1 A description of impacts to minority or low-income populations within a 0.6 mile radius of the center of the facility (urban location) or within a 4 mile radius of the center of the facility (rural location).

10.2 If appropriate, an assessment of the potential for criticality.

6.1 A summary of the irreversible and irretrievable commitment of resources.

6.1 An analysis of the proposed alternative and other alternatives as required by 10 CFR 51.45(c).

6.1 A list of the permits, licenses, approvals, and other entitlements and the discussion of the status of compliance with these requirements required in 10 CFR 51.45(d).

## 6.2 Rationale For Chosen Alternative

6.2 A description of why the licensee selected the preferred alternative described in the decommissioning plan.

6.2 If the licensee has not selected the environmentally preferable alternative, an explanation of why this alternative was not selected.

## 7.0 ALARA Analysis

7.0 A description of how the licensee or responsible party will achieve a decommissioning goal below the dose limit.

7.0 *A description of the impact of a pump-and-treat system, including the management of related waste (e.g., sediment, leachate, air emissions, etc.).*

7.0 A quantitative cost benefit analysis.

7.0 A description of how costs were estimated.

7.0 A demonstration that the doses to the average member of the critical group are ALARA.

## 8.0 Planned Decommissioning Activities

## 8.1 Contaminated Structures

NA A summary of the remediation tasks planned for each room or area in the contaminated structure in the order in which they will occur.

NA A description of the remediation techniques that will be employed in each room or area of the contaminated structure.

NA A summary of the radiation protection methods and control procedures that will be employed in each room or area.

NA A summary of the procedures already authorized under the existing license and those for which approval is being requested in the decommissioning plan.

NA A commitment to conduct decommissioning activities in accordance with written, approved procedures.

NA A summary of any unique safety or remediation issues associated with remediating the room or area.

NA For Part 70 licensees, a summary of how the licensee will ensure that the risks addressed in the facility's Integrated Safety Analysis will be addressed during decommissioning.

## 8.2 Contaminated Systems and Equipment

NA — A summary of the remediation tasks planned for each system *(including leachate pump and treat equipment)* in the order in which they will occur, including which activities will be conducted by licensee staff and which will be performed by a contractor.

NA — A description of the techniques that will be employed to remediate each system in the facility or site.

NA — A description of the radiation protection methods and control procedures that will be employed while remediating each system.

NA — A summary of the equipment will be removed or decontaminated and how the decontamination will be accomplished.

NA — A summary of the procedures already authorized under the existing license and those for which approval is being requested in the decommissioning plan.

NA — A commitment to conduct decommissioning activities in accordance with written, approved procedures.

NA — A summary of any unique safety or remediation issues associated with remediating any system or piece of equipment.

NA — For Part 70 licensees, a summary of how the licensee will ensure that the risks addressed in the facility's Integrated Safety Analysis will be addressed during decommissioning.

## 8.3.1 Soil

8.3.1 — A summary of the removal/remediation tasks planned for surface and subsurface soil at the site in the order in which they will occur including which activities will be conducted by licensee staff and which will be performed by a contractor.

8.3.1 — A description the techniques that will be employed to remove or remediate surface and subsurface soil at the site.

10.1 — A description of the radiation protection methods and control procedures that will be employed during soil removal/remediation.

2.1 — A summary of the procedures already authorized under the existing license and those for which approval is being requested in the decommissioning plan.

8.3.1 — A commitment to conduct decommissioning activities in accordance with written, approved procedures.

8.3.1 — A summary of any unique safety or removal/remediation issues associated with remediating the soil.

N/A — For Part 70 licensees, a summary of how the licensee will ensure that the risks addressed in the facility's Integrated Safety Analysis will be addressed during decommissioning.

## Surface and Groundwater

NA — A summary of the remediation tasks planned for ground and surface water in the order in which they will occur, including which activities will be conducted by licensee staff and which will be performed by a contractor.

NA — A description the remediation techniques that will be employed to remediate the ground or surface water.

NA — A description of the radiation protection methods and control procedures that will be employed during ground or surface water remediation.

| | |
|---|---|
| NA | A summary of the procedures already authorized under the existing license and those for which approval is being requested in the decommissioning plan. |
| NA | A commitment to conduct decommissioning activities in accordance with written, approved procedures. |
| NA | A summary of any unique safety or remediation issues associated with remediating the ground or surface water. |

### 8.3.2 Leachate

| | |
|---|---|
| 8.3.2 | A summary of the remediation tasks planned for leachates in the order in which they will occur, including which activities will be conducted by licensee staff and which will be performed by a contractor. |
| 8.3.2 | A description of the techniques that will be employed to pump and treat leachates. |
| NA | A description of the radiation protection methods and control procedures that will be employed during pump and treat activities. |
| 8.3.2 | A commitment to conduct all pump and treat activities in accordance with written, approved procedures. |
| 8.3.2 | A summary of any unique safety or issues associated with the operation and maintenance of the pump and treat system. |

### 8.3.4 Schedules

| | |
|---|---|
| 8.3.4 | A Gantt or PERT chart detailing the proposed remediation tasks in the order in which they will occur. |
| 8.3.4 | A statement acknowledging that the dates in the schedule are contingent on NRC approval of the decommissioning plan. |
| 8.3.4 | A statement acknowledging that circumstances can change during decommissioning, and, if the licensee determines that the decommissioning cannot be completed as outlined in the schedule, the licensee or responsible party will provide an updated schedule to NRC. |
| 8.3.4 | If the decommissioning is not expected to be completed within the timeframes outlined in NRC regulations, a request for alternative schedule for completing the decommissioning. |

## 9.0 Project Management and Organization

### 9.1 Decommissioning Management Organization

| | |
|---|---|
| 9.1 | A description of the decommissioning organization *including specialty contractor identified by technical disciplines.* |
| 9.3 | A description of the responsibilities of each of these decommissioning project units. |
| 9.1 | Description of the reporting hierarchy within the decommissioning project management organization, *including the radiation safety officer qualification and experience.* |
| 9.3 | A description of the responsibility and authority of each unit to ensure that decommissioning activities are conducted in a safe manner and in accordance with approved written procedures. |

## 9.2 Decommissioning Task Management

9.2 A description of the manner in which the decommissioning tasks are managed, *including supervision of contractors.*

9.2 A description of how individual decommissioning tasks are evaluated and how the RWPs are developed for each task.

9.2 A description of how the RWPs are reviewed and approved by the decommissioning project management organization.

9.2 A description of how RWPs are managed throughout the decommissioning project.

9.4 A description of how individuals performing the decommissioning tasks are informed of the procedures in the RWP.

## 9.3 Decommissioning Management Positions and Qualifications

9.3 A description of the duties and responsibilities of each management position in the decommissioning organization and the reporting responsibility of the position.

9.3 A description of the duties and responsibilities of each chemical, radiological, physical and occupational safety-related position in the decommissioning organization and the reporting responsibility of the position.

9.3 A description of the duties and responsibilities of each engineering, quality assurance, and waste management position in the decommissioning organization and the reporting responsibility of the position.

9.3 The minimum qualifications for each of the positions describe above, and the qualifications of the individuals currently occupying the positions.

9.3 A description of all decommissioning and safety committees.

### 9.3.1 Radiation Safety Officer

9.3.1 A description of the health physics and radiation safety education and experience required for individuals acting as the licensee's or responsible party's RSO.

9.3.1 A description of the responsibilities and duties of the RSO.

9.3.1 A description of the specific authority of the RSO to implement and manage the licensee's or responsible party' radiation protection program.

## 9.4 Training

9.4 A description of the radiation safety training that the licensee will provide to each employee.

9.4 A description of any daily worker "jobside" or "tailgate" training that will be provided at the beginning of each workday or job task to familiarize workers with job-specific procedures or safety requirements.

9.4 A description of the documentation that will be maintained to demonstrate that training commitments are being met.

## 9.5 Contractor Support

9.5 A summary of decommissioning tasks that will be performed by contractors.

9.5 A description of the management interfaces that will be in place between the licensee or responsible party's management and on-site supervisors and contractor management and on-site supervisors.

9.5 A description of the oversight responsibilities and authority that the licensee or responsible party will exercise over contractor personnel.

9.5 A description of the training that will be provided to contractor personnel by the licensee or responsible party and the training that will be provided by the contractor.

9.5 A commitment that the contractor will comply with all radiation safety and license requirements at the facility.

# 10.0 Health and Safety Program During Decommissioning

## 10.1 Radiation Safety Controls and Monitoring For Workers

### 10.0.1 Air Sampling Program

10.1.1 A description which demonstrates that the air sampling program is representative of the workers breathing zones.

10.1.1 A description of the criteria which demonstrates that air samplers with appropriate sensitivities will be used; and that samples will be collected at appropriate frequencies.

10.1.2 A description of the conditions under which air monitors will be used.

10.1.1 A description of the criteria used to determine the frequency of calibration of the flow meters on the air samplers.

10.1.1 A description of the action levels for air sampling results.

10.1.1 A description of how minimum detectable activities (MDA) for each specific radionuclide that may be collected in air samples are determined.

### 10.1.2 Respiratory Protection Program

10.1.2 A description of the process controls, engineering controls or procedures to control concentrations of radioactive materials in air.

10.1.2 A description of the evaluation which will be performed when it is not practical to apply engineering controls or procedures.

10.1.2 A description of the considerations used which demonstrates respiratory protection equipment is appropriate for a specific task based on the guidance on assigned protection factors.

10.1.2 A description of the medical screening and fit testing required before workers will use any respirator that is assigned a protection factor.

10.1.2 A description of the written procedures maintained to address all the elements of the respiratory protection program.

10.1.2 A description of the use, maintenance, and storage of respiratory protection devices.

10.1.2 A description of the respiratory equipment users training program.

10.1.2 A description of the considerations made when selecting respiratory protection equipment.

## 10.1.3 Internal Exposure Determination

10.1.3 A description of the monitoring to be performed to determine worker exposure.

10.1.3 A description of how worker intakes are determined using measurements of quantities of radionuclides excreted from, or retained in the human body.

10.1.3 A description of how worker intakes are determined by measurements of the concentrations of airborne radioactive materials in the workplace.

10.1.3 A description of how worker intakes, for an adult, a minor, and a declared pregnant woman are determined using any combination of the measurements above as may be necessary.

10.1.3 A description of how worker intakes are converted into committed effective dose equivalent.

## 10.1.4 External Exposure Determination

10.1.4 A description of the individual-monitoring devices which will be provided to workers..

10.1.4 A description of the type, range, sensitivity, and accuracy of each individual-monitoring device

NA A description of the use of extremity and whole body monitors when the external radiation field is non-uniform.

10.1.4 A description of when audible-alarm dosimeters and pocket dosimeters will be provided.

10.1.4 A description of how external dose from airborne radioactive material is determined.

10.1.4 A description of the procedure to insure that surveys necessary to supplement personnel monitoring are performed.

10.1.4 A description of the action levels for worker's external exposure, and the technical bases and actions to be taken when they are exceeded.

## 10.1.5 Summation of Internal and External Exposures

10.1.5 A description of how the internal and external monitoring results are used to calculate TODE and TEDE doses to occupational workers.

10.1.3 A description of how internal doses to the embryo/fetus, which is based on the intake of an occupationally-exposed, declared, pregnant woman will be determined.

10.1.3 A description of the monitoring of the intake of a declared, pregnant woman if determined to be necessary.

10.1.5 A description of the program for the preparation, retention and reporting of records for occupational radiation exposures.

## 10.1.6 Contamination Control Program

10.1.6 A description of the written procedures to control access to, and stay time in, contaminated areas by workers if they are needed.

10.1.6 A description of surveys to supplement personnel monitoring for workers during routine operations, maintenance, clean-up activities, and special operations.

| | |
|---|---|
| 4.3 and 10.1.1 | A description of the surveys which will be performed to determine the baseline of background radiation levels and radioactivity from natural sources for areas where decommissioning activities will take place. |
| 10.1.6 | A description in matrix or tabular form which describes contamination action limits (that is, actions taken to either decontaminate a person, place or area, or restrict access, or modify the type or frequency of radiological monitoring). |
| RSP(1) | A description (included in the matrix or table mentioned above) of proposed radiological contamination guidelines for specifying and modifying the frequency for each type of survey used to assess the reduction of total contamination. |
| 10.1.6 | A description of the procedures used to test sealed sources, and to insure that sealed sources are leaked tested at appropriate intervals. |
| 10.1.6 | *Description of procedures to release equipment and material from the site.* |

## 10.1.7 Instrumentation Program

| | |
|---|---|
| RSP | A description of the instruments to be used to support the health and safety program. |
| 10.1.7 | A description of instrumentation storage, calibration and maintenance facilities for instruments used in field surveys. |
| 10.1.7 | A description of the method used to estimate the MDC or MDA (at the 95 percent confidence level) for each type of radiation to be detected. |
| 10.1.7 | A description of the instrument calibration and quality assurance procedures. |
| 10.1.7 | A description of the methods used to estimate uncertainty bounds for each type of instrumental measurement. |
| 10.1.7 | A description of air sampling calibration procedures or a statement that the instruments will be calibrated by an accredited laboratory *as per Regulatory Guide 8.25 and NUREG-1400.*. |

## 10.2 Nuclear Criticality Safety

| | |
|---|---|
| NA | A description of how the NCS functions, including management responsibilities and technical qualifications of safety personnel, shall be maintained when needed throughout the decommissioning process. |
| NA | A description of how an awareness of procedures and other items relied on for safety shall be maintained throughout decommissioning among all personnel with access to systems that may contain fissionable material in sufficient amounts for criticality. |
| NA | A summary of the review of NCSA's or the ISA indicating either that the process needs no new safety procedures or requirements, or that new requirements or analysis have been performed. |
| NA | A summary of any generic NCS requirements to be applied to general decommissioning, decontamination, or dismantlement operations, including those dealing with systems that may unexpectedly contain fissionable material. |

## 10.3 Health Physics Audits, Inspections and Record-Keeping Program.

| | |
|---|---|
| 10.3 | A general description of the annual program review conducted by management. |
| 10.3 | A description of the records to be maintained of the annual program review and audits. |

(1) RSP=Radiation Safety Program (Waste Management, 1993)

| | |
|---|---|
| 10.3 | A description of the types and frequencies of surveys and audits to be performed by the RSO and RSO staff. |
| 13.7 | A description of the process used in evaluating and dealing with violations of NRC requirements or license commitments identified during audits. |

# 11.0 Environmental Monitoring and Control Program

## 11.1 Environmental ALARA Evaluation Program

| | |
|---|---|
| 11.1 | A description of ALARA goals for effluent control. |
| 11.1 | A description of the procedures, engineering controls, and process controls to maintain doses ALARA. |
| 11.1 | A description of the ALARA reviews and reports to management. |

## 11.2 Effluent Monitoring Program

| | |
|---|---|
| 4.3 | A demonstration that background and baseline concentrations of radionuclides in environmental media *(air, soil, vegetation, sediments, ground and surface waters, leachates)* have been established through appropriate sampling and analysis. |
| 11.1 | A description of the known or expected concentrations of radionuclides in effluents. |
| 11.1 | A description of the physical and chemical characteristics of radionuclides in effluents. |
| 11.1 | A summary or diagram of all effluent discharge locations. |
| 11.1 | A demonstration that samples will be representative of actual releases. |
| 11.2 | A summary of the sample collection and analysis procedures. |
| 11.2 | A summary of the sample collection frequencies. |
| 11.2 | A description of the environmental monitoring recording and reporting procedures. |
| 11.2 | A description of the quality assurance program to be established and implemented for the effluent monitoring program. |

## 11.3 Effluent Control Program

| | |
|---|---|
| 11.3 | A description of the controls that will be used to minimize releases of radioactive material to the environment. |
| 11.1 (limit) 11.3 (action) | A summary of the action levels and description of the actions to be taken should a limit be exceeded. |
| NA | A description of the leak detection systems for ponds, lagoons, and tanks. |
| NA | A description of the procedures to ensure that releases to sewer systems are controlled and maintained to meet the requirements of 10 CFR 20.2003. |
| 11.3 | A summary of the estimates of doses to the public from effluents and a description of the method used to estimate public dose. |

# 12.0 Radioactive Waste Management Program

## 12.1 Solid Radwaste

12.1 A summary of the types of solid radwaste that are expected to be generated during decommissioning operations.

12.1 A summary of the estimated volume, in cubic feet, of each solid radwaste type summarized under bullet 1 above.

4.9 A summary of the radionuclides (including the estimated activity of each radionuclide) in each estimated solid radwaste type summarized under bullet 1 above.

12.1 A summary of the volumes of Class A, B, C and Greater-than-Class-C solid radwaste that will be generated by decommissioning operations.

12.1 A description of how and where each of the solid radwaste summarized under bullet 1 above, will be stored on-site prior to shipment for disposal.

NA A description of how the each of the solid radwastes summarized under bullet 1 above, will be treated and packaged to meet disposal site acceptance criteria prior to shipment for disposal.

12.1 If appropriate, how the licensee or responsible party intends to manage volumetrically contaminated material.

12.1 A description of how the licensee or responsible party will prevent contaminated soil, or other loose solid radwaste, from being dispersed after exhumation and collection.

12.1 The name and location of the disposal facility that the licensee intends to use for each solid radwaste type summarized under Bullet 1 above.

## 12.2 Liquid Radwaste

12.2 A summary of the types of liquid radwaste that are expected to be generated during decommissioning operations.

12.2 A summary of the estimated volume, in liters, of each liquid radwaste type summarized under bullet 1 above.

12.2 A summary of the radionuclides (including the estimated activity of each radionuclide) in each liquid radwaste type summarized under bullet 1 above.

12.2 A summary of the estimated volumes of Class A, B, C and Greater-than-Class-C liquid radwaste that will be generated by decommissioning operations.

12.2 A description of how and where each of the liquid radwastes summarized under bullet 1 above, will be stored on-site prior to shipment for disposal.

12.2 A description of how the each of the liquid radwastes summarized under bullet 1 above, will be treated and packaged to meet disposal site acceptance criteria prior to shipment for disposal.

12.2 The name and location of the disposal facility that the licensee intends to use for each liquid radwaste type summarized under bullet 1 above

## 12.3 Mixed Waste

| | |
|---|---|
| NA | A summary of the types of solid and liquid mixed waste that are expected to be generated during decommissioning operations. |
| NA | A summary of the estimated volumes, in cubic feet of each solid mixed waste type summarized under bullet 1 above and in liters for each liquid mixed waste. |
| NA | A summary of the radionuclides (including the estimated activity of each radionuclide) in each type of mixed waste type summarized under bullet 1 above. |
| NA | A summary of the estimated volumes of Class A, B, C and Greater-than-Class-C mixed waste that will be generated by decommissioning operations. |
| NA | A description of how and where each of the mixed wastes summarized under bullet 1 above, will be stored on-site prior to shipment for disposal. |
| NA | A description of how the each of the mixed wastes summarized under bullet 1 above, will be treated and packaged to meet disposal site acceptance criteria prior to shipment for disposal. |
| NA | The name and location of the disposal facility that the licensee intends to use for each mixed waste type summarized under bullet 1 above. |
| NA | A discussion of the requirements of all other regulatory agencies having jurisdiction over the mixed waste. |
| NA | A demonstration the that the licensee possess the appropriate EPA or State permits to generate, store and/or treat the mixed wastes. |

# 13.0 Quality Assurance Program

## 13.1 Organization

| | |
|---|---|
| 13.1 | A description of the QA program management organization. |
| 13.1 | A description of the duties responsibilities of each unit within the organization and how delegation of responsibilities is managed within the decommissioning program. |
| 13.1 | A description of how work performance is evaluated. |
| 13.1 | A description of the authority of each unit within the QA program. |
| Fig. 9-1 | An organization chart of the QA program organization. |

## 13.2 Quality Assurance Program

| | |
|---|---|
| 13.2 | A commitment that activities affecting the quality of site decommissioning will be subject to the applicable controls of the QA program and activities covered by the QA program are identified on program defining documents. |
| 13.2 | A brief summary of the company's *site specific* QA policies. |
| 13.2 | A description of provisions to ensure that technical and quality assurance procedures required to implement the QA program are consistent with regulatory, licensing, and QA program requirements and are properly documented and controlled. |
| 13.7 | A description of the management reviews, including the documentation of concurrence in these quality-affecting procedures. |
| 13.2 | A description of the quality-affecting procedural controls *required* of the principal contractors. |

13.2 A description of how NRC will be notified of changes (a) for review and acceptance in the accepted description of the QA program as presented or referenced in the DP before implementation and (b) in organizational elements within 30 days after the announcement of the changes.

13.7 A description is provided of how management regularly assesses the scope, status, adequacy, and compliance of the QA program.

13.1 A description of the instruction provided to personnel responsible for performing activities affecting quality.

9.4 A description of the training and qualifications of personnel verifying activities for formal training and qualification programs, documentation includes the objectives and content of the program, attendees, and date of attendance.

9.4 A description of the self-assessment program to confirm that activities affecting quality comply with the QA program.

13.2 A commitment that persons performing self-assessment activities *(e.g. auditing one' own department)* are not to have direct responsibilities in the area they are assessing.

13.2 A description of the organizational responsibilities for ensuring that activities affecting quality are (a) prescribed by documented instructions, procedures, and drawings; and, (b) accomplished through implementation of these documents.

10 & 14 A description of the procedures to ensure that instructions, procedures, and drawings include quantitative acceptance criteria and qualitative acceptance criteria for determining that important activities have been satisfactorily performed.

## 13.3 Document Control

13.3 A summary of the types of QA documents that are included in the program.

13.3 A description of how the licensee or responsible party develops, issues, revises and retires QA documents.

13.3 *Retention policy – until license is terminated*

## 13.4 Control of Measuring and Test Equipment

10.1.7 A summary of the test and measurement equipment used in the program.

13.4 A description of how and at what frequency the equipment will be calibrated.

13.4 A description of the daily calibration checks that will be performed on each piece of test or measurement equipment.

13.4 A description of the documentation that will be maintained to demonstrate that only properly calibrated and maintained equipment was used during the decommissioning.

## 13.5 Corrective Action

13.5 A description of the corrective action procedures for the facility, including a description of how the corrective action is determined to be adequate.

13.5 A description of the documentation maintained for each corrective action and any follow-up activities by the QA organization after the corrective action is implemented.

## 13.6 Quality Assurance Records

| | |
|---|---|
| 13.6 | A description of the manner in which the QA records will be managed. |
| 13.6 | A description of the responsibilities of the QA organization. |
| 13.6 | A description of the QA records storage facility. |

## 13.7 Audits and Surveillances

| | |
|---|---|
| 13.7 | A description of the audit program. |
| 13.7 | A description of the records and documentation generated during the audits and the manner in which the documents are managed. |
| 13.7 | A description of all follow-up activities associated with audits or surveillances. |
| 13.7 | A description of the trending/tracking that will be performed on the results of audits and surveillances. |

## 14.0 Facility Radiation Surveys

### Release Criteria

| | |
|---|---|
| Table 5-4 | A summary table or list of the $DCGL_W$ for each radionuclide and impacted media of concern. |
| 14.0 | If Class 1 survey units are present, a summary table or list of area factors that will be used for determining a $DCGL_{EMC}$ for each radionuclide and media of concern. |
| 14.0 | If Class 1 survey units are present, the $DCGL_{EMC}$s for each radionuclide and medium of concern. |
| Table 5-4 | If multiple radionuclides are present, the appropriate $DCGL_W$ for the survey method to be used. |

### Characterization Surveys

| | |
|---|---|
| 4.4 | A description and justification of the survey measurements for impacted media |
| 4.4 | Description of the field instruments and methods that were used for measuring concentrations and the sensitivities of those instruments and methods. |
| App. B-3 | A description of the laboratory instruments and methods that were used for measuring concentrations and the sensitivities of those instruments and methods. |
| App. B-3 | The survey results including tables or charts of the concentrations of residual radioactivity measured. |
| Fig. 8-1 | Maps or drawings of the site, area, or building showing areas classified as non-impacted or impacted. |
| 4.4 and 14.1 | Justification for considering areas to be non-impacted. |
| 4.3-4.7 | A discussion of why the licensee considers the characterization survey to be adequate to demonstrate that it is unlikely that significant quantities of residual radioactivity have gone undetected. |

| | |
|---|---|
| NA | For areas and surfaces that are inaccessible or not readily accessible, a discussion of how they were surveyed or why they did not need to be surveyed. |
| NA | For sites, areas, or buildings with multiple radionuclides, a discussion justifying the ratios of radionuclides that will be assumed in the final status survey or an indication that no fixed ratio exists and each radionuclide will be measured separately. |

## Remedial Action Support Surveys

| | |
|---|---|
| Table 14-1 | A description of field screening methods and instrumentation. |
| 14.10 | A demonstration that field screening should be capable of detecting residual radioactivity at the DCGL. |

## 14.2 Final Status Survey Design

| | |
|---|---|
| 14.2 | A brief overview describing the final status survey design. |
| Fig. 8-1 | A description and map or drawing of impacted areas of the site, area, or building classified by residual radioactivity levels (Class 1, Class 2, or Class 3) and divided into survey units with an explanation of the basis for division into survey units. |
| Fig. 4-1 | a description of the background reference areas and materials, if they will be used, and a justification for their selection. |
| 14.2 | A summary of the statistical tests that will be used to evaluate the survey results. |
| 14.4 | A description of scanning instruments, methods, calibration, operational checks, coverage, and sensitivity for each media and radionuclide. |
| 14.5 | For *in situ* sample measurements made by field instruments, a description of the instruments, calibration, operational checks, sensitivity, and sampling methods with a demonstration that the instruments and methods have adequate sensitivity. |
| 14.6.4 | A description of the analytical instruments for measuring samples in the laboratory, calibration, sensitivity, and methods with a demonstration that the instruments and methods have adequate sensitivity. |
| 14.7 | A description of how the samples to be analyzed in the laboratory will be collected, controlled, and handled. |
| 14.10 | A description of the final status survey investigation levels and how they were determined. |
| 14.10 | A summary of any significant additional residual radioactivity that was not accounted for during site characterization. |
| App. B-3 | A summary of direct measurement results and/or soil concentration levels in units that are comparable to the DCGL and if data is used to estimate or update the survey unit. |
| 14.11.2 | A summary of the direct measurements or sample data used to both evaluate the success of remediation and to estimate the survey unit variance. |

## 14.12 Final Status Survey Report

14.12 An overview of the results of the final status survey.

14.12 A discussion of any changes that were made in the final status survey from what was proposed in the Decommissioning Plan or other prior submittals.

14.12 A description of the method by which the number of samples was determined for each survey unit.

14.12 A summary of the values used to determine the numbers of sample and a justification for these values.

14.12 The survey results for each survey unit include:

- 14.12 The number of samples taken for the survey unit.
- 14.12 A map or drawing of the survey unit showing the reference system and random start systematic sample locations for Class 1 and 2 survey units and random locations shown for Class 3 survey units and reference areas.
- 14.12 The measured sample concentrations.
- 14.12 The statistical evaluation of the measured concentrations.
- 14.12 Judgmental and miscellaneous sample data sets reported separately from the those samples collected for performing the statistical evaluation.
- 14.12 A discussion of anomalous data including any areas of elevated direct radiation detected during scanning that exceeded the investigation level or measurement locations in excess of $DCGL_W$.
- 14.12 A statement that a given survey unit satisfied the $DCGL_W$ and the elevated measurement comparison if any sample points exceeded the $DCGL_W$.

14.12 A description of any changes in initial survey unit assumptions relative to the extent of residual radioactivity

14.12 If a survey unit fails, a description of the investigation conducted to ascertain the reason for the failure and a discussion of the impact that the failure has on the conclusion that the facility is ready for final radiological surveys.

14.12 If a survey unit fails, a discussion of the impact that the reason for the failure has on other survey unit information.

# 15.0 Financial Assurance

## 15.1 Cost Estimate

Table 6-1 A cost estimate that appears to be based on documented and reasonable assumptions.

## Certification Statement

NA The certification statement is based on the licensed possession limits and the applicable quantities specified in 10 CFR 30.35, 40.36, or 70.25.

NA Licensee is eligible to use a certification of financial assurance and, if eligible, that the certification amount is appropriate.

## 15.2 Financial Mechanism

15.2 The financial assurance mechanism supplied by the licensee or responsible party consists of one or more of the following instruments:

- ______ trust fund
- ______ escrow account
- ______ government fund
- ______ certificate of deposit
- ______ deposit of government securities
- ______ surety bond
- ______ letter of credit
- ______ line of credit
- Yes insurance policy
- ______ parent company guarantee
- ______ self guarantee
- ______ external sinking fund
- ______ statement of intent
- ______ by special arrangements with a government entity assuming custody or ownership of the site

App. E The financial assurance mechanism is an originally signed duplicate.

______ The wording of the financial assurance mechanism is identical to the recommended wording provided in Appendix F.

______ For a licensee regulated under 10 CFR Part 72, a means is identified in the decommissioning plan for adjusting the financial assurance funding level over any storage and surveillance period.

15.2 The amount of financial assurance coverage provided by the licensee for site control and maintenance is at least as great as that calculated using the formula provided in this SRP.

## 16.0 Restricted Use/Alternate Criteria

## Restricted Use

## Eligibility Demonstration

NA A demonstration that the benefits of dose reduction are less than the cost of doses,

NA injuries and fatalities.

NA A demonstration that the proposed residual radioactivity levels at the site are ALARA.

## Institutional Controls

NA A description of the legally enforceable institutional control(s) and an explanation of how the institutional control is a legally enforceable mechanism.

NA A description of any detriments associated with the maintenance of the institutional control(s).

NA A description of the restrictions on present and future landowners.

NA A description of the entities enforcing, and their authority to enforce, the institutional control(s).

NA A discussion of the durability of the institutional control(s).

NA A description of the activities that the entity with the authority to enforce the institutional controls may undertake to enforce the institutional control(s).

NA The manner in which the entity with the authority to enforce the institutional control(s) will be replaced if that entity is no longer willing or able to enforce the institutional control(s) (this may not be needed for Federal or State entities).

NA A description of the duration of the institutional control(s), the basis for the duration, the conditions that will end the institutional control(s) and the activities that will be undertaken to end the institutional control(s).

NA A description of the plans for corrective actions that may be undertaken in the event the institutional control(s) fail.

NA A description of the records pertaining to the institutional controls, how and where will they will be maintained, and how the public will have access to the records.

## Site Maintenance and Financial Assurance

NA A demonstration that an appropriately qualified entity has been provided to control and maintain the site.

NA A description of the site maintenance and control program and the basis for concluding that the program is adequate to control and maintain the site.

NA A description of the arrangement or contract with the entity charged with carrying out the actions necessary to maintain control at the site.

NA A demonstration that the contract or arrangement will remain in effect for as long as feasible, and include provisions for renewing or replacing the contract.

NA A description of the manner in which independent oversight of the entity charged with maintaining the site will be conducted and what entity will conduct the oversight.

NA A demonstration that the entity providing the oversight has the authority to replace the entity charged with maintaining the site.

NA A description of the authority granted to the third party to perform, or have performed, any necessary maintenance activities.

NA Unless the entity is a government entity, a demonstration that the third party is not the entity holding the financial assurance mechanism.

NA A demonstration that sufficient records evidencing to official actions and financial payments made by the third party are open to public inspection.

NA A description of the periodic site inspections that will be performed by the third party, including the frequency of the inspections.

NA A copy of the financial assurance mechanism provided by the licensee or responsible party.

NA A demonstration that the amount of financial assurance provided is sufficient to allow an independent third party to carry out any necessary control and maintenance activities.

## Obtaining Public Advice

NA A description of how individuals and institutions that may be affected by the decommissioning were identified and informed of the opportunity to provide advice to the licensee or responsible party.

NA A description of the manner in which the licensee obtained advice from these individuals or institutions.

NA A description of how the licensee provided for participation by a broad cross-section of community interests in obtaining the advice.

NA A description of how the licensee provided for a comprehensive, collective discussion on the issues by the participants represented.

NA A copy of the publicly available summary of the results of discussions, including individual viewpoints of the participants on the issues and the extent of agreement and disagreement among the participants.

NA a description of how this summary has been made available to the public.

NA A description of how the licensee evaluated the advice, and the rationale for incorporating, or not incorporating, the advice from affected members of the community into the decommissioning plan.

## Dose Modeling and ALARA Demonstration

NA A summary of the dose to the average member of the critical group when radionuclide levels are at the DCGL with institutional controls in place, as well as the estimated doses if they are no longer in place.

NA A summary of the evaluation performed pursuant to Section 7 of this SRP demonstrating that these doses are ALARA.

NA If the estimated dose to the average member of the critical group could exceed 100 mrem/yr (but would be less than 500 mrem/yr) when the radionuclide levels are at the DCGL, a demonstration that the criteria in 10 CFR 20.1403(e) have been met.

## Alternate Criteria

NA A summary of the dose in TEDE(s) to the average member of the critical group when the radionuclide levels are at the DCGL (considering all man-made sources other than medical).

NA A summary of the evaluation performed pursuant to Section 7 of this SRP demonstrating that these doses are ALARA.

NA An analysis of all possible sources of exposure to radiation at the site and a discussion of why it is unlikely that the doses from all man-made sources, other than medical, will be more than 1 mSv/yr (100 mrem/yr).

NA A description of the legally enforceable institutional control(s) and an explanation of how the institutional control is a legally enforceable mechanism.

NA A description of any detriments associated with the maintenance of the institutional control(s).

NA A description of the restrictions on present and future landowners.

NA A description of the entities enforcing and their authority to enforce the institutional control(s).

NA A discussion of the durability of the institutional control(s).

NA A description of the activities that the party with the authority to enforce the institutional controls will undertake to enforce the institutional control(s).

NA A description of the manner in which the entity with the authority to enforce the institutional control(s) will be replaced if that entity is no longer willing or able to enforce the institutional control(s).

NA A description of the duration of the institutional control(s), the basis for the duration, the conditions that will end the institutional control(s) and the activities that will be undertaken to end the institutional control(s).

NA A description of the corrective actions that will be undertaken in the event the institutional control(s) fail.

NA A description of the records pertaining to the institutional controls, how and where they will be maintained, and how the public will have access to the records.

NA A description of how individuals and institutions that may be affected by the decommissioning were identified and informed of the opportunity to provide advice to the licensee or responsible party.

NA A description of the manner in which the licensee obtained advice from affected individuals or institutions.

NA A description of how the licensee provided for participation by a broad cross-section of community interests in obtaining the advice.

NA A description of how the licensee provided for a comprehensive, collective discussion on the issues by the participants represented.

NA A copy of the publicly available summary of the results of discussions, including individual viewpoints of the participants on the issues and the extent of agreement and disagreement among the participants.

NA A description of how this summary has been made available to the public.

NA A description of how the licensee evaluated advice from individuals and institutions that could be affected by the decommissioning and the manner in which the advice was addressed.

# List of Definitions and Acronyms

<u>action level</u> - The numerical value that will cause the decision-maker to choose one of the alternative actions. It may be a regulatory threshold standard (*e.g.*, Maximum Contaminant Level for drinking water), a dose - or risk-based concentration level (*e.g.*, DCGL), or a reference-based standard. See investigation level.

<u>activity</u> - See radioactivity.

<u>ALARA</u> **(acronym for As Low As Reasonably Achievable)** - A basic concept of radiation protection that specifies that exposure to ionizing radiation and releases of radioactive materials should be managed to reduce collective doses as far below regulatory limits as is reasonably achievable considering economic, technological, and societal factors, among others. Reducing exposure at a site to ALARA strikes a balance between what is possible through additional planning and management, remediation, and the use of additional resources to achieve a lower collective dose level. A determination of ALARA is a site-specific analysis that is open to interpretation, because it depends on approaches or circumstances that may differ between regulatory agencies. An ALARA recommendation should not be interpreted as a set limit or level.

<u>ALI</u> - Annual Limit on Intake.

<u>ANSI</u> - American National Standards Institute.

<u>area</u> - A general term referring to any portion of a site, up to, and including, the entire site.

<u>background radiation</u> - Radiation from cosmic sources; naturally occurring radioactive material, including radon (except as a decay product of source or special nuclear material); and global fallout as it exists in the environment from the testing of nuclear explosive devices or from nuclear accidents like Chernobyl, which contribute to background radiation and are not under the control of the cognizant organization. Background radiation does not include radiation from source, byproduct, or special nuclear materials regulated by the cognizant federal or state agency. Different definitions may exist for this term. The definition provided in regulations or the regulatory program being used for a site release should always be used if it differs from the definition provided here.

calibration - Comparison of a measurement standard, instrument, or item with a standard or instrument of higher accuracy to detect and quantify inaccuracies and to report or eliminate those inaccuracies by adjustments.

CDE (committed dose equivalent) - The dose equivalent calculated to be received by a tissue or organ over a 50-year period after the intake into the body. It dose not include contributions from radiation sources external to the body. CDE is expressed in units of Sv or rem.

CEDE (committed effective dose equivalent) - The sum of the committed dose equivalent to various tissues in the body, each multiplied by the appropriate weighting factor (Wt ). CEDE is expressed in units of Sv or rem. See TEDE.

characterization survey - A type of survey that includes facility or site sampling, monitoring, and analysis activities to determine the extent and nature of contamination. A characterization survey provides the basis for acquiring the necessary technical information to develop, analyze, and select appropriate cleanup techniques.

Class 1 area - An area that is projected to require a Class 1 final status survey.

Class 1 survey - A type of final status survey that applies to areas with the highest potential for contamination, and that meets the following criteria: (1) impacted, (2) potential for delivering a dose above the release criterion, (3) potential for small areas of elevated activity, and (4) insufficient evidence to support reclassification as Class 2 or Class 3.

Class 2 area - An area that is projected to require a Class 2 final status survey.

Class 2 survey - A type of final status survey that applies to areas that meet the following criteria: (1) impacted, (2) low potential for delivering a dose above the release criterion, and (3) little or no potential for small areas of elevated activity.

Class 3 area - An area that is projected to require a Class 3 final status survey.

Class 3 survey - A type of final status survey that applies to areas that meet the following criteria: (1) impacted, (2) little or no potential for delivering a dose above the release criterion, and (3) little or no potential for small areas of elevated activity.

classification - The act or result of separating areas or survey units into one of three designated classes: Class 1 area, Class 2 area, or Class 3 area.

composite sample - A sample formed by collecting several samples and combining them (or selected portions of them) into a new sample, which is then thoroughly mixed.

contamination - The presence of residual radioactivity in excess of levels that are acceptable for release of a site or facility for unrestricted use.

criterion - See release criterion.

DAC - Derived Air Concentration.

Data Quality Objectives (DQOs)

DCGL (derived concentration guideline level) - A derived, radionuclide-specific activity concentration within a survey unit corresponding to the release criterion. The DCGL is based on the spatial distribution of the contaminant and hence is derived differently for the nonparametric statistical test ($DCGL_W$) and the Elevated Measurement Comparison ($DCGL_{EMC}$). DCGLs are derived from activity/dose relationships through various exposure pathway scenarios.

decay - See radioactive decay.

derived concentration guideline level - See DCGL

detection limit - The net response level that can be expected to be seen with a detector with a fixed level of certainty.

detection sensitivity - The minimum level of ability to identify the presence of radiation or radioactivity.

distribution coefficient ($K_d$) - The ratio of elemental (*i.e.*, radionuclide) concentration in soil to that in water in a soil-water system at equilibrium. $K_d$ is generally measured in terms of gram weights of soil and volumes of water ($g/cm^3$ or g/ml).

dose equivalent (dose) - A quantity that expresses all radiations on a common scale for calculating the effective absorbed dose. This quantity is the product of absorbed dose (rads) multiplied by a quality factor and any other modifying factors. Dose is measured in Sv or rem.

elevated measurement - A measurement that exceeds a specified value $DCGL_{EMC}$.

Elevated Measurement Comparison (EMC) - This comparison is used in conjunction with the Wilcoxon test to determine if there are any measurements that exceed a specified value $DCGL_{EMC}$.

exposure pathway - The route by which radioactivity travels through the environment to eventually cause radiation exposure to a person or group.

exposure rate - The amount of ionization produced per unit time in air by X-rays or gamma rays. The unit of exposure rate is Roentgens/hour (R/h); for decommissioning activities, the typical units are microRoentgens per hour (:R/h), *i.e.*, $10^{-6}$ R/h.

facility - As used in this Decommissioning Plan, "facility" carries the Webster's Dictionary definition, which is something that is built, installed, or established to serve a particular purpose. "Facility" does not carry the specific meaning defined in the Michigan Part 201 Statute.

FEMA - Federal Emergency Management Agency.

final status survey - Measurements and sampling to describe the radiological conditions of a site, following completion of decontamination activities (if any) in preparation for release.

FSS - final status survey.

GET - General Employee Training.

$H_D$ - deep dose equivalent.

half-life ($t_{1/2}$) - The time required for one-half of the atoms of a particular radionuclide present to disintegrate.

HASP - Health and Safety Plan.

hot spot - Area of elevated activity.

HP - Health Physicist or Health Physics.

HSP - Health and Safety Plan.

HSO - Health and Safety Officer.

hypothesis - An assumption about a property or characteristic of a set of data under study. The goal of statistical inference is to decide which of two complementary hypotheses is likely to be true. The null hypothesis (H0 ) describes what is assumed to be the true state of nature, and the alternative hypothesis (Ha ) describes the opposite situation.

indistinguishable from background - The term indistinguishable from background means that the detectable concentration distribution of a radionuclide is not statistically different from the background concentration distribution of that radionuclide in the vicinity of the site or, in the case of structures, in similar materials using adequate measurement technology, and survey and statistical techniques.

investigation level - A derived media-specific, radionuclide-specific concentration or activity level of radioactivity that (1) is based on the release criterion, and (2) triggers a response, such as further investigation or cleanup, if exceeded. See action level.

license - A license issued under the regulations in Parts 30 through 35, 39, 40, 60, 61, 70, or Part 72 of 10 CFR.

licensee - The holder of a license.

license termination - Discontinuation of a license, the eventual conclusion to decommissioning.

MARSSIM - Multi-Agency Radiation Survey and Site Investigation Manual.

MCL - Maximum Contaminant Level. A National Primary Drinking Water Standard, established by the USEPA pursuant to the Safe Drinking Water Act (SDWA, 1974, as amended).

MDA - Minimum detectable activity.

MDC - Minimum detectable concentration.

measurement - For the purpose of MARSSIM, it is used interchangeably to mean (1) the act of using a detector to determine the level or quantity of radioactivity on a surface or in a sample of material removed from a medium being evaluated, or (2) the quantity obtained by the act of measuring.

millirem - One thousandth of a rem.

minimum detectable concentration (MDC) - The minimum detectable concentration (MDC) is the a priori activity level that a specific instrument and technique can be expected to detect 95 percent of the time. When stating the detection capability of an instrument, this value should be used. The MDC is the detection limit, DL, multiplied by an appropriate conversion factor to give units of activity.

minimum detectable count rate (MDCR) - The minimum detectable count rate (MDCR) is the a priori count rate that a specific instrument and technique can be expected to detect.

MSHA - Mine Safety and Health Administration.

M.S.L. - Mean sea level.

NEPA - National Environmental Policy Act.

NIOSH - National Institute for Occupational Safety and Health.

NIST - National Institute of Standards and Technology.

normal distribution - A family of bell-shaped distributions described by the mean and variance.

NVLAP - National Voluntary Laboratory Accreditation Program.

OSHA - Occupational Safety and Health Administration.

pCi/g - Picocuries per gram.

PM - Project Manager.

QA - Quality Assurance.

QAO - Quality Assurance Officer.

QAPP - Quality Assurance Project Plan.

QA/QC - Quality Assurance/Quality Control.

QC - Quality Control.

QIP - Quality Implementing Procedure.

quality Assurance (QA) - An integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the customer.

quality Control (QC) - The overall system of technical activities that measure the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer, operational techniques, and activities that are used to fulfill requirements for quality.

radioactive decay - The process by which large unstable atoms become more stable by emitting radiation. The radiation can be emitted in the form of a positively charged ALPHA particle, a negatively charged BETA particle, or gamma rays or x-rays.

radiation survey - Measurements of radiation levels associated with a site, together with appropriate documentation and data evaluation.

release criterion - A regulatory limit expressed in terms of dose or risk.

rem (radiation equivalent man) - The conventional unit of dose equivalent. The corresponding International System (SI) unit is the Sievert (Sv): 1 Sv = 100 rem.

residual radioactivity - Radioactivity in structures, materials, soil, groundwater, and other media at a site resulting from activities under the cognizant organization's control. This includes radioactivity from all sources used by the cognizant organization, but excludes background radioactivity as specified by the applicable regulation or standard. It also includes radioactive materials remaining at the site as a result of routine or accidental releases of radioactive material at the site and previous burials at the site, even if those burials were made in accordance with the provisions of 10 CFR Part 20.

RESRAD - Computer code used to determine residual radioactivity in the environment.

RI/FS - Remedial Investigation and Feasibility Study.

RSO - Radiation Safety Officer.

RWP - Radiation Work Permit.

RWT - Radiation Worker Training.

sample - (as used in MARSSIM) A part or selection from a medium located in a survey unit or reference area that represents the quality or quantity of a given parameter or the nature of the whole area or unit; a portion serving as a specimen.

scanning - An evaluation technique performed by moving a detection device over a surface at a specified speed and distance above the surface to detect radiation.

site - As defined in the USNRC Source Material License No. SUC-1565, the site is the SCA Services property (now S.C. Holdings), located at 2370 Two Mile Road, Bay County, Michigan.

soil activity (soil concentration) - The level of radioactivity present in soil and expressed in units of activity per soil mass (typically Bq/kg or pCi/g).

source term - All residual radioactivity remaining at the site, including material released during normal operations, inadvertent releases, or accidents, and that which may have been buried at the site in accordance with 10 CFR Part 20.

standard operating procedure - A written document that details the method for an operation, analysis, or action with thoroughly prescribed techniques and steps, and that is officially approved as the method for performing certain routine or repetitive tasks.

subsurface soil sample - A soil sample that reflects the modeling assumptions used to develop the DCGL for subsurface soil activity. An example would be soil taken deeper than 0.5 foot below the soil surface to support surveys performed to demonstrate compliance with 40 CFR 192.

surface contamination - Residual radioactivity found on building or equipment surfaces and expressed in units of activity per surface area ($Bq/m^2$ or $dpm/100\ cm^2$).

surface soil sample - A soil sample that reflects the modeling assumptions used to develop the DCGL for surface soil activity. An example would be soil taken from the first 0.5 foot of surface soil to support surveys performed to demonstrate compliance with 40 CFR 192.

TEDE (total effective dose equivalent) - The sum of the effective dose equivalent (for external exposure) and the committed effective dose equivalent (for internal exposure). TEDE is expressed in units of Sv or rem. See CEDE.

TLD - Thermoluminescent dosimeter.

TODE - Total organ dose equivalent.

traceability - The ability to trace the history, application, or location of an entity by means of recorded identifications. In a calibration sense, traceability relates measuring equipment to national or international standards, primary standards, basic physical constants or properties, or reference materials. In a data collection sense, it relates calculations and data generated throughout the project back to the requirements for quality for the project.

unrestricted area - Any area where access is not controlled by a licensee for purposes of protection of individuals from exposure to radiation and radioactive materials—including areas used for residential purposes.

unrestricted release - Release of a site from regulatory control without requirements for future radiological restrictions. Also known as unrestricted use.

unusable data - Data (measurements) that are mislabeled, lost, or do not meet quality control standards. Less-than data are not considered to be missing or unusable data.

USEPA - United States Environmental Protection Agency.

USNRC - United States Nuclear Regulatory Commission.

Wilcoxon Rank Sum (WRS) test - A nonparametric statistical test used to determine compliance with the release criterion when the radionuclide of concern is present in background.

# Section 1
# Executive Summary

The SCA Hartley & Hartley Landfill Site is a former waste disposal facility located in Kawkawlin Township, Michigan, that accepted municipal and industrial waste from the 1950s until 1978. There are two main disposal areas on the site – the Northwest Landfill and the East Landfill. During the period from 1970 to 1972, thorium-bearing foundry slag was disposed in the Northwest Landfill, and in two small slag piles (Slag Piles A and B). There is no record of disposal of thorium-bearing slag outside the Northwest Landfill and the two slag piles. In 1995, the USNRC issued Source Materials License No. SUC-1565 for thorium and uranium in waste at the SCA Hartley & Hartley Landfill Site. This Decommissioning Plan is being prepared in order to allow the USNRC to terminate the license.

During the period from 1970 to 1972, thorium-bearing foundry slag was also disposed at the adjacent MDNR Landfill, which is also known as the Tobico Marsh State Game Area Site. The MDNR Landfill is not part of the SCA Hartley & Hartley Landfill Site. The MDNR has a separate Source Materials license (SUC-1581) for their Site, and the State of Michigan is pursuing closure separately from the SCA Hartley & Hartley Landfill Site.

The current owner of the property is S.C. Holdings, Inc., successor by merger to SCA Services, Inc. The SCA Hartley & Hartley Landfill Site is located at 2370 South Two Mile Road, Kawkawlin, Michigan 48706. The site is surrounded by the Tobico Marsh State Game Area, which is undeveloped woodlands and marsh. Light commercial and residential properties are located south of the site.

Post-closure activities at the SCA Hartley & Hartley Landfill Site included construction of slurry walls and subsurface clay dikes, and compacted clay covers over the Northwest and East Landfills. A series of investigations have been performed since closure of the landfills to establish the concentrations of radioactive constituents in on-site media (waste, groundwater, surface water, soil, and sediment) and in background media. Based on the data from the various phases of investigation, there is no evidence of migration of radioactive materials from the Northwest Landfill or the two slag piles to the environment.

In addition to the engineering controls constructed in the early 1980s, several site features decrease the potential for the migration of contaminants from the site. The site is underlain by a thin sand aquifer, which is in turn underlain by a clay till aquitard that is more than 50 feet thick. The depth to groundwater at the site is commonly less than 5 feet. The thick clay layer below the shallow sand aquifer serves to isolate the thin shallow aquifer from the underlying regional sandstone aquifer. This greatly reduces the potential for the migration of contaminants from the landfill to the regional aquifer. In addition, the ground surface over most of the site is between 585 and 590 feet mean sea level (M.S.L.), an elevation that is very nearly the same as the local base level of the Tobico Lagoon, which is hydraulically connected to Lake Huron, which is 3,500 feet from the SCA Hartley & Hartley Landfill Site, and which is at an average elevation of 580 feet M.S.L. Being at an elevation so near that of base level tends to decrease the potential for erosion in the area of the landfill. This greatly reduces the potential for the migration of constituents from the landfill resulting from the erosion of the engineered landfill cover.

Based on the results of the site investigations, a RESRAD simulation was developed to estimate the potential post-decommissioning radiological dose to an industrial worker on the site over a 1,000-year period. Using model input parameters consistent with a future industrial worker, derived concentration guideline levels (DCGLs) were developed for the Northwest Landfill and for surface soil outside the Northwest Landfill. The DCGLs for these areas are summarized below:

**Derived Concentration Guideline Levels for the SCA Hartley & Hartley Landfill Site**

| ISOTOPE | DCGLs FOR THE NORTHWEST LANDFILL (pCi/g) | DCGLs FOR SURFACE SOIL OUTSIDE THE NORTHWEST LANDFILL (pCi/g) |
|---|---|---|
| Lead-210 | 0.61 | Not applicable |
| Radium-226 | 0.61 | 108 |
| Radium-228 | 18.67 | 228 |
| Thorium-228 | 17.96 | Not applicable |
| Thorium-230 | 2.54 | 206 |
| Thorium-232 | 18.67 | 141 |
| Uranium-234 | 2.54 | 358 |
| Uranium-238 | Not applicable | 358 |
| Lead-210 | 2.54 | Not applicable |

These concentrations resulted in modeled maximum residual doses of 1.4 mrem/year for the Northwest Landfill and 24.6 mrem/year for other on-site areas. Because these exposure levels are less than 25 mrem/year, S.C. Holdings believes that it is appropriate to terminate its license for unrestricted release.

Modeling exposures at this site for an industrial worker are consistent with recent USNRC guidance for basing decommissioning decisions on more realistic future use scenarios. The exposure scenario was selected based on site characteristics. The resident farm family was not found to be a likely land use scenario, given the unsuitability of the site for development as a farm: the concentrations of organic compounds and inorganic materials in the leachate exceed water quality standards for human consumption, and the landfill leachate has been demonstrated to be phytotoxic. In addition, the shallow depth to groundwater, and the lack of soil with suitable foundation characteristics (much of the wetland areas of the site are underlain by several feet of organic wetland soil, and the landfilled areas consist of heterogeneous municipal and industrial waste) greatly restrict the areas of the site that are suitable to build on. However, limited portions of the site may be suitable for the construction of a light industrial facility.

Several remedial alternatives were considered for the site, and two were given detailed consideration: (1) excavation of the waste and off-site disposal, and (2) on-site consolidation of the two slag piles into the Northwest Landfill, and construction of an engineered cover over the Northwest Landfill. The costs for excavation and off-site disposal are on the order of $92,000,000, and the costs for on-site consolidation and construction of an engineered cover are about $1,900,000. On-site consolidation is likely to entail less risk than excavation and off-site disposal, because there is much less uncertainty in a remedy that involves closing the landfill in place, than in excavating the Northwest Landfill and transporting it to an off-site disposal facility. Because the risks and costs of on-site consolidation and cover improvement are less than for excavation and off-site disposal, the on-site consolidation and cover improvement alternative was selected by S.C. Holdings. This remedy will minimize the long-term exposure of human or ecological receptors to radioactive materials, while minimizing the short-term exposure.

An As Low As Reasonably Achievable (ALARA) analysis that compared the benefits of dose reduction with the associated costs was conducted. The ALARA analysis showed that excavating the licensed material and disposing it in an off-site facility would likely result in "net public or environmental harm." Alternately, the radiation exposures associated with consolidating the radiologically contaminated material on-site and improving the cover over the Northwest Landfill were found to be ALARA.

Decommissioning activities can begin once the USNRC amends the license to incorporate the Decommissioning Plan. Assuming that this occurs by July 2005, the field decommissioning activities would begin in October 2006 and continue through approximately October 2007. The

Final Status Survey and Construction Certification would then be completed with the license termination estimated in March 2009. Consequently, S.C. Holdings requests amendment of the current license to incorporate this Decommissioning Plan.

# Section 2
# Facility Operating History

This section contains a description of the relevant history of the site, including the licensing of the facility by the USNRC, relevant site operations, and closure activities. (Refer to the List of Definitions and Acronyms for the definitions of the terms "site" and "facility," as used in this Decommissioning Plan.)

## 2.1 License Number/Status/Authorized Activities

The current USNRC license for the SCA Hartley & Hartley Landfill Site is Source Materials License No. SUC-1565, Docket No. 040-09022 (USNRC, 1995). The license was issued to SCA Services on June 14, 1995. The current owner of the property is S.C. Holdings, Inc. (S.C. Holdings), successor by merger to SCA Services, Inc. The license authorizes possession for those activities leading to the decommissioning of the SCA Hartley & Hartley Landfill Site. The license was amended on September 7, 1999 (Amendment No. 1) and on October 10, 2001 (Amendment No. 2). Amendment No. 1 extended the due date for submittal of the Decommissioning Plan to October 1, 2000. Amendment No. 2 extended the due date for the Decommissioning Plan to September 30, 2003. In a letter dated November 19, 2003, the USNRC extended the due date for submittal of the Decommissioning Plan to November 30, 2003.

The radionuclides, the maximum amounts of material the licensee may possess, and the chemical/physical form of the radionuclides authorized under the license are listed in Table 2-1. The license does not specify maximum activity levels. The licensed material is encapsulated in the Northwest Landfill, or, for the two slag piles outside of the Northwest Landfill (Slag Piles A and B), is covered with temporary caps, and currently presents no radiological exposure. No off-site disposal of radionuclides has occurred under the current license.

The locations of the Northwest Landfill, the two slag piles, and other pertinent features of the site are shown on Figure 2-1.

Radiological monitoring is not required under the current license. However, a variety of investigations have been conducted at the site, although most of these were designed to characterize chemical contamination regulated under the State of Michigan's Part 201 environmental remediation program (MI, 1994). Some of these investigations also yielded radiological information. A discussion of the site investigations conducted to date is presented in Subsection 4.4.

## 2.2 License History

S.C. Holdings (as SCA Services) submitted a source material license application to the USNRC on July 7, 1993, and a supplement dated September 30, 1994, to possess uranium and thorium at the SCA Hartley & Hartley Landfill Site (another part of the former Hartley & Hartley Site is owned by the Michigan Department of Natural Resources [MDNR]). Source Materials License No. SUC-1565 was issued in response to that application (no license had previously been issued for this material). No other licenses have been issued for this site. All activity associated with the source material (*i.e.*, landfilling) had ceased prior to issuance of the license. The license has been amended two times to extend the due date for the submittal of the Decommissioning Plan, as discussed in Subsection 2.1.

Note that the items listed under "License History" in the Acceptance Review Checklist provided by the USNRC (letter dated May 1, 2001) are not applicable to the Decommissioning Plan for the SCA Hartley & Hartley Landfill Site for the following reasons: (1) radionuclides were not used by prior site owners/operators; (2) radionuclides were not authorized, used, or stored under previous licenses; and (3) the only "use" of radionuclides at the site under the current license is the continued possession of thorium-bearing slag as a landfilled waste. Consequently, this portion of the Decommissioning Plan has been adapted to site-specific circumstances.

## 2.3 Previous Decommissioning Activities

In the Safety Evaluation Report (USNRC, 1994), the USNRC decided that decommissioning at the SCA Hartley & Hartley Landfill Site was to proceed in two phases. Phase 1 entailed characterization studies and initial site consolidation. Phase 2 would be developed as part of the Decommissioning Plan. Phase 1 was completed with the installation of containment structures (slurry walls, clay dikes, and clay caps) in 1984, and the multiple site characterization studies that were performed from 1978 through May 2003. Descriptions of site closure and post-closure activities are presented in Subsections 2.6 and 2.7. The closure and post-closure activities were conducted under the State of Michigan's remedial response authority to address chemical contamination. While these activities were not performed under the Site Decommissioning Management Plan administered by the USNRC, they achieved the common objectives of stabilizing and containing the waste materials, and minimizing potential exposures to on-site workers and the public. Consequently, the content of this subsection has been adapted to site-specific circumstances. Phase 2 of the decommissioning process described in the Safety Evaluation Report is described in this Decommissioning Plan.

## 2.4 Spills

No spills of radioactive material have been documented in the operating records for the SCA Hartley & Hartley Landfill Site. However, a walk-over gamma survey conducted during the Phase I Field Investigation (REI, 1993a) revealed two small areas of uranium/thorium slag outside the slurry wall around the Northwest Landfill (Slag Piles A and B shown on Figure 2-1). It is unknown when or how the slag came to be placed in these two areas.

Slag Pile A is located immediately west of the Northwest Landfill. The slag was described during the 1996 characterization study (see Subsection 4.4.6) as a dark-brown sand-sized material with occasional larger pieces of metallic slag. The slag was mixed with finer grained soil and cattails. The slag was delineated in an "L-shaped" area measuring approximately 115 feet by 90 feet (in the longest dimensions), with an estimated thickness of 2.0-2.5 feet. The amount of material containing slag in Slag Pile A is estimated to range from 164 to 211 cubic yards ($yd^3$). Analytical results for samples collected in 1996 indicate that the activity of total thorium isotopes (Th-230, Th-232, and Th-228) ranged from 11.6 pCi/g to 18.1 pCi/g in the slag, and less than 1.0 pCi/g in the underlying soil (Appendix A). Samples of the slag collected in May 2003 were gray-brown and ranged in size from silt or fine sand to "clumps" up to 3 inches in diameter. Radioactivity levels for the samples collected in May 2003 (see Subsection 4.4.10) were somewhat higher than for those collected in 1996, with total thorium isotope activity ranging from 11.2 pCi/g to 58.5 pCi/g. The material in Slag Pile A had been covered with clay in 1996 (Earth Tech, 2003a). Test pits excavated in May 2003 documented up to 3 feet of topsoil and clay over the slag. The slag is described as measuring roughly 6 inches in thickness and was observed to be underlain by native peat.

Slag Pile B is located immediately southwest of Cell A, within the area surrounded by the clay dike. The slag material in Pile B was described as being dark brown to black sand-sized material mixed with soil and industrial rubble. Slag Pile B measures approximately 65 feet by 65 feet, with a thickness estimated at 2.5 feet, resulting in an estimated volume of 245 to 390 $yd^3$. Samples collected in 1996 (see Subsection 4.4.6) reported total thorium isotope activity ranging from 1.4 pCi/g to 6.4 pCi/g in the upper 1.5 to 3.0 feet of material, to 0.7 pCi/g to 11.5 pCi/g in the underlying material (Appendix A). Samples collected in May 2003 describe the material as being black fine to coarse saturated sand. Analytical results for samples collected in May 2003 (see Subsection 4.4.10) indicate total thorium isotope activity ranging from 0.95 pCi/g to 36.0 pCi/g. The material in Slag Pile B had been covered with clay in 1993 (Earth Tech, 2003a). Test pits excavated in May 2003 documented 0.5 foot to 2 feet of clay/topsoil over about 3 feet of slag.

## 2.5 Prior On-Site Burials

Aerial photographs from 1938 and 1950 show the site to be undisturbed. There were no surface water bodies on the site at that time. Relict beach ridges in the area along the Saginaw Bay contained significant volumes of sand. Aerial photographs from October 1955 show that sand quarrying operations had begun adjacent to the Hartley & Hartley property to the south and east, on what are currently the SCA Hartley & Hartley Landfill Site, the MDNR Landfill, and the Bangor Township Landfill properties, respectively. Significant sand quarrying was conducted during the late 1950s and early 1960s. Sand was likely quarried down to the glacial till, resulting in the large ponds that currently lie southwest of what is now the East Landfill, south of the site on the Hartley's property, and north of the Bangor Township property (Earth Tech, 2003a). Waste disposal operations began at the SCA Hartley & Hartley Landfill Site in 1962 (REI, 1994a). The East Landfill was developed where sand had been excavated to the till surface. The Northwest Landfill was developed in an area where sand was only partially excavated.

While licensed material was only disposed in the Northwest Landfill, details of disposal in the East Landfill are included here to document the history of the entire SCA Hartley & Hartley Landfill property, as defined in the USNRC materials license. The locations of the features described in this section are shown on Figure 2-1.

### 2.5.1 Northwest Landfill

The area referred to as the Northwest Landfill is not an engineered and constructed disposal area. The area was initially a shallow excavation used to mine sand. The excavation was later used to store tanks containing liquids and to dispose of waste oil, solvents, and drums.

Foundry waste containing magnesium-thorium slag was also disposed in the Northwest Landfill beginning in late 1970. The vitreous slag, generated by Wellman Dynamics, at a site in Bay City, Michigan, was derived from casting and foundry operations involving magnesium-thorium alloys. Both thorium-bearing and non–thorium-bearing slags are known to have been disposed over the years during which the Hartley & Hartley Landfill was in operation, but there is no record of exactly where the thorium-bearing slag was deposited. The thorium-bearing slag was disposed in the Northwest Landfill starting in the second half of 1970 and ending sometime in 1972.

The thorium-bearing and non–thorium-bearing slags are comparable in physical appearance, differing only in the occurrence of thorium and uranium in slags derived from magnesium-thorium alloys (MACTEC, 2003). As discussed in Subsection 2.6 (Site Closure Activities), the Northwest Landfill was encapsulated (*i.e.*, a subsurface slurry wall was constructed around its perimeter, and a clay cover was constructed over the surface) in 1984 as part of the closure activities.

### 2.5.2 East Landfill

Waste disposal operations began in the East Landfill in 1962. Waste was first disposed in the East Landfill, in the area southeast of Cell No. 1 (Figure 2-2). Earth Tech (2003) estimated that this initial disposal area encompasses the approximately 7.2 acres southeast of Cell No. 1, which is surrounded by clay dikes (as-built drawings were not prepared).

The first waste disposal license for the site was issued for the East Landfill by the Michigan Department of Public Health (MDPH) in September 1967. Typical wastes included municipal solid waste, foundry sand, drummed liquid chemicals, cutting oils, paint sludges, and plating wastes. There are no records of disposal of thorium-bearing slag in the East Landfill.

Prior to 1969, flammable liquid wastes were disposed by pouring them into a pond and igniting them. In 1969, a liquid waste incinerator was permitted and installed. Typically, waste oils and aqueous wastes were blended, and were then allowed to separate (prior to incineration). The oil layer was used as the primary fuel source for the incinerator, and the aqueous stream was injected into the burn chamber to moderate the kiln temperature. The resulting ash was landfilled on-site.

During the development of the site for disposal, clay dikes were installed as vertical barriers to contain the waste. The dikes were constructed as fill was placed, forming "cells" that contained different phases of deposition. Cells 2 and 3 were constructed in November 1972, Cell 4 was added in December 1973, and Cells 5 and 1A, comprising the Sand Storage Area, were added in April 1975. According to the available records, Cells 1 through 4 were not lined with a manmade liner. Instead, bermed, remolded clay till and the underlying, native glacial till were used to isolate these waste disposal cells from the environment. The cells were either constructed on top of the glacial till or extended a few feet into the till.

Cell 5 was excavated to a depth of approximately 10 feet into the till, and was lined with a polyvinyl chloride (PVC) liner. An underdrain for leachate collection was also installed in this cell. The leachate was directed to a 72-inch–diameter manhole and was pumped to the on-site incinerator, where it was burned.

Waste treatment and disposal operations continued at the site until December 1978, when the facility was closed. Two additional cells, referred to as Cells A and B, were under construction when the facility was closed. There is no record of waste disposal in these cells, although some operations may have been conducted in the southern corner of Cell B. These excavated cells have subsequently filled with water from precipitation.

### 2.5.3 Tobico Marsh SGA Site

The Tobico Marsh State Game Area Site (also referred to as the MDNR Site, or the MDNR Landfill) is a USNRC-licensed facility (License Number SUC-1581; Docket Number 040-09015) located on 3 acres at the northwestern corner of the SCA Hartley & Hartley Landfill Site. The MDNR acquired this property as part of a settlement of a lawsuit brought by the State of Michigan against Hartley & Hartley, Inc. (MDNR, 1998).

The operational history of the MDNR Site is mostly anecdotal from aerial photographs that indicate disposal operations at the site as early as March 1966. The source of radioactive material at the MDNR Site is the same as at the SCA Hartley & Hartley Landfill Site (*i.e.*, Wellman Dynamics Foundry in Bay City, Michigan). Photographs taken in 1969 show numerous drums and waste piles that include "grayish white material" that was later determined to be magnesium-thorium slag. Photographs taken in 1983 suggest that the exposed material had been covered with soil (MDNR, 1998).

A Decommissioning Plan was recently submitted to the USNRC by the MDNR for its site (MACTEC, 2003). This plan is currently under agency review.

## 2.6 Site Closure Activities

Clay dikes and berms were constructed while the site was in operation to contain the landfilled wastes. After landfilling operations ceased on December 31, 1978, additional engineering controls were implemented as part of site closure (Earth Tech, 2003a). This section describes the containment actions that were implemented, as well as the ongoing monitoring activities that are conducted as part of the response activities required under the consent order from the State.

Both the East Landfill and the Northwest Landfill are encapsulated with clay covers and low-permeability subsurface vertical barriers (*i.e.*, clay dikes around the East Landfill and slurry walls around the Northwest Landfill). The encapsulating vertical barriers isolate the waste material from the surface water and groundwater flow systems. The clay covers also prevent direct contact with waste materials and reduce the amount of infiltration of precipitation. Monitoring has shown that leachate has accumulated in both landfills, indicating that the low-permeability vertical barriers are significantly impeding the lateral movement of groundwater.

### 2.6.1 Slurry Wall and Clay Cover for the Northwest Landfill

The walk-over magnetometer survey that was performed over the Northwest Landfill in February 1983 suggested the presence of significant numbers of buried metal drums and drum fragments. The MDNR and S.C. Holdings agreed that a slurry wall and clay cover should be installed to contain the waste materials. Consequently, the 1984 Amendment to the 1980 Consent Order, dated September 28, 1984, required encapsulation of the Northwest Landfill and the MDNR Landfill, and specified environmental monitoring requirements for the SCA Hartley & Hartley Landfill Site (but not including the MDNR Landfill) through the year 2015 (Earth Tech, 2003a).

Ground/Water Technology, Inc., designed and constructed the slurry wall around the Northwest Landfill and the MDNR Landfill. The perimeter of the slurry wall was established based on the earlier magnetometer survey. Prior to constructing the slurry wall, 28 borings were drilled along the proposed slurry wall alignment to determine the necessary depth of the slurry wall, such that the wall would penetrate (key) into a minimum of 2 feet of the native glacial till. The slurry wall was designed to be 3 feet wide. In order to achieve an adequate permeability, the slurry wall material consisted of 2.5 to 3 percent bentonite mixed with clay. Laboratory tests determined the hydraulic conductivity of the slurry to be less than $10^{-7}$ cm/s. Construction of the slurry wall around the Northwest Landfill began in July 1984 and was completed in August 1984 (Earth Tech, 2003a).

The adequacy of the slurry wall construction was documented by collecting three Shelby tube samples from the completed slurry wall. Hydraulic conductivity tests confirmed an in-place hydraulic conductivity of less than $10^{-7}$ cm/s, as documented in the closure certification report (Ground/Water Technology, 1985). That report includes soil boring logs, bentonite certifications, hydraulic conductivity testing results, daily progress reports, and as-built drawings.

A 2-foot–thick clay cover was constructed over the Northwest Landfill enclosed by the slurry wall. Prior to installing the cover, general fill from off-site was placed over the landfill and was graded so that water would drain off the cover. The clay cover was covered with topsoil and seeded. The cover was inspected following installation and found to be in compliance with the specifications. Construction of the cover is also documented in the closure certification report (Ground/Water Technology, 1985).

### 2.6.2 Clay Dike Around the East Landfill

The East Landfill is encapsulated by a soil cover (clay cover) and subsurface vertical barriers (clay dikes). The original clay dike that encircled the perimeter of the East

Landfill was constructed during the period of 1977 to 1979, as illustrated on Figure 2-3. The clay dike (also referred to as a cut-off wall) was constructed of clay excavated from off-site locations (Earth Tech, 2003a).

S.C. Holdings conducted hydrogeological and geotechnical investigations to establish the adequacy of the clay dike for isolating the East Landfill from surface water and groundwater resources. This investigation included excavating seven test pits, installing six monitoring wells, drilling one soil boring, and installing four piezometers. This investigation concluded that shallow groundwater was in close association with surface water, and that the shallow groundwater flow system was isolated from the bedrock aquifer by a clay till that underlies the shallow aquifer and measures 60-100 feet in thickness (Wehran, 1979).

As part of the Wehran study, 22 additional test pits were excavated around the East Landfill (in February 1978). These test pits were excavated at 500-foot intervals to evaluate the degree to which the clay dike was keyed into the underlying glacial till. Based on the results of these test pits, S.C. Holdings concluded that approximately 950 feet of the clay dike had not been properly constructed. This led to the reconstruction of the dike along the eastern side of the East Landfill, which was completed in July 1979 (Earth Tech, 2003a).

An additional phase of investigation, involving the excavation of 54 more test pits and the collection of geotechnical samples to test the density and permeability of the dike material, was conducted from May through August 1979. Shelby tube samples were obtained at 1,000-foot intervals (total of 13 samples) along the clay dike. The 19 additional test pits indicated that repairs were needed in the section of the dike located on the southern and western sides of the East Landfill. The clay dike around these areas was reconstructed in July 1979 (Earth Tech, 2003a).

Details of the geotechnical investigations and the certification of closure are contained in Wehran (1979). This report contains the results of the hydraulic conductivity tests that showed that the clay used to construct the original and reconstructed dikes had hydraulic conductivities of less than $10^{-7}$ cm/s. The Wehran (1979) report concluded that the clay dike is keyed into the glacial till, and therefore isolates the East Landfill from surface water and groundwater resources.

### 2.6.3 Clay Cover Over the East Landfill

Once the final grades of the East Landfill were reached, a 2-foot–thick clay cover was constructed over the waste to minimize leachate generation. An MDNR inspection report by Caden and Thorton dated June 8, 1978, documented that the slopes of Cells 1-4 were seeded and covered with final clay cover. An inspection report prepared by the MDNR dated January 3, 1979, states that "Cell 5 has been capped but the depth of cover is unknown." Later inspection reports prepared by the MDNR in August 1979 state that 20 to 24 inches of compacted clay had been placed over Cells 1 through 5 (Earth Tech, 2003a).

In 1979, Edmands Engineering, Inc., was hired by the MDNR to verify the depth of the compacted clay cover over the East Landfill by randomly checking the depth at various locations. The results of the survey are documented in two letters to the MDNR. The first letter, dated August 30, 1979, states that the survey was performed on August 29, 1979, under MDNR guidance. The letter states, "it was found that the final cover has a range of 13 to 108 inches, with the average depth being 42+ inches." The letter also states that a portion of the northern part of Cell 5 "...lacks the required minimum of 2 feet of final cover." The second letter, dated September 5, 1979, states that additional cover has been placed over the northern half of Cell 5. Six test pits were excavated to check the depth of the clay cover. Waste was not encountered at a depth of less than 24 inches in any of the test pits (Earth Tech, 2003a). Cells 6 through 9 remained open and eventually filled with precipitation. Cells 6 and 7 were later collectively referred to as Cell A, and Cells 8 and 9 became Cell B (refer to Figures 2-1 and 2-2).

### 2.6.4 MDNR Landfill

The MDNR Landfill (also referred to as the Tobico Marsh State Game Area [SGA] Site, or the MDNR Site) and the Northwest Landfill at the SCA Hartley & Hartley Landfill Site were encapsulated as part of a 1984 Amendment to the 1980 Consent Order between S.C. Holdings and the MDNR. A clay cover, measuring 2 feet in thickness, was also installed at both sites. A Remedial Investigation (RI) (E.C. Jordan, 1986) and a Feasibility Study (FS) (GZA/Donohue, 1987) were conducted for the MDNR Site. These documents concluded that the closed site poses minimal risk to human health or the environment as long as access to subsurface soil is restricted. Groundwater and surface water were determined to be unsuitable for potable use, and therefore the risk via those pathways was insignificant. Consequently, the FS focused on cover repairs, access restrictions, and groundwater monitoring. A leachate extraction and treatment system was installed by the MDNR to reduce leachate head levels within the encapsulated area. The leachate extraction system was never operated though, owing to conflicts with the discharge requirements of the West Bay County Wastewater Treatment Plant (Earth Tech, 2003a).

## 2.7 Site Post-Closure Activities

Post-closure activities at the site were initiated in 1984 and have included the following:

- Ongoing compliance with the monitoring and maintenance requirements contained in the 2002 Addendum by Consent to the 1980 Consent Order for Closure and the 1984 Amendment to the 1980 Consent Order
- Site characterization under the jurisdiction of the State of Michigan's environmental response law (Natural Resources and Environmental Protection Act [NREPA] of 1994, as amended [Act 451]) and the USNRC's Division of Waste Management Site Decommissioning Management Plan (SDMP) Program (10 CFR 20)

Site activities required pursuant to the 2002 Addendum by Consent to the 1980 Consent Order and the 1984 Amendment to the 1980 Order have involved the routine monitoring of groundwater and leachate levels, as well as the sampling of leachate, groundwater, and surface water for chemical analysis (Earth Tech, 2003a).

In September 1988, Dell Engineering, Inc., analyzed the performance of the clay dike, slurry wall, and clay caps. Subsurface investigations included drilling four soil borings into the clay dike, drilling three soil borings into the slurry wall, and collecting three Shelby tube samples from each of the landfill caps. Two Shelby tube samples were also collected from each of the soil borings. Hydraulic conductivity tests were performed on all of the Shelby tube samples from the slurry wall, clay dike, and clay caps and were reported in the report "Site Closure Integrity Investigation" (Dell Engineering, Inc., March 1990). The average hydraulic conductivity reported for each containment feature is provided in Table 2-2. The Dell report concluded that the clay dike (East Landfill) and slurry wall (Northwest Landfill) were meeting or exceeding regulatory requirements and noted that no leachate seeps were observed on the clay cover on the Northwest Landfill. However, the Dell report also states that the East Landfill cover was in poor condition with extensive gas and leachate seeps (Earth Tech, 2003a).

Groundwater monitoring wells and piezometers installed both inside and outside of the encapsulated areas on the site indicate that leachate is accumulating within the Northwest Landfill, the East Landfill, and the MDNR Landfill. Recent water level measurements show significant head differences between the groundwater and leachate, especially in the East Landfill. These head differences indicate that the integrity of the slurry walls and clay dikes is intact, and that they are functioning as designed. However, these head differences, along with erosion of the clay cover owing to surface water runoff, have resulted in sporadic leachate outbreaks around the East Landfill.

The only building that remains on-site is the former office and laboratory building at the southeastern corner of the site. This building is outside the area of known waste disposal.

A 6-foot-high chain-link fence topped with three strands of barbed wire surrounds the landfills. Fencing also extends around the entire S.C. Holdings' property boundary. Signs identifying the property as a radiological site are also posted. There are locked gates near the entrance to the site and near the monitoring wells located adjacent to the facility.

The 1984 Amendment to the 1980 Consent Order also specifies requirements for leachate management at the site. In response to this requirement, S.C. Holdings routinely inspects the soil covers on the East and Northwest Landfills. These inspections have been conducted on an annual basis since 1993, usually in the late spring or summer. Additional cover material is placed in areas of leachate seeps, if any are identified. Other site conditions, such as security measures (gates, signs, fencing) and the integrity of the monitoring wells, are also noted during the annual site inspections. Appropriate repairs are made to address unacceptable conditions (Earth Tech, 2003a).

Leachate may be extracted from within the containment structures around the East, Northwest, and the MDNR Landfills.[1] (Leachate removal will reduce the likelihood that landfilled-related constituents are released into the environment via groundwater contamination and migration.) Leachate may be extracted from the landfills, including the East Landfill, prior to placing additional cover materials, if any, over the landfills. This would reduce the amount of settlement that could occur as a result of increasing the pore space within the landfill. The leachate management plans for all three landfills will need to be approved by the MDEQ for compliance with applicable state regulations.

The operation of the leachate extraction system is incidental to the decommissioning effort at the site, and is not a principal activity as defined in the USNRC's regulations. The operation of the leachate extraction system does not require a radioactive materials license because the leachate does not contain radioactive materials at concentrations greater than the MCLs. Specifically, analyses to date of leachate from the Northwest Landfill have yielded concentrations of Ra-226 and Ra-228 that total less than 5 pCi/L, and concentrations of uranium-238 that are less than 30 pCi/L. In spring 2004, S.C. Holdings will collect additional samples of the leachate in the Northwest Landfill to confirm the historical results.
S.C. Holdings will operate the leachate extraction system as required by the State of Michigan. Samples will be collected periodically during the operation of the leachate extraction system to verify that the concentration of radioactive material has not changed.

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[1] S.C. Holdings is also responsible for remedial response actions to address chemical concerns at the MDNR Landfill under the State of Michigan Part 201 program.

In addition, the MDNR may be required to obtain approval from the USNRC to extract leachate from their landfill. S.C. Holdings' proposed plan for leachate extraction from the Northwest Landfill is discussed in Subsection 8.3.

Coordination of the decommissioning activities with activities required pursuant to the 2002 Addendum by Consent to the 1980 Consent Order and the 1984 Amendment to the 1980 Consent Order is discussed in Subsection 8.4.

# Section 3
# Facility Description

## 3.1 Site Location and Description

The SCA Hartley & Hartley Landfill Site is located in an unincorporated area of Kawkawlin Township in Bay County, Michigan. The site's mailing address is 2370 South Two Mile Road, Kawkawlin, Michigan 48706. Its legal description is the South ½ of the Northeast ¼ and the North ½ of the Southeast ¼ of Section 25, Township 5 North, Range 4 East of the Michigan Meridian.

Figure 3-1 shows the location of the site, which is approximately 5 miles north of Bay City and 1 mile west of Saginaw Bay (Lake Huron). The Tobico Marsh and adjacent Tobico Marsh State Game Area (SGA) are located between Saginaw Bay and the Site. The Tobico Marsh SGA comprises over 1,000 acres designated as a state wildlife refuge. In 1976, the U.S. Department of the Interior designated the Tobico Marsh a registered national landmark.

The site is identified by the following federal and state identification numbers:

- USNRC License Number SUC-1565; Docket Number 040-09022
- USEPA Site ID# MID000605956
- MDEQ Site ID# 09000015

### 3.1.1 Site Physical Features

The SCA Hartley & Hartley Landfill Site comprises about 170 acres, approximately 50 acres of which were developed for landfilling, and approximately 40 acres of which are actually filled with refuse. There are two main landfilled areas: the "East Landfill" (approximately 32 acres) and the "Northwest Landfill" (approximately 8 acres). There are also two cells, designated "Cell A" and "Cell B," that are adjacent to the northwestern side of the East Landfill. When the facility ceased operations, these cells were under construction in preparation for future landfilling. The cells, which comprise approximately 10 acres, have subsequently filled with precipitation. The clay dike around these cells is keyed into the clay dike around the filled portion of the East Landfill. The physical features of the site are shown on Figure 3-2.

There are several ponds located on the site that were either excavated for sand as part of a quarry operation prior to landfilling or that had been excavated during site activities for cell construction or cover material.

Several on-site roads provide access to different areas on the site. The main road forms a loop, from the site entrance along the western side of the East Landfill, along the northern edge of the Northwest Landfill, along the northern property line, and along the eastern side of the East Landfill back to the site entrance.

Areas of the site that were never developed are still covered with cattail marsh or forest. Cattails are present over the southwestern one-third of the site (West Marsh Area) and in the northeastern corner of the site (Northeast Pond Area). Cattails are also present in the northcentral area of the site between Cell A and the Northwest Landfill (North Pond Area). Forests have developed on beach ridges at both the extreme southwestern corner (Southwest Trail Area) and the extreme northeastern corner of the site.

Topography in the vicinity of the site is generally flat, with elevations of between 585 feet and 595 feet above mean sea level (M.S.L.). The sand dunes east of the site reach elevations of approximately 595 feet M.S.L., while areas with ponded water are generally at elevations of 585 feet M.S.L. The East Landfill is the highest topographic feature in the area, at an elevation of 625 feet M.S.L. The elevation of the Northwest Landfill is approximately 592 feet M.S.L. Cells A and B have spillways that maintain the water level elevations at 587.5 feet M.S.L. The elevation of Tobico Lagoon and Saginaw Bay/Lake Huron are approximately 580 feet M.S.L. A topographic map of the vicinity of the SCA Hartley & Hartley Landfill Site is presented as Figure 3-3.

The former site operations building is located in the southeastern corner of the site, near the site entrance from Two Mile Road (see Figure 3-2). A 6-foot-high chain-link fence surrounds the encapsulated areas of the site. A 6-foot-high chain-link fence also runs along the southern and western property lines of the site. This fence was installed to restrict access to the site by hunters and fishermen using the surrounding Tobico Marsh State Game Area. The fencing on the site is shown on Figure 2-2.

### 3.1.2 Adjacent Properties

Surrounding property locations are described in Table 3-1, beginning with those nearest to the site and continuing outward toward Bay City. These locations are shown on Figures 3-1 and 3-3. The eastern side of the site is bounded by the Bangor Township Landfill, a municipal landfill that operated from 1967 to 1986. The northeastern, northern, and western sides of the site are bounded by the Tobico Marsh State Game

Area (Tobico Marsh SGA), an undeveloped expanse of marshland and forest owned by the State of Michigan and maintained by the Michigan Department of Natural Resources (MDNR) as a wildlife refuge and for public hunting. Water bodies on the MDNR property south of the site, along Beaver Road, are used by the public for sport fishing. The Bay City State Recreation Area is located approximately 0.5 mile east of the site on Saginaw Bay.

Adjacent to the northwestern corner of the SCA Hartley & Hartley Landfill Site is a separate USNRC-licensed facility known as the MDNR Tobico Marsh State Game Area Site (Sources Materials License No. SUC-1581), which is commonly referred to as the "MDNR Landfill." Formerly part of the Hartley & Hartley property, the MDNR Landfill was obtained by the State as part of a land trade with the Hartley family in 1974. The property line along the southwestern corner of the site is shared with the northeastern property line of a public golf course (Spring Valley Golf Course) on Beaver Road.

The southern side of the site is primarily bounded by a small parcel of land that continues to be owned by the Hartleys. It was obtained as part of the 1974 land trade to serve as a buffer between the landfill and adjacent property. This property runs from Two Mile Road to within a few hundred feet of the golf course. The balance of the land along the southern side of the site is the State-owned and MDNR-maintained property described above.

Some light commercial and industrial properties are located southeast of the site, across Two Mile Road. Two single-family homes are located further south, on the northeastern corner of the intersection of Two Mile Road and Beaver Road. The nearest residential properties to the site are located along Beaver Road, approximately 0.2 mile to the south of the site. Other nearby residences include those located along Schmidt Road, Jose Road, South Huron Road (Highway 13), Oak Lane, and Old Kawkawlin Road to the west (0.4 mile or more away from the site); 2-Mile Road, Lauria Road, and Scott Drive to the south (0.3 mile or more away from the site); and Killarney Beach Road, Carrier Lane, and Tobico Beach Road to the east (0.6 mile or more from the site). Nearby population centers include Kawkawlin Township, approximately 1.2 miles south of the site, and Bay City, approximately 5.0 miles south of the site. Several additional businesses and residences are found along the southern side of Beaver Road.

## 3.2 Population Distribution

The year 2000 population of Bay County was estimated at 110,157 individuals, with 5,104 persons in Kawkawlin Township (U.S. Bureau of Census, 2000). The population within a

1-mile radius of the site is estimated at 1,375 individuals.[2] Approximately 35 residential properties exist within a 0.5-mile radius of the site. The population data for Bay County, Michigan, over the past 50 years are presented in Table 3-2.

The population of Bay County is projected to continue to decline over the next 20 years, based on U.S. Bureau of Census data. Table 3-3 presents the projected future population projections for Bay County through 2020 (U.S. Bureau of Census, 2000).

### 3.2.1 Minority Population Demographics

Localized demographic data tabulated by census tract and block group are useful in assessing whether minority or low-income populations in the immediate vicinity of the site are significantly greater than those in the larger region. According to the U.S. Office of Management and Budget's (OMB) Directive No. 15 (OMB, 1978), persons who are Black or African American, Hispanic, Asian or Pacific Islander, American Indian, Eskimo, or Aleut, or other nonwhites are identified as minorities. A geographic area is determined to have a minority population if (1) the minority population in the area is larger than 50 percent of the total population, or (2) the minority population percentage in the area under consideration is "meaningfully greater" than the minority population percentage in the general population or another appropriate larger unit of geographic analysis (MACTEC, 2003).

The site is located within (and near the eastern edge of) Census Tract #2861, Block Group #4. Blocks 1, 2, and 3 in Census Tract #2861 describe the population to the west of the site. Blocks 2 and 4 in Tract #2862 describe the population north of the site. Census Tract #2860, with Block Groups 1, 2, and 3, lies to the east of the site. The southern side of the site is bounded by Block Groups 1 and 3 of Census Tract #2857. The 2000 Census block groups surrounding the site are mapped on Figure 3-4 (MACTEC, 2003).

The population of Bay County is composed of approximately 94.9 percent white single-race persons, while the greater Saginaw–Bay City–Midland area is composed of approximately 85 percent white single-race persons (U.S. Bureau of Census, 2000). Table 3-4 presents the population demography for Bay County, Michigan, based upon ethnicity as reported in the 2000 U.S. Census data. Inspection of Table 3-4 reveals that percentages of minority populations in both the census tract and block group geographic divisions are substantially less than the 50 percent criterion for identifying local minority populations. It is also evident from the percentage figures reported in

(2) This estimation was conservatively derived by multiplying the approximate number of livable structures (as determined from topographic maps and aerial photos) by five people. The year 2000 U.S. Census data for Bay County, Michigan, indicates that the average household size is 2.47 people.

Table 3-4 that the minority population percentages in the geographic units in the immediate vicinity of the site are not "meaningfully greater" than the minority population percentage in the two larger geographic units considered (Bay County and the greater Saginaw–Bay City–Midland area). In fact, the minority population percentage generally decreases as the geographic units consider smaller land areas near the site. From these data, there is no considerable minority population in the area potentially affected by the site (MACTEC, 2003).

### 3.2.2 Low-Income Population Demographics

Low-income populations are identified as those communities within the region for which the percent of the population living in poverty exceeds 25 percent (Michigan State Budget Office, 1996). The 2000 Census block group estimates that, approximately 9.7 percent of Bay County is at or below the poverty level, based on income for calendar year 1999. A broader survey (2000 U.S. Bureau of Census ) covering the greater Saginaw–Bay City–Midland area estimates that approximately 12 percent of the population lives at or below the poverty level. U.S. Bureau of Census calculations estimate the upper and lower bounds of this estimate to be between 8.9 and 15.1 percent, respectively. Comparisons of the regional poverty statistics with those from the 2000 Census block groups in the immediate vicinity of the SCA Hartley & Hartley Landfill Site are presented in Table 3-5. No localized population (as demarcated by census block group) in the immediate vicinity of the site exceeds the low-income population threshold (more than 25 percent earning at or below the poverty level [MACTEC, 2003]).

All but one block census group population in the immediate vicinity of the site has a poverty rate lower than the county poverty rate, and none exceed the rate for the broader region described.[3] The geographic trend in low-income demographics is graphically portrayed on Figure 3-5.

## 3.3 Current/Future Land Use

Bay County, Michigan, although predominantly rural, has an urban center (Bay City) near its southern end. Nearly half of the land in the county is used for agricultural purposes, principally for producing potatoes, sugar beets, beans, corn, and wheat. The City of Pinconning, Michigan, to the north of the site, is known for its cheese production, while Bay City is home to manufacturers of automotive parts, petroleum, cement, chemicals, beet sugar, and heavy machinery. While a significant portion of the land area of the county is agricultural, the economy relies most heavily on the services, retail trade, manufacturing, and

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[3] Caution should be exercised in making direct comparisons of poverty rates computed for a block group because the sample size for a block group is relatively small, resulting in larger margins of error.

state and local government sectors (Figure 3-6). Less than 1 percent of workers are employed in agricultural occupations (U.S. Bureau of Census, 2000). There are several tracts of public land along Saginaw Bay: Pinconning and Bay City State Parks, Quanicassee and Nayanquing Point Wildlife Areas, and Tobico Marsh SGA. The SCA Hartley & Hartley Landfill Site is nearly surrounded by the Tobico Marsh SGA, as discussed in Subsection 3.1.2.

A 6-foot-high chain-link fence surrounds the Northwest and East Landfills and extends along the southern and western property lines. Signs are posted to warn of radiological hazards and to prohibit unauthorized access. The land use in the surrounding Tobico Marsh SGA land is recreational, with the types of recreation varying by season. Common activities include hunting, fishing, and naturalist activities.

Population growth is a key element in assessing the potential for changes in land use patterns and increased development. The population in Bay County has been decreasing over the past 20 years, with a corresponding increase in the amount of farmland lying fallow. Economic and agricultural statistics for the region show a decreasing trend in the importance of agricultural land uses. The U.S. Bureau of Census and state statistical resources project that the population of Bay County as well as that of the greater Saginaw–Bay City–Midland metropolitan area will continue to decrease over the next 20 years (U.S. Bureau of Census, 2000). Despite historical trends and future projections, development in the vicinity of the site cannot be ruled out. The development of some commercial and residential properties along the major highway corridors is possible, but significant development along the stretch of Beaver Road to the south and east of the site is unlikely. This is due to a variety of factors, such as numerous wetlands in the area and the abundance of public land (established state game and recreation areas).

Several attributes of the site conspire to prevent future development of the site. These include depth to groundwater, water quality, and engineering characteristics of the soil.

The shallow depth to groundwater is a serious limitation to site development. Much of the site is covered by ponds or wetlands, where the water table is at, or very near, the ground surface for much of the year. Encouraging drainage through engineering measures, such as construction of surface or subsurface drains, is unlikely to be effective because the low areas are very nearly at the same elevation as local base level (Lake Huron). As a result, development of residential or industrial properties in these areas of the site is unlikely. The shallow water table and ponded water in the marshy areas at the site create poor conditions for farming.

On the other hand, development of residential or industrial properties on land currently covered by the wetlands could be achieved by placing fill over the wetlands. Filling on top of the organic soil in the wetlands around the landfill will still pose the potential for soil instability, unless the organic soil is removed first. Even if the organic soil currently at the ground surface proves to be stable enough to be a subgrade layer for construction purposes, the fill placed over the wetland soil would constitute a barrier to direct contact with radionuclides that may be present within the wetland soil.

Much of the site is covered by the East and Northwest Landfills. The landfills would be poorly suited for construction because the fill materials are expected to be unstable when loaded and landfill gases may be present. The surface of the landfill likely would not support a large structure (say a house or a factory building) without undergoing substantial subsidence. The waste in the East and Northwest Landfills was not placed in an engineered manner. The resultant heterogeneity of the filled areas will cause differential settlement if the waste is loaded. Depending on when a structure is built on either of the landfills and the size of the structure, settlement ranging from inches to feet will likely occur. Piles could be driven through the waste and into the underlying natural soil; however, this would be extremely costly. The potential for gases that could enter a proposed building would require that measures such as a gas extraction system and an impermeable layer be installed beneath the building. Given that ample land for development is available in nearby upland areas, it is unlikely that a building that requires these costly design measures would be constructed on the landfills.

The areas of the site underlain by sandy soil with a water table more than 5 feet below grade may be more conducive to active land use. The remainder of the site consists of roads and several areas with sandy soil (for example, in the beach ridges in the southwestern, and northeastern corners of the site, and the area of the office building in the southeastern corner of the site). Note that these areas range from 1,200 to 2,100 feet from the Northwest Landfill, the area in which the thorium-bearing slag was disposed. Limitations to site development are discussed in more detail in Subsection 5.2.2.

## 3.4 Meteorology and Climatology

Meteorological and climatic information presented in this section was compiled from federal and state historical weather databases covering approximately 30-year periods (extending from 1951 to 1980 or 1961 to 1990, depending upon the data source) (Michigan State University, 2003). The SCA Hartley & Hartley Landfill Site is located in southeastern Bay County near the southwestern edge of Saginaw Bay and Lake Huron. The proximity to the lake tends to moderate the temperatures in its vicinity.

The effect of Lake Huron on the Bay City area's climate is most influential during periods of northeasterly winds. Under these conditions, the Bay City area receives cooler summer temperatures. Westerly winds blowing over Lake Michigan (to the west) often produce cloudiness and precipitation, modifying fall and early winter temperatures (MACTEC, 2003).

### 3.4.1 General Meteorology and Climatology

Summers are moderately warm, with the warmest period usually occurring in July. The mean daily temperature in July averages 71.5 °F. Winters are moderately cold, with the coldest period usually occurring in January, when the average daily temperature is 21.6 °F. Precipitation amounts (Table 3-6 and Figure 3-7) and the daily chance of precipitation are usually well distributed throughout the year (Figure 3-8). On average, the wettest month is August (2.93 inches) and the driest month is February (1.18 inches). Summer precipitation comes mainly in the form of afternoon showers and thunderstorms. Local conditions at the SCA Hartley & Hartley Landfill Site are presumed to be similar to overall regional conditions (MACTEC, 2003).

Annual snowfall for the 30-year period averages 38.8 inches. January typically has the greatest monthly snowfall, averaging 11.3 inches. The average date for the last freezing temperature is May 1, while the average date of the first freezing temperature is October 17. The freeze-free period, or growing season, averages 167.9 days annually. Table 3-6 presents the 30-year monthly average temperature ranges and precipitation levels (MACTEC, 2003).

Wind conditions at the site are typically mild, with winds typically from the south and west and blowing to the north and east. A cumulative average wind rose plot using data from the Saginaw MBS Airport meteorological station (Station #72639) collected over a 5-year period, from 1987 to 1991, is presented on Figure 3-9 (Lakes Environmental Software, Inc., 1998). The average wind speed is calculated to be approximately 4.2 meters per second (9.35 mph), with calm winds being reported approximately 7 percent of the time (MACTEC, 2003).

### 3.4.2 Extreme Meteorology and Climatology

The Bay City area seldom experiences prolonged periods of hot, humid weather in the summer, or extreme cold during the winter. The highest average monthly maximum temperature in the 30-year period between 1951 and 1980 was 89.1°F in July 1955, and the lowest average monthly minimum temperature was 4.6°F in January 1977. On average, temperatures in excess of 90°F occur only 10 days out of the year, and only 1 day in the 30-year period exceeded 100°F. The high and low temperatures for the 30-year period are listed in Table 3-7. Thunderstorms occur an average of 33 days out of the year. While drought occurs periodically, the Palmer Drought Index indicates that drought conditions rarely reach extreme severity, historically occurring only 3 percent of the time. The largest single snowfall total, 24.0 inches, was recorded in January 1914. The greatest total monthly snowfall on record, 42.5 inches, occurred in December 1929. The greatest seasonal snowfall was 85.8 inches, recorded during the winter of 1911-1912.

The smallest seasonal snowfall total was 7.3 inches, recorded during the winter of 1931-1932. The greatest snow depth was recorded in January 1979 at 25 inches. The severe weather maximum precipitation (by month) for the 30-year period is presented in Table 3-8 (MACTEC, 2003).

Monthly mean weather-related extremes are plotted in time series on Figure 3-10 for the 30-year period beginning in 1961. The same time-series data are normalized to the corresponding mean extreme value over the 30-year period and are presented in high/low bar graphs on Figure 3-11 to portray the relative variability in the extreme weather data and to identify anomalies (MACTEC, 2003).

Tornadoes occur infrequently in this part of Michigan. When tornadoes or funnel clouds are reported, they are typically category F0 or F1, with little or no property damage reported (MACTEC, 2003).

### 3.4.3 Ambient Air Quality

The ambient air quality for the entire State of Michigan is in attainment for each of the five "criteria" pollutants as described by the National Ambient Air Quality Standards (NAAQSs) (MDEQ, 2000). In addition to the ambient air quality standards for so-called criteria pollutants, the federal government has categorically designated 156 national parks and wilderness areas as Class 1 areas subject to enhanced air quality protection guidelines. Some American Indian tribal governments have also designated lands under their jurisdiction as Class 1 areas. The SCA Hartley & Hartley Landfill Site is not located in a Class 1 area as designated by federal or tribal governments. The Class 1 area closest to the site is the Seney Wilderness Area, located 200 miles to the north in the Upper Peninsula of Michigan. The first downwind Class 1 area is the Lye Brook Wilderness Area, located approximately 550 miles to the east in the State of Vermont (MACTEC, 2003).

## 3.5 Geology and Seismology

### 3.5.1 Geotechnical Parameters

In general, this area of Michigan consists of glacial drift overlying Paleozoic bedrock. This portion of the continent is known as the Eastern Lakes Region of the Central Lowlands Physiographic Province (Fenneman, 1938). This area is characterized by low, rolling to flat topography shaped by Pleistocene glaciation. The most prominent tectonic feature in the area is the Michigan Basin. The sedimentary rocks of the Michigan Basin were deposited in an intracratonic basin (situated within a stable continental region) during Paleozoic time, and were exposed at the surface after subsequent uplift (Dorr & Eschmann, 1970).

This region of the continent is tectonically stable, exhibiting a very low potential for earthquakes. For this reason, no map showing local seismic features is available. Karst features are rare, but *are* found in Michigan. Most notably, several large sinkholes are present in the Alpena area, located approximately 100 miles north of the SCA Hartley & Hartley Landfill Site. The relatively flat topography in the area precludes mass wasting other than beach erosion of coastal dunes and terraces. The low dunes surrounding the site are consolidated by vegetation and are unlikely to catastrophically fail. Subsidence may occur at the East Landfill with time, as a result of the degradation of putrescible waste (decomposed organic waste).

There are coal mines in Bay County, Michigan, and the surrounding area. Historical operations that date from the mid-1800s to the 1950s removed significant quantities of coal from the Saginaw Formation (Stark and McDonald, 1980). Thin coal seams are noted in logs for nearby wells. However, there is no evidence of coal mining in the site area. Sand quarries are located along the former shoreline of Lake Huron, and several are found near the site. The site itself was once operated as a sand quarry.

The following sections summarize the geology of the site and the surrounding area. It includes a brief description of the soil, the glacial geology, and the bedrock geology.

### 3.5.2 Soil

Three soil types are present at the site, and two others are common in the area. The three soil types at the site are "Dumps"; "Belleville loamy sand, ponded"; and "Wixom loamy sand." "Pipestone-Tobico fine sand" and "Belleville loamy sand" are also common in the immediate area of the site (USDA, 1980). The following sections describe these soil types (Earth Tech, 2003a).

#### *Dumps*

This soil type is a USDA term that was used in the RI Report to describe the areas that are filled with refuse. Most areas that have this type of soil are active landfills that do not have a final vegetative cover, but rather, layers of soil covering the refuse. This unit covers most of the eastern and northern areas of the site. It is also present at the adjacent Bangor Township Landfill.

*Belleville Loamy Sand, Ponded*

This is a nearly level, poorly drained soil in broad, flat depressions. It is covered with 6 to 36 inches or more of water throughout most of the year. Typically, the surface layer is very dark-gray loamy sand, about 11 inches thick. The subsoil is dominantly grayish-brown loose sand, about 25 inches thick. The substratum is multicolored clay loam and loam. Permeability is high in the sandy upper part of the soil and moderately low in the loamy lower part. In most areas, the soil is ponded and supports marsh vegetation. This soil is found in the cattail area that covers the western area of the site and is also found to the north of the site.

*Wixom Loamy Sand*

This is a nearly level, somewhat poorly drained soil on broad, slightly convex uplands and on low knolls and ridges. Typically, the surface layer is very dark-brown loamy sand, about 9 inches thick. The upper part of the subsoil is multicolored loose sand, and the lower part of the subsoil and the substratum is brown mottled loam. Permeability is high in the sandy upper part of the soil and moderately low in the loamy lower part. Most areas of this soil in Bay County are farmed, and a few areas are woodland. This soil is found only on the extreme southwestern corner of the site in the Southwest Trail Area at the SCA Hartley & Hartley Landfill Site.

### 3.5.3 Glacial Geology

Site geology was evaluated based on logs for borings installed during the RI and on logs for local domestic water supply wells (Earth Tech, 2003a), as well as on published regional information (Furrand and Bell, 1984; Dorr and Eschmann, 1970). The glacial geology at the near surface is dune sand and lacustrine (shoreline) sand and gravel. The dune sand is characterized as pale-brown well-sorted fine to medium sand, chiefly quartz with some heavy minerals. The lacustrine sand is characterized as pale-brown to pale–reddish-brown well-sorted fine- to medium-grained sand, commonly including occasional lenses of small gravel mixed with quartz sand. These deposits occur chiefly as former beach and near-shore littoral deposits of the glacial Lake Huron, and may include intercalated lacustrine clay and peat, locally veneered by eolian sand and interdune deposits of organic soil. The lacustrine sand and dune deposit is the material that was excavated to form the depressions in which the East Landfill, the Northwest Landfill, and the MDNR Landfill were constructed. The lacustrine sand forms the uppermost saturated unit (aquifer) at the SCA Hartley & Hartley Landfill Site.

Underlying the eolian and lacustrine sand is fine-textured glacial till, which is described as gray, grayish-brown, or reddish-brown nonsorted glacial debris; the matrix is predominantly clay, clay loam, or silty clay loam, with occasional gravel and cobbles suspended in the clay matrix. The glacial till unit occurs as lacustrine ground moraine, till plain, or undifferentiated ground moraine–end moraine complexes. The glacial till unit includes small areas of coarser textured tills, as well as small areas of outwash. Well logs from the area give a total thickness of the glacial till deposits of 75 to 110 feet (Earth Tech, 2003a). Of this total thickness, eolian/lacustrine sand is generally about 0 to 10 feet thick, and the glacial till is generally about 60 to 100 feet thick. The clay may directly overlie the bedrock, or locally, a sand and gravel outwash deposit is present (Furrand and Bell, 1984).

The glacial till forms a thick confining layer that impedes hydraulic communication between the bedrock aquifer and the shallow aquifer. Deep test borings were drilled by Wehran (1979) to depths up to 56 feet into the glacial till and did not reach bedrock. The upper 40 feet of the strata consisted of gray clay and silt (40 to 65 percent), with (35-50 percent) medium- to fine-grained sand, with a trace (0-10 percent) of gravel. Occasional cobbles were also encountered during the excavation and drilling. The till was very stiff to hard, unstratified, and had low permeability. The permeability of the unit was estimated through laboratory testing to be $1.0 \times 10^{-8}$ cm/s (Earth Tech, 2003a).

### 3.5.4 Bedrock Geology

Figure 3-12 is a regional bedrock map of the state of Michigan (MDEQ-Geologic Survey Division, 1987). The uppermost bedrock formation below the site and all of Bay County is the Saginaw Formation of the Pennsylvanian Period. Well logs from the area indicate that the top of bedrock is between 60 and 110 feet below the ground surface. The Saginaw Formation consists of interbedded layers of limestone, shale, and sandstone, with some thin layers of coal. The Saginaw Formation in the site area reaches approximately 300 feet in thickness (Stark and McDonald, 1980).

### 3.5.5 Seismology

The state of Michigan is located in the tectonically stable interior of North America. This area of Michigan has a very low potential for having a damaging earthquake. The strongest earthquake to strike Michigan occurred on August 10, 1947, and measured 4.7 on the Richter Scale, causing minor damage (USGS, 2003a).

The seismicity of the site and region is very low. Seismic activity is very infrequent because of the stability of the regional geology. Earthquakes within 200 miles of the site of a magnitude (Richter Scale) of 3 or greater, within the last 100 years, are listed in Table 3-9.

The Michigan Basin is an example of an intracratonic basin. The Michigan Basin accumulated great thicknesses of marine sediment during the Early Paleozoic era, and is a relatively stable geologic environment. There are no known or inferred faults in the site or vicinity (Dorr and Eschmann, 1970). The crust underlying the Great Lakes Basin continues to uplift through isostatic rebound, resulting from post-glacial retreat; but little tectonic activity (*e.g.*, faulting or earthquakes) is associated with isostatic rebound.

### 3.5.6 Karst Features and Landslide Risk

Karst terrain is a feature not commonly associated with the geomorphology and structural geology of Michigan. Northern Alpena and Presque Isle Counties located approximately 100 miles to the north of the site, comprise the only prominent karst topography in the lower peninsula of Michigan. Karst features include sinkholes near the towns of Leer and Posen that have developed in Devonian limestone (Dorr and Eschmann, 1970).

Landslides are an uncommon phenomenon in Michigan because the lack of topographic relief is generally not conducive to their occurrence. Because there is no sharp contrast between the elevation of the land surface and the surface of Lake Huron (relief is less than 10 feet), landslides are not of concern at the SCA Hartley & Hartley Landfill Site. Landslides do occur along the eastern shoreline of Lake Michigan, approximately 150 miles west of the site. These landslides are the results of shoreline erosion, owing to the high topographic relief on the western edges of the lake.

## 3.6 Surface Water Hydrology

This section describes the hydrology of the site and the surrounding area, as well as the proximity to surface water, flood plains, and wetlands. Surface water features discussed in this section are shown on Figure 3-13.

### 3.6.1 Proximity to Surface Water

There are numerous surface water bodies at the site and in the area surrounding the site. Several small ponds on the site were excavated during the late 1950s and early 1960s (based on the inspection of aerial photographs), when the site was used as a sand quarry (Earth Tech, 2003a). Linear ponds surrounding the Northwest Landfill were excavated for subgrade with which to construct site access roads. The glacial till material found beneath the surficial sand was used to construct perimeter roads and clay cut-off walls around the waste disposal areas. Also, two unused landfill cells, Cells A and B, which were under construction at the time of site closure, are now large ponds.

Indian Town Drain, a surface drainage way, is located south of the site and flows south into the Kawkawlin River, which discharges into Saginaw Bay. Indian Town Drain was extended along the southwestern corner of the site by the former landfill owners in an attempt to improve the surface drainage of the western portion of the site. An unnamed drain is also present northwest of the site. This ditch, which flows to the west, north, and then to the east to Tobico Lagoon, was probably constructed to drain farmland along South Huron Road, though it may convey some surface water in the northwestern corner of the site to Tobico Lagoon.

Tobico Lagoon is located approximately 0.5 mile east of the site in the Tobico Marsh SGA. The lagoon is approximately 3 miles long and 0.5 mile wide, and includes both open water and wetland areas. The lagoon is separated from the site by several beach ridges that are also part of the Tobico Marsh SGA.

Saginaw Bay is approximately 1 mile east of the site and is part of Lake Huron. All of the surface water in the area ultimately drains into Saginaw Bay.

### 3.6.2 Lake Huron Water Resource Data

Water level measurements from the Great Lakes Region have been recorded since at least the beginning of the 1900s. Lake Michigan–Lake Huron water level data recorded from 1918 to 2000 are shown on a hydrograph (Figure 3-14). Water levels have ranged between a high of 582 feet (1986) and a low of 577 feet (1964) above mean sea level (M.S.L.) (U.S. Army Corps of Engineers, 2003). Table 3-10 summarizes the physical characteristics of Lake Huron.

Natural drainage patterns for the site are directed eastward toward Saginaw Bay; however, many area streams drain southward to larger rivers before emptying into the bay.

### 3.6.3 Existing and Proposed Water Control Structures and Diversions

The U.S. Fish and Wildlife Service has implemented water control measures for flow restoration actions for the Tobico Marsh. Some water control measures implemented recently (2002-2003) include a water control weir, a flap gate, county drains, and irrigation practices in the watershed. The goal of the restoration effort is "to facilitate to the extent practicable, natural fluctuations of water levels within Tobico Marsh, while providing adequate flood protection to residences riparian to Tobico Marsh." Other ecological restoration projects, and projects that will enhance public use of Tobico Marsh, may also be considered (MACTEC, 2003).

### 3.6.4 Kawkawlin River Historical Stream Flow-Duration Data

The North Branch of the Kawkawlin River is the nearest large stream to the site, and the main Kawkawlin River is the largest fluvial system within several miles. Figure 3-15 illustrates the local drainage area for the Kawkawlin River and a portion of the nearby Saginaw River. Stream flow data are recorded in the North Branch of the Kawkawlin River at:

USGS 04143500, North Branch Kawkawlin River, Bay County, Michigan
Hydrologic Unit Code 04080102
Latitude 43° 40'05", Longitude 83°85'13" NAD27
Drainage area 101.00 square miles
Gauge datum 584.00 feet above sea level NGVD29

Historical stream flow data for the north branch of the Kawkawlin River from 1951 through 1982 are presented in Table 3-11 (USGS, 2003b).

### 3.6.5 Site and Adjacent Drainage Areas and Surface Gradients

The area surrounding the site is approximately 585 feet above mean sea level, is relatively flat, and usually contains standing or ponded surface water throughout the year. Aerial photography (Figure 3-16) showing current site conditions (*i.e.*, post-disposal activity) illustrates the surface water features in the site area, which appear black in the photograph. The light-colored landfill areas are also obvious, because they are mowed. The majority of the area southwest of the filled areas of the SCA Hartley & Hartley Landfill Site contains standing water and is densely vegetated with cattails, and appears as featureless with a light-green color. Darker areas of trees are north and southwest of the site, indicating less marshy conditions. Relict beach dunes are the prominent feature to the northeast of the site. The dunes are lightly colored areas separated by long, thin dark areas of standing water.

A surface water drainage divide runs along the highest features at the site (the landfills and roads connecting the landfills). The divide extends from the southeastern corner to the northeastern corner of the site. Surface water on the southwestern half of the site drains southward toward Indian Town Drain. The drain conveys water south and east to the Kawkawlin River toward Saginaw Bay in the east/northeast. Runoff in the northwestern half of the site is to the northeast, toward Tobico Marsh. Drains were not constructed on the sandy dune soil on the northeastern half of the site, so rainfall here either evaporates or infiltrates to recharge shallow groundwater.

### 3.6.6 Proximity to Flood Plains

The entire site falls within the 100-year flood plain, according to the Flood Insurance Rate Map for the area dated April 2, 1993 (Figure 3-17). All of the surrounding areas to the east, north, and west of the site are also within the 100-year flood plain. The extent of the local flood plain is based on poor drainage in the area, and not on expected flooding of the Kawkawlin River, Indian Town Drain, or Saginaw Bay. To the south of the site, most of the area is also within the 100-year flood plain, except Beaver Road and Two Mile Road, which fall within the 500-year flood plain.

### 3.6.7 Proximity to Wetlands

Much of the site and the surrounding area is wetlands. On the site, a cattail marsh covers most of the southwestern and northcentral portions of the site, and a small area on the northeastern corner (Figure 3-18). A cattail marsh also surrounds the site on the northern and western sides. Many of these marshlands contain permanent standing water and are underlain by an interval of organic-rich soil or peat. The only areas of the site that are not wetlands are the landfills and associated roadways and the remnant beach ridges at the northeastern and southeastern corners of the site.

## 3.7 Groundwater Hydrology

Much of the site and surrounding area is characterized by numerous ponds and wetlands. As such, the shallow aquifer is either at or near the ground surface. The unsaturated zone, where present, ranges from 0 to 10 feet in thickness. The unsaturated zone consists of the uppermost portion of the shallow sand unit, which is composed of fine sand and occasional peat. The shallow aquifer is isolated from the bedrock aquifer by a thick confining layer of glacial till. Because it is so thin (approximately 5-10 feet), the shallow aquifer is not viable for large-scale withdrawal. Moreover, the shallow aquifer is so close to the ground surface that it is readily affected by agricultural practices, septic drain fields, and surficial chemicals, such as road salt.

The site is located within the East-Central Lower Peninsula Hydrogeological Province, which is characterized by glacial lake plains and glacial till deposits that overlie sandstone aquifers (Earth Tech, 2003a). The glacial lake and till deposits have low yields, and most wells screened in this unit produce only about 10 gallons per minute. The deep sandstone aquifers contain highly mineralized water that does not meet some of the drinking water quality standards (MACTEC, 2003).

The following sections describe the depth to the saturated zone, the hydrologic gradients, the proximity to drinking water aquifers, and the current and potential groundwater use.

### 3.7.1 Saturated Zone

The saturated zone is at, or very near, the surface over most of the site and surrounding areas. This is evidenced by the abundance of wetlands and open water that fill any excavation, ditch, or low area. The widespread, but thin, sand deposit comprises the shallow aquifer, conveying groundwater to the nearby surface ditches, marshes, and ponds.

Six monitoring wells were originally installed at the SCA Hartley & Hartley Landfill Site in 1977 (Wehran, 1979). These wells were constructed with 2-inch-outer diameter steel casing with 3-foot-long stainless-steel screens. Four additional, similarly constructed wells were installed in 1988 (Dell Engineering, 1990). Other wells were installed at an unknown time(s), and as many as 15 wells and four piezometers may have been present at the site at one time (REI, 1993a). Six wells were abandoned as part of the Phase IIB Intrusive Investigation (REI, 1997a), and presently, there are 11 monitoring wells and three piezometers at the site. Well construction for the existing wells and water levels in July 2000 are summarized in Table 3-12.

Depth to water in monitoring wells outside the containment areas ranges from 0.06 foot below ground surface (feet bgs) at MW-40A to 5.42 feet bgs at MW-39. In July 2000, groundwater elevations outside the containment ranged from 586.36 feet M.S.L. at MW-40A to 585.12 feet M.S.L. at DWN-03 (Table 3-12). The apparent lower elevation recorded at MW-39 (583.79 feet M.S.L.) may be a reflection of a downward vertical gradient and the short well screen of this partially-penetrating well. Higher water levels at MW-40A may be influenced by the higher surface water elevations in Cell A. Groundwater elevations inside the containment ranged from 586.38 to 593.98 feet M.S.L. The higher elevation inside the containment is largely due to the effectiveness of low-permeability containment (clay dikes and slurry walls) that results in the buildup of leachate head in the encapsulated area.

Slug tests were performed in 15 of the monitoring wells in 1994 to estimate the hydraulic conductivity of the saturated material at the site. The estimated hydraulic conductivity of the shallow sand aquifer ranges from $4.5 \times 10^{-3}$ cm/s to $2.6 \times 10^{-4}$ cm/s, with an average $2.1 \times 10^{-3}$ cm/s (REI, 1995). Hydraulic conductivity of the glacial till beneath the sand is presumed to be much lower; however, no wells that could provide slug test data are completed in this strata. Vertical permeability measured in 12 laboratory samples of the clay till range from $9.7 \times 10^{-5}$ cm/s to $9.6 \times 10^{-9}$ cm/s (10 samples by REI [1996] and two samples by Wehran [1979]). The geometric mean of the 10 samples analyzed by REI was $4.52 \times 10^{-6}$ cm/s.

### 3.7.2 Groundwater Flow Gradients

The near-surface groundwater/surface water at the southern and western area of the site flows south to the Indian Town Drain. Groundwater at the eastern and northern sides of the site likely flows east or northeast into the Tobico Lagoon. The local groundwater flow divide is defined by the topographic high points (that is, the landfills). The highly permeable sand presumed in the area of the dunes probably results in slight mounding of groundwater in the topographically higher area.

The horizontal hydraulic gradients are nearly flat throughout the site, but may be steeper locally because of modification in the aquifer by the containment structures and the ditches surrounding the landfills. The horizontal gradient to the east measured from MW-40A to MW-39 was 0.0006 (dimensionless) in October 10, 1994, but 0.003 in July 2000. Water levels along the western side of the site suggest that the horizontal gradient is 0.0001 trending south from temporary piezometers MW-12 and Q-26 in the West Marsh Area. The corresponding groundwater velocities for the above gradients range from 0.012 ft/day to 0.058 ft/day, using the average hydraulic conductivity ($2.1 \times 10^{-3}$ cm/sec or 5.76 ft/day) and a porosity of 30 percent.

Vertical gradients within the shallow sand aquifer are expected to be minimal within the thin (<10 feet thick) unit. Vertical gradients between the sandstone aquifer and the shallow aquifer cannot be determined from the available information. In any event, the thick clay aquitard (glacial till) impedes hydraulic communication between the shallow soil aquifer and the sandstone aquifer.

### 3.7.3 Proximity to Drinking Water Aquifers

The potential drinking water aquifers in the area of the site are the shallow sand, the discontinuous sand layers within the fine-grained glacial till, and the underlying sandstone aquifer (Saginaw Formation).

#### *Shallow Sand Aquifer*

The shallow sand unit is approximately 5-10 feet in thickness on the SCA Hartley & Hartley Landfill Site, but the total thickness of the sand (saturated and unsaturated zones) may exceed 15 feet in the areas of existing beach ridges. In low areas, the shallow sand is often overlain by several feet of peat. In general, the saturated thickness of the shallow sand aquifer is less than 8 feet (Wehran, 1979).

The proximity of the shallow aquifer to surface water bodies and extensive areas of marsh greatly affect water quality in the shallow aquifer. Reducing conditions, caused by the accumulation of plant material in the marshes, result in high levels of dissolved solids. Chemical data beneath the shallow sand aquifer indicate that shallow groundwater exceeds several Michigan Part 201 drinking water criteria (Table 3-13). Concentrations of arsenic, cadmium, chloride, chromium, iron, lead, manganese, magnesium, nitrogen, and sodium all exceed state residential/commercial drinking water criteria. The presence of these metals typically imparts an adverse taste and color, making it less likely that the shallow sand aquifer would be used by future residents or site workers.

Under the Michigan Well Construction Code Administrative Rules (R325.1632[4]), a surface casing must extend at least 25 feet below the ground surface in order to prevent surface or shallow groundwater contamination from migrating into the producing internal (screened) portion of the well. Note that the shallow sand aquifer at the SCA Hartley & Hartley Landfill Site extends from the ground surface to 5 or 10 feet below grade. Hence, water wells constructed at the site in the future would be prevented by Michigan law from being completed in the shallow aquifer, further reducing the likelihood that people using the site would be exposed to shallow groundwater.

### *Clay Till*

The shallow sand aquifer is underlain by a clayey glacial till, with a thickness of up to 122 feet. The till is dense and clayey, with occasional sand lenses. Layers of sand were not found within the till in borings beneath the site (Wehran, 1979; Earth Tech, 2001), but sand layers have been observed regionally (Twenter and Cummings, 1985). Therefore, it is unlikely that the site contaminants could migrate significant distances, laterally or vertically, through these discontinuous sand units to affect groundwater quality at a distance from the site. Moreover, the discontinuous sand layers in the glacial till generally do not produce water of sufficient quantity or quality to be used as a domestic water source (Twenter and Cummings, 1985).

*Saginaw Formation*

The Saginaw Formation consists of interbedded shale and sandstone, and in places contains coal beds. The thickness of the Saginaw Formation is approximately 300 feet (Stark and McDonald, 1980). Available data on water quality from the Saginaw Formation was evaluated based on regional studies performed by the US Geologic Survey and the Michigan Department of Natural Resources (Twenter and Cummings, 1985; Dannemiller and Baltusis, 1990). Data from the two studies are summarized in Table 3-14. Water in the Saginaw Formation commonly is highly mineralized (Twenter and Cumming, 1985), and commonly contains concentrations of inorganic constituents that exceed the Part 201 residential groundwater cleanup criteria for iron, manganese, sodium, chloride, and sulfate (Table 3-14). Although water supply wells are installed in the Saginaw Formation, it is a marginal resource, with modest yields and poor water quality. For these reasons, most residences in the vicinity of the SCA Hartley & Hartley Landfill Site are served by local utilities for drinking water. The utilities' source of water is Lake Huron.

Well logs for the site and surrounding area were obtained from the MDEQ, Geological Survey Division (Earth Tech, 2003a). A review of these well logs found that, in the immediate area of the site, wells have encountered water contained within sand seams in the glacial till at depths ranging from 40 feet to 80 feet. Wells that did not encounter a sand seam within the glacial till were drilled deeper and encountered water in bedrock at depths of about 140 feet. The well log for an oil exploration well drilled on-site in 1980 found glacial till to a depth of 122 feet (Hartley, 1983). Some of the private water wells produced an adequate quantity and quality of water, as discussed in Subsection 3.7.4. However, some of the well logs noted that the production from the wells was low or inadequate, so the wells were abandoned. Some well logs also noted water quality problems, such as a "salty" or "sickening taste," particularly in the bedrock wells (Earth Tech, 2003a).

### 3.7.4 Current Groundwater Use

Groundwater in the area is rarely used because of the low transmissivity of the glacial/lacustrine sediment, the questionable quality and limited extent of the uppermost sand aquifer, and the poor quality of the groundwater in the bedrock aquifers. Most of the residences in the area obtain their water from Saginaw Bay via municipal water supply. A review of MDEQ well logs found that most of the private wells in the area are located approximately 1 mile west of the SCA Hartley & Hartley Landfill Site, along Highway M-13, north of Kawkawlin. All of these wells were installed in the late 1960s and 1970s. There are also several private wells on Beaver Road that are located ¼ to ½ mile southwest of the site. These wells were also installed in the deep sandstone aquifer in the 1960s and 1970s. Two irrigation wells were also installed in 1994, and three dry wells were drilled in 1996 at the Spring Valley Golf Course, located ½ mile southwest of the site. Groundwater in the bedrock aquifer flows toward Saginaw Bay to the northeast (Earth Tech, 2003a).

### 3.7.5 Distribution Coefficients for the Radionuclides of Interest at the Site

The distribution (or partitioning) coefficient, $K_d$, is a measure of the distribution of a chemical species (including radionculides) between solid and liquid media that are in equilibrium with one another. $K_d$ is defined as the ratio of the mass of a solute species adsorbed or precipitated on the solids per unit mass of soil (mg/kg) to the solute concentration in liquids within the pore spaces in the soil (mg/L). High $K_d$ values indicate stronger chemical/physical bonds to the solid media; whereas, lower $K_d$ values indicated a chemical's preference to the liquid media.

Literature values for thorium are provided in Sheppard and Thibault (1990), for several soil types that are present at the SCA Hartley & Hartley Landfill Site. The $K_d$ values range from 3,200 (unitless) in sand to 5,800 in clay, and 89,000 in organic soil. These $K_d$ values are some of the highest for any element in these soil types. Distribution coefficients were changed from the RESRAD defaults (described in Section 5) to reflect the types of soil that are present beneath the SCA Hartley & Hartley Landfill Site for the radioisotopes of interest in the slag. The default coefficients provided by RESRAD assume a different type of soil, and consequently, may overestimate the potential for migration. The $K_d$ coefficients that were used in the dose calculation for this assessment are discussed in Subsection 5.2.3. Given the range of soil types present in the Northwest Landfill, it is appropriate to assign a more likely value for each element, including thorium, radium, uranium, and lead. These values are deemed to be conservative; the physical and chemical characteristics of the thorium-bearing slag create a material that has very low solubility, and hence, the radionuclides do not leach from the matrix. A much higher distribution coefficient is appropriate for this slag material than was used in the RESRAD simulations. The greater distribution coefficient indicates the inability of the radionuclides to escape the chemical and physical matrix of the slag and results in a much lower radiation dose than is indicated.

At the SCA Hartley & Hartley Landfill Site, thorium is present in vitreous slag that is expected to have low leachability and to be physically stable. Moreover, the $K_d$ of thorium is sufficiently high that dissolved thorium would rapidly bind to aquifer solids, in the event that thorium was leached from the slag.

Leachability studies performed on comparable thorium-bearing slag found at a site in Washington, Pennsylvania (Molycorp), indicate that very little thorium will be leached out of the slag in the environment (Foster Wheeler Environmental Corporation, 1995). Radiological analysis of leachate that indicates thorium levels within the range of background in groundwater (see Subsection 4.7.7), and samples collected from within the containment areas at the adjacent MDNR site (MACTEC, 2003), support the contention that thorium is not readily leached from the slag, even in the more reducing environment of a landfill.

### 3.7.6 Typical Geologic Cross Sections Showing Groundwater Elevations

Two cross sections were developed for the Remedial Investigation (Earth Tech, 2003a) that span the entire site using data from the various intrusive investigations at the site (Figure 3-19). These cross sections include the various surface water bodies, the leachate elevation levels, and the groundwater containment structures. Precise flow directions cannot be discerned on a drawing of this scale, owing to the large site area and the low hydraulic gradients. However, this drawing illustrates the location of the slurry walls and clay dikes in relation to the landfills, the height of the leachate levels in relation to groundwater and surface water levels, and the subsurface conditions. The cross sections illustrate that the containment structures (clay dikes and slurry walls) and the site geology (clay till aquitard) are effective in containing the leachate within the landfills.

## 3.8 Natural Resources

The Tobico Marsh State Game Area and surrounding area is home to many freshwater fish species. The following fish species are found in the Tobico Marsh State Game Area and/or surrounding waters: brown trout, burbot, carp, catfish, chinook salmon, coho salmon, lake trout, northern pike, rainbow trout, walleye, white bass, white perch, white sucker, whitefish, and yellow perch (MACTEC, 2003).

In addition to the presence of fish in the area's waters, agricultural lands in the region are used for both field crops and livestock. Field crops include beans, cantaloupes, cauliflower, corn, hay, oats, onions, peppers, potatoes, pumpkins, soybeans, sugar beets, and wheat. Livestock species include beef cows, milk cows, hogs, pigs, sows, and sheep (MACTEC, 2003).

Groundwater resources consist of two aquifer units in the area; sand and gravel often found below the till, and a sandstone unit in the Saginaw Formation (Stark and McDonald, 1980). However, surface water from Lake Huron is abundant and is therefore the main source of the local water supply.

There are no oil or gas resources in, or adjacent to, the site. The oil well reported by Hartley (1983) evidently was a dry hole. The Kawkawlin Oil Field is located about 2 miles southwest of the site (Figure 3-1). The Saginaw and Bay County area contains coal reserves that comprise the majority of the estimated 115 million metric tons remaining in Michigan (Michigan Department of Commerce, 1977).

## 3.9 Ecology/Endangered Species

An ecological risk assessment was conducted for the RI effort. This risk assessment focused on chemical data, consistent with the scope of the RI. The risk assessment is summarized in the RI (Earth Tech, 2003a) and in two reports (ASTI 1996 and ASTI 1999).

### 3.9.1 Commercially or Recreationally Important Vertebrate Species

Commercially or recreationally important vertebrate animals known to inhabit the site were inventoried as part of the ecological risk assessment conducted for the RI. The following species were actually observed at the site (ASTI, 1999).

*Mammal Species*

- Beaver
- Domestic cat
- Eastern chipmunk
- Eastern cottontail rabbit
- Muskrat
- Raccoon
- Red fox
- Virginia opossum
- White-tail deer

*Fish Species*

Fish were also inventoried by ASTI from six of the water bodies located on-site (South Pond, North Pond, North Ditch, Cell A, Cell B, and West Pond). Fish were netted in each of the water bodies and identified. The following species were found:

- Black crappie
- Bowfin
- Carp
- Common bluegill
- Golden shiner
- Green sunfish
- Hybrid sunfish
- Northern black bullhead
- Northern largemouth bass
- Northern Pike
- Northern yellow bullhead
- Pumpkinseed sunfish

*Bird Species*

The following bird species were observed either on the site or flying over it.

- American bittern
- American black duck
- American coot
- American crow
- American goldfinch
- American kestrel
- American redstart
- American robin
- American tree sparrow
- American wigeon
- Bald eagle
- Bank swallow
- Barn swallow
- Belted kingfisher
- Black-billed cuckoo
- Black-capped chickadee
- Black-crowned night heron
- Blue jay
- Blue-winged teal
- Bobolink
- Brown thrasher
- Brown-headed cowbird
- Bufflehead
- Canada goose
- Caspian tern
- Cedar waxwing
- Chimney swift
- Common goldeneye
- Common grackle
- Common loon
- Common merganser
- Common snipe
- Common yellowthroat
- Cooper's hawk
- Dark-eyed junco
- Double-crested cormorant
- Downy woodpecker
- Eastern bluebird
- Eastern kingbird
- Eastern meadowlark
- Eastern phoebe
- European starling
- Foster's tern
- Golden-crowned kinglet
- Gray catbird
- Great blue heron
- Great crested flycatcher
- Great egret
- Greater yellowlegs
- Green heron
- Green-winged teal
- Hooded merganser
- Horned lark
- House finch
- House sparrow
- House wren

- Killdeer
- Least bittern
- Lesser scaup
- Lesser yellowlegs
- Mallard
- Marsh wren
- Morning dove
- Mute swan
- N. rough - winged swallow
- Northern cardinal
- Northern flicker
- Northern harrier
- Northern oriole
- Northern shrike
- Osprey
- Ovenbird
- Palm warbler
- Pied-billed grebe
- Purple martin
- Red-tailed hawk
- Red-winged blackbird
- Ring-billed gull
- Ring-necked duck
- Rock dove
- Rose-breasted grosbeak
- Ruby-crowned kinglet
- Rufous-sided towhee
- Rusty blackbird
- Spotted sandpiper
- Swainson's thrush
- Swamp sparrow
- Tree swallow
- Tufted titmouse
- Turkey vulture
- Vesper sparrow
- Virginia rail
- Warbling vireo
- Western meadowlark
- White-crowned sparrow
- White-throated sparrow
- Willow flycatcher
- Winter wren
- Wood duck
- Yellow warbler
- Yellow-rumped warbler
-

### *Reptiles/Amphibians*

The following is a list of reptiles and amphibians identified at the site during the ecological inventory (ASTI, 1999):

- American toad
- Wood frog
- Leopard frog
- Midland painted turtle

- Eastern garter snake
- Green frog
- Snapping turtle

### 3.9.2 List of all Commercially Important Floral Species Known to Occur Within 5 Kilometers of the Site

No commercially important (*i.e.*, important to business) floral species are known to occur within 5 kilometers of the site. There are, however, recreationally important floral species within 5 kilometers of the site (MACTEC, 2003).

### 3.9.3 List of All Commercially Important Invertebrate Species Known to Occur Within 5 Kilometers of the Site

The commercial and recreational fishery in Lake Huron consists primarily of vertebrate species, based on data from the Great Lakes Science Center of the U.S. Geological Survey (2003). Of the 21 species listed in the table for commercial fish production in 2001 from Lake Huron, none are invertebrates. However, in vertebrates form the base of the food web, and are important as forage for organisms at higher tropic levels, such as fishes and birds.

### 3.9.4 Threatened and Endangered Species

Michigan's federally-listed threatened (T) and endangered species (E) are as follows (United States Fish and Wildlife Service, 2003):

*Animals*

- American burying beetle - E
- Bald eagle - T
- Clubshell - E
- Copperbelly water snake - T
- Eastern puma - E
- Gray wolf - T
- Hungerford's crawling water beetle - E
- Indiana bat - E
- Karner blue butterfly - E
- Kirtland's warbler - E
- Mitchell's satyr butterfly - E
- Northern riffleshell - E
- Piping plover - E

*Plants*

- American hart's-tongue fern - T
- Dwarf lake iris - T
- Eastern prairie fringed orchid - T
- Houghton's goldenrod - T
- Lakeside daisy - T
- Michigan monkey-flower - E
- Pitcher's thistle - T
- Small whorled pogonia - T

Of these, the bald eagle is the only species thought, or known, to be present within a 5-kilometer radius of the site (MACTEC, 2003). Bald eagles were observed at the site during the ecological inventory (ASTI, 1996). Three other birds listed as endangered by the State of Michigan were also observed at the site, including the osprey, Caspian tern, and least bittern (ASTI, 1996). Six species listed as of "special concern" by the MDNR were observed at the site: black-crowned night heron, American bittern, Forster's tern, northern harrier, Cooper's hawk, and western meadowlark.

# Section 4
# Radiological Status of the Facility

Numerous investigations conducted over the last 23 years have resulted in a large body of analytical data for the site. These investigations have delineated the nature and extent of radionuclides derived from the disposal of thorium-bearing slag at the SCA Hartley & Hartley Landfill Site. As described in Subsection 4.4, the slag was generated during the manufacture of magnesium-thorium alloys at the Wellman Dynamics foundry located in Midland, Michigan (ORAU, 1986).

## 4.1 Contaminated Structures

There is one structure on the SCA Hartley & Hartley Landfill Site, the former office and laboratory building. The building is outside the fenced and placarded area. There is no record indicating that thorium slag was ever used or stored in this building. A baseline radiation survey was conducted in the building in December 1992 to confirm that past activities at the site had not contaminated the building. The building was characterized by collecting 150 wipe samples of various surfaces throughout the structure. The wipe samples were counted for alpha and beta contamination using a Ludlum 2929 meter. Results of the investigation indicated no readings above background (REI, 1993a).

## 4.2 Contaminated Systems and Equipment

No contaminated systems or equipment are known to exist at the facility. The types of equipment that were used to transport and dispose of the slag are not known, but probably included standard earthmoving equipment and trucks. No such equipment is currently present on-site, and no record of the disposition of the equipment used during site operations is available.

## 4.3 Background Radioactivity

The background activity levels for radionuclides of potential concern at the SCA Hartley & Hartley Landfill Site have been established through a field sampling and laboratory analysis study that was conducted in December 2002 (RMT, 2003b). Samples were collected at locations 0.7 to 2.3 miles north-northwest of the site in an environment similar to the area that surrounds the former landfills (Figure 4-1). Ten samples were collected of each of the following media:

- **Upland soil** - Upland soil is the sandy soil found in the dunes on the eastern side of the property and in the subsurface below approximately 4 feet. This is the Wixom loamy sand that was mined at the site prior to landfilling activity. The upland soil is characterized by a higher sand content than that of the wetland soil. Samples of upland soil were collected from the top 0 to 0.5 foot of surficial material. Vegetation (including leaves and large roots), was removed to the extent practicable prior to placing the samples in bottles in order to obtain a representative sample of the soil matrix.
- **Wetland soil** - Wetland soil is a silty sand containing a large percentage of organic material. This is the Belleville loamy sand that is found in areas often thickly vegetated with cattails. The wetland soil is characterized by a higher organic content than that of the upland soil. Samples of wetland soil were collected from the top 0 to 0.5 foot of surficial material. Vegetation was removed to the extent practicable prior to placing the sample in bottles in order to obtain a representative sample of the soil matrix.
- **Groundwater** - Groundwater samples were collected at depths of approximately 2 to 5 feet below grade using manual methods (*i.e.*, hand-driven Geoprobe® rods equipped to sample groundwater). Groundwater samples were not filtered in the field, consistent with the groundwater sampling procedures under the State of Michigan's environmental response program (State of Michigan, 1994). Samples were collected using low-flow sampling techniques to minimize turbidity (less than 10 nephelometric turbidity units [NTUs] as a target). Groundwater sampling was conducted using a peristaltic pump capable of delivering a flow of as little as 100 mL per minute (mL/min). The temporary well points were installed and then purged until the field parameters consolidated, after which time the pump rate was decreased to approximately 100 mL/min for sampling. The following consolidation criteria were used: readings for three consecutive measurements within ±1°C for temperature, ±0.2 pH units, ±10 percent for conductivity, and ±5 NTUs. Consolidation measurements and daily calibration data were recorded in the field logbook or on the sample collection sheets.
- **Surface water** - Surface water samples were collected from ditches and ponds at the same location as the sediment samples were collected. At each location, the pH, specific conductance, temperature, and turbidity were measured using hand-held, portable equipment, and recorded. All hand-held instrumentation was calibrated in the field on a daily basis.
- **Sediment** - Sediment samples were defined as unconsolidated material covered by flowing water or lying at the bottom of a still body of water that was generally clear of vegetation. Sediment samples were collected from the top 0.5 foot of material. Any large pieces of vegetation were removed from the sample prior to placing the sample in bottles.

The background samples were collected along three east-west access roads at distances ranging from 3,500 feet to 12,400 feet north of the SCA Hartley & Hartley Landfill Site, as shown on Figure 4-1. This distribution of samples was designed to provide areal variability in the background activity levels. The sample locations were determined in the field using hand-held Global Positioning System (GPS) units (ETREX® or equivalent). The locations of the sampling points were determined to within 50 feet.

In addition to the 10 field samples of each medium, a duplicate of a sample for each medium was also collected for quality control assessment. An equipment blank, a field duplicate, and a set of matrix spikes/matrix spike duplicates (MSs/MSDs) were also collected to assess data quality. Duplicates were prepared by homogenizing the sample in a stainless-steel bowl and removing separate aliquots for the sample and the duplicate. The equipment blanks were prepared by pouring deionized water into a decontaminated sampling vessel or over a piece of sampling equipment (*e.g.*, through sample tubing or into a stainless-steel bowl) and then pouring the water into the sample bottles. The samples were shipped via overnight carrier using proper chain-of-custody procedures.

As part of the field sampling procedures, all samples were field-screened for radioactivity using a Ludlum digital rate meter with a gamma scintillation probe. No readings above background were recorded for the background samples.

The samples were analyzed by Outreach Laboratories of Broken Arrow, Oklahoma, for the following parameters:

- Isotopic thorium by alpha spectroscopy (LANL ER 200)
- Isotopic uranium by alpha spectroscopy (LANL ER 290)
- Radium-226 (water) by gross beta (SM-7500)
- Radium-228 (water) by gross beta (EPA Method-904/9320)
- Radium (as Bi-214 and Ac-228 in soil/sediment) by gamma spectroscopy (HASL 300)
- Strontium-90 by gross beta (EICHROM SRW01)
- Cesium-137 by gamma spectroscopy (HASL 300)

Strontium-90 and cesium-137 are fission products that are commonly detected in surface media in areas affected by fallout from historical nuclear bomb testing. No past disposal of wastes containing these isotopes at the SCA Hartley & Hartley Landfill Site has been recorded.

The analytical results for the background study are presented in Appendix B-1. This appendix includes the field and the QC sample results. The analytical data were used to calculate the mean and the 95 percent Upper Confidence Limit (UCL) above the mean for each radioisotope detected in each medium. The results of these statistical measures are presented in Table 4-1.

## 4.4 Site Characterization Studies

Numerous studies have been conducted at the SCA Hartley & Hartley Landfill Site since environmental issues were first addressed by S.C. Holdings in 1977. This section focuses on the studies that were used in developing the current understanding of the nature and extent of radiological constituents at this site.

Surface contamination was first discovered at the SCA Hartley & Hartley Landfill Site through aerial surveys. Aerial radiological surveys of two areas were conducted by EG&G for the USNRC in 1980 over broad areas of Bay County. The EG&G (1981) report indicated two locations within the Bay County area that merited further investigation based on excess levels of thallium-208. These two areas were the MDNR site and the northwestern corner of the S.C. Holdings property (REI, 1993a).

Analyses of samples of slag and metal pieces collected from the site and adjacent areas by the USNRC, the USEPA, the MDNR, and the Michigan Department of Public Health (MDPH) confirmed the presence of thorium at concentrations above the range of background. Subsequent radiological surveys (walk-over gamma surveys) performed by Oak Ridge Associated Universities (ORAU) for the USNRC in 1984 found elevated thorium activity at the Northwest Landfill, which was in the process of being encapsulated at the time, the MDNR site (also being encapsulated at the time), and on the northernmost portion of the property owned by the Hartleys (ORAU, 1985a, 1985b, 1986). ORAU (1985a) observed that the slag in the Northwest Landfill was located in two areas and placed in a discrete interval measuring 6-8 inches in thickness and buried beneath 1-4 feet of fill. The ORAU data were presented as a series of tables with no supporting documentation. Therefore, these data can only be used qualitatively in the Decommissioning Plan. Reported values of gamma radiation at 1 m above the ground surface in the Northwest Landfill ranged from 0.007 to 0.010 mrem/hr with an average of 0.008 mrem/hr. Contact gamma exposure rates ranged from 0.02 mrem/hr to 0.06 mrem/hr.

Subsequently, site characterization data (chemical and radiological) were collected by S.C. Holdings in accordance with the requirements and procedures defined in the following project documents that were approved by the MDEQ, the MDPH, and/or the USNRC:

- Remedial Investigation/Feasibility Study Work Plan (RI/FS Work Plan). SCA Hartley & Hartley Landfill, Bay County, Michigan (REI, 1994a).
- Field Sampling Plan (FSP). SCA Hartley & Hartley Landfill, Bay County, Michigan (REI, 1994b).
- Quality Assurance Project Plan (QAPP). SCA Hartley & Hartley Landfill, Bay County, Michigan (REI, 1994c).

- Health and Safety Plan (HASP) Site Characterization. SCA Hartley & Hartley Landfill, Bay County, Michigan (REI, 1994d).
- Final Workplan Addendum for Additional Site Characterization and Leachate Treatability Studies. SCA Hartley & Hartley Landfill, Bay County, Michigan (REI, 1996).
- Workplan Addendum for Waste Characterization. SCA Hartley & Hartley Landfill, Bay County, Michigan (SCA Services, Inc.; 1996).
- Revised Quality Assurance Project Plan. SCA Hartley & Hartley Landfill, Bay County, Michigan (Earth Tech, 2000a).
- Revised Site-Specific Health and Safety Plan. Hartley & Hartley Landfill (Earth Tech, 2000b).

The various phases of site characterization activity are briefly described in the following subsections of this report. Note that investigations conducted under the auspices of the MDEQ to characterize the chemical contamination at this site are also presented in the Decommissioning Plan, because these studies yielded information documenting the physical conditions at the site and because the chemical data can be used to corroborate the radiological results. For example, the presence or absence of certain chemicals in site media can be used to corroborate conclusions regarding potential contaminant migration pathways for radiological species.

### 4.4.1 Oak Ridge Associated Universities (ORAU) - 1985

This study was requested by the USNRC to evaluate the ongoing closure of the SCA Hartley & Hartley Landfill Site and to assess radiological conditions at the Northwest Landfill. ORAU conducted a series of walkover surveys of the area of the Northwest Landfill at progressively finer intervals to characterize areas of elevated radiation. Soil samples were collected in areas of concern, and test pits (trenches) were excavated in certain areas to expose the slag and accommodate sampling of the source material. Samples were also collected of potentially affected media. The study concluded that the slag that was buried in the Northwest Landfill had been adequately covered during closure. The ORAU report concluded that the site did not "pose a potential hazard to the general public through direct exposure or migration" (ORAU, 1985a).

### 4.4.2 Phase I Investigation - 1992

The Phase I site investigation was conducted by the USNRC licensee, S.C. Holdings, in December 1992 and included completion of a nonintrusive, surface gamma survey of selected areas of the property to determine the extent of radiological materials. A 100-foot by 100-foot grid was established over those areas of the site that appeared to have been influenced by previous site activity. Surface gamma readings were measured at 16 points (every 25 feet) within each of the 366 grid elements defined by the 100-foot by 100-foot grid. This work was described in a technical memorandum (REI, 1993a), and was later summarized in the RI Report (Earth Tech, 2003a). The Phase I report concluded that the gamma exposure level was elevated above background, but does not present a "significant acute or chronic hazard to on-site workers, the general public, or the environment." However, it was noted that the ALARA policy necessitates limiting site access.

### 4.4.3 Phase IIA Investigation - 1994

The Phase IIA (nonintrusive) investigation was conducted by S.C. Holdings in October 1994 in accordance with the approved RI/FS Workplan (REI, 1994a). Because the Phase IIA Investigation was conducted prior to the issuance of the USNRC Materials License for possession of radiological materials at this site, this phase of the investigation did not include the use of invasive field procedures. However, S.C. Holdings implemented the Radiation Safety Program (Waste Management, 1993), which had been submitted as part of the USNRC license application in July 1993 during the Phase IIA Investigation.

During the Phase IIA investigation, sediment, surface water, and groundwater samples were collected from areas around the Northwest Landfill, the East Landfill, and from locations thought to represent background. Leachate samples from the existing monitoring wells in the Northwest Landfill and East Landfill were collected for characterization, and surface soil samples were collected from the landfill covers to confirm that elevated radiation readings from the Phase I investigation were due to material that was subsequently covered. A nonintrusive electromagnetic survey was conducted to assist in locating buried drums in and around the Northwest Landfill. The results for the Phase IIA investigation were documented in a technical memorandum (REI, 1995).

In 1994, ASTI personnel conducted an inspection for the presence of regulated wetlands. A follow-up investigation was conducted in October 1994 to document the presence of plant and animal species at the S.C. Holdings site. In 1996, ASTI conducted additional surveys of the site to further identify territorial vertebrate and fish species at the site (ASTI, 1996). The combination of work conducted in 1994 and 1996 was summarized in a technical memorandum (REI, 1997), and in the RI Report (Earth Tech, 2003a).

### 4.4.4 Phase IIB Investigation - 1995

The Phase IIB (intrusive) investigation was conducted by S.C. Holdings in September 1995, after the USNRC issued a materials license to S.C. Holdings. This investigation focused on the sampling of the waste material within the Northwest and East Landfills, surface and subsurface soil located outside the landfills, and soil thought at the time to represent background. Gamma logging of boreholes was performed to assess subsurface radiation levels. Chemical and geotechnical analyses were performed on soil and waste samples. On-site ponds were sounded to estimate the volume of water within the ponds and to measure the thickness of the sediment in the bottom of the ponds. The results of this investigation were described in a technical memorandum (REI, 1997a) and were summarized in the RI Report (Earth Tech, 2003a).

### 4.4.5 RI Addendum for Additional Site Characterization Investigation - 1996

The work conducted under the MDEQ-approved Work Plan Addendum (REI, 1996) provided additional information beyond those activities already completed under the approved 1994 RI/FS Work Plan (REI, 1994a). Additional borings were installed in the Northwest Landfill and East Landfill, and additional chemical characterization of the leachate in the landfills (including the MDNR Landfill) was completed to evaluate leachate collection and treatment technologies. No radiological data were collected during this study. Results of this investigation were summarized in a technical memorandum (REI, 1997b) and in the RI Report (Earth Tech, 2003a).

### 4.4.6 RI Addendum for Waste Characterization - 1996

This investigation, conducted in 1996 by S.C. Holdings under the approved Work Plan Addendum (REI, 1996), was necessary to plan for remediation of the two areas in which the thorium-bearing slag had been deposited outside of the landfill containment areas (*i.e.*, Slag Piles A and B). The investigation included chemical and radiological analysis of Slag Piles A and B. At the request of the USNRC, temporary clay covers were placed over both of the slag piles to minimize radiation exposures. No report was generated from this investigation, but estimates were made of the volumes of radiologically contaminated material in Slag Piles A and B (Appendix A).

### 4.4.7 MDEQ/Northwest Landfill Sampling Event - 1997

In April 1997, representatives of the MDEQ noted a small seep on the western side of the Northwest Landfill, outside of the slurry wall. The MDEQ also reported an organic sheen on surface water adjacent to the seep. In May 1997, S.C. Holdings sampled the sediment, surface water, and leachate. Only the leachate and soil sample were analyzed for gross alpha, gross beta, and isotopic thorium. Th-232, at a concentration of 0.43 pCi/L, was the only isotope detected. This sampling event is documented in the RI Report (Earth Tech, 2003a).

### 4.4.8 RI Addendum for Perimeter Sampling - 2000

At the request of the MDEQ, S.C. Holdings collected additional sediment, surface water, and shallow groundwater samples in marshlands, both on-site and off-site. In addition, soil borings were drilled to 60 feet below ground surface to assess the thickness of the glacial till beneath the site and to determine if there was a sand unit beneath the site that could be used to monitor deep groundwater quality. No water-bearing unit was encountered in any of the borings, so no monitoring wells were installed. Results of this sampling event are presented in a technical memorandum (Earth Tech, 2001a) and in the RI Report (Earth Tech, 2003a).

### 4.4.9 Limited Confirmation Sampling - December 2002

In December 2002, S.C. Holdings collected three wetland soil samples and one groundwater sample in the West Marsh Area to confirm previous analytical results that appeared to be anomalously high. These samples were collected during the field mobilization for the background study (see Subsection 4.3). The same sampling procedures and analytical methods were used as in the background study. Wetland soil samples were collected at locations A97, F8, and J18 to verify previous detections of strontium-90, which was not known to have been used or disposed at the site. Additionally, a groundwater sample was collected at H8 to verify previous reported detections of Ra-226/Ra-228. The locations of the samples were determined in the field by a registered land surveyor (Wade-Trim, Inc., of Bay City, Michigan) using a portable differential GPS unit (accuracy within 0.1 foot) to ensure that the confirmation samples were located within a few feet of the original samples, which had all been collected in July 2000 as part of the RI Addendum for Perimeter Sampling (refer to Subsection 4.4.8).

The results for the confirmation samples collected in December 2002 are discussed in Subsection 4.4.10, along with the results for the additional confirmation samples collected in May 2003. In summary, none of the confirmation samples verified the initial results.

### 4.4.10 May 2003 Site Characterization Studies

In May 2003, S.C. Holdings conducted a sampling campaign at the SCA Hartley & Hartley Landfill Site to resolve technical issues related to the development of the

Decommissioning Plan for this site and, to a lesser extent, the State of Michigan response activities (State of Michigan, 1994). This work was conducted in accordance with a sampling plan that had been submitted to the USNRC (RMT, 2003). The objectives of the sampling activities were as follows:

1. To confirm certain analytical results for radiological testing performed in 2000 (confirmation samples)
2. To delineate the boundaries of preliminary Class 1 and Class 2 survey units around the Northwest Landfill and along segments of the northern edge of the West Marsh Area (delineation samples)
3. To establish if the ratio of Th-230/Th-232 in the magnesium-thorium slag is consistent enough to determine if the ratio could support a reduced analytical program for the Final Status Survey
4. To confirm the extent of specific chemical constituents to support the State of Michigan environmental response activities

The scope of the investigative activities was developed based on an evaluation of the historical data for this site, and on the outcomes of discussions regarding these data with the USNRC.[4] The sampling plan for this investigation was submitted to the USNRC on May 30, 2003, for informational purposes.[5]

A total of 54 field samples were collected to address the objectives listed above. These samples were collected in accordance with the procedures described in the Sampling Plan, on May 19 through May 21, 2003, at the locations shown on Figure 4-2.

Twenty-five confirmation samples (wetland soil, sediment, and surface water) were collected to confirm the radiological analyses performed in 2000, which yielded anomalously high values (Earth Tech, 2003a). As indicated in Table 4-2, with one exception, the confirmation samples were analyzed for isotopic thorium, isotopic uranium, and progeny, using the methods listed in Table 4-3. In addition, one wetland soil sample (SOW-ITD3C) was analyzed for bis-2(ethylhexyl)phthalate (BEHP) only, to confirm or deny an elevated BEHP concentration reported as part of the State of Michigan environmental response activities.

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(4) Meeting with the USNRC in Rockville, Maryland, on April 3, 2003, and teleconference meetings with the USNRC on May 12 and May 14, 2003. The record of the April 3 meeting was prepared by the USNRC and is dated June 17, 2003. The records of the May 12 and May 14 teleconference meetings were prepared by RMT and are dated June 30, 2003 (revised), and May 30, 2003, respectively.

(5) During the May 14, 2003, teleconference meeting in which the proposed sampling activities were outlined, USNRC representatives said that they did not need to review the Sampling Plan before the fieldwork was initiated.

Nineteen delineation samples (wetland soil and sediment) (Table 4-4) were also collected around the Northwest Landfill and along segments of the northern edge of the West Marsh Area to delineate the boundaries of preliminary Class 1 and Class 2 survey units. The locations of these samples were selected using the known extent of chemical contamination, based on the premise that the extent of chemical contamination could serve as an indication of the presence of radiological constituents. In addition, some of these samples were analyzed for either chromium or polychlorinated biphenyls (PCBs), to further delineate the extent of these constituents in areas that are to be excavated as part of the Part 201 response activities. These samples were analyzed for the radiological and chemical parameters listed in Table 4-3.

In addition, 10 samples of the radioactive source material (magnesium-thorium slag from Wellman Dynamics) were collected for laboratory analyses from each of the two slag piles shown on Figure 4-3. Slag Pile A is located west of the slurry wall around the Northwest Landfill. Slag Pile B is located southwest of Cell A, at the northwestern end of the East Landfill. The slag samples were analyzed for the radiological parameters listed in Table 4-3.

In addition to the environmental samples described above, field duplicate samples, equipment rinsate samples, and matrix spike/matrix spike duplicate samples were collected or prepared to provide quality control of field and laboratory procedures. A summary of the field and sampling program is presented in Table 4-5. Field methods are described in Appendix C-1. Data validation is discussed in Appendix C-2.

The analytical results for the May 2003 sampling event, as well as for the samples collected in December 2002 that were not background samples (refer to Subsection 4.4.9), are included in Appendices B-2 and B-3. The results for the samples collected to support activities pursuant to the State of Michigan's environmental response program are presented in Subsection 8.4. The significance of these results will be further evaluated as part of the Remedial Action Plan for this site, which will be submitted to the MDEQ following the State's approval of the Remedial Investigation Report.

The following is a discussion of the findings for the May 2003 sampling campaign for radiological constituents.

### *Confirmation of Analytical Results for Radiological Testing Performed in 2000*

The analytical results for the wetland soil, sediment, groundwater, and surface water samples collected in May 2003 to confirm suspect results of radiological testing performed in 2000 (and for those four samples collected in December 2002 for the same purpose) are presented in Table 4-6. This table includes the results for the initial (2000) samples as well as those for the confirmation samples collected at the same locations.

Comparison of the initial sample results with the confirmation sample results showed that the original observations of elevated radioactivity in site media were not confirmed. The levels of radioactivity observed in the confirmation samples were commonly one to two orders of magnitude lower than the levels observed in the initial samples, especially for the values that had been anomalously high.

The elevated bis-2(ethylhexyl)phthalate concentration (1,900 μg/kg) was not detected (590U μg/kg) in the recent sampling.

### *Delineation of the Boundaries of Preliminary Class 1 and Class 2 Survey Units around the Northwest Landfill and along Segments of the Northern Edge of the West Marsh Area*

The analytical results for the wetland soil samples collected to delineate the preliminary boundaries of Class 1 and Class 2 survey units around the Northwest Landfill and along segments of the northern edge of the West Marsh Area are presented in Table 4-7. The results showed that radioactivity in sediment and wetland soil in the area adjacent to the Northwest Landfill was similar to background levels.

Some of these samples were also analyzed for PCBs or chromium—chemicals that may be useful in delineating the extent of environmental contamination in the West Marsh Area. The results for the chemical analyses are also discussed in Subsection 8.4.

### *Ratio of Th-230/Th-232 in the Magnesium–Thorium Slag*

The slag in Slag Pile A consisted of mottled gray to brown sand- to boulder-size chunks of vitreous material. The slag was present in a layer roughly 6 inches thick.

The material in Slag Pile B was quite different than the material in Slag Pile A. The material in Slag Pile B resembled foundry sand; it consisted of dark-brown fine to medium sand, with a trace of gravel and silt. The material in Slag Pile B was present in a layer roughly 6 inches to 30 inches thick.

The analytical results for Thorium-230 (Th-230) and Thorium-232 (Th-232) in the waste (slag) samples collected from the two slag piles outside of the Northwest Landfill are presented in Table 4-8. This table also presents the ratio of these two radionuclides. Analytical results indicate that seven of the samples at Slag Pile A, and only one of the three samples from Slag Pile B, encountered radioactive slag.

Thorium isotope activities in samples WST-SP-8 and WST-SP-9 were indistinguishable from background and were probably samples of nonradioactive slag, other fill, or soil. This was consistent with the observations of the field personnel, who reported difficulty in distinguishing any apparent slag at Slag Pile B, and who had recorded very few radiation readings above background with their field instrumentation.

The highest activity level for Th-230 (21.0 pCi/g) was recorded at sample WST-SP-2, and the highest Th-232 activity (19.6 pCi/g) was reported in sample WST-SP-1, both from Slag Pile A. The mean of the Th-230/Th-232 ratios from the magnesium-thorium slag samples was 1.19, with a standard deviation of 0.317 for n=8 samples.[6] Therefore, Th-230 is present in nearly equal amounts to Th-232 in the slag samples. However, in the individual slag samples, the Th-230/Th-232 ratio ranged from 0.6 to 1.6. This result is consistent with the analytical work that was conducted by Dow Chemical in 1999 (Dow, 1999). Dow Chemical reported that the ratio of Th-230:Th-232 ranged from 1:1 to 1:3. Consequently, the presence of Th-232 and progeny that emit gamma radiation is adequate to predict the concentration of Th-230.

## 4.5 Screening of Historical Site Data

As discussed in Subsection 4.4, site characterization data (analytical and physical) have been collected at the SCA Hartley & Hartley Landfill Site over a period of 20 years. These data were collected by a number of parties (contractors) under State of Michigan and USNRC environmental cleanup programs. Consequently, a variety of sampling procedures and laboratory methods have been employed. Moreover, the environmental significance of the entire radiological data set had not been evaluated in the context of meeting the USNRC's requirements to terminate the source material license for this site.

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[6] The data from the two samples of slag that did not have elevated radioactivity, and that contained no visible slag, were not included in the statistical computations.

In order to assess the environmental significance of the historical radiological data for purposes of developing a decommissioning plan, it is important to confirm the validity of the data and to assess its usability for its intended purpose. For the SCA Hartley & Hartley Landfill Site, this evaluation was performed through a series of data review and screening steps. The initial data review step was to gather all of the historical radiological data for the site (through the May 2003 sampling event) and to enter it into an electronic database. The available records documenting the genesis and quality of the historical data were then evaluated. For example, records of analytical methods, detection limits, reporting limits, quality assurance/quality control and validation procedures (by both the laboratories and the data validators) were systematically examined. When important pieces of information affecting the quality of such historical data were not in the project files, additional measures were taken to locate the information. This included searching all known S.C. Holdings records for this site, contacting the laboratories and the former data validator, reviewing raw data from laboratory instruments (*e.g.*, emission spectra), and checking the completeness and accuracy of results that were manually transcribed from laboratory reports to tables in reports. Information about the genesis and quality of the historical data was also entered into the database (such as the analytical methods, errors associated with each measurement, detection limits, and data validation flags). In addition, it was essential to be able to match a sample result with a physical location.

The historical data set was then screened to eliminate those data that are inappropriate for use in developing a decommissioning plan. The data screening process was discussed in concept with the USNRC during a meeting in Rockville, Maryland, on April 3, 2003,(7) and was discussed in detail with the Agency during a conference call on May 14, 2003,(8) and during another meeting in Rockville on September 9, 2003.(9) Appendix B-2 contains a summary of the historical data for this site, and the reason for excluding certain values from the data set used to develop the remainder of the decommissioning plan. The data in Appendix B-2 are sorted by sample identification number, then medium, then analyte. Note that results for short-lived radionuclides reported from gamma spectroscopy, and the results for potassium-40, are not included in Appendix B-2 because they lack relevance to the decommissioning effort, and because Appendix B-2 would be too bulky. These data can be provided upon request.

The first data screening step was to eliminate data for which the reported result could not be verified with a reasonable degree of confidence. These data were of such uncertain quality that they were judged to be unsuitable for the technical evaluations needed to support license

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(7) Report of meeting. USNRC, June 17, 2003.

(8) Record of May 14, 2003, conference call. Letter from RMT, Inc., to the USNRC. May 30, 2003. (USNRC acceptance of meeting record. Letter from the USNRC to Waste Management, Inc., June 17, 2003.)

(9) The USNRC is preparing a meeting report.

termination. This determination was made only after all efforts to locate critical information had been exhausted, and with consideration of the nature and quality of the information that was available. For example, a few results were simply numbers contained in a table that was not part of a report, and had no supporting documentation. For these data, it was not even possible to assess whether a typographical error had been made. Other data lacked survey coordinates that could be used to accurately plot the sample location on a site map. Best professional judgment was used in assessing the accuracy of the reported location information (not all of the older sample locations were surveyed). Preference was given to keeping the analytical results for a sample even if the sample location was not precisely known.

The second data screening step was to exclude nondetect values for solid media samples that had detection limits that were greater than the DCGLs (for example, if the detection limit was 5.2 pCi/g and the DCGL was 0.2 pCi/g, then that nondectect result was excluded from the data set)(see Section 5 for development of the DCGLs). In addition, data that had an "Effective Detection Limit" that is greater than the DCGLs was excluded. The "Effective Detection Limit" is a term used to describe the situation in which the reported result is greater than the detection limit, but is qualified with a "U" flag (for example, if a result is reported as 5.2U pCi/g and the detection limit is reported as 3.0 pCi/g, the Effective Detection Limit is 5.2 pCi/g). Similar to the comparison of the detection limits to DCGLs, if the Effective Detection Limit was 5.2 pCi/g and the DCGL was 0.2 pCi/g, then that value was excluded from the data set. These data were eliminated to prevent nondetect values from becoming false-positive indicators of contamination. This screening step is not relevant for liquid media, as DCGLs do not apply to these media.

The third screening step was to exclude strontium-90 (Sr-90) and cesium-137 (Cs-137), which were detected at higher-than-expected levels in several of the on-site samples and in the background samples (refer to Subsection 4.3, Table 4-6, and Appendix B-2). The anomalously high levels of Sr-90 and Cs-137 in on-site media were not confirmed by the resampling in those areas. A review of site records did not indicate any historical use or disposal of wastes containing these radionuclides at this site. These radionuclides are commonly associated with fallout from nuclear weapons testing, although it is unknown why these constituents are present in the background at the levels detected. The USNRC agreed that Sr-90 and Cs-137 do not need to be further evaluated in the decommissioning plan.

The last data screening step was to substitute the December 2002 and May 2003 resampling results for the corresponding suspect results from the sampling campaign conducted in 2000 (refer to Subsections 4.4.9 and 4.4.10). If the target analyte in the suspect sample was not confirmed, then all of the data for that sample were replaced with the complete set of results for the new sample. Confirmation samples are identified by the "C" suffix that was appended to the sample identification number.

## 4.6 Decommissioning Plan Data Set

The data set used in the remainder of this Decommissioning Plan is presented in Appendix B-3. These are the data that remained after the four-step data screening process described in Subsection 4.5. The historical radiological data that were excluded are flagged in Appendix B-2.

The data in Appendix B-3 are sorted by medium, then sample identification number, then analyte. The data were organized in this manner to assist the reader in following the discussions of the characterization results by medium in Subsection 4.7, and to complement the data presentation in Appendix B-2.

## 4.7 Summary of Characterization Results

This subsection summarizes the site characterization data by media type. The sub-subsections for each medium describe the sampling campaign(s) in which the data were generated, and compare the mean for the on-site data for each medium to the corresponding mean background value for that medium (Table 4-9). This comparison was conducted as a screening assessment to put the on-site data into context with the naturally-occurring background levels of the radioisotopes of interest. Only data included in the Decommissioning Plan Data Set (Subsection 4.6 and Appendix B-3) were compared with the background values. This approach was used to preliminarily assess whether the on-site radiation levels were elevated above background levels. Note that the statistical methods specified in the MARSSIM will be used to evaluate data for the Final Status Survey.

### 4.7.1 Surface Soil

(Note that the results of the ORAU study are not discussed here because no data validation information was available. However, none of the data collected from the ORAU studies contradict the conclusions based on the successive studies conducted by S.C. Holdings.)

An initial assessment of surface contamination consisted of a walk-over gamma survey conducted in December 1992 (REI, 1993a). The survey area covered all accessible portions of the SCA Hartley & Hartley Landfill Site (*i.e.*, the nonmarshland areas that are accessible by road). Three surveys were conducted as follows:

1. The primary survey involved collecting 16 surface (1 to 2 inches off the ground surface) gamma measurements spaced 25 feet apart within 100-foot grid elements that covered the site. Results of this survey are summarized on Figure 4-4.

2. A secondary survey was conducted in conjunction with the above survey to support an analysis of relative risk. In this survey, gamma measurements were collected at a distance of 1 meter above the ground. These measurements were collected at each of the northwestern corners of the 100-foot grid elements. Results of this survey are illustrated on Figure 4-5.
3. Seventy-three grid elements that were associated with elevated radiation levels were subjected to a comprehensive walk-over of the entire 100-foot area at a distance of 1 to 2 inches off the ground. The purpose of this survey was to identify potential "hot spots." Results of this survey revealed that the highest measurements are found at small holes that were used to inspect the "carrier pipe from the MDNR's property," at leachate seeps, and at slag piles. The highest reading measured 500,000 counts per minute (CPM) at the site of the slag pile south of the Cell A pond (*i.e.*, Slag Pile B).

Results of the gamma survey identified those areas of the SCA Hartley & Hartley Landfill Site that warranted further study. The report concluded that the general site radiation exposure was 20 percent greater than the background radiation exposure, but did not present an imminent threat to workers, the general public, or the environment.

Surface soil was sampled during the Phase IIA (nonintrusive) Investigation (REI, 1995), and the RI Addendum Investigation (Earth Tech, 2001a). Up to 58 surface soil samples were collected for radionuclide analyses during characterization. Of this total, 50 were wetland soil and eight were upland soil. Figure 4-6 illustrates the distribution of soil samples collected at the site. Note that the surface soil sample locations cover the primary exposure pathways, and generally surround all areas of the site. However, the highest density of soil samples is in, and around, the Northwest Landfill.

Table 4-9 provides summary statistics for the occurrence of radionuclides at the SCA Hartley & Hartley Landfill Site in the various media identified at the site. The summary suggests that mean activity levels of radionuclides in surface soil are similar to mean background levels for this medium. Surface soil at the SCA Hartley & Hartley Landfill Site includes two soil types: sandy upland soil and organic-rich wetland soil. The mean value represented for Th-228 is elevated with respect to the mean background for upland soil. No other isotope is elevated in upland soil. Mean activities of thorium isotopes in wetland soil are either slightly higher or lower than the background mean, suggesting that they are generally present at background levels. Uranium isotopes in wetland soil are below the mean background levels. The significance of the elevated radioactivity in site samples will be evaluated in the discussion of derived concentration guideline levels (DCGLs) in Section 5.

### 4.7.2 Landfill Cover Soil

The East Landfill was covered with at least 2 feet of clay and seeded in 1979 (Earth Tech, 2003a). The source of the cover material could not be confirmed; however, clay used for the cut-off walls in the East Landfill was obtained from two local off-site sources, "Dobson's pit" and "Carland's pit" (Wehran, 1979). It is believed that the cover material was derived from similar (if not the same) material. The Northwest Landfill was covered with 2 feet of clay in 1984 (Ground/Water Technology, 1985).

Samples for radiological analyses of the covered areas were collected as part of the Phase IIA (nonintrusive) Investigation (REI, 1995). Results of these samples are summarized in Table 4-9. Since no background data are available for the clay, these samples are compared to the background mean for wetland soil. The mean for the landfill cover soil data indicates that the activity levels of radionuclides in the cover are similar to the mean background levels in wetland soil. The activity levels for Ra-228 and Ra-226 in the clay landfill cover materials were slightly higher than the mean in background wetland soil. The slightly higher levels of radium may be due to the higher clay content of the landfill cover relative to the wetland soil.

### 4.7.3 Subsurface Soil

A total of 39 subsurface soil samples were used to characterize the nature and extent of radionuclides at the SCA Hartley & Hartley Landfill Site. The locations of these samples are illustrated on Figure 4-7. Subsurface soil samples were collected in the Phase IIB (intrusive) Investigation (REI, 1996) using truck- and all terrain vehicle–mounted drilling rigs capable of advancing hollow-stemmed augers. Samples were collected to determine if radionuclides were present in the clay beneath the Northwest Landfill and to determine if radionuclides were present in areas outside the containment. The distribution of sediment samples is illustrated on Figure 4-7.

In addition to radiological analyses, a downhole geophysical (natural gamma) survey was conducted in 46 borings and 16 existing monitoring wells to document the location of the waste, identify any areas of subsurface contamination outside the containment, and confirm the location and gamma signature of the underlying clay. The downhole survey was problematic because the intensity of gamma emissions of native clay was similar to the radioactive slag. Review of the gamma logs indicates elevated readings (>100 cps) in many of the borings in both landfills and outside the containment areas. The elevated readings often occurred in a specific interval that coincided with the top of the clay till. Elevated gamma readings were also observed within waste areas at similar levels to the gamma readings in the clay till, suggesting that there are intervals of interim cover. Intervals of elevated gamma were sampled for radionuclides of concern in some instances, and radionuclides were not elevated with respect to background. Subsurface samples were also screened in the field with a hand-held sodium-iodide detector. Typically, the hand-held device reads background levels of radiation even when the downhole gamma detector reads elevated levels.

The full data set of subsurface soil was compared to the background mean for upland soil, since the shallow soil is predominantly lacustrine dune sand, like the upland soil (Table 4-9). Mean activities of radioisotopes of concern are typically below the population of background values (Table 4-9). The mean Ra-226 activity (0.285 pCi/g) was slightly greater than the background mean (0.261 pCi/g). The mean Th-228 activity (0.257 pCi/g) is above the background activity (0.074 pCi/g), and the mean Th-232 activity is also slightly elevated (0.191 pCi/g over the mean background of 0.103 pCi/g). This may be due to the higher levels of radionuclides present in the subsurface soil (which often includes clay till) and the use of background upland soil activity as a surrogate for all subsurface soil. Upland soil (beach sand) has a much lower clay content than the clay till. Gamma radiation in the clay till could be attributed to the source of the material. Importantly, the Elliott Lake Mine that was the source of the thorium-containing magnesium ore is located across Lake Huron. Glacial transport of this material could account for the elevated gamma levels in the till. The significance of the elevated mean activities over background will be further evaluated when compared to DCGLs in Section 5.

### 4.7.4 Surface Water

Twenty-nine surface water samples were used for radiological characterization of the SCA Hartley & Hartley Landfill Site. These samples were collected primarily from the Phase IIA (nonintrusive) Investigation (REI, 1995) and the RI Addendum (perimeter) Investigation (Earth Tech, 2001a). The locations of these samples were selected to provide data from those water bodies that comprise the most likely exit pathways from a release from the site (Figure 4-8).

A statistical summary of surface water data is provided in Table 4-9. The values of radioisotopes of concern are below the mean for background surface water, except that the mean activity level for Ra-226 is elevated slightly. The wide distribution of surface water locations (Figure 4-8) and the generally low activity levels exhibited by the data, suggest that no release of radionuclides to surface water has occurred.

### 4.7.5 Sediment

Sediment was sampled for radiological characterization to determine if constituents had eroded from the site and had been deposited in the numerous ponds and ditches found throughout the site. For the purpose of this Decommissioning Plan, sediment was defined as solid, non-vegetative surface material found beneath a perennial water body. Sediment samples were collected primarily in the Phase IIA (nonintrusive) Investigation (REI, 1995) and the RI (perimeter) Addendum Investigation (Earth Tech, 2001a). Up to 69 analyses are available for isotopes of concern from these sediment samples. Figure 4-9 illustrates the distribution of sediment samples.

Table 4-9 provides a statistical summary of those data. None of the mean values of radiological constituents of concern are elevated above their respective background mean levels. These data suggest that radionuclides of concern in sediment are indistinguishable from background and are not impacted by activity at the site.

### 4.7.6 Groundwater

Seventeen groundwater samples for site characterization were collected from on-site monitoring wells and temporary well points at the SCA Hartley & Hartley Landfill Site (Figure 4-10). These samples were collected primarily from the Phase IIA (nonintrusive) Investigation (REI, 1995) and the RI Addendum (perimeter) Investigation (Earth Tech, 2001a). Three groundwater monitoring wells are found immediately adjacent to the Northwest Landfill, with other groundwater sample locations primarily in downgradient positions to the landfill areas (Figure 4-10).

The mean activity levels for the radioisotopes of concern are below the background values for all thorium isotopes (Table 4-9). The mean values for Ra-226, Ra-228, and U-238 are above the mean for the background values; however, these levels are below the Maximum Concentration Levels (MCLs) established by the USEPA for drinking water.

### 4.7.7 Leachate

Leachate data provide an indication on the leachability of the radioisotopes of concern, as well as a measure of which constituents could migrate to groundwater if the containment measures fail. Leachate data are available for three wells installed in the Northwest Landfill and four wells in the East Landfill. Sampling was conducted in 1992, 1994, and 2003; but not all of the available locations were sampled during any one of these events, and the radioisotopes analyzed varied among events. Figure 4-10 illustrates the locations of the leachate monitoring wells.

Most radioisotopes of concern are not detected in the leachate. Only Ra-228 is present in leachate at activities where the mean value (1.704 pCi/g) exceeds the mean background value for groundwater (0.393 pCi/L) (Table 4-9), but is well below the MCL (5 pCi/L). This suggest that the isotopes of concern do not leach appreciably, which is consistent with previous studies (*i.e.*, MACTEC, 2003).

### 4.7.8 Waste Characterization

Waste samples have been analyzed at both landfill areas and at the two slag piles. The purpose of sampling the known slag deposits was to provide an understanding of the radioisotopes present in the source material and their respective activity levels. Analytical data from the areas with known slag deposits (*e.g.*, Slag Piles A and B, and at the Northwest Landfill) and the from East Landfill, where there is no record of slag deposition, are summarized separately in the following subsections for the purposes of comparison.

#### *Source Material (Slag Piles and Northwest Landfill)*

Slag samples were collected by ORAU (1985a), but these data were not added to the characterization data set because no laboratory reports were included in their document. ORAU (1985a) reported the slag to be a gray material with "mixed rock and clay consistency," with values of Th-232 and Th-228 up to 443 pCi/g and 415 pCi/g, respectively. The USNRC reviewed the ORAU report and verified the average concentration of the slag (USNRC, 2001). The average concentrations were used for the radiation dose estimates contained in Section 5 of this Decommissioning Plan. Samples of the slag that were collected subsequent to the ORAU sampling event did not verify the magnitude of the values reported by ORAU. Table 4-9 summarizes the statistical analysis of the slag samples collected in May 2003. All radioisotopes, except U-234, exceed background levels for wetland soil. Figure 4-11 illustrates the location of slag waste samples. The concentrations of radioactive material was used to verify the potential radiation doses. Section 5 describes the calculation of the DCGLs.

The characterization data set for this Decommissioning Plan includes samples of buried waste analyzed as part of an initial waste characterization of the slag piles in 1996 (Earth Tech, 2003a), and additional samples of the slag piles collected in 2003 (refer to Subsection 4.4.10) to determine the Th-230/Th-232 ratio of the material. Analysis of the material in the slag piles in 2003 indicated maximum activity levels of Th-230 and Th-232 of 21 pCi/g and 19.6 pCi/g, respectively, confirming levels reported in 1996. Most samples of the waste collected in 2003 indicate that the Th-230/Th-232 ratio is generally 1:1. Activity levels for thorium isotopes are typically between 5 and 10 pCi/g.

### *Waste Samples (East Landfill)*

The Decommissioning Plan data set includes a total of 15 analyses of the waste material from within the East Landfill. These samples have been used to confirm historical site knowledge that the waste in the East Landfill does not contain radionuclides above background values. Consequently, the East Landfill is classified as a Class 3 area (as discussed further in Section 8).

# Section 5
# Dose Modeling Evaluations

## 5.1 License Termination

S.C. Holdings is proposing to terminate License No. SUC-1565 under unrestricted release conditions. Improvements to the cover on the Northwest Landfill (described in Section 8) will reduce the potential radiation exposures to less than 25 millirem per year over background to an industrial worker on-site. The derived concentration guideline levels (DCGLs) for the rest of the site are also sufficient to reduce the public's exposure to less than 25 millirem per year over an exposure duration of 1,000 years. A description of the dose potential associated with all applicable exposure scenarios (pathways) under unrestricted release of the site is presented in the following subsection.

## 5.2 Unrestricted Release Using Site-specific Criteria

### 5.2.1 Acceptable Dose Limit

The primary purpose of the USNRC requirements for disposal of radiological constituents in the Northwest Landfill is to ensure that the radiation dose limits for members of the general public are satisfied. The USNRC promulgated a radiation dose limit to define negligible risk in the following regulation (USNRC, 1997):

> "A site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a total effective dose equivalent (TEDE) to an average member of the critical group that does not exceed 25 millirem (0.25 mSv) per year, including that from groundwater sources of drinking water, and the residual radioactivity has been reduced to levels that are As Low As Reasonably Achievable (ALARA). Determination of the levels which are ALARA must take into account consideration of any detriments, such as deaths from transportation accidents, expected to potentially result from decontamination and waste disposal."

For the decommissioning of the Northwest Landfill, a dose objective of 25 millirem above background is applicable and is therefore used as the basis for demonstrating that the S.C. Holdings Hartley & Hartley Landfill Site should be released for unrestricted use. The method for evaluating the dose objective is provided below.

### 5.2.2 Assessment Methodology

Decommissioning of the SCA Hartley & Hartley Landfill Site for unrestricted release requires an assessment of the dose that a person may incur as a result of exposure to radiological constituents at the site. For unrestricted release, the expected dose cannot exceed the 25 millirem/year over background release criterion. Because the magnitude of a specific person's radiation dose is dependent not only on the amount of radioactivity present, but also on the person's time and motion relative to the location of the radioactivity, person-specific doses can be difficult to assess. However, it is possible to perform a dose assessment that establishes a conservative estimate of exposure (*i.e.*, one that is well above the average case) by assuming a constant and continuous presence at the site.

The USNRC published an analysis of the license termination rule, including a variety of sections to address realistic exposure scenarios, as well as release limits and future legacy sites (USNRC, 2003). The USNRC discussed the process for selecting and justifying land use scenarios for the 1,000-year dose assessment period. The USNRC discussed the option to define a "reasonably foreseeable land use" rather than the conservative scenario, such as a resident farm family. The reasonable foreseeable future was defined as the next few decades and possibly as many as 100 years. The USNRC concludes this approach is more realistic and risk-informed. Consequently, the reasonable use of the land at the SCA Hartley & Hartley Landfill Site in the foreseeable future is an industrial use. This land use scenario matches the other applications that exist in the immediate area.

To model the dose for the potentially exposed population, exposure scenarios need to be established to represent the likely use of the property following decommissioning and the termination of the radioactive materials license. The exposure scenarios account for patterns of human activity that could affect the release of radioactivity from the contaminated area and the potential radiation exposure received at the exposure location. The selection of an exposure scenario depends on the location and size of the site, the physical characteristics of the site, and other factors.

Future land use was discussed briefly in Subsection 3.3. For the assessment in this Decommissioning Plan, the following key assumptions were made:

- The critical group is an industrial worker who works 8 hours per day on the site and does not ingest meat and milk from livestock raised on the site, as specified in the manual for RESRAD (Yu et al., 2001).
- Municipal water (*i.e.*, uncontaminated water) is used for drinking and irrigation purposes.

- No water or food from the site is consumed.
- A hypothetical industrial worker works at the SCA Hartley & Hartley Landfill Site after the improvements to the cover are completed.
- Workers leave the site after their work shift is completed each day and do not work on the weekends.
- Leachate from the Northwest Landfill does not contain radioactivity above background levels.

The calculation of a radiation exposure using the scenario of an industrial worker is conservative. The site is currently fenced and placarded. The fencing, placards, and monuments are expected to prevent access and discourage trespassers over the short term (the next 30 years).

Several attributes of the site conspire to prevent future development of the site. These include depth to groundwater, water quality, and engineering characteristics of the soil.

The shallow depth to groundwater is a serious limitation to site development. Much of the site is covered by ponds or wetlands, where the water table is at, or very near, the ground surface for much of the year. Encouraging drainage through engineering measures, such as construction of surface or subsurface drains, is unlikely to be effective because the low areas are very nearly at the same elevation as local base level (Lake Huron). As a result, development of residential or industrial properties in these areas of the site is unlikely. The shallow water table and ponded water in the marshy areas at the site create poor conditions for farming.

On the other hand, development of residential or industrial properties on land currently covered by the wetlands could be achieved by placing fill over the wetlands. Filling on top of the organic soil in the wetlands around the landfill will still pose the potential for soil instability, unless the organic soil is removed first. Removal of this shallow organic soil would also remove radionuclides that may be present in the organic soil. Even if the organic soil currently at the ground surface proves to be stable enough to be a subgrade layer for construction purposes, the fill placed over the wetland soil would constitute a barrier to direct contact with radionuclides that may be present within the wetland soil.

Much of the site is covered by the East and Northwest Landfills. The landfills would be poorly suited for construction because the fill materials are expected to be unstable when loaded and landfill gases may be present. The surface of the landfill likely would not support a large structure (say a house or a factory building) without undergoing substantial subsidence. The waste in the East and Northwest Landfills was not placed in an engineered manner. The resultant heterogeneity of the filled areas will cause differential settlement if the waste is loaded. Depending on when a structure is built on either of the landfills and the size of the structure, settlement ranging from inches to feet will likely occur. Piles could be driven through the waste and into the underlying natural soil; however, this would be extremely costly. The potential for gases that could enter a proposed building would require measures such as the installation of a gas extraction system and an impermeable layer beneath the building. Given that ample land for development is available in nearby upland areas, it is unlikely that a building that requires these costly design measures would be constructed on the landfills.

The remainder of the site consists of roads and several areas with sandy soil (for example, in the beach ridges in the southwestern, and northeastern corners of the site, and the area of the office building in the southeastern corner of the site). The areas of the site underlain by sandy soil with a water table more than 5 feet below grade may be more conducive to future active land use. Note that these areas range from 1,200 to 2,100 feet from the Northwest Landfill, the area in which the thorium-bearing slag was disposed.

Industrial use of the SCA Hartley & Hartley Landfill Site property is a conservative land use scenario, given the site characteristics. Portions of the site underlain by upland soil may be suitable for light industry, as evidenced by existing light industrial land use at properties abutting the Northwest Landfill.

Water quality in the shallow sandy aquifer beneath the site would also tend to discourage future site development for residential and agricultural use. First, the concentrations of several inorganic and organic constituents in shallow water exceed Michigan residential water quality standards, as outlined in Table 3-13. For example, sodium, chloride, iron, and manganese are all present at concentrations that would render the water nonpotable, so that development of a residential water supply from this aquifer is not feasible. In addition, Michigan well construction administrative rules would prohibit development of water supply wells in the shallow aquifer, as discussed in Subsection 3.7.3, because there is not enough vertical separation between the ground surface and the base of the aquifer (only 5 to 10 feet) to allow construction of a well that has enough casing between the ground surface and the top of the producing interval of the well (minimum 25 feet).

Also, the water from the area of the landfills has such high salinity that is likely to be phytotoxic. The leachate from the landfills (inside the containment) is phytotoxic, based on a pilot-scale evaluation of the feasibility of using hybrid poplars as an alternative cover for the East Landfill (Ecolotree, 1998). The high salinity in the shallow water at this site is likely to persist for an indefinite period. As such, this water would be unsuitable for irrigation or other agricultural use.

Hypothetical industrial workers may incur a radiation dose via the following pathways:

- Inhalation of resuspended radioactive material (*e.g.*, dust)
- Direct exposure to gamma radiation
- Ingestion of soil

The industrial worker exposure scenario was selected for this dose assessment because the exposure of permanent workers occurs over a long time period, and results in a high, or conservative, estimate of potential radiation dose. Table 5-1 lists the pathways that were included in the industrial worker scenario for the SCA Hartley & Hartley Landfill Site. An explanation is provided below for those pathways that were modified or excluded from the radiation dose evaluation.

It was assumed that the industrial worker does not ingest groundwater from a well on the property that is potentially contaminated by water percolating through the residual radioactive slag based on the poor water quality in the shallow aquifer (Table 3-13). It was further assumed that water from a municipal source would be used for all water supply purposes (*e.g.*, on-site utilities, drinking water, irrigation of landscaping).

A computer code, RESRAD Version 6.2, was used to model radionuclide fate and transport, and to assess the radiation dose incurred by a hypothetical industrial worker from the residual radioactivity that would exist after the cover is installed (USNRC, 2000d). This model calculates the radiation dose expected to be received by a hypothetical industrial worker beginning from the time of site closure and extending into the future (*i.e.*, 1,000 years). It takes into account potential uses of the site and potential migration of radioactive materials through the environment over time through both natural processes and human activities that could be expected to alter the patterns or rates of constituent movement. In general, the dose assessment process consists of two steps:

1. The development of representations of site physical conditions and potentially exposed populations, and the expression of these representations in mathematical terms.
2. The use of a mathematical model with input from the representations and/or technical literature to estimate future exposures and radiation TEDEs, or as a function of time.

### 5.2.3 Input Parameters

The computer model RESRAD includes default parameters for each of the pathways that are used by the code to complete the calculations. These default parameters were evaluated and compared with the site-specific conditions that exist at the SCA Hartley & Hartley Landfill Site. Many of the default parameters were found to be representative of site conditions and were used in the calculations. The analysis of parameters was performed to identify critical elements that may significantly change the results of the RESRAD calculation. Elements such as the source term, the distribution coefficients, and the hydrogeology of the site, especially beneath the Northwest Landfill, are summarized in this section. The impact of these parameters are discussed in Subsection 5.4 in more detail. The USNRC references documents, NUREG-6697 and NUREG-5512, were used to evaluate the site-specific parameters (USNRC, 2000c and 1999).

Selected parameters were changed in the model to match site conditions; these parameters are described in the sections that follow, and are listed in Tables 5-2 and 5-3 (the most critical parameters that were changed in the calculations were the distribution coefficients [$K_d$] for the slag in the Northwest Landfill).

*Source Term*

The source term for the computer model defines the composition of the radionuclides in the Northwest Landfill, as well as the inventory and placement of the materials under the engineered cover. The source term for the Northwest Landfill consists of the slag, containing uranium and thorium in concentrations measured by ORAU (ORAU, 1985a). The concentrations of the individual radionuclides present in the Northwest Landfill are provided in Table 5-4 (these are the DCGLs for the Northwest Landfill). Radioactive progeny of uranium and thorium with a radioactive half-life of less than 180 days are assumed to be in equilibrium with their first parent with a half-life of greater than 180 days. For the purposes of the radiation dose calculations, the dose conversion factors designated "parent+D" are used by RESRAD.

The Northwest Landfill is bounded by a slurry wall with an area of 32,375 square meters (Earth Tech, 2003a). The radioactive material is assumed to have been placed in the landfill in an heterogeneous manner; on average, the thickness of the fill containing slag is approximately 4 meters (Earth Tech, 2003a). For purposes of the RESRAD model and for establishing a conservative model, it was assumed that the radionuclides were evenly distributed throughout the landfill. Two additional piles of slag, located near the East

Landfill and west of the Northwest Landfill (Slag Piles A and B), will be excavated and placed on the Northwest Landfill before the cover improvements are completed (this material will be covered with the same degree of protectiveness as the waste currently present in the Northwest Landfill, that is, with a minimum of 34 inches of compacted clay plus 6 inches of topsoil).

### *Physical Characteristics*

The RESRAD computer model uses the physical characteristics of the site to estimate the potential migration of radionuclides and the ultimate distribution of the radioactive materials in the pathways for exposure of the "industrial worker" over the course of 1,000 years. RESRAD identifies several parameters as "high" priority with respect to the calculation of the radiation dose. Site-specific information was obtained for these parameters in connection with the Northwest Landfill. The density of the cover materials is assumed to be 2.3 g/cm$^3$ (Dell, 1990). The density of pieces of metal found in the magnesium/thorium was estimated at approximately 2.0 g/cm$^3$ (ORAU, 1985a). The maximum depth of the roots was assumed to be 0.9 meter; this value is a conservative default value for the RESRAD model (USNRC, 2000b). It should be noted that the MDEQ prohibits plants with roots that may extend into the protective layer of a landfill cover from growing on the cover.

High levels of dissolved solids (many of which are comprised of various salts) in the leachate in the Northwest Landfill make it unlikely that plants with deep root systems will penetrate into the main mass of waste. It is assumed that the industrial worker does not ingest any plants that are grown at the SCA Hartley & Hartley Landfill Site. No vegetable-bearing plants currently grow on or near the landfill. No edible plants are expected to be planted on the landfill. The cover is likely to support the growth of local grasses and plants with a limited root depth; these plants will be sufficient to minimize erosion of the cover. It is reasonable to assume that the location at which the industrial worker is actively employed is paved with either concrete or asphalt. However, in an effort to be conservative, no such covers were assumed.

### *Soil Liquid Distribution Coefficients*

Distribution coefficients were changed from the RESRAD defaults to reflect the types of soil that exist below the SCA Hartley & Hartley Landfill Site for the elements of interest in the slag. A discussion of the distribution coefficients is provided in Subsection 3.7.5 of this Decommissioning Plan. The $K_d$ coefficients that were used in the dose calculation for this assessment are presented in Table 5-2. The vitreous slag creates a solid matrix that does not permit the thorium and uranium to leach into the groundwater.

### *Cover Improvements*

The existing cover over the Northwest Landfill will be improved to meet the USNRC's requirements for decommissioning and to address the chemical concerns at this site under Michigan Part 201 regulations. A Remedial Action Plan (RAP) to address State requirements will be prepared and submitted once the Remedial Investigation Report is approved by the MDEQ. The cover will be designed to prevent direct contact with the waste, to reduce infiltration of precipitation through the cover, and to serve as a substantial attenuator of direct radiation exposure in proximity to the cover. A cross section of the final cover is presented on Figure 5-1.

The Northwest Landfill will be covered with a soil barrier at least 0.9 meter (approximately 34 inches) in thickness and 6 inches of topsoil. The cover will be seeded with suitable low maintenance, drought-resistant grass species.

The final cover slope will be approximately 2 percent over the majority of the area, with slopes up to 25 percent at the edges of the cover to transition to the surrounding topography. The relocation of the slag piles within the limits of the Northwest Landfill may require slopes steeper than 2 percent to minimize the amount of existing cover that needs to be disturbed and/or the amount of fill required to upgrade the cover over the Northwest Landfill. The erosion rate used in the RESRAD model was 0.6 m/yr, which is a conservative default value that demonstrates that the proposed cover will provide a sufficient barrier for 1,000 years.

### *Radon*

The exposure pathway for radon gas was not considered in this assessment. The USNRC documented their concurrence with this approach in the Statement of Consideration for the License Termination Rule (USNRC, 1997a), which states:

> "Following the approach taken in the proposed rule, this final rule includes radiological criteria for residual radioactivity that is distinguishable from background. Because of natural transport of radon

gas in outdoor areas due to diffusion and air currents, doses from exposure to radon in outside areas due to radium in the soil are negligible. Therefore, in implementing the final rule, licensees will not be expected to demonstrate that radon from licensed activities is indistinguishable from background on a site-specific basis..."

## 5.3 Surface Soil

DCGLs were derived for the surface soil, outside of the Northwest Landfill. Two areas were previously identified to contain slag (*i.e.*, Slag Piles A and B). Slag in these two areas will be excavated and placed under the improved cover on the Northwest Landfill. The DCGLs for the surface soil are provided in Table 5-5. By definition, the DCGLs represent the concentration of radioactive materials that would result in less than 25 millirem per year for the maximally exposed member of the population. For the purposes of this evaluation, it was assumed that the radioactive materials are present at the surface of the soil and do not have a cover or any means to restrict the release of contamination. The computer code RESRAD was used to calculate the concentration of radionuclides in the soil that yields approximately 25 millirem per year.

## 5.4 Uncertainty

Uncertainty analysis in RESRAD is the computation of the total uncertainty induced in the output as a result of the inherent error in each of the input parameters. This kind of quantitative analysis helps determine the relative importance of the contributions of the uncertainties in the input parameters to the total uncertainty in the calculated dose. Also, the results uncertainty analysis can be used as a basis for determining the cost-effectiveness of obtaining additional information or data on input parameters.

Uncertainty in scenarios is the result of the lack of absolute knowledge about the future uses of the SCA Hartley & Hartley Landfill Site, and the Northwest Landfill in particular. It is important to recognize that the evaluation period of 1,000 years is not intended to predict the future scenarios for the next 1,000 years, but to evaluate the continued protectiveness of a given DCGL for 1,000 years into the future. This is plausible, given the anticipated future uses of the site and the current social and economic conditions.

### 5.4.1 Method to Address Uncertainty

Calculations regarding uncertainty were performed with RESRAD using the Latin hypercube sampling (LHS) method for a collection of input parameter distributions. The LHS method provides a process for multiparameter sampling. The dose estimate is generated in quantile value (at 50$^{th}$ percentile and 90$^{th}$ percentile) of the resulting analysis. Development of distributions contained as the default values in RESRAD resulted from data analysis by the USNRC to obtain the most up-to-date information. Relevant data were obtained from USNRC-sponsored references, including NUREG-5512 and combined with a literature search. The result of the distribution parameters provided by RESRAD 6.2 was to analyze the available data and to make the most plausible distribution assignments for each selected parameter for use in dose calculations. The parameter values define a generic screening calculation that has a limited risk of underestimating a site-specific dose calculation based on the exposure scenario and the RESRAD computer model. The distribution that underlies the parameter values in NUREG 5512 serves as a basis for developing site-specific parameter values for the model used for the SCA Hartley & Hartley Landfill Site.

The parameter distributions assigned in the Parameter Distribution Report were selected to be representative of adult male workers in generic site conditions that might be found on average throughout the United States. Only data provided directly from the USNRC or obtained from readily available, citable, published sources were used. Assignment of an appropriate distribution to a RESRAD input parameter was determined primarily by the quantity of relevant data available. Documented distributions were used where available. Empirical distributions were available for some parameters within the context of the critical group or national average. For those parameters for which additional sampling was not expected to significantly change the distribution's shape (*i.e.*, the variability of the parameter was well represented), statistical data were used directly.

The following steps were used to evaluate uncertainty for this site:

1. Each scenario was evaluated using the deterministic module of RESRAD to identify a concentration in the soil corresponding to the deterministic regulatory limit.
2. Exposure pathways that contribute most significantly to the radiation dose were identified. Direct exposure to gamma radiation from the surface soil was consistently the most significant pathway for exposure for the surface soil and was detected in the first year of the evaluation. Migration via the water pathways represented the dominant pathway of potential exposure for the Northwest Landfill after 1,000 years.
3. Where site-specific knowledge was lacking, or where the default parameter distribution was judged to be reasonably representative of the site conditions, the RESRAD default was used.
4. The LHS algorithm was set to obtain 900 hundred samples or 300 samples repeated three times.

### 5.4.2 Parameter Distributions

There are more than 200 parameters in the RESRAD code. The USNRC established priorities for the significant parameters that contributed to the radiation dose calculation The RESRAD parameters were ranked into three levels of priority: Priority 1 (high priority), Priority 2 (medium priority), and Priority 3 (low priority). Priority 1 parameters are those for which detailed distributions were developed as default parameters in the computer code.

Radiation doses vary from site to site, and can be characterized more easily because data on them can be found in readily available literature. Parameters ranked as Priority 3 have less impact on radiation doses, vary less from site to site, cannot be easily characterized, because little or no data on them are available, or are irrelevant within the scope of this project. The method used to prioritize parameters took into account the following four criteria: (1) relevance of the parameter to the dose calculations, (2) variability of the radiation dose as a result of changes in the parameter value, (3) parameter type (physical, behavioral, or metabolic), and (4) availability of data in the literature.

For the purposes of this analysis, the RESRAD default parameter distributions for Priority 1 parameters were used. The following parameters were assigned Priority 1 by the USNRC and given the same weight for the radiation dose assessment for the SCA Hartley & Hartley Landfill Site.

- Distribution coefficients
- Density of the cover materials
- Density of the contaminated zone
- Density of the saturated zone
- Total porosity of the saturated zone
- Effective porosity of the saturated zone
- Hydraulic conductivity of the saturated zone
- Thickness of the unsaturated zone
- Depth of the roots
- Transfer factors to the plants

Default parameter distributions were used for selected Priority 2 parameters. A complete list of the input parameters and the distributions for both Priority 1 and 2 is provided in Table 5-3. A description of the parameter distribution is provided below for the Priority 1 parameters.

### 5.4.3 Distribution Coefficients

The distribution coefficient ($K_d$) or soil/water partition coefficient, is an empirical parameter that estimates the distribution of radionuclides between the solid and liquid phases. The units for $K_d$ that are used in RESRAD are cubic centimeters per gram ($cm^3/g$) or milliliters per gram (mL/g). The distribution parameter is established as lognormal-n; values are assigned according to the chemical element. The values for each radionuclide are provided in Table 5-3. In the $K_d$ model, it is assumed that the liquid and solid phases in soil are at equilibrium and that there is a linear relationship between solute concentration in the solid and liquid phases. Although several mechanisms may affect the retention of radionuclides in soil, the model lumps all of them into one value. In the RESRAD code, the $K_d$ values are used to estimate the retardation factors, which are the ratios of relative transport speeds of radionuclides to that of water in soil. The larger the value of $K_d$ for a radionuclide, the greater the soil retention for that radionuclide, and the more slowly the radionuclide will move through the soil column. Additional information about the $K_d$ values is provided in Subsection 3.7.5.

### 5.4.4 Density

RESRAD uses the wet density values for four distinct materials (cover layer, contaminated zone, unsaturated zone, and saturated zones. The wet density is the ratio of the mass of soil and water to its total volume, including solid content, moisture content, and pore volumes together. The parameter distribution is established by the USNRC to be truncated normal with a mean of $1.52 \pm 0.23$ $cm^3/g$. The characteristics of the contaminated, unsaturated, and saturated zones are represented by several parameters, such as wet bulk density, total porosity, effective porosity, hydraulic conductivity, and others. These properties depend on the particle size distribution of the soil. Because the U.S. Department of Agriculture (USDA) soil texture classification is also based on the relative proportions of the different particle size classes, probability distributions for each of the parameters can be developed for each of the soil classes (Carsel, 1988). These class-specific probability distributions of parameters for soil texture are more compact and relevant for each class of soil than an overall distribution encompassing all types of soil.

### 5.4.5 Porosity

The total porosity of a porous medium is the ratio of the pore volume to the total volume for a representative sample of the medium. Separate input values are required for the contaminated, saturated, and unsaturated zones. The parameter distribution is established by the USNRC to be truncated normal and is assumed to have a mean value of 0.425 ± 0.0867. For the effective porosity, the mean is assumed to be 0.355 ± 0.0906 (Earth Tech, 2001a). This is within the range of porosities typically encountered in a porus medium (0.25 to 0.5) (Freeze and Cherry, 1979).

Total porosity is one of the many parameters characterizing the contaminated, unsaturated, and saturated zones. The total porosity value is used along with the saturation ratio in determining the moisture content in soil, which in turn is used to determine the retardation factor and the transport speed of water in the contaminated zone. In the unsaturated zone, the total porosity value is used to calculate the time required for water to percolate through the layer of interest, such as the waste, the unsaturated zone, or the saturated zone. In the saturated zone, it is used to calculate the time required for radionuclides to move with groundwater from the upgradient edge to the downgradient edge of the contaminated zone.

### 5.4.6 Hydraulic Conductivity

The hydraulic conductivity of a soil is the measure of the ability of that soil to transmit water when subjected to a hydraulic gradient and is measured in meters per year. RESRAD uses separate hydraulic conductivity values for three soil materials: contaminated, unsaturated, and saturated zones.

The uncertainty distribution is established by the USNRC to be bounded lognormal distribution. A lower limit is established to be greater than 0.004 and no greater than 9,250 m/yr. The hydraulic conductivity for the saturated zone is assumed to be 662 m/yr (0.0021 cm/s), while the conductivity for the unsaturated zone is calculated to be 1,090 m/year, given the presence of sandy loam soil (Earth Tech, 2001a). The hydraulic conductivity of a soil governs the rate of groundwater flow within that soil. The rate of groundwater flow increases with increasing hydraulic conductivity. The hydraulic conductivity of a particular soil is affected by the size, abundance, and geometry of the open pores within the soil. Fine-grained soil, such as clay and silt, has very small pores and has much lower hydraulic conductivity than coarse-grained soil, such as sand and gravel. In the saturated zone, hydraulic conductivity is used to determine the groundwater flow rate and is assumed to be an important parameter in the potential migration of radionuclides via the water pathway. The groundwater flow rate affects the travel time in the aquifer to the water point of use as well as the dilution factor for radionuclides in well water. The saturated hydraulic conductivity values related to the contaminated and unsaturated zones of the soil should represent the vertical component of hydraulic conductivity.

### 5.4.7 Thickness of the Unsaturated Zone

The uncontaminated unsaturated zone is the portion of the uncontaminated zone that lies below the bottom of the contaminated zone and above the water table. The RESRAD code has provisions for up to five different horizontal strata (unsaturated zones). It is assumed for this radiation dose assessment that only one layer exists. The layer is characterized by six radionuclide independent parameters: (1) thickness of the layer, (2) soil density, (3) total porosity, (4) effective porosity, (5) soil-specific "b" parameter, and (6) hydraulic conductivity.

The thickness is measured in meters, and the distribution is defined by the USNRC to be bounded lognormally. The mean of the parameter distribution is assumed to be $2.296 \pm 1.276$, with a value greater than 0.181 and less than 320 meters. The thickness of the unsaturated zone beneath the Northwest Landfill is assumed to be 1 meter. In order to migrate outside of the contaminated zone and come in contact with the groundwater table, a radionuclide must traverse the unsaturated zone thickness. The greater the thickness, the longer the travel time (breakthrough time). The breakthrough time affects the ingrowth and decay of radionuclides, and is an important factor that affects the quantity of radionuclides reaching the groundwater table.

### 5.4.8 Depth of Roots

The depth of roots represents the average root depth of the various plants growing on the proposed final cover. The maximum root depth was conservatively assumed to be 0.9 meters, which is the default value for the RESRAD model. The distribution of roots is assumed to be uniform. The actual root depth for the grass species that are proposed for the final cover is in the range of 0.10 to 0.15 meters (refer to Subsection 8.3.2 for a list of potential grass species).

This parameter is used to calculate the cover and depth factor for the plant, meat, and milk exposure pathways because edible plants become contaminated through the root uptake of radionuclides. The uptake of radionuclides from plant roots is assumed possible only when the roots extend to the contaminated zone and is limited to the fraction of roots that have direct contact with contaminated soil.

Each species of grass has characteristic rooting habits that it will tend to follow if the soil is deep, uniform, and equally moist throughout. When the upper portion of the soil is kept moist, plants will obtain most of their moisture supply near the surface. As the moisture content of the upper layers decreases, the plants draw more water from the lower layers, which will encourage more root development in the lower levels. Fewer roots exist in the lower portion of the root zone because of the inability of the root system to extract enough moisture from the lower levels.

### 5.4.9 Transfer Factors to Plants

The plant/soil concentration ratios for root uptake are given by the vegetable/soil transfer factors. In the RESRAD code, the plant/soil transfer factor is expressed as the ratio: picocuries per gram (pCi/g) plant (wet)/pCi/g soil (dry) for each chemical element (Yu et al., 1993). The uncertainty distribution for these elements is assumed to be truncated lognormal-n, where the value is assigned as a default parameter of the RESRAD code. Table 5-3 lists the distribution parameter that was used for each chemical element. The default selected by the USNRC was determined to be appropriate for each element, including thorium, uranium, radium and lead.

The plant/soil transfer factor is defined as the ratio of radionuclide concentration in vegetation to that of the soil. The plant/soil transfer factor of a radionuclide varies in a complex manner with soil properties and the geochemical properties of the radionuclide in the soil. The transfer factor for a given plant type can vary from site to site and season to season. In addition, management practices such as plowing, liming, fertilizing, and irrigating greatly affect the plant/soil transfer ratio (IAEA, 1994). Sparse data exist for most radionuclides, and the data that do exist are restricted to only limited vegetation types (NCRPM, 1999). The values of the plant/soil transfer factors can vary over several orders of magnitude.

## 5.5 Results

The radiation analysis was performed using RESRAD 6.2 and the parameter distributions described in Subsection 5.4 of this report. The results are discussed below, and are summarized in Table 5-6.

### 5.5.1 Northwest Landfill

The Northwest Landfill will only contain those isotopes that are currently present and will be covered with an improved cover. In spite of the inherent conservatism built into this analysis, it is clear that the maximally-exposed annual radiation dose from all pathways is less than 2 millirem per year. As important, the groundwater is not ingested by the industrial worker; it is assumed that the worker ingests water from a municipal water source. The output of the RESRAD code is provided in Appendix D.

The radiation exposure was calculated to be less than 2 millirem per year, after 1,000 years. This radiation exposure was based on the presence of the radionuclides in the Northwest Landfill, as described in Table 5-4. The principal element of the exposure was found to be the result of direct radiation exposure after the cover erodes; this pathway for exposure contributed approximately 35 percent to the total dose. The analysis of the uncertainty indicated an average radiation exposure of 5 ± 2 millirem per year. The minimum exposure was calculated to be 2 millirem per year after 1,000 years. The maximum exposure was calculated to be 14 millirem. In this analysis, the groundwater pathway was suppressed along with the plant pathway.

### 5.5.2 Surface Soil Outside the Northwest Landfill

The DCGLs provided in Table 5-5 reflect the concentration of radionuclides that may be present outside of the Northwest Landfill and result in a maximum exposure of less than 25 millirem per year over background. The presence of these isotopes will be verified after the remediation is completed and the final status survey is implemented. Information regarding the final status survey is provided in Section 14 of this Decommissioning Plan. The output of the RESRAD code is provided in Appendix D.

The radiation exposure resulting from the DCGLs was calculated to be 25 millirem per year, observed after 1 year. The principal element of the exposure was found to be the result of direct radiation exposure from the surface of the soil; this pathway for exposure contributed approximately 85 percent to the total dose. The analysis of the uncertainty indicated an average radiation exposure of 23 ± 2 millirem per year. The minimum exposure was calculated to be 10 millirem per year after 1 year. The maximum exposure was calculated to be 25 millirem per year over background.

# Section 6
# Decommissioning Alternatives and Rationale

S.C. Holdings will meet USNRC's requirements for managing licensed radioactive materials in a manner that ensures that exposures are As Low As Reasonably Achievable (ALARA) taking into account economic and societal factors (10 CFR Part 20). In addition, S.C. Holdings will take actions necessary to ensure that a future industrial worker does not incur radiation doses in excess of 25 millirem per year after the license is terminated. These two objectives (*i.e.*, the dose limit contained in 10 CFR 20.1402 and the ALARA provisions) form the basis for the level of effort necessary for decommissioning the S.C. Holdings Hartley & Hartley Landfill Site.

S.C. Holdings has identified three alternatives that meet these two criteria. The first alternative is to consolidate and cover the radioactive materials on-site. The second alternative is to excavate and transport the contents of the Northwest Landfill and the two small slag piles (Slag Piles A and B) to the Envirocare Low-Level Waste Disposal Facility located in Utah. The final alternative is "no-action," which would leave the Northwest Landfill and the two slag piles in their current configuration and take only those actions necessary to control erosion or correct problems that may develop.

S.C. Holdings plans to consolidate the radiologically contaminated material on the site into a single area of the site (*i.e.*, the Northwest Landfill), and to improve the cover over the Northwest Landfill to provide appropriate radiation protection for a period of 1,000 years (refer to Section 8 for details).

Certain State of Michigan environmental regulations may be applicable or relevant and appropriate (ARAR) to the decommissioning activities at the SCA Hartley & Hartley Landfill Site. State regulations pertaining to environmental remediation, landfill closure, and/or management of hazardous waste will be taken into consideration as the remedy for the SCA Hartley & Hartley Landfill Site is developed.

## 6.1 Alternatives Considered

### 6.1.1 On-Site Consolidation and Cover Improvement

On-site material containing elevated levels of radioactivity (*i.e.*, thorium-bearing slag mixed with soil) would be consolidated on-site. The thorium-bearing slag in the two waste piles *outside* the Northwest Landfill (*i.e.*, in Slag Piles A and B) would be excavated and relocated *into* the Northwest Landfill (see Figure 2-1). The existing cover over the Northwest Landfill would be upgraded to limit potential radiation exposure to an industrial worker on the site for a period of 1,000 years. The cover design for this alternative would include the 24 inches of existing low-permeability soil, plus an additional 10 inches of low-permeability soil, for a total of 34 inches (0.9 meter) of low-permeability cover material. This barrier layer would be overlain by 6 inches of topsoil that would be seeded with suitable grass species (see Figure 5-1). The slope on the majority of the cover will be approximately 2 percent, with some areas along the perimeter of the landfill having a slope up to 25 percent. Slopes greater than 2 percent along the perimeter of the cover are needed to transition from the covered area to the surrounding topography. The consolidation of Slag Piles A and B within the Northwest Landfill may require slopes steeper than 2 percent to minimize disturbance of the existing cover materials and to reduce the amount of fill required to achieve final grades over the Northwest Landfill. The cover would be designed to minimize erosion and reduce the infiltration of precipitation through the cover.

The Final Status Survey would be conducted in all Class 2 and Class 3 areas prior to excavating Slag Piles A and B. The results of the laboratory analyses would be used to confirm that Slag Piles A and B are the only areas outside of the Northwest Landfill that need to be excavated.

The Final Status Survey would be conducted in the excavated areas at which Slag Piles A and B were formerly present prior to filling the excavations, and prior to completing the cover improvements in the Northwest Landfill. This sequencing of activities would allow for excavating additional soil in the excavated areas as needed to achieve the DCGLs plus background for surface soil. Once residual soil concentrations have been confirmed as being acceptable, the excavations would be filled with uncontaminated soil and graded to match the surrounding surfaces.

The consolidation of radiologically contaminated materials and the landfill cover improvement activities described above could be completed in one construction season (approximately May through November). These activities would be conducted by an earthmoving contractor using standard earthmoving equipment. On the order of eight workers may be employed to complete this work. The labor categories would include construction foreman, truck drivers, heavy equipment operators, general laborers, and construction quality assurance personnel. These workers would receive the Radiation Worker Training described in Subsection 9.4.3. The above work would be conducted in accordance with the Health and Safety Program during Decommissioning described in Section 10.

The exposure to workers during the construction of the landfill cover will be limited, as the existing 2-foot cover will provide sufficient protection to workers during the time frame of the cover construction. In the event grading activities expose waste in the Northwest Landfill, and while the slag piles are being relocated, appropriate measures will be taken to suppress windblown particulates; and the waste will be covered with general fill at the end of each day to reduce potential pathways.

The cover over the Northwest Landfill would be inspected and maintained as necessary to ensure that the cover vegetation becomes well established and that the cover improvements were successfully implemented. Repairs would be made as necessary to ensure that the decommissioning objectives are met.

As part of the response activities required under the Consent Order with the State to address chemical concerns, leachate may be extracted from the Northwest Landfill. As discussed further in Subsection 8.3.2, operation of a leachate extraction system in the Northwest Landfill would not require a radioactive materials license because the leachate does not contain radiation at concentrations greater than the MCLs.

The estimated costs to implement the on-site consolidation alternative are presented in Table 6-1. These are order-of-magnitude costs developed for using in comparing decommissioning alternatives.

Community resources, such as land use and property values are not likely to be affected by the use of the SCA Hartley & Hartley Landfill property as a waste disposal facility, inasmuch as the site has been a waste disposal facility for roughly 50 years already. The on-site containment alternative is not likely to have an appreciable affect on geology, hydrogeology, air quality, or hydrology, because disturbance of the waste disposal area (the Northwest Landfill) will be kept to a minimum. The on-site containment alternative will not have an appreciable effect on minority or low income populations within 4 miles of the facility relative to the other alternatives. Using the site for containment of low-level radioactive material will result in the long-term commitment of the Northwest Landfill as a waste disposal facility.

### 6.1.2 Off-Site Disposal

On-site material containing elevated levels of radioactivity would be excavated and transported to the Envirocare of Utah facility near Clive, Utah, for disposal. This would result in the on-site radioactive contamination left at the site being reduced to levels less than 25 mrem/year. The acceptable level for the soil is the DCGL for surface soil (as defined in Section 5 of this Plan) plus background. The total amount of material that would be disposed off-site is assumed to be approximately 87,000 cubic yards from the Northwest Landfill and approximately 1,400 cubic yards form the two slag piles. Approximately 4,400 covered trucks, or 900 railcars with a 20–cubic yard capacity, or 100–cubic yard capacity, respectively, would be used for the off-site transport of material from the Northwest Landfill and the two slag piles.

Because the thorium-bearing slag was not known to have been deposited in a discrete portion of the Northwest Landfill, and because it is not possible to visually differentiate between the thorium-bearing slag and the non–thorium-bearing slag, this alternative would entail excavating the entire Northwest Landfill, as well as the two waste piles outside the Northwest Landfill (*i.e.*, Slag Piles A and B), and transporting all materials to the Envirocare facility via truck and railcar.

The Final Status Survey would be conducted in the Class 3 areas that are outside of the Northwest Landfill. Samples and direct radiation measurements, as described in Section 14, would be collected and analyzed to verify that the concentrations of radioactive material are less than the DCGLs provided in Subsection 5.5 and Table 5-6.

The results of the laboratory analyses would be used to confirm that the Northwest Landfill and Slag Piles A and B are the only areas that need to be excavated. The Final Status Survey would be conducted in the three Class 1 areas (the Northwest Landfill and Slag Piles A and B) to confirm that residual soil concentrations are acceptable (that is, less than the DCGLs plus background for surface soil). Once this has been determined, the excavations would be filled with uncontaminated soil and graded to match the surrounding surface contours.

Excavating the radiologically contaminated materials on-site and transporting them to the Envirocare facility would required extensive planning to address health and safety concerns and off-site transport issues. The potential exposures to the industrial chemicals that were also disposed in the Northwest Landfill would likely require excavation of the Northwest Landfill using Class A personal protective equipment. The logistics needed to control potential radiological exposures would require detailed planning and scheduling for an activity of this scale. Moreover, it is unknown whether

Envirocare could/would accept the quantity of material associated with the SCA Hartley & Hartley Landfill Site.

This alternative may require more than one construction season to complete, owing to the anticipated low productivity associated with the health and safety requirements, and possible limitations by the disposal facility. The estimated time to complete the actions for this alternative is approximately 2 years, assuming Envirocare is able to receive 25 trucks/5 railcars per day, and the work can be conducted 5 to 6 months each year.

The estimated costs to implement the off-site disposal alternative are presented in Table 6-2. These are rough order-of-magnitude costs developed for use in comparing decommissioning alternatives. A more refined cost estimate for off-site disposal is likely to be higher than the estimate presented in Table 6-2 because additional consideration would have to be given to the many uncertainties currently associated with this alternative.

Community resources, such as land use and property values are not likely to be affected by the off-site disposal alternative inasmuch as the area nearest to the Northwest Landfill (the MDNR Landfill) is used as a waste disposal area, or as open space (Tobico Marsh). The off-site disposal alternative is not likely to have an appreciable effect on the geology or hydrology of the site. However, during the removal action, there could be a significant effect on air quality, due to dust released during excavation and handling of the waste material. In addition, there will be a significant short-term effect on the ecology, due to the volume of material that would need to be moved. The off-site disposal alternative would not have an appreciable effect on low-income or minority populations, relative to other alternatives. Removal of the Northwest Landfill would result in no commitment of the Northwest Landfill, but the East Landfill would remain a waste disposal facility for an indefinite period, regardless of actions that may be taken at the Northwest Landfill.

### 6.1.3 No-Action

Consideration of the no-action alternative is required by the regulations for implementing the NEPA standards in order to provide a baseline for comparison with the other alternatives. The no-action alternative would be to leave the site in its current condition without additional actions to reduce radiation levels. The Northwest Landfill and the two slag piles outside the Northwest Landfill would also remain in their present condition and location.

Only those actions required by the MDEQ to address chemical contamination under the Michigan Part 201 environmental response program would be implemented. These requirements would be specified in a Remedial Action Plan that will be developed by S.C. Holdings after the MDEQ approves the Remedial Investigation Report (Earth Tech, 2003a). In the Northwest Landfill, likely remedial response activities include improving the cover over the Northwest Landfill and installing a leachate extraction system. It is not anticipated that any action will be taken with regard to Slag Piles A and B under the Part 201 response actions.

The RESRAD model was used to calculate potential radiation exposure under the no-action alternative. The radiological exposures would not only exceed the criterion for unrestricted release (25 millirem/yr), but would also exceed the release criterion for restricted release (100 millirem/yr). A summary of the results is provided in Table 5-6. Consequently, the site would not be successfully decommissioned and the USNRC license could not be terminated.

## 6.2 Rationale for Chosen Alternative

The chosen alternative for the decommissioning the SCA Hartley & Hartley Landfill is on-site consolidation. This alternative is summarized in Subsection 6.1.1 and is described in more detail in Section 8. The rationale for selecting this alternative is that it would reduce potential radiation exposures to an industrial worker at the site for a period of up to 1,000 years. This alternative can be implemented in substantially less time than the off-site disposal alternative and poses much less risk of radiation and chemical exposures to decommissioning personnel and the public. Moreover, on-site management of the thorium-bearing slag eliminates the potential for accidental spills along interstate highways and rail routes that could occur if the material were to be excavated and transported to the Envirocare facility in Utah, a distance of approximately 1,800 miles from the SCA Hartley & Hartley Landfill Site.

On-site consolidation can be implemented using standard earthmoving equipment and field methods. Because limited, if any, waste in the Northwest Landfill will be uncovered or moved, there is far less chance of encountering unanticipated field conditions that might necessitate changes to the Decommissioning Plan. Lastly, the costs associated with the off-site disposal alternative would be at least an order-of-magnitude more than on-site consolidation and cover improvement. The cost differential is estimated to be on the order of $90,000,000.

A site in another state with residual radioactivity that is similar in physical form to that found at the Hartley & Hartley site had its characterization results incorporated into a Draft Environmental Impact Statement (DEIS) prepared by the USNRC, and into a Remedial Investigation and Feasibility Study (RI/FS) prepared by the licensee (USNRC, 1996;

PTI Environmental Services, Inc., 1996). Both of these documents concluded that on-site consolidation and cover improvement (the proposed decommissioning methodology) would have no significant impact on the environment and that additional action under NEPA would not be necessary.[10]

The regulatory decision on the preferred decommissioning alternative for this out-of-state site is equally applicable to the SCA Hartley & Hartley Landfill Site. Therefore, S.C. Holdings has elected to implement the on-site consolidation and cover improvement alternative for decommissioning, because it maximizes the radiological protection of people and the environment, minimizes risks to workers and members of the public, maintains radiation exposures ALARA when economic and societal issues are taken into account, and it is consistent with an option previously deemed acceptable by the USNRC.

(10) 63 CFR 64976, 1988.

# Section 7
# ALARA Analysis

S.C. Holdings' goal for this decommissioning effort is to contain the slag and comingled soil and waste in the Northwest Landfill and to improve the cover over the Northwest Landfill so that the potential exposures to radiation and radioactive materials for an industrial worker at the site are minimized. The cover will be designed, constructed, and initially maintained to reduce radiation exposures to below the radiation dose limit for unrestricted release (25 millirem/year over background) for a period of 1,000 years.

This section presents the quantitative As Low As Reasonably Achievable (ALARA) analysis in support of the termination of S.C. Holdings' license at the SCA Hartley & Hartley Landfill Site. This analysis consists of identifying, quantifying, and comparing to the extent practical, the benefits and costs that would be associated with two decommissioning alternatives.

## 7.1 Approach

The USNRC regulations contain specific requirements for a demonstration that residual radioactivity has been reduced to a level that is ALARA (10 CFR Part 20.1402; 10 CFR Part 20.1404; and USNRC, 2000d). Because it is sometimes difficult or impossible to place a monetary value on a potential impact, a simplified method for demonstrating compliance with the ALARA requirement described in NUREG-1727 can be used. This method is used to estimate when a decommissioning alternative is cost effective using generalized estimates for the decommissioning alternative. If the desired beneficial effects ("benefits") from the decommissioning alternative are greater than the undesirable effects or "costs" of the action, the decommissioning alternative evaluated is determined to be cost effective and would be recommended for implementation. Conversely, if the benefits are less than the costs, the levels of residual radioactivity associated with the selected decommissioning action are ALARA, and the decommissioning alternative would not be recommended.

Some of the benefits associated with excavating the thorium-bearing slag and contaminated soil in the Northwest Landfill and Slag Piles A and B, and disposing it off-site, include the following:

- Reduction in the collective radiation dose to an on-site industrial worker
- Avoidance of regulatory costs
- Increase in the value of the property

- Improvement of the aesthetics of the surrounding area
- Possible reduction in public opposition

Some of the costs associated with the off-site disposal alternative include the following:

- Increase in the cost of decommissioning
- Increase in the radiation dose to the remediation workers
- Increase in nonradiological risks
- Increase in the cost of transportation and disposal
- Massive disruption to the environment during decommissioning

In order to compare the benefits and costs of the decommissioning alternatives at the SCA Hartley & Hartley Landfill Site, it is necessary to use a comparable unit of measure. Consequently, all benefits and costs are given a monetary value, using assumptions that are site specific, when possible, and defaults from NUREG-1727, as necessary. It is assumed that the costs would be incurred during decommissioning planning, implementation, and post-closure, but after the characterization work is completed. The operation of the leachate extraction system is incidental to the decommissioning effort for the site, and is not a principal activity as defined in the USNRC's regulations. In the simplest form of the analysis, it is necessary to demonstrate that the radiation dose to persons who occupy the site in the future is averted. This analysis demonstrates that excavation of the Northwest Landfill and Slag Piles A and B, and the shipment of these materials to an off-site licensed disposal facility is not justified when compared to consolidating Slag Piles A and B within the Northwest Landfill and improving the cover over the Northwest Landfill.

## 7.2 Residual Radioactivity Levels that are ALARA

The residual radioactivity level that is ALARA is the concentration, at which the benefit from removal equals the cost of removal (USNRC, 2000c). If the total cost, $Cost_T$, is set equal to the present worth of the collective dose averted, the ratio of the concentration, to the $DCGL_W$ can be determined. If the remedial level, RL, exceeds 1.0, then the $DCGL_W$ is determined to be too high and would not be considered ALARA.

Mathematically, this is expressed as follows:

$$RL = \frac{Concentration}{DCGL_W} = \frac{Cost_T}{\$2{,}000 \times P_D \times 0.025 \times F \times A} \times \frac{r+\lambda}{1-e^{-(r+\lambda)N}},$$

where

| | | |
|---|---|---|
| RL | = | remediation level, as a fraction of the $DCGL_W$, |
| Concentration | = | average concentration of residual activity in the area being evaluated, |
| $DCGL_W$ | = | derived concentration guideline level equivalent to the average concentration of residual radioactivity that would give a dose of 25 mrem/yr to the average member of the critical group, |
| $Cost_T$ | = | total cost of decommissioning alternative, in dollars, |
| $2,000 | = | monetary value of one person-rem averted (Table D2, NUREG-1727, Appendix D), |
| $P_D$ | = | population density for critical group scenario, in people/$m^2$, |
| 0.025 | = | annual dose to average member of critical group from residual radioactivity at $DGCL_w$ concentration, in rem/yr, |
| A | = | area being evaluated, in $m^2$, |
| F | = | fraction of the residual radioactivity in the area removed by the decommissioning alternative, |
| r | = | monetary discount rate, in $year^{-1}$, |
| $\lambda$ | = | radiological decay constant, in $year^{-1}$, |
| N | = | number of years over which the collective dose is calculated. |

Acceptable values for population density, $P_D$, are provided in NUREG-1496. The monetary discount rate, r, is provided in NUREG-0058. It is assumed that 100 percent of the thorium-bearing slag is removed (F), and that the collective dose is calculated for 1,000 years (N). The values selected for these variables are provided below:

| PARAMETER | ACCEPTABLE VALUE |
|---|---|
| $P_D$ | 0.0004 person/$m^2$ |
| F | 1.0 |
| r | 0.03 per year |
| N | 1,000 years |

The derivation of the total cost, $Cost_T$, is provided below. The derivation of the acceptable concentration of residual radioactivity is provided in Section 5 of this Decommissioning Plan.

## 7.3 Calculation of Total Cost

The calculation of total cost includes the monetary costs for the following:

The total cost, $Cost_{T}$, is calculated as follows:

where

$$Cost_T = Cost_R + Cost_{WD} + Cost_{ACC} + Cost_{TF} + Cost_{WDose},$$

| | | |
|---|---|---|
| $Cost_R$ | = | remedial action, |
| $Cost_{WD}$ | = | transportation and disposal of wastes generated, |
| $Cost_{Acc}$ | = | workplace accidents that occur because of the remedial actions, |
| $Cost_{TF}$ | = | traffic fatalities resulting from the transportation of the waste, |
| $Cost_{Wdose}$ | = | radiation dose received by workers performing the remedial action. |

## 7.4 Cost of Decommissioning

As described in Subsection 6.1.2, the cost for consolidating Slag Piles A and B into the Northwest Landfill and improving the cover over the Northwest Landfill was estimated to be on the order of $1,900,000. In contrast, the cost to excavate on-site material containing elevated levels of radioactivity (the Northwest Landfill and Slag Piles A and B) and to transport these materials to the Envirocare of Utah facility for disposal was estimated to be on the order of $92,000,000. These estimates, which are used as $Cost_R$, were based on 1,400 cubic yards (1,070 $m^3$) and 106,100 cubic yards (81,100 $m^3$), respectively, of material requiring remediation (see details in Tables 6-1 and 6-2).

## 7.5 Cost of Waste Disposal

The unit disposal costs are highly uncertain. A study in 2000 reviewed disposal costs at both commercial and DOE low-level radioactive waste disposal sites. The commercial costs at the Envirocare of Utah facility were found to be the lowest, ranging from $4.80/$ft^3$ to $17/$ft^3$ ($170 to $600/$m^3$), depending on the volume, chemical, and radiological characteristics of the waste stream. The cost of waste transport and disposal, $Cost_{WD}$, is calculated as follows:

$$Cost_{WD} = V_A \times Cost_V,$$

where

| | | |
|---|---|---|
| $Cost_{WD}$ | = | cost of waste disposal, |
| $V_A$ | = | volume of slag and soil removed from the Northwest Landfill (81,100 $m^3$). |

| | | |
|---|---|---|
| $Cost_V$ | = | cost of waste disposal at Envirocare of Utah, near Clive, Utah, $592/m³. |

This cost is not applicable if Slag Piles A and B are consolidated within the Northwest Landfill and the cover over the Northwest Landfill is improved.

## 7.6 Cost of Workplace Accidents

The risk of workplace accidents is reduced by using trained remediation workers and implementing an effective health and safety program. However, accidents and injuries, as well as fatalities, are possible. The cost estimate is based on the cumulative labor requirements (3,200 person-hours for on-site consolidation and 19,200 person-hours for off-site disposal), the workplace accident fatality rate identified by the USNRC (4.2E-8 fatalities per worker hour), and the monetary value of a fatality ($3,000,000). This estimate is $2,400, which is also insignificant when compared to the other remediation costs.

The cost of workplace accidents, $Cost_{ACC}$, is calculated as follows:

$$Cost_{ACC} = \$3{,}000{,}000 \times F_W \times T_A,$$

where

| | | |
|---|---|---|
| $3,000,000 | = | monetary value of a fatality, equivalent to $2,000 per person-rem, |
| $F_W$ | = | workplace fatality rate, $4.2 \times 10^{-8}$ fatalities per hour worked, |
| $T_A$ | = | worker time required for remediation, 3,200 or 19,200 worker-hours. |

## 7.7 Cost of Traffic Fatalities

The risk of a traffic accident and injury increases with each shipment and also increases with the distance driven. Transportation of contaminated soil from the SCA Hartley & Hartley Landfill Site near Bay City, Michigan, to the disposal site at Clive, Utah, requires approximately 1,800 miles to complete the trip and poses risks to the public. While truck shipments will travel the interstate highway system, the risk of a fatality is measurable. The number of shipments depends on the area remediated and the volume of contaminated soil excavated. Approximately 5,300 truckloads or 1,400 railcar loads are estimated to be needed. An estimate of the monetary value of the nonradiological transportation risk was developed, based on a transportation accident fatality rate (3.8E-8 fatalities per km) and the monetary value of a fatality ($3,000,000). The cost of traffic fatalities incurred during the shipment of slag, $Cost_{TF}$, is calculated as follows:

$$Cost_{TF} = \frac{\$3{,}000{,}000 \times V_A \times F_T \times D_T}{V_{SHIP}},$$

where

| | | |
|---|---|---|
| \$3,000,000 | = | monetary value of a fatality, equivalent to \$2,000 per person-rem, |
| $V_A$ | = | volume of slag and soil removed from the Northwest Landfill and Slag Piles A and B (81,100 $m^3$), |
| $F_T$ | = | traffic fatality rate, $3.8 \times 10^{-8}$ fatalities per kilometer traveled, |
| $D_T$ | = | distance traveled, 2,876 kilometers, |
| $V_{SHIP}$ | = | volume of truck shipment, 57.3 $m^3$. |

This cost estimate is found to be approximately \$464,000. While these costs are higher than those for radiological and nonradiological risk, these costs are a small percentage (0.5 percent) of the total decommissioning costs.

This cost would not be incurred if Slag Piles A and B are consolidated within the Northwest Landfill and the cover is improved.

## 7.8 Cost of Radiation Dose

Radiation dose to decommissioning workers is measured in both direct exposure as well as inhalation and ingestion of contaminated soil and slag. Both pathways for exposure can be reduced to ALARA by following the requirements of the radioactive materials license and the health and safety plan developed to decommission the site. If Slag Piles A and B were consolidated within the Northwest Landfill, it is estimated that 3,200 person-hours would be required to relocate the slag and improve the cover over the Northwest Landfill. If the Northwest Landfill were excavated, it is estimated that 19,200 person-hours would be required to remove 106,100 cubic yards (81,100 $m^3$) of slag and contaminated soil/other wastes.

Assuming an occupational exposure rate on the order of 15 microR per hour, the cumulative occupational exposure would be less than 19,200 person-rem. The cost of radiation dose to decommissioning workers is calculated as follows:

$$Cost_{WDose} = \$2{,}000 \times D_R \times T_R,$$

where

| | | |
|---|---|---|
| \$2,000 | = | monetary value of person-rem averted, |
| $D_R$ | = | total effective dose equivalent to decommissioning workers, $15 \times 10^{-6}$ rem/hour, |

| | | |
|---|---|---|
| $T_R$ | = | time worked to complete the decommissioning activities, 3,200 or 19,200 person-hours. |

## 7.9 Environmental Degradation

Environmental degradation would result if Slag Piles A and B were consolidated within the Northwest Landfill and the cover improved and if the Northwest Landfill and Slag Piles A and B were excavated and the contents shipped off-site. The environmental degradation would be the result of tree and brush removal, and the disturbance around the Northwest Landfill and near the boundary of the Tobico Marsh; erosion is predicted to increase. In the short-term, the existing habitat would be destroyed and the terrain modified as a result of remediation. With appropriate mitigative measures (*e.g.*, soil erosion controls, site restoration, etc.), and time, the site would be restored, thereby resulting in no net environmental degradation costs. Therefore, no irreversible and irretrievable loss in environmental resources in the long-term is expected.

## 7.10 ALARA Conclusions

This analysis compares the benefits of dose reduction with costs. These costs include occupational fatalities, occupational doses, transportation fatalities, and environmental degradation. These benefits and costs were quantified above. This analysis indicates that, for most situations, the benefits are less than the net public or environmental harm cost elements. The table below summarizes the costs for the categories enumerated above.

| COST ELEMENTS | ON-SITE CONSOLIDATION AND ENGINEERED COVER | EXCAVATION AND OFF-SITE DISPOSAL |
|---|---|---|
| Decommissioning | $1,900,000 | 92,000,000 |
| Workplace accidents | 0 | 2,400 |
| Transportation accidents | 0 | 465,000 |
| Radiation dose | 100 | 580 |
| Environmental degradation | 0 | 0 |
| Residual Level (RL) | <0.001 | <0.001 |

Excavating the licensed material and disposing it in an off-site facility would likely result in "net public or environmental harm." Conversely, the ALARA analysis demonstrates that consolidating the thorium-bearing slag in Slag Piles A and B into the Northwest Landfill and then improving the cover over the Northwest Landfill is consistent with USNRC regulations (10 CFR 20.1402), and the associated potential radiation exposures would be ALARA.

# Section 8 Planned Decommissioning Activities

This section describes S.C. Holdings' approach for decommissioning the SCA Hartley & Hartley Landfill Site. It describes the sequence of field decommissioning work, including a phased Final Status Survey, and a schedule for completing the decommissioning activities. As summarized in Subsection 6.1.1, the selected decommissioning alternative is on-site consolidation of radiologically contaminated material into a single location and placement of an engineered barrier over the Northwest Landfill. This decommissioning alternative was developed to control potential radiological exposures to an industrial worker at the site for a period of at least 1,000 years. This decommissioning action includes the following major components:

- Excavating the licensed materials in Slag Piles A and B and placing these materials in the Northwest Landfill
- Installing a leachate collection system in the Northwest Landfill
- Constructing an engineered barrier over the Northwest Landfill (clay and vegetated topsoil)

Prior to implementing these actions, a decommissioning workplan will be submitted to the USNRC. This document will present the final design and technical specifications, the health and safety plans (HASPs), the construction methods, and the construction quality assurance procedures and documentation requirements. The decommissioning workplan will also present the implementation and documentation requirements for the Final Status Survey.

The Final Status Survey will be conducted in two phases in order to provide efficient implementation of the field decommissioning activities. Additional details regarding the Final Status Survey are presented in Subsection 8.3 and in Section 14.

## 8.1 Contaminated Structures

No contaminated structures have been identified at the SCA Hartley & Hartley Landfill Site. The Final Status Survey will document that the surfaces inside the office building satisfy the USNRC criterion for unrestricted release.

## 8.2 Contaminated Systems and Equipment

No contaminated systems or equipment have been identified for remediation. Based upon the findings of routine surveillance activities and previous radiological site characterizations, as well as on historical process knowledge, no additional facilities with residual radioactivity remain at the site.

## 8.3 On-Site Consolidation of Radiologically Contaminated Material and Placement of an Engineered Cover Over the Northwest Landfill

### 8.3.1 Sequencing of Field Decommissioning Activities

The SCA Hartley & Hartley Landfill Site has been divided into radiological survey units based on site operating history and site characterization data. There are three Class 1 survey units at the site: the Northwest Landfill, Slag Pile A, and Slag Pile B. The area surrounding the Northwest Landfill is designated as a Class 2 survey unit; however, there are no Class 2 survey units around Slag Piles A and B. This is because Slag Piles A and B (Survey Units 1A and 1B) are of such limited area (0.2 and 0.1 acre, respectively), and these areas will be over-excavated, based on visual observation, and then tested to ensure that all radiologically contaminated material is removed from these areas. The dimensions of the slag piles are based on the results of the gamma walk-over (REI, 1993a) and characterization work conducted in 1996 (Appendix A) and 2003 (see Subsection 4.4.10). The results of the gamma walk-over demonstrate that no residual contamination is present beyond the slag piles. Therefore, there will be no Class 2 areas surrounding Slag Piles A and B.

The East Landfill is a Class 3 survey unit based upon historical process knowledge, which indicates that industrial and municipal solid wastes were disposed in this portion of the site, but not the thorium-bearing slag from Wellman Dynamics. This designation is supported by site characterization data for the East Landfill (see Appendix B-3), which does not indicate the presence of radioactive slag material in this area. Figure 8-1 identifies the following radiological survey units at the site:

| SURVEY UNIT ID | CLASSIFICATION | DESCRIPTION |
|---|---|---|
| 1A | 1 | Slag Pile A |
| 1B | 1 | Slag Pile B |
| 1C | 1 | Northwest Landfill |
| 2A | 2 | Haul road between Slag Pile A and the Northwest Landfill |
| 2B | 2 | Haul road between Slag Pile B and the Northwest Landfill |
| 2C | 2 | Area surrounding the Northwest Landfill |
| 3 | 3 | All other areas of the site, including the East Landfill |

Survey Units 2A and 2B were assigned their classifications based on S.C. Holdings' plans to excavate the material in Slag Piles A and B and reconsolidate these materials into the Northwest Landfill, not on the history or other evidence of radiological contamination in these areas. Because radiologically contaminated material could be deposited along the haul roads between the slag piles and the Northwest Landfill in the course of transporting the excavated material from the two slag piles to the Northwest Landfill, the haul roads between the slag piles and the Northwest Landfill are designated Class 2 survey units. This designation will provide more intensive sampling for the Final Status Survey to ensure that radiological contamination was not inadvertently spread during the course of decommissioning fieldwork.

The following sequence of field decommissioning actions and Final Status Survey sampling will be conducted:

1. Collect samples of the surface soil in the Class 2 survey unit surrounding the Northwest Landfill (Survey Unit 2C) and in the Class 3 areas, except for the East Landfill. Analyze these soil samples for the radiological parameters associated with the thorium-bearing slag. The new data, in conjunction with the historical radiological data in these areas, will comprise the Final Status Survey for these areas. Samples will not be collected in the East Landfill because the historical data for the East Landfill (Appendix B-3) are sufficient for the Final Status Survey.
2. Install erosion control and sediment control systems to prevent off-site migration of regulated material during construction activities and to control the runon of precipitation into the work area.
3. Excavate the regulated materials in Slag Piles A and B (Survey Units 1A and 1B), and place these materials in suitable areas in the Northwest Landfill. The slag piles will be over-excavated (that is, extra material, laterally and vertically, will be

removed) based on visual observation to negate the need for Class 2 survey units around these limited areas of known radiologically contaminated material. As possible, the excavated materials will be placed in areas of the Northwest Landfill that require additional fill to achieve final grades; however, other considerations (*e.g.*, haul distance) may suggest placement in other areas. Other radiologically contaminated decontamination and/or demolition material or equipment may also be placed in the Northwest Landfill. Physical controls will be placed along the haul roads between Slag Piles A and B and the Northwest Landfill to limit the area in which radiologically contaminated materials could spread during the waste consolidation activities.

4. Collect samples of the residual surface soil in the areas where Slag Piles A and B (Survey Units 1A and 1B) were excavated, and collect surface soil samples in the haul roads used to transport material from Slag Piles A and B to the Northwest Landfill (Survey Units 2A and 2B). Analyze all of these soil samples for radiological parameters associated with the thorium-bearing slag. Residual levels of radiation in these areas will be compared with the DCGLs presented in Table 5-5.

5. Install a leachate collection system in the Northwest Landfill. The leachate collection system will generally be composed of the following components:

   - Approximately four extraction wells in the Northwest Landfill. A submersible pump will be installed in each extraction well. Appropriate measures will be designed and installed to facilitate routine maintenance and to provide security from vandalism.

   - Leachate transfer piping within the Northwest Landfill.

   - A below-grade connection to the existing leachate header pipe that was previously installed by the MDNR on the SCA Hartley & Hartley Landfill to transport leachate from the MDNR Landfill to a load-out facility to be constructed in the southeastern corner of the SCA Hartley & Hartley Landfill Site property.

   - (Although not part of the decommissioning activities overseen by the USNRC, the truck load-out facility to be installed in the southeastern corner of the site to collect and load leachate from the East Landfill into tanker trucks for transportation and disposal at an off-site treatment and disposal facility will also be used to collect and load out leachate from the Northwest Landfill, and possibly from the MDNR Landfill as well, pending approval by the USNRC and the MDEQ. The design for the load-out facility for the East Landfill has been approved by the MDEQ [Earth Tech, 2003] and has been provided to the USNRC for informational purposes.)

6. Construct an engineered barrier over the Northwest Landfill (Survey Unit 1C). The engineered barrier will consist of the following layers over the waste:
   - The existing 24 inches of clay will be left in place to provide radiation shielding from the thorium-bearing slag in the waste. The surface vegetation (grass) will be removed to allow for the placement of additional clayey soil.
   - A minimum of 10 inches of imported low-permeability soil ($1 \times 10^{-7}$ cm/s) will be placed over the existing clay to further shield the radiation from the thorium-bearing slag in the waste and to reduce the infiltration of precipitation.
   - A minimum of 6 inches of imported topsoil will be placed over the new layer of low-permeability soil to support cover vegetation.

The topsoil layer will be planted with suitable plant species to provide erosion protection.

Existing documentation of the source term for the licensed material (ORAU, 1985) is appropriate and adequate to determine the necessary thickness of cover material needed to provide protection from radiological exposures to the buried thorium-bearing slag in the Northwest Landfill. This determination was made using the RESRAD computer code, and the site-specific input parameters for a potential future industrial worker on the site. Consequently, documentation of the placement of the engineered barrier over the Northwest Landfill, in accordance with a Construction Quality Assurance Plan (to be developed as part of the decommissioning workplan) will serve as the Final Status Survey for the Northwest Landfill (Survey Unit 1C). No additional samples of the waste or new cover material will be collected.

Initiation of the decommissioning planning activities will begin once the MDEQ has approved a Remedial Action Plan (RAP) to address the chemical exposures pursuant to the State of Michigan environmental response regulations (State of Michigan, 1994). Coordination of the decommissioning activities with the remedial actions required under state regulations is discussed further in Subsection 8.4.

Additional details for the planned field decommissioning activities, in accordance with the USNRC document entitled *Consolidated NMSS Decommissioning Guidance*, as well as a schedule for these activities, is provided below.

### 8.3.2 Conceptual Design

The engineered barrier over the Northwest Landfill will be designed to meet the dose criterion for license termination for unrestricted use (USNRC, 1997b). Engineering plans and specifications will be provided in a subsequent submission, and may include the following elements:

- Final contour plan
- Cover system design details
- Description of final cover material
- Description of erosion control measures
- Construction Quality Assurance Plan

Primary design considerations are as follows: (1) physical characteristics of the regulated materials (*e.g.*, size and density), (2) volumes of the regulated material, and (3) relative location of the regulated material. The cover will be designed to minimize the relocation of regulated material, while establishing a stable cover. Design details will be developed to address the following:

- Required radiological shielding (by placing additional soil [clay and topsoil] over the existing 2-foot-thick clay cover to achieve the calculated thickness of soil necessary to withstand 1,000 years of erosion)
- Drainage of precipitation off of the cover
- Long-term cover slope
- Long-term erosion controls
- Dust control during on-site construction activities
- Measures to minimize the need for waste material handling
- Use of low-maintenance vegetative species

#### *Engineered Cover Over the Northwest Landfill*

Construction of the cover will be initiated through preparation of the final subgrade for cover construction. Surface drainage systems will be constructed that will direct surface runoff from the cover away from the landfilled material. Cover preparation may involve the physical movement of slag and other materials using standard construction equipment (front-end loaders, bulldozers, dump trucks), such that effective consolidation and compaction are achieved.

During consolidation of the various regulated materials into a single pile, comprehensive health and safety protocols will be followed to avoid exposing workers and nearby residents to site contaminants, and to prevent the migration of contaminants into the surrounding environment. Water and/or other appropriate dust-control media will be used during all material movement activities. Monitoring and appropriate dust control activities will be performed to minimize vehicle-induced fugitive dust generation. Material loading and unloading activities will also be monitored and controlled in a similar fashion. Further, real-time dust and radiological monitoring will be performed by the Decommissioning Contractor to ensure that exposures to radiological contaminants as well as other constituents of potential concern (*i.e.*, metals) do not occur as a result of materials handling activities.[11] These actions, combined with the fact that the closest residence is more than 400 meters (0.25 mile) from the S.C. Holdings' property boundary, will ensure that radiological and safety conditions that cannot be distinguished from those prior to the start of work will be maintained.

The final cover will be constructed over a prepared subgrade The barrier layer in the final cover will consist of a compacted soil that is 0.9 meter (34 inches) thick. The thickness of the barrier layer was calculated using the RESRAD computer model, which demonstrated that the potential for radiation exposures from all exposure pathways over the next 1,000 years is less than 25 millirem per year over background (refer to Section 5). The cover in its entirety will consist of 34 inches of a suitable compacted soil, overlain by 6 inches of topsoil that will be seeded with low maintenance, drought-resistant grass.

Surface water drainage features, such as diversion berms, will be constructed, as necessary, to control surface water runoff and the potential erosion.

Final cover soil material will be secured from a certified off-site source, and will be of appropriate grain size and quality to be stable and to augment the overlying vegetative soil layer. Proposed location and dimensions of the final cover are depicted on Figure 5-1.

Given the current conditions at the site, a successional old-field community is proposed in order to provide long-term consolidation of the cover and

(11) In the event that exposure levels above established site-specific health and safety action levels are identified, additional dust control activities (*e.g.*, increased application of water or other control medium or use of different/supplemental controls systems) will be implemented.

minimize future maintenance requirements, while promoting rehabitation by indigenous species, as well as migrating birds. The vegetation will include a mixture of grass species. Upland areas may be planted with a mix of perennial species during the growing season to establish permanent vegetative consolidation. Perennials develop a strong sturdy root structure that generally inhibits the growth of volunteer woody vegetation that may affect the integrity of the cover. The seed mix may include the following legume species:

**Lawn Seed Mixture**

| SCIENTIFIC NAME | COMMON NAME |
|---|---|
| *Agrostis alba* | Red top |
| *Andropogon scoparius* | Little bluestem |
| *Andropogon virginicus* | Broom-sedge |
| *Echinochloa crusgalli* | Barnyard grass |
| *Festuca rubra* | Red fescue |
| *Lolium perenne* | Perennial ryegrass |
| *Poa annua* | Annual bluegrass |
| *Poa palustris* | Fowl bluegrass |

**Meadow Seed Mixture**

| SCIENTIFIC NAME | COMMON NAME |
|---|---|
| *Agrostis gigantea* | Black bentgrass |
| *Andropogon gerardii* | Big bluestem |
| *Deschampsia cespitosa* | Tufted hair-grass |
| *Elymus canadensis* | Canada wild rye |
| *Panicum virgatum* | Switchgrass |
| *Poa nemoralis* | Bluegrass |
| *Sorghastrum nutans* | Indian grass |

### *Leachate Extraction System in the Northwest Landfill*

S.C. Holdings will install a leachate extraction system in the Northwest Landfill (pursuant to the Consent Order with the State of Michigan). The leachate extraction system will consist of four wells approximately 15 feet deep, and piping that will transfer the leachate from the Northwest Landfill to the leachate storage and load-out facilities for the East Landfill. S.C. Holdings will also manage the collection and disposal of leachate in the MDNR Landfill, as required under the Consent Order with the State. However, the Consent Order does not require S.C. Holdings to address radiological concerns in connection with the leachate in the MDNR Landfill. A conceptual layout of the leachate extraction systems for the Northwest, the East, and the MDNR Landfills is shown on Figure 8-2.

The leachate extraction wells and piping in the Northwest Landfill will be installed during the field mobilization for consolidating Slag Piles A and B into the Northwest Landfill and upgrading the cover over the Northwest Landfill. This Plan will cover all intrusive decommissioning (that is, work that may involve contact with thorium-contaminated soil at concentrations greater than the DCGLs).

The operation of the leachate extraction system is incidental to the decommissioning effort of the site, and is not a principal activity as defined in the USNRC's regulations. The operation of the leachate extraction system does not require a radioactive materials license because the leachate does not contain radioactive materials at concentrations greater than the MCLs. Specifically, analyses to date of leachate from the Northwest Landfill have yielded concentrations of Ra-226 and Ra-228 that total less than 5 pCi/L, and uranium-238 is less than 30 pCi/L (USEPA, 2002). In spring 2004, S.C. Holdings will collect additional samples of the leachate in the Northwest Landfill to confirm the historical results. As required by the State of Michigan, S.C. Holdings may operate the leachate extraction system. Samples may be collected periodically during the operation of the leachate extraction system to verify that the concentration of radioactive material has not changed.

*Surface Water and Groundwater*

Decommissioning activities are not needed to address surface water or groundwater, as these media have not been adversely affected by the thorium-bearing slag.

### 8.3.3 Final Status Survey

The survey will follow protocols and methods established in the *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).* The primary purpose of the Final

Status Survey will be to confirm that the formerly contaminated areas of the site meet the established exposure criteria for the site. A detailed discussion of the Final Status Survey is provided in Section 14.

### 8.3.4 Schedule for Implementing the Decommissioning Activities

A schedule for implementing the decommissioning activities at the SCA Hartley & Hartley Landfill Site is presented on Figure 8-3.

S.C. Holdings acknowledges that the dates shown in the schedule on Figure 8-3 are contingent upon the USNRC's approval of the Decommissioning Plan. S.C. Holdings also acknowledges that circumstances may change during decommissioning, and, if the licensee determines that the decommissioning cannot be completed as outlined in the schedule, the licensee or responsible party will provide an updated schedule to the USNRC.

### 8.3.5 S.C. Holdings' Commitment Statement

S.C. Holdings is committed to the implementation of conservative radiological protection practices, and intends to be consistent with federal requirements that licensed radioactive materials be handled and released in a manner that ensures that exposures are As Low As Reasonably Achievable (ALARA), taking into account economic and societal factors. Because the goal of decommissioning at the SCA Hartley & Hartley Landfill Site is to ensure that a future industrial worker at the site does not incur radiation doses in excess of 25 millirem per year after the license is terminated, these two objectives (*i.e.*, the dose limit contained in 10 CFR 20.1402 and the ALARA provisions) form the basis for the level of effort necessary for decommissioning of this facility.

## 8.4 Coordination with State of Michigan Response Actions

In addition to the decommissioning activities required under the USNRC's Site Decommissioning Management Plan (SDMP), S.C. Holdings is also conducting environmental response activities to address chemical contamination at the site under the State of Michigan's Part 201 (Environmental Remediation) of the Natural Resources and Environmental Protection Act (NREPA), 1994 PA 451, as amended. These response activities are being conducted pursuant to the November 7, 1980, Stipulation and Consent Order for Closure ("Order"), as modified by the September 25-28, 1984, Amendment to the November 7, 1980, Stipulation and Consent Order for Closure ("Amendment"), both of which were augmented and modified by the December 2, 2002, Addendum by Consent for Payment of Past Response Activity Costs, Future Oversight Costs, and Performance of Response Activities ("Addendum"), all of which were entered into with the MDEQ.

In the Addendum, the term "facility" has the specific meaning defined in the Part 201 statute at 324.20101(1)(o). For purposes of the Part 201 response activities, the "facility" includes the properties identified in the Order and the Amendment as the Kawkawlin Site, the SCA Property, and the State Property, as well as any area, place, or property where a hazardous substance(s) originating at or from these properties has come to be located in excess of applicable requirements. To reduce confusion with Part 201 terminology, the use of the term "facility" in the Decommissioning Plan has been minimized. Additionally, the term "site" also has specific meaning in the context of Part 201. Note, however, that the term "site" is always used in the Decommissioning Plan to carry the definition used in the USNRC Source Materials License No. SUC-1565, which is the SCA Services (now S.C. Holdings, Inc.) property located at 2370 Two Mile Road, Bay County, Michigan.

At present, S.C. Holdings has submitted to the MDEQ a Remedial Investigation (RI) Report, which also includes an Ecological Risk Assessment (Earth Tech, 2003a). Upon approval of the RI Report by the MDEQ, S. C. Holdings will prepare and submit a combined Feasibility Study/Remedial Action Plan (FS/RAP) to evaluate alternatives for addressing chemical concerns and to select a remedy for this purpose. The RAP is the State's decision document for a site, analogous to the USNRC's Decommissioning Plan. Ultimately, a single remedy for the site, including, in this instance, the Northwest Landfill, the East Landfill, the MDNR Landfill (to address chemical concerns only), and nonlandfilled areas, will address the radiological and chemical concerns, and will meet the more stringent of the requirements established by USNRC and the MDEQ, as applicable.

In addition to consolidating the thorium-bearing slag in Slag Piles A and B into the Northwest Landfill, improving the cover over the Northwest Landfill, and installing a leachate collection system (wells and header piping) in the Northwest Landfill (as described in Subsection 8.3), S.C. Holdings anticipates that, as part of the Part 201 response actions, an improved cover will be constructed over the East Landfill, a leachate extraction system will be installed in the East Landfill, and a truck load-out facility will be installed to temporarily store and eventually transport leachate from the East, Northwest, and MDNR Landfills to an off-site disposal facility. The design for the leachate collection system and truck load-out facility for the East Landfill has been approved by the MDEQ as an interim response action (Earth Tech, 2003b). In addition, S.C. Holdings anticipates that it will excavate soil/sediment containing chemicals of concern above State-approved criteria from certain areas at the site (see Figure 4-2) and place these materials on the East Landfill prior to constructing the final cover over the East Landfill. Long-term monitoring and maintenance activities required by the State are expected to be conducted for a period of at least 30 years following completion of the Part 201 response activities.

*Supplemental Sampling Activities Conducted in May 2003*

In order to resolve certain issues associated with the planned remediation activities to address chemical contamination at the site, in May 2003, as part of the other radiological site characterization activities that were conducted during that sampling campaign (refer to Subsection 4.4.10), additional wetland soil, sediment, and surface water samples were collected and analyzed for the radiological parameters associated with the thorium-bearing slag (these parameters are listed in Table 4-3). Some samples were also analyzed for PCBs, chromium, or bis-2(ethylhexyl)phthalate (see Table 4-4).

Additional wetland soil, sediment, and surface water samples were collected in the West Pond Area, the Northwest Pond Area, and the North Pond Area to clarify whether environmental media in some of the areas that are scheduled to be excavated to address PCB contamination as part of the Part 201 response activities contain radiation levels that may affect disposal options for the excavated materials. Samples were collected from locations at which a historical radiological result appeared to be anomalously high and/or in areas where the areal distribution of existing radiological data may not be sufficient to determine the disposal requirements for the excavated solid media. The preliminary areas in which sediment is planned to be excavated to address PCB contamination are shown on Figure 4-2, as are the locations at which samples were collected in these areas in May 2003. The samples were analyzed for the radiological parameters listed in Table 4-3, and the results are contained in Appendix B-3. Because the radiation levels in these samples were similar to site background, disposal requirements for the excavated soil and sediment should be based on chemical parameters only (likely in the East Landfill).

Five wetland soil samples (SOW-NWLF13, SOW-H9, SOW-J8, SOW-N9, and SOW-O10), were analyzed for PCBs in addition to radiological parameters. Two other wetland soil samples (SOW-NWLF9 and SOW-NWLF10) were analyzed for chromium in addition to radiological parameters, and one wetland sample, SOW-ITD3C, was analyzed for bis-2(ethylhexyl)phthalate, in addition to the radiological parameters. The locations of these samples are shown on Figure 4-2. The chemical results for these samples are contained in Appendix B-4, and the radiological results are presented in the Decommissioning Plan Data Set in Appendix B-3.

Wetland soil samples SOW-NWLF13, SOW-H9, SOW-J8, SOW-N9, and SOW-O10 were collected in areas believed to be outside the area to be excavated to address PCB contamination in sediment. As shown in Table 4-7 and Appendix B-4, PCBs were not detected in sample SOW-H9, but further delineation of PCB impacts at the other sample locations may be needed under the State of Michigan environmental response program (State of Michigan, 1994).

Wetland soil samples SOW-NWLF9 and SOW-NWLF10 were collected in areas believed to be outside the area to be excavated to address chromium contamination in sediment. As shown in Table 4-7 and Appendix B-4, chromium was reported at concentrations of 11.2 mg/kg and 17.9 mg/kg in SOW-NWLF9 and SOW-NWLF10, respectively. The significance of these results, which were affected by matrix interferences, will be evaluated under the State of Michigan environmental response program. Wetland soil sample SOW-ITD3C was analyzed for bis-2(ethylhexyl)phthalate. This sample was collected in the drainage ditch south of the site (see Figure 4-2) at a location at which a sample collected as part of the remedial investigation under the State of Michigan environmental response program had an elevated level of this chemical. Bis-2(ethylhexyl)phthalate in sample SOW-ITD3C, which was collected in May 2003, was not detected in sample SOW-ITD3C. This result is included in Appendix B-4.

# Section 9
# Project Management and Organization

## 9.1 Decommissioning Management Organization

S.C. Holdings will maintain responsibility for all site activities conducted under the requirements of License No. SUC-1565. The primary point of contact for S.C. Holdings is the Radiation Safety Officer (RSO) for the SCA Hartley & Hartley Landfill Site, who, at present, is Phillip Mazor, an employee of Waste Management, Inc.

Figure 9-1 shows the organizational structure for the decommissioning of the S.C. Holdings Hartley & Hartley Landfill Site. This arrangement serves to minimize administrative functions, keep overhead costs to a practical minimum, provide maximum flexibility for resource allocation, and facilitate S.C. Holdings' oversight of the decommissioning operations. The subsections below describe the decommissioning organization.[12]

## 9.2 Decommissioning Task Management

Radiation Work Permits (RWPs) will be used for the administrative control of personnel entering or working in areas that may have radiological hazards. Work techniques will be specified in such a manner that the exposure for all personnel, individually and collectively, is maintained As Low As Reasonably Achievable (ALARA).

RWPs will not replace the Radiation Safety Program (Waste Management, 1993); rather, they will supplement those procedures. The radiation work described in this Decommissioning Plan will be considered when specific procedures are developed for work in a radiologically controlled area. RWPs will describe the job to be performed, define protective clothing and equipment to be used, and identify personnel monitoring requirements. RWPs will also specify any special instructions or precautions pertinent to radiation hazards in the area, including listing the radiological hazards present; the area dose rates, and the presence and intensity of hot spots; removable surface radioactivity; and other hazards as appropriate. The RSO will ensure that ambient radiation, surface radioactivity, and airborne radioactivity surveys are performed, as required to define and document the radiological conditions for each job.

[12] An individual may serve one or more roles during decommissioning. Likewise, each role described herein may be fulfilled by more than one individual. Those individuals specifically assigned to each role will be named and their qualifications presented in the associated workplans.

RWPs will be established for tasks with an elevated dose potential, or the possibility of significant radiological hazards. These RWPs will be reviewed and approved by the RSO prior to implementation.

## 9.3 Decommissioning Management Positions and Qualifications

Site decommissioning will be implemented by personnel possessing the appropriate qualifications and experience to serve in the project roles assigned to them. Figure 9-1 presents the organization of decommissioning roles and assignments. The following is a description of the key positions in this organization.

### 9.3.1 Radiation Safety Officer

The RSO will have an Associate degree (or equivalent), and should have completed course work and/or have experience with the following:

- Principles and practices of radiation protection
- Radioactivity measurements, monitoring techniques, and the use of instruments
- Mathematics and calculations basic to the use and measurement of radioactivity
- Biological effects of radiation
- Safety practices applicable to protection from the radiation, chemical toxicity, and other properties of the radioactive materials in use at the SCA Hartley & Hartley Landfill Site
- Radiological surveys and the evaluation of results
- Evaluation of radioactive material processing facilities for proper operations from a radiological safety standpoint
- Familiarity with applicable USNRC, USEPA, and OSHA regulations, as well as the terms and conditions of any licenses and permits issued to S.C. Holdings by these agencies

The RSO is an individual who, by virtue of qualifications and experience, has been given the authority to implement the Radiation Safety Program for the SCA Hartley & Hartley Landfill Site. The RSO is qualified to direct the use of radioactive material for its intended purpose in a manner that protects health and minimizes danger to life or property. The RSO is responsible for recognizing potential radiological hazards, developing a radiation safety program to protect against these hazards, training workers in safe work practices, and supervising day-to-day radiation safety operations.

The RSO is responsible for recommending the type and quantity of staff and resources necessary for full implementation of the Radiation Safety Program. The RSO has the responsibility and authority to terminate any work activities that could or do violate regulatory requirements for radiological protection pursuant to "Stop Work Authority."

### 9.3.2 Other Management Positions

*Decommissioning Contractor*

S.C. Holdings will retain a Decommissioning Contractor to implement this Plan under the direction and control of S.C. Holdings. The Decommissioning Contractor, to be selected by S.C. Holdings following USNRC approval of this Plan, will prepare the final workplans, prequalify and select all subcontractors, monitor subcontractor's performance, perform and document the Final Status Surveys, facilitate communications with federal and state regulatory authorities, and provide on-site project management and site-specific health and safety support (radiological, industrial hygiene, and industrial safety) during the construction phase. To fulfill this role, the Decommissioning Contractor will have demonstrated experience in facility decommissioning, industrial safety/surveillance, radiological safety/surveillance, license/regulatory interactions, negotiations and compliance demonstration, development of technical bases for radiological operations, and preparation of standard operating procedures to implement these technical bases.

*Project Manager*

The Decommissioning Contractor will designate an individual to serve as the Project Manager on behalf of S.C. Holdings. The Project Manager will be responsible for the following:

- Verifying that the personnel used by each subcontractor are provided with the proper radiation protection and industrial safety training, and that they possess the requisite knowledge of the details of the job assignment
- Observing work in progress to verify adherence to the radiological and industrial safety rules and procedures
- Recommending changes to operational and radiological protection practices to the subcontractors
- Enforcing compliance with S.C. Holdings' site rules and license requirements
- Reviewing reports and results provided by subcontractors

- Establishing and maintaining a records management system to verify that project documents, such as correspondence, procedures, drawings, specifications, contract documents, changes to documents, and inspection records, are controlled

### *Health and Safety Officer*

The Health and Safety Officer (HSO) will report to the Decommissioning Project Manager. The HSO will be a health physicist who will be present at the SCA Hartley & Hartley Landfill Site during all on-site work. This person will be knowledgeable in the following radiation protection and industrial safety topics:

- Principles and practices of radiation protection
- Radioactivity measurements, monitoring techniques, and the use of instruments
- Mathematics and calculations basic to the use and measurement of radioactivity
- Biological effects of radiation
- Safety practices applicable to protection from radiation, chemical toxicity, and other properties of the materials that may be encountered during the decommissioning
- Radiological surveys and evaluation of results
- Evaluation and implementation of the final workplans for proper operations from a radiological safety standpoint
- Applicable USNRC, USEPA, and OSHA regulations, as well as the terms and conditions of any licenses and permits issued by regulatory agencies to Waste Management
- The requirements contained in USNRC License No. SUC-1565

The responsibilities of the HSO will include, but are not limited to, the following:

- Establishing the health and safety requirements for field activities
- Verifying that subcontractors implement the requirements of the Radiation Safety Program in an acceptable manner
- Evaluating both chemical and radiation health and safety issues in conjunction with the RSO

- Reviewing the results of surveys, sampling, and environmental monitoring to identify trends and potential for personnel exposure
- Evaluating the effectiveness of engineering and administrative control, including the requirements for personal protective equipment
- Developing new safety protocols and procedures necessary for new field activities
- Providing internal review and approval for work-related documents
- Auditing key aspects of the Health and Safety Program
- Making recommendations to the Project Manager regarding the control of existing and potential industrial, chemical, and radiological hazards
- Stopping work if conditions indicate the potential for unnecessary radiation exposure to site personnel or members of the public, or for unsafe working conditions

*Quality Assurance Officer*

The Decommissioning Contractor will assign a Quality Assurance Officer (QAO) for the project. The QAO will be responsible for the following:

- Providing technical assistance and peer review of all deliverables
- Preparing and reviewing the QAPP
- Coordinating with the analytical laboratories, as necessary
- Overseeing subcontractor quality control activities to ensure compliance with the QAPP
- Tracking laboratory submittals and sample analyses, and verifying delivery of data, as necessary
- Coordinating validation of analytical data
- Monitoring the on-site activities
- Preparing and submitting QA reports, as required

## 9.4 Training

All Waste Management employees, and consultants and contractors working on decommissioning activities with unescorted access to the facility will be trained in regard to the type and magnitude of the radiological, chemical, and physical hazards they might face (all visitors to the site will be escorted). The following subsections briefly describe the various training programs that will be implemented by the RSO or his/her designee as part of this Decommissioning Plan.

### 9.4.1 Visitor Training

Visitors to the work zone will be trained by reading and signing a briefing form. The briefing form will contain information about the hazards present in the work zone, the requirement that all visitors be escorted while on-site, and information about who the visitor should contact if they have questions.

### 9.4.2 General Employee Training

General Employee Training (GET) in radiation protection will be administered to all project personnel who will have the potential to receive more than 100 millirem total effective dose equivalent (TEDE) during implementation of this Plan. GET, to be provided at the start of fieldwork, will consist of an oral presentation by the HSO, hand-out materials, and completion of a form acknowledging receipt of training. GET will address the following topics:

- The type and form of radioactive material present at the facility
- The location of the USNRC's and S.C. Holdings' radiation protection policies and procedures
- Employee and management responsibilities for radiation safety
- Identification of radiation postings and barriers
- Protective equipment and procedures
- Work zone setup and decontamination procedures
- Emergency procedures
- How to contact S.C. Holdings representatives and project radiation safety staff

A self-graded exam to test employee proficiency in the class subject matter will be administered. A passing score of 70 percent is required.

### 9.4.3 Radiation Worker Training

Radiation Worker Training (RWT) will be administered to all project personnel who will have the potential to receive more than 500 millirem TEDE during implementation of this Plan. RWT will address the following topics:

- Radioactivity and radioactive decay
- Characteristics of ionizing radiation

- Manmade radiation sources
- Acute effects of exposure to radiation
- Risks associated with occupational radiation exposures
- Special considerations with respect to exposure of women of reproductive age
- Dose-equivalent limits
- Modes of exposure (internal and external)
- Dose-equivalent determinations
- Basic protective measures (time, distance, and shielding)
- Specific procedures for maintaining exposures As Low As Reasonably Achievable (ALARA)
- Radiation survey instrumentation (calibration, use, and limitations)
- Radiation monitoring programs and procedures
- Contamination control, including protective clothing, equipment, and workplace design
- Personnel decontamination
- Emergency procedures
- Warning signs, labels, and alarms
- Responsibilities of employees and management
- How to contact S.C. Holdings' representatives and project radiation safety staff

RWT will consist of a classroom lecture and procedure review, a 2-hour practical demonstration, a question/answer period, and a handout. The duration of training is approximately 6 hours. A self-graded exam to test employee proficiency in the class subject matter shall be administered. A passing score of 70 percent is required.

### 9.4.4 Tailgate Safety Training

A tailgate safety meeting will be conducted at the beginning of each work shift, whenever significant changes in job scope are made, whenever significant changes in site conditions (physical or radiological) occur, or whenever new personnel arrive at the job site. Health and safety procedures and issues for the day, any unique hazards associated with an activity, and a review of any significant topics from previous activities will be presented at this meeting. The information discussed will be recorded, which will serve as confirmation that the information was presented to those persons whose signatures are on the form. There will be at least one signed form for each work shift. All tailgate safety training forms will be incorporated into the decommissioning records.

### 9.4.5 Training Records

A form will be developed to demonstrate that training commitments have been met. This form will include the following information: the facility name; the date; the time; the task number; the type of work; the hazardous/radioactive materials used; the protective clothing/equipment used; the chemical, radiological, and physical hazards; emergency procedures; the hospital's/clinic's telephone numbers; the paramedic's telephone number; the hospital's address; any special equipment needed; and any other safety topics that may be relevant. All training records will be incorporated into the decommissioning records.

## 9.5 Contractor Support

The efforts of the Decommissioning Contractor will be focused on nuclear, health and safety, regulatory compliance, and project management matters. Specialty services necessary to complete certain aspects of the Plan (*e.g.*, engineering design, construction, surveying, and laboratory analyses) may be subcontracted to firms with the appropriate skills and experience. Each subcontractor will designate a Task Manager and, as necessary, a health and safety and/or quality control contact, who will report to the Task Manager. At all times, however, the Decommissioning Contractor will remain responsible for the scope, quality, and timeliness of services provided by all subcontractors. The RSO will verify that the subcontractor personnel are adequately informed of the hazards, the preventive measures, and the procedures associated with performing each decommissioning task. The RSO will verify that subcontractor personnel perform decommissioning activities in accordance with all license commitments and USNRC requirements.

# Section 10
# Health and Safety Program During Decommissioning

S.C. Holdings will complete the decommissioning action described herein in a manner that protects workers, the surrounding environment, and the public. The Radiation Safety Program established by S.C. Holdings (Waste Management, 1993) and documented in License No. SUC-1565 serves as the basis for exposure limits and minimizes the spread of contamination.

Comprehensive health and safety requirements and access controls will be specified in the final workplans. A site-specific Health and Safety Plan (HSP) will be developed to describe the practices to reduce employee exposure to radioactive materials and hazardous chemicals, as well as construction safety concerns. The HSP will remain in effect during all on-site decommissioning activities. S.C. Holdings will maintain documentation sufficient to demonstrate the effectiveness of the health and safety program.

On-site health and safety will be monitored by the Health and Safety Officer (HSO), operating under the direction of the Radiation Safety Officer (RSO), and pursuant to the requirements of the license. As necessary, the HSO will conduct tailgate safety training, implement the surveillance and individual monitoring programs, perform release surveys for personnel and equipment during decommissioning operations, and maintain all health and safety records generated during the decommissioning efforts.

The Decommissioning Contractor's operations, and those of all subcontractors, will be governed by procedures that meet the requirements of 10 CFR 19 and 20, and License No. SUC-1565. The procedures described in the Radiation Safety Program (Waste Management, 1993) were reviewed by the USNRC as part of the license application process. At a minimum, the Decommissioning Contractor will maintain copies of the following procedures, along with their technical basis, at the site for regulatory inspection:

- Radiation Safety Program
- Health and Safety Plan
- Training and qualifications of radiation protection and safety personnel
- Training requirements in radiation, chemical, and industrial safety

- Medical surveillance and radiation exposure monitoring
- Instrumentation

Copies of these procedures, as applicable, will be present at the job site. Deviations from the procedures will be approved by the RSO.

Each member of the project team will assume certain health and safety responsibilities. These will include, but are not limited to, the following:

- The RSO will be responsible for overseeing implementation of the Radiation Safety Program and making changes to reflect field conditions that were not anticipated during that program's development. Changes to the Radiation Safety Program will be made only with the approval of the RSO.
- The HSO will be responsible for implementing the HSP, and for recommending to the RSO any changes to the HSP.
- The designated health and safety contact for each subcontractor will be responsible for verifying field implementation of the HSP's provisions. This will include communicating site requirements to all personnel on the job, supervising field activities, and consulting with the HSO regarding appropriate changes to this Decommissioning Plan.
- All on-site project team members will be responsible for understanding and complying with all site health and safety requirements, including proper maintenance of health and safety equipment and facilities. This understanding will be documented by signature prior to any team member being authorized to work on decommissioning operations.

S.C. Holdings will provide a workplace in which employees, visitors, and contractors are adequately protected from hazards, including the hazards associated with exposure to radiation and radioactive material. While the exposures associated with the planned decommissioning operations are low, all exposures are assumed to entail some risk to employees, visitors, and contractors. Therefore, S.C. Holdings has adopted the following three principles to govern decommissioning work activities with the potential for exposure to radiation or radioactive materials:

- No activity or operation will be conducted unless its performance will produce a net positive benefit.
- Radiation exposures will be kept As Low As Reasonably Achievable (ALARA), considering economic and societal costs.
- No individual will receive radiation doses in excess of federal limits.

The ALARA requirement will be communicated to all subcontractors at the outset of this project. All individuals must understand their responsibilities to reduce their radiation exposure. Methods to be used to reduce exposure will be reviewed during GET and tailgate safety training. Monitoring and surveillance information will be summarized and reviewed by the workforce on a planned and periodic basis. Requirements to implement the ALARA program at the SCA Hartley & Hartley Landfill Site are described in the Radiation Safety Program (Waste Management, 1993).

## 10.1 Radiation Safety Controls and Monitoring for Workers

Radiation, airborne radioactivity, and contamination surveys will be conducted during site decommissioning in accordance with the procedures described in the Radiation Safety Program. The purposes of these surveys are as follows:

- To protect the health and safety of workers
- To protect the health and safety of the general public
- To demonstrate compliance with the applicable license, federal and state requirements, as well as Decommissioning Plan commitments

Radiation safety personnel assigned to the project will assess the effectiveness of posted warning signs during the conduct of these surveys. Surveys will be conducted using survey instrumentation and equipment suitable for the nature and range of hazards anticipated. Equipment and instrumentation will be calibrated, and where applicable, operationally tested prior to use in accordance with procedural requirements. Routine surveys will be conducted at a specified frequency to ensure that contamination and radiation levels in unrestricted areas do not exceed license, or federal, state, or site limits. The HSO or his/her designee, will also perform surveys during decommissioning whenever work activities create a potential to impact radiological conditions.

Control levels for radiation exposures have been established for this decommissioning action. Based on knowledge of the radiological constituents present at the site and the existing exposure rates, the maximum individual exposures are not expected to exceed 300 millirem total effective dose equivalent (TEDE) over the life of the project. The radiation dose is based on the potential exposure to both external and internal sources of radiation. The sources of external radiation average 10 micro R per hour (μR/hr) whole body exposure. Assuming 50 hours per week of exposure and 4 weeks of time during construction of the cover for the Northwest Landfill, the calculated exposure is less than 2 millirem of whole body external exposure. Internal exposure is estimated to be less than 10 percent of the derived air concentration (DAC) for thorium and the associated progeny. This potential dose corresponds to less than 20 DAC-hours of exposure. If air samples detect the presence of gross alpha radiation in excess of 10 percent of the DAC for thorium-232, the RSO will evaluate the need for a bioassay program, as specified in Section 4.5 of the Radiation Safety Program. The detection limit of a bioassay sample collection process is less than 300 millirem for the project duration. Surveillance will be performed by the Decommissioning Contractor to verify that exposures are minimized and within acceptable guidelines.

As required in 10 CFR 20.1502, the need for individual monitoring for internal and external exposures will be determined and documented prior to the start of work based on existing data. Potential exposures to personnel working at the site during decommissioning include direct contact (*e.g.*, ingestion exposure pathway) and airborne dusts that may be contaminated (inhalation exposure pathway). Personnel will perform routine monitoring for radioactive contamination to minimize the spread of contamination and consequently the ingestion pathway. Exposures from contamination in surface water and sediment are less likely because the concentrations of radioactive materials in these media are similar to background levels, based on resampling performed in May 2003 (see Subsection 4.4.10). However, because the exposure potential is expected to be less than 500 millirem TEDE, individual monitoring for on-site personnel is not required. Nonetheless, at the discretion of the HSO, individual monitoring may be implemented.

### 10.1.1 Air Sampling Program

The Air Sampling Program for the decommissioning activities will generally consist of samples collected in a work location that is representative of the air that a worker breathes.(13) However, the head of the sampling device will not be placed in such a manner as to interfere with the work or the normal movements of the worker.

Appropriate air sampling equipment will be selected. The type of sampling that is desired will determine the appropriate collection media (*e.g.*, glass fiber, cellulose, membrane, or quartz) required to collect the contaminant. The frequency at which air filters will be changed will be determined based on the radiological and physical condition of the work location, worker stay times, and the type of air sampling performed. Air samples will be collected in accordance with NUREG-1400 (USNRC, 1993b).

Air sampling will be performed prior to initiating construction activities to document antecedent radioactive levels (*i.e.*, background), as soon as operations begin, and routinely during construction, and after any significant changes in operating conditions. Sampling durations will be determined prior to the start of sample collection, based on

(13) Stationary air monitors may be used to evaluate exposures to the public and workers, to determine and track airborne radiological conditions, to verify the effectiveness of engineering and process controls, to promptly detect any loss of control of airborne material, and to satisfy regulatory requirements. These devices, along with the breathing zone sampling, will be used as input to respiratory protection decisions and for tracking internal dose potential.

how routinely or nonroutinely the area is occupied, the likelihood of exceeding a predetermined percentage of a derived air concentration (DAC) or DAC-hour exposure, the length of time required by the operating activity, and any other conditions as warranted. The minimum detectable concentration (MDC) is also a determining factor for sampling duration and will be evaluated prior to sample collection. MDC will be based on 10 percent of the specified DAC.

Following air sample collection, the filter media will be counted with sufficient time (typically 1 minute) to achieve the minimum detectable activity (MDA) for the specific type of radioactivity. After the count, the activity of the air sample will be calculated and compared with the specific DAC value of the radionuclide being sampled. An action level will be based on not exceeding 10 percent of the applicable annual limit on intake (ALI) and DAC regulatory values listed in 10 CFR 20, Appendix B, Table 1. Measurement results will be reported in units of concentration.

Samplers will be charged, calibrated, deployed, and retrieved by the HSO (or designee). Filters will be collected on a daily basis and stored for at least 24 hours in order for the short-lived radon progeny to decay. The samples will then be counted in-house for determination of gross alpha activity. Any filters with gross alpha activity significantly in excess of background (*i.e.*, three times background) will be forwarded, by overnight carrier, to a commercial analytical laboratory for determination of the presence of thorium and uranium isotopes. The laboratory will establish the minimum detectable activity for specific isotopes; the results will be reviewed to establish a consistent ratio between the gross alpha results measured in the field and the isotope-specific activities recorded by the analytical laboratory. Documentation of breathing zone sampling will be maintained on standardized forms, which will be placed in the decommissioning records. A Chain-of-Custody Form will be completed for all laboratory transfers.

### 10.1.2 Respiratory Protection Program

In controlling the concentrations of radioactive materials in air, the use of process controls, engineering controls, or administrative procedures will be used. Examples may include the use of stay times, exhaust ventilation, diversion of airflow, dust suppression, fixative coatings, or some combination of methods. The use of respiratory protection will be implemented only if these methods are deemed ineffective at controlling intakes of radioactivity by workers.

In the event that respiratory protection is implemented by the HSO, the program will require the use of equipment that is certified by the National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA) and procedures that comply with 10 CFR 20, Subpart H. The RSO, the Decommissioning Project Manager, and the HSO will concur on the need, and on the procedural requirements, for a Respiratory Protection Program, prior to implementation.

Air-purifying respirators approved by NIOSH and/or MSHA include full-face piece assemblies with air-purifying elements to provide respiratory protection against hazardous vapors, gases, and/or particulate matter to individuals in areas with airborne radioactive materials. Individuals may be required to use full-face supplied-air respirators for work in areas with actual or potential airborne radioactivity. The RSO will also ensure that the Respiratory Protection Program meets the requirements of 10 CFR Part 20, Subpart H.

When respiratory protection equipment requires cleaning, the filter cartridges will be removed. The respirator will be cleaned and sanitized after every use with a cleaner/sanitizer and then rinsed thoroughly in warm water in accordance with the Radiation Safety Program (Waste Management, 1993).

Respiratory protective equipment will be kept in proper working order. Any respirator that shows evidence of excessive wear or that has failed inspection will be repaired or replaced. Respiratory protective equipment that is not in use will be stored in a clean dry location.

### 10.1.3 Internal Exposure Determination

A combination of indirect bioassay and breathing zone air sampling may be used to determine internal exposures incurred by on-site workers during decommissioning. The Indirect Bioassay Program would consist of baseline, termination, and routine monitoring at a frequency sufficient to assess Committed Effective Dose Equivalents (CEDEs) equal to a fraction of the Annual Limit on Intake (ALI). In addition, "special" or "diagnostic" sampling will be implemented in the event air sample data and/or process knowledge warrant stricter control and monitoring. All samples will be analyzed by a laboratory that meets the performance criteria in ANSI N13.30.

The RSO (or designee) will determine the validity of bioassay and air monitoring results prior to their inclusion in the internal dose assessment process. The RSO will typically evaluate the following items to ascertain the validity of monitoring results:

- Sample collection errors
- Radiation background interference during counting
- Calibration errors
- Computer software errors

- Errors due to counting geometry
- Statistical errors

Only valid bioassay or air monitoring results, as determined by the RSO, will be used for assessment of internal radiation dose. Different weighting factors would be used for an adult or a declared pregnant woman. No minors will be allowed on this site during the construction phase of the decommissioning effort.

If the data are not valid, the RSO will document the basis for that conclusion, and will include the documentation in the individual's dosimetry record. The RSO will also estimate the internal dose to the individual via other means and will include the estimate in the individual's exposure history. The RSO will identify the route of entry (*e.g.*, inhalation or ingestion) as the most likely route based upon current knowledge of exposure conditions. The lung clearance class for intake by inhalation will be selected based upon current knowledge of the chemical form and/or particle size. The assessment of internal radiation dose will follow the requirements of the USNRC Regulatory Guide 8.9 (USNRC, 1993) and ANSI 13.30 (ANSI, 1996).

The stochastic committed effective dose equivalents for the organ or tissue of interest ($CEDE_T$) incurred by workers will be estimated using the following equation:

$$CEDE_T(millirem) = \frac{Intake}{ALI_s} x\, 5{,}000,$$

where

| | | |
|---|---|---|
| Intake | = | the activity taken into the body as determined from bioassay measurements, |
| $ALI_s$ | = | the stochastic Annual Limit on Intake for the radionuclide of interest. |

### 10.1.4 External Exposure Determination

Monitoring for radiation exposures from sources that are outside of the body (external exposure monitoring) will be conducted in accordance with the Radiation Safety Program, as warranted. Monitoring may, as determined by the RSO, be extended to visitors or others, depending on the extent of the radiological hazards present in the work areas to be entered. However, individual monitoring devices will only be provided to individuals with the potential to meet or exceed 500 mrem effective dose equivalent in a calendar year.

Individual monitoring devices, at a minimum, will consist of a whole body thermoluminescent dosimeter (TLD) or equivalent (*e.g.*, an optical dosimeter). The dosimeter will be able to measure radiation levels as high as 5,000 mrem/quarter and will be able to measure at least 10 mrem/quarter The TLDs will be ordered from a vendor who has been approved in advance by the Decommissioning Contractor, and whose program has met the requirements of ANSI N13.11. In addition, the vendor must demonstrate accreditation by the National Voluntary Laboratory Accreditation Program (NVLAP).(14)

A number of additional external exposure control methods will be implemented during the decommissioning efforts, such as RSO review and validation of all monitoring results and the application of "time," "distance," and "shielding" in the workplace. In all cases, however, they will be consistent with the requirements and procedures described in the Radiation Safety Program. Radiation surveys will be conducted by the RSO in order to supplement personnel monitoring. The gamma exposure rate will be monitored during times when there is the potential for employees to come into direct contact with the slag. Action levels are specified in the Radiation Safety Program for the site (Waste Management, 1993).

### 10.1.5 Summation of Internal and External Exposures

Internal and external radiation exposures will be assessed at least each quarter during field decommissioning activities. The total organ dose equivalent (TODE) is computed by summing the deep dose equivalent ($H_D$) from external sources, as determined from external radiation monitoring, and the committed dose equivalent (CDE), as determined from internal radiation monitoring.(15) The total effective dose equivalent (TEDE) is determined by summing the committed effective dose equivalent (CEDE) from sources internal to the body, and the $H_D$. The TEDE will be compared to the acceptable radiation level, depending on the worker's classification. That is, a declared pregnant woman is allowed to receive 500 mrem over a 9-month gestation period. An adult radiation

(14) The use of extremity monitoring or multiple dosimetry is not applicable to this work because uniform exposures are expected. The use of dosimeters equipped with alarms will not be required at this site based on site-specific knowledge and previous site surveys, and because general area dose rates demonstrate that dosimeters equipped with alarms are unnecessary. Furthermore, external dose from airborne radioactive material is negligible and not a viable exposure pathway at this site. Therefore, these issues will not be discussed further in this Decommissioning Plan.

(15) If external radiation monitoring is not performed, $H_D = 0$.

worker is allowed to receive 1,250 mrem/quarter. Records for radiation monitoring of site personnel will be retained as described in the site license.

### 10.1.6 Contamination Control Program

The procedures for limiting access to contaminated areas will address the responsibilities of all authorized personnel; contamination limits; posting, labeling, and tagging requirements; protective clothing requirements of each level of contamination encountered; entry and exit requirements; measurement methodologies; and decontamination of personnel and training requirements, as described in the Radiation Safety Program (Waste Management, 1993). Routine surveys will be performed throughout the decommissioning process, with each survey being planned in advance with regard to the specific radiation type, the predetermined radiation levels, the location where radiation is expected, and any special condition warranting a survey.

The initial level of protection for the intrusive tasks of this decommissioning operation (*i.e.*, where residual radioactivity may be encountered) will be hard hats, Tyvek® or cloth coveralls, safety glasses with side shields, steel-toed boots, and gloves. Upgrading or downgrading the level of protection will be based on ambient conditions as work proceeds. The HSO will notify the RSO if it is deemed necessary to upgrade to a higher level of protection.

To ensure that radioactive materials remain under the control of S.C. Holdings, each worker involved in this decommissioning effort and working in a contaminated area will be frisked using calibrated, hand-held instruments prior to leaving the contaminated work area. Equipment and materials will be frisked and decontaminated, as necessary, prior to exiting the controlled area. Records of release surveys will be maintained on standardized forms and maps and will be placed in the decommissioning records. Release criteria will be consistent with those contained in the Radiation Safety Program.

In the event that a sealed radioactive source is used at the site, the RSO will verify the conditions of the license, which regulates the use of the sealed source. This will include verifying the training of the operators and the frequency of wipe tests.

### 10.1.7 Instrumentation Program

Radiation survey equipment and instrumentation suitable for detecting and quantifying the radiological hazards to workers and the public will be present on-site throughout the remediation and final release surveys. The selection of equipment and instrumentation to be utilized will be based upon knowledge of the radiological contaminants, concentrations, chemical forms, and chemical behaviors that are expected to exist as demonstrated during radiological characterization, and as known through a review of the operating history of the SCA Hartley & Hartley Landfill Site. Equipment and instrumentation selection will also take into account the working conditions, contamination levels, and source terms that are reasonably expected to be encountered during the performance of decommissioning work, as presented in this Plan. In all cases, the program will be consistent with the requirements in Radiation Safety Program (Waste Management, 1993).

All instruments will be calibrated and maintained according to the Radiation Safety Program and ANSI Standard N323-1978 (ANSI, 1978). All instruments will be calibrated using radiation sources that are traceable to the National Institute of Standards and Technology (NIST). If applicable, each rate meter will be calibrated with a specific detector.

Each instrument will be response-checked using a reference source, and pre-operational checks will be performed on each instrument on a daily basis or as needed. Preoperational checks will include battery function, high voltage, response to reference source, reset button function, audible response function if applicable, physical condition, current calibration, and response to background radiation. These results will be documented, and any instruments failing any of the preoperational checks will be tagged and taken out of service.

## 10.2 Nuclear Criticality Safety

The licensed radioactive materials present at the SCA Hartley & Hartley Landfill Site are natural uranium and natural thorium, with progeny in equilibrium. The uranium-235 activity in the slag is less than 1 percent by weight, meaning it does not meet the definition of Special Nuclear Material found in 10 CFR 70.4. Because the radioactive materials (the slag) cannot trigger or sustain a critical reaction, nuclear criticality safety measures are not necessary.

## 10.3 Health Physics Audits, Inspections, and Record Keeping

During the implementation of this Plan, at least one assessment each year of site personnel's compliance with the Health and Safety Plan will be performed by the RSO or his/her designee. Informal compliance assessments and inspections will be completed by the HSO on a daily basis, with unexpected, nonconforming, and unusual items and situations documented, along with their resolution. During the course of construction at the site, at least one assessment will include a review of each element of the Radiation Safety Program, including but not limited to: occupational radiation exposure, radiation surveys, training, and release of equipment for unrestricted use.

## 10.4 Public Health and Safety Requirements

The safety of the public during the decommissioning project is an important priority. S.C. Holdings is committed to minimizing the likelihood that public health and safety will be compromised or impacted during the project. Therefore, access to active construction areas will be limited to authorized construction personnel. Fences and locked gates will be used to eliminate the potential for the public to inadvertently enter the site. If deemed necessary, security guards will be employed to monitor temporary locations where a fence is considered to offer insufficient protection. Signs prohibiting unauthorized entry will also be posted at all gates. Unauthorized access is further restricted by the natural terrain, which is not easily traversed.

The potential spread of contamination off-site will be minimized by surveying persons before they leave the controlled area to verify that no radioactive contamination remains on their clothing. Equipment will also be inspected to verify that no contamination above the limits established by the project plans remains on its surface. Airborne dust and debris will be minimized by the use of wet methods during intrusive work, as feasible.

## 10.5 General Health and Safety Requirements

General health and safety requirements for the decommissioning effort will be designed to meet the requirements of the OSHA Construction Standard (29 CFR 1926), applicable USNRC regulations, and other site-specific requirements established by S.C. Holdings. The requirements will remain in effect throughout the decommissioning process. The following issues will be addressed in the Health and Safety Plan (HSP), prepared by an individual who is certified by the American Board of Industrial Hygiene:

- A description of the facility or site, including the availability of resources such as roads, water supply, electricity, and telephone service
- A description of the known hazards and an evaluation of the risks associated with the incident and with each activity conducted
- A list of key personnel (including the Health and Safety Officer) and their alternates who are responsible for site safety and response operations, and for protection of public health
- A delineation of the work area, including a map
- A description of the levels of protection to be worn by personnel in the work area
- A description of the medical monitoring program
- The standard operating procedures for verifying the proper use and maintenance of personal protective equipment
- The procedures for controlling site access

- A description of the decontamination procedures for personnel and equipment
- The site emergency procedures and the availability of emergency medical care for injuries, and for radiological and toxicological impacts
- The procedures for monitoring fugitive emissions, including the frequency and the type of monitoring, the monitoring techniques, and equipment calibration and maintenance
- The procedures for protecting workers from weather-related problems

Changes to the HSP may be made by the HSO to accommodate changed field conditions. Changes will be documented and explained to the project personnel as necessary.

A copy of the HSP, as approved by the RSO and the HSO, will be maintained on-site for the duration of the decommissioning effort, and its provisions will be covered in applicable training programs.

### 10.5.1 Site/Area Access Control

The HSO or his/her designee will enter the work area before the daily safety meeting and/or work begins in order to verify that work zones have been appropriately established. The daily site entry procedures follow:

- Determine the wind direction, and stay apprised of it throughout the day, identifying the direction during the tailgate safety meetings and whenever activities with the potential to create airborne dust are performed.
- Confirm the proper placement of emergency information and the operational status of equipment.
- Visually scan for signs of actual or potential life- or health-threatening hazards.
- Note the physical conditions of the site, and determine potential exposure pathways.
- Identify new boundaries of the work zones.
- Document site activities in a "Field Activity Daily Log," including observations related to field conditions and the site, and to the samples collected.

In general, access to the work area will be limited to the Decommissioning Contractor and subcontractor personnel.

### 10.5.2 Medical Monitoring Program

All personnel involved in on-site remedial activities will participate in a medical and health monitoring program. This program will follow the general guidelines established by OSHA in 29 CFR 1910.120. Unscheduled medical examinations may be conducted at the request of an employee after a suspected exposure is measured or reported.

Any team member who develops a lost-time illness or sustains a lost-time injury during production operations will be re-examined by a physician. The physician must certify that the employee is fit to return to work before further participation in the decommissioning effort.

### 10.5.3 Emergency Procedures

In the event of an accident or other emergency situation, appropriate measures will be taken to reduce the affect on worker health and safety. Minor accidents will be investigated by the subcontractor and reported to the HSO. The actions necessary to correct the situation will be documented. A first aid kit will be available in the work area for handling minor incidents. Should there be an incident that cannot be handled by the subcontractor in conjunction with the HSO (*e.g.*, a major accident, fire, or chemical release), the HSO will notify the RSO of the location and the nature of the incident, and what type of assistance is needed. In addition, the HSO will notify the RSO of all first aid incidents, so that the potential for radionuclide uptake through wounds can be assessed.

A list of emergency response telephone numbers will be compiled and distributed during tailgate safety training, and will be posted in the site building. Prior to the start of each day's work activities, the nearest hard-wired telephone will be identified for use during an emergency. A hard-wired telephone will be maintained in the site office building, which will serve as the communications base for the on-site decommissioning work. In addition, a radio will be worn by the HSO, which will be compatible with the communication systems used by the subcontractors. The list of emergency telephone numbers will be readily available on-site, along with the directions to the nearest hospital.

# Section 11
# Environmental Monitoring and Control Program

## 11.1 Environmental ALARA Evaluation Program

S.C. Holdings is committed to reducing exposures to radioactive materials and direct radiation to levels that are As Low As Reasonably Achievable (ALARA). The ALARA requirement extends to exposures to contractor personnel assigned to implement the Decommissioning Plan, to emissions to the environment, and to exposures to members of the public living near the SCA Hartley & Hartley Landfill Site.

Pathways for potential exposure may exist during the construction of the upgraded cover and during intrusive work when the thorium-bearing slag is disturbed. Engineering and administrative controls will be implemented during construction in order to minimize and maintain these exposures to ALARA.

The principal source of potential radiation exposure is contaminated airborne dust that could be inhaled or ingested. To the extent practical, excavated soil will be wetted to reduce the generation of airborne dust to concentrations that are less than 10 percent of the USNRC limits for off-site discharge as described in Subsection 11.3, below (USNRC, 1991).

Air monitoring will be performed to monitor the level of contaminated dust, both near the immediate work areas, as well as in locations designated by the RSO as representing the perimeter of the site. Air sampling stations will be established as described in Subsection 10.1. The RSO will review the results of the Air Sampling Program periodically and will prepare a summary for S.C. Holdings. The report will summarize the air sampling results and the applicable limits, and will identify any trends relating to elevated results. If necessary, the RSO will modify the field practices and verify that the changes were adequate to reduce airborne dust concentrations to ALARA. Any sample that exceeds 10 percent of the USNRC's airborne limit will be reviewed by the RSO within 24 hours after it is identified. The investigation will be documented, and the source of the elevated readings will be identified and evaluated.

To further ensure compliance with the ALARA requirement, personnel working directly with contaminated soil will wear the necessary personal protective clothing to reduce the spread of radioactive contamination and minimize the intake of radioactivity. Portable, calibrated radiation survey instruments will be used to assess radiological conditions and to verify that the workers are free of surface contamination before leaving the restricted area and the facility at the end of every work shift. A description of the contamination control program is provided in Subsection 10.1.6.

## 11.2 Effluent Monitoring Program

The primary routes of contaminant transport during the on-site decommissioning activities are anticipated to be airborne dust from the handling of the waste, preparation of the site, covering operations, and from the movement of vehicles and equipment. The location from which potential contaminant migration is most likely to occur is the Northwest Landfill, where licensed materials are currently landfilled, and where the existing cover will be upgraded. There are also two other small areas at which licensed material is known to be stored outside of the Northwest Landfill (Slag Piles A and B). Radioactive constituents in these areas could become airborne during excavation of the slag from these areas for consolidation within the Northwest Landfill. Other areas that have the potential for effluent discharges (airborne transport of dust) include temporary haul roads that may be used for transporting radioactive materials to the Northwest Landfill, and the residual radioactivity on concrete pads or other surfaces scheduled for decontamination.

Area air samples will be collected in locations that present the possibility of airborne effluent releases. In addition, samplers will be positioned downwind of work locations to ensure that the samples collected within the immediate work area are representative of actual releases. The positions of the air samplers will be evaluated frequently by the HSO to take into account any shifts in prevailing wind direction and any movement in the locations of dust-generating operations.

Air samples will be collected as described in the Radiation Safety Program, which addresses air sampler and filter selection, sampling durations and frequencies, sampler calibration, and action levels for airborne activity. In general, environmental air samples will be collected at the following frequencies: before operations with radioactive materials begin to determine a baseline value for airborne activity, as soon as decommissioning operations begin and routinely thereafter, and after any significant change in operating conditions. Air samples will be collected during any dust-generating operations. The frequency of sample collection will be determined based on the radiological and physical conditions present at the work location and the type of air sampling being performed. Consideration will be given to more frequent filter changeouts during high dust conditions, as determined using best professional judgment.

Air sampling results will be recorded on standard survey forms, which will include information such as the sample location and number, the date and time of sample collection, the volume sampled, the type of air sampler and filter used, the analytical results, the sample MDA, and the calculated airborne concentrations.[16] Sampling information will be incorporated into the final status survey report and the decommissioning records. Filters that exceed action levels set in the Radiation Safety Program will be stored and recounted after an appropriate length of time and/or forwarded to a commercial analytical laboratory for further analysis. The HSO will inform the RSO of the results for samples that exceed action levels, and the results for the confirmation testing.

## 11.3 Effluent Control Program

Waste materials that could become airborne during the various operations described in Section 8 provide the most likely migration pathway through which contaminants could enter the environment during the decommissioning process. Measures that may be instituted to minimize the release of airborne materials to the environment include the application of water spray to excavation areas, to materials in the cover area during grading and compaction, and during the off-loading of earthen materials from vehicles and equipment. Dust suppressant materials, such as calcium chloride, may be used on temporary haul roads.

Actions to be taken in the event an action level for airborne releases is exceeded include the following: stopping the suspect work activity; conducting additional air, radiation, and contamination surveys as applicable; notifying the RSO; preparing dose estimates for workers and the general public because of the release; and implementing corrective measures to site work procedures and this Plan, as necessary, to prevent future releases.

The potential for releases of site contaminants via surface water runoff will be controlled by silt fence and by not exposing radioactive materials during a precipitation event, and by consolidating and covering any exposed radioactive material at the end of each work day (in case of precipitation during a nonworking period).

Radiation dose to the public will be estimated based on air samples collected at the perimeter of the SCA Hartley & Hartley Landfill Site. The dose will be calculated using the methods described in Subsection 10.1.3.

[16] The calculation of the sample MDA will be performed in accordance with the Radiation Safety Program (Waste Management, 1993).

# Section 12
# Radioactive Waste Management Program

## 12.1 Solid Radioactive Waste

The materials that are the focus of the decommissioning activities are the licensed radioactive materials in the Northwest Landfill and in the two piles that are located outside of the Northwest Landfill (these piles [Slag Piles A and B] contain the same thorium-bearing slag as was placed in the Northwest Landfill). All of these thorium-bearing slag materials satisfy the requirements of Class A Waste, as defined by 10 CFR 61. The slag materials are noncombustible solids. The estimated volumes of material at each location, including licensed material (slag) and intermingled solids, such as non–thorium-bearing slag, soil debris, and other nonlicensed wastes, are listed in Table 12-1.

All of the thorium-bearing slag will be contained within the covered area of the Northwest Landfill. No radioactive waste is expected to be shipped off-site for disposal. The temporary storage of materials on-site will be minimized. Residual radioactive waste above the applicable release criteria will be transported to the Northwest Landfill for disposal under the upgraded cover.[17]

As practical, disposable equipment and supplies, such as personal protective equipment, air filters, and wipe samples, will be transported to the Northwest Landfill and placed under the upgraded cover. Alternatively, such articles may be surveyed to verify that they satisfy the radioactive release criteria for off-site disposal in a licensed Waste Management, Inc., landfill. The RSO will verify that any disposable equipment and supplies shipped off-site are suitable for the planned alternative disposal method.

## 12.2 Liquid Radioactive Waste

Liquids containing radioactivity above background levels may be generated during the decommissioning process. Leachate within the Northwest Landfill may be encountered during grading of this area. Additionally, the material in Slag Piles A and B may be saturated (by groundwater) when these piles are excavated if the water table happens to be elevated. Moreover, water spray that is used to minimize dust generation could become contaminated

[17] As described in Section 11, excavated materials from Slag Piles A and B, and the radioactive materials in the Northwest Landfill, will be sprayed with water to minimize dust generation during excavation, grading of piles, off-loading of materials from vehicles/equipment, etc.

above background levels. In any event, the volume of liquid potentially containing radioactive material will be ALARA.

Any liquid that is generated during the decommissioning process that may contain radioactivity above the MCLs for drinking water will be containerized (in appropriate and labeled containers) and tested to determine disposal requirements and options. If a liquid does not contain radioactivity above background levels, it will be disposed in accordance with applicable criteria for chemical (nonradioactive) constituents as "investigation-derived waste." Disposal of these types of liquids may range from on-site discharge (in a nonnuisance manner) to transport, treatment, and disposal at a licensed off-site facility. Disposition of liquid investigation-derived waste will be documented in the decommissioning records.

If a liquid contains radioactivity above the MCLs for drinking water, it will be discharged to the Northwest Landfill if there is a suitable location within the slurry wall around the Northwest Landfill for a liquid to rapidly infiltrate. If a liquid is discharged to the Northwest Landfill, its disposal will be monitored continuously (ponded liquid, if any, will not be left unattended), and its disposal will be documented in the decommissioning records. Disposal within the Northwest Landfill will be approved by the RSO and S.C. Holdings prior to implementation.

Once a leachate extraction system is installed in the Northwest Landfill, any liquid containing radioactivity above the MCLs for drinking water will be injected directly into the leachate extraction system piping at a suitable location (this situation is not expected to occur, though, because liquids containing radioactivity above background levels are unlikely to be generated after completion of the waste consolidation and cover upgrade activities). In the unexpected event that liquids containing radioactivity above background levels are generated after the cover upgrade is completed in the Northwest landfill, but before the leachate extraction system is operational, then S.C. Holdings will develop a plan to address the specific circumstances, and present the plan to the USNRC for review and approval prior to implementation. Liquid disposal under situation-specific circumstances, if any, will be documented in the decommissioning records.

## 12.3 Mixed Waste

No solid or liquid mixed waste is present at the SCA Hartley & Hartley Landfill Site because disposal of chemical wastes in the Northwest Landfill ceased in 1971, which was prior to the enactment of the Resource Conservation and Recovery Act (RCRA) in 1976, which set forth the definitions of hazardous wastes (an essential component of a mixed waste).

# Section 13
# Quality Assurance Program

Decommissioning activities will be performed in a manner that will ensure that the end result is consistent with the objectives of this Plan, and that uncertainties have been appropriately considered. The Quality Assurance Program will be implemented throughout the decommissioning process, including construction, the Final Status Survey, validation of the data, and the interpretation of the results.

## 13.1 Quality Assurance Organization

Persons responsible for ensuring that the Quality Assurance Program has been established and for verifying that activities affecting quality are being correctly performed will have sufficient authority, access to work areas, and organizational freedom to accomplish the following:

- Identify quality problems.
- Initiate, recommend, or provide solutions to quality problems through designated channels.
- Verify implementation of solutions.
- Ensure that further decommissioning activities are controlled until proper resolution of a nonconformance or deficiency has occurred.

The QA Officer for the project will have direct access to responsible management at a level at which appropriate corrective actions can be implemented, as necessary. Therefore, the QA Officer will report to the Decommissioning Project Manager to ensure that required authority and organizational freedom are provided.

The QA Officer may authorize others to implement specific elements of the Quality Assurance Program. The following subsections contain a brief description of the quality assurance responsibilities of each position (other responsibilities were discussed in Section 9).

### 13.1.1 Radiation Safety Officer

The RSO will be responsible for recommending to the Decommissioning PM the type and quantity of staff and resources necessary for full implementation of the Radiation Safety Program. The RSO is designated by the USNRC in writing and may not be changed without the written approval of the USNRC and amendment of the radioactive materials license.

The RSO will have the responsibility and authority to terminate any work activities that may violate regulatory or S.C. Holdings requirements for radiological protection. Specific work activities will be permitted to proceed to a safe condition after implementation of the stop-work order. Stop-work orders will be lifted after the out-of-compliance conditions have been alleviated.

### 13.1.2 Decommissioning Project Manager

Overall control and authority for radiation protection will rest with the Decommissioning Project Manager (PM). The responsibilities of the PM will include, but are not limited to, the following:

- Review the procedures to decommission the site with the RSO and S.C. Holdings. Submit changes to the Decommissioning Plan approved by the RSO and S.C. Holdings to the USNRC. The PM will not implement the changes until they are approved by the USNRC in writing.
- Ensure that the capability of radiation protection services are sufficient to meet the requirements of this Decommissioning Plan and applicable state or federal regulations.

### 13.1.3 Health Physics Technicians

The RSO may designate authority for implementing certain aspects of the Radiation Safety Program to health physics technicians. The responsibilities and authority of health physics technicians may include the following:

- Ascertain compliance with rules and regulations, site-specific license conditions, and the guidelines approved and specified by the RSO.
- Provide technical support for some or all aspects of radiation protection, including field operations.
- Monitor and maintain equipment associated with the use, storage, and/or disposal of radioactive material.
- Provide consultation on all aspects of radiation protection to personnel at all levels of responsibility.
- Administer and coordinate the distribution of personnel and area dosimeters on an as-needed basis.
- Maintain personnel/area monitoring records, notify personnel and management of exposures approaching maximum permissible limits, recommend appropriate corrective action, and evaluate exposures reported by contract dosimetry services.
- Perform other monitoring/surveillance tasks as directed by the RSO.

## 13.2 Quality Assurance Program

A Quality Assurance Project Plan (QAPP) consistent with applicable guidelines will be developed for the execution of decommissioning activities at the SCA Hartley & Hartley Landfill Site. The QAPP will be reviewed and approved by S.C. Holdings prior to its implementation. The objective of the QAPP is to ensure confidence in the sampling, analysis, interpretation, and use of chemical and radiological data generated during the decommissioning project.

The QAPP will ensure collection of reliable data by serving as the instrument of control for field and analytical activities associated with the project. Stated within the QAPP are the quality assurance policies, quality control criteria, and reporting requirements that must be followed by site and contractor personnel when carrying out their assigned responsibilities on this project. The QAPP describes the functional activities and quality assurance/quality control (QA/QC) protocols necessary to collect data of adequate quality.

### 13.2.1 Procedures

Supporting Quality Implementing Procedures (QIPs) will provide step-by-step details for complying with the project QA requirements. The final radiological survey, including development of sampling plans, direct measurements, sample analysis, instrument calibration, daily functional checks of instruments, and sampling methods, will be performed according to written procedures. These written procedures will be reviewed and approved by the Decommissioning PM.

### 13.2.2 Subcontractor Services

The activities to be conducted during decommissioning will require the services of various specialty subcontractors, such as a qualified earthmoving contractor(s) and a licensed surveyor. Each subcontractor will be provided with written instructions to complete their tasks. Subcontractor activities will be performed under the direct supervision of the Decommissioning Contractor in accordance with the QAPP.

### 13.2.3 Laboratory Services

For off-site sample analysis, a qualified analytical laboratory recommended by the Decommissioning Contractor and approved by S.C. Holdings will perform those radiological analyses required for the project. The laboratory will be responsible for all bench-level QA/QC, data reduction, data reporting, and analytical performance monitoring. Laboratory accuracy will be evaluated by the analysis of blank and spiked samples. Sample handling protocols, analytical procedures, and reporting procedures employed by the analytical laboratory will be described in the laboratory's Quality Assurance Plan.

The laboratory will be responsible for ensuring that laboratory personnel working on this project are familiar with the QAPP and good laboratory practices, and that appropriate laboratory personnel meet the requisite qualifications for their positions within the laboratory. The Laboratory Director, or his/her representative, will review and approve all reports. The Laboratory Director will also be responsible for ensuring that laboratory personnel have appropriate training to perform assigned responsibilities, and to manage the laboratory and its staff on a daily basis.

The laboratory will have a QA Designee who will be responsible for ensuring that the QA/QC requirements of the QAPP, the laboratory Quality Assurance Plan, and its associated operating procedures are strictly followed. The QA Designee will be responsible for reviewing data; alerting the Decommissioning Project Manager and the Laboratory Director of the need for corrective action, as necessary; performing internal audits as specified by the QAPP; and maintaining the QC records. The QA Designee will also be responsible for preparing project-specific QA/QC Plans, as necessary.

### 13.2.4 Surveys and Sampling Activities

Trained individuals following written procedures will perform radiation and contamination surveys using properly calibrated instruments, as specified in the QAPP. Radiation survey data will be retained by S.C. Holdings until the radioactive materials license is terminated by the USNRC.

Field quality control samples (*e.g.*, field duplicates, field blanks, and equipment rinsate blanks) will be collected as specified in the QAPP. The designated sampler will also prepare split samples in the field as may be requested by the USNRC. Split samples will be collected, prepared, and documented in the same manner as for field duplicate samples.

QC hold points will be utilized as necessary to ensure the quality of surveys and sampling. For example, during the Final Status Survey, the RSO will establish action levels or hold points where a review and signature are required before proceeding to fill an excavation or to place a clean cover over a surface that was decontaminated. Hold points will also be used to ensure that debris is moved only after the QA Officer has verified that the proper sampling and survey information for the debris in question has been obtained.

## 13.3 Document Control

Data will be recorded and documented in a data management system. The radiation survey maps will designate the location being surveyed, as well as the name of the surveyor. To the extent practical, state plane coordinates will be used to define the location of a soil sample. If not available, site-specific references will be used to locate a sample.

Data management personnel will ensure that chain-of-custody and data management procedures are followed for samples related to the Final Status Survey. The Decommissioning Contractor will establish procedures to properly handle, ship, and store samples after they are collected.

Both direct radiation measurements and analytical results will be documented. The results for each survey measurement and/or each sample will be listed in tabular form along with the corresponding grid block location.

Radiation survey data will be recorded in a verifiable manner and reviewed for accuracy and consistency. Each of the major phases of the decommissioning process will be documented in a manner that is suitable for audits or assessments.

Changes to the Decommissioning Plan and the proposed QAPP will be submitted to the USNRC for review and approval before they are implemented.

The records discussed in the preceding paragraphs will be maintained until the license is terminated by the USNRC.

## 13.4 Control of Measuring and Test Equipment

Procedures for the calibration, maintenance, accountability, operation, and quality control of radiation detection instruments implement the guidelines established in American National Standard Institute (ANSI) standard ANSI N323-1978 and ANSI N42.17A-1989 (ANSI, 1978; 1989). Proper maintenance of equipment varies, but maintenance information and use limitations are provided in the vendor documentation and in the Radiation Safety Program. Equipment used for measuring and analyzing will be tested and calibrated before initial use and will be recalibrated if maintenance or modifications could invalidate earlier calibrations. Field and laboratory equipment, specifically used for obtaining final radiological survey data, will be calibrated based on standards traceable to the National Institute of Standards and Technology (NIST).

Minimum frequencies for calibrating equipment will be established and documented. Equipment used for measuring will be tested at least once on each day the equipment is used.

Test results will be recorded in tabular or graphic form and will be compared with predetermined, acceptable performance ranges. Equipment that does not conform to the performance criteria will be promptly removed from service until the deficiencies can be resolved.

Audits and inspections will be conducted during the course of the decommissioning project. Work practices will be evaluated, and corrections will be made as necessary. The need for corrective actions will be documented and reviewed by the Decommissioning PM and the RSO. The corrective action and the concurrence by the Decommissioning PM and RSO will be documented in writing. The person or department responsible for implementing the corrective action will be assigned, and a schedule will be established to implement the change. After the finding is closed out, a surveillance will be conducted within 30 days to verify that the problem has been alleviated. Significant conditions adverse to quality, the cause of the conditions, and the corrective action taken to preclude repetition will be documented and reported to the appropriate levels of management for review and assessment.

## 13.5 Corrective Action

Deficiencies and conditions that do not conform to this Decommissioning Plan or License SUC-1565 will be corrected using a corrective action program. The Quality Assurance Officer has overall responsibility for reporting all procedure and contract violations found. All personnel assigned to the Decommissioning Contractor are encouraged to identify non-conforming conditions and report them to their supervisor and/or the QA Officer. The RSO will determine if the deficiency requires work to be stopped or if notification is required to the USNRC.

A deficiency or nonconforming condition is documented on a Corrective Action Request (CAR) Form. The form is completed by the individual who reported the nonconformance and submitted to the QA Officer who will review the CAR for completeness. The completed form will provide a detailed description of the nonconforming condition and reference the affected documents that apply. The person writing the CAR will sign the document. The QA Officer will review the form and maintain a log of all CARs; a unique sequential number will be assigned. The QA Officer will assign the responsible party to resolve the nonconforming condition and notify the Decommissioning PM and the RSO.

The responsible parties will establish a schedule to resolve the nonconforming condition. The QA Officer will provide a report to the Decommissioning PM listing all open CARs and the person(s) responsible for the corrective action. The report will list those CARs that are past due, those past due for more than 30 days, and those that are past due for 90 days or longer. The parties assigned the responsibility to resolve the deficiency will provide a detailed description of the actions taken to correct the causes of the nonconforming condition and preventive actions to prevent recurrence.

The QA Officer will review the response and verify that the actions address the original concern and provide effective preventive actions. If satisfactory, the QA Officer will accept the response and close the CAR. The log will be updated to indicate the current status of the CAR.

After corrective action has been completed and verified by the QA Officer, the closed CAR (original) will be filed. The QA Officer and the project RSO will evaluate the effectiveness of corrective action. After an agreed-upon time frame, either the person who generated the CAR or the QA Officer, or both, may verify implementation and effectiveness of the corrective action taken. If needed, a new CAR will be issued to address additional required corrective action.

## 13.6 Quality Assurance Records

Quality assurance records will be monitored by the Decommissioning Contractor.

### 13.6.1 Laboratory Data

Data reduction, QC review, and reporting will be the responsibility of the analytical laboratory. Data reduction includes all automated and manual processes for reducing or organizing raw data generated by the laboratory. The laboratory will provide a data package for each set of analyses that will include a copy of the raw data in electronic format, and any other information needed to check and recalculate the analytical results.

Once a data package is received from the laboratory, the analytical results and pertinent QC data will be entered into a computer database. The data packages will serve as basic reference sheets for data validation, as well as for project data use.

### 13.6.2 Field Survey Data

The generation, handling, computations, evaluation, and reporting of final radiological survey data will be as specified in the Decommissioning Contractor's procedures. Included in these procedures will be a system for data review and validation to ensure consistency, thoroughness, and acceptability of the data. Qualified health and safety, operations, and/or engineering personnel will review and evaluate survey data.

### 13.6.3 Data Evaluation

Prior to releasing data for use by project staff, selected data will undergo data evaluation based on the intended end use of the data. Data points chosen for evaluation will be examined to determine compliance with QA requirements and other factors that determine the quality of the data. Data taken during a characterization survey will be subjected to quality verification before use as Final Status Survey (FSS) data. Data taken during a prior survey (*e.g.*, characterization survey) may be usable as FSS data, provided that the data are subjected to quality verification and that they satisfy the data quality objectives.

Any rejected sample data or data omissions identified during the data validation will be evaluated to determine their impact on the project. Other corrective action may include resampling and reanalyzing, evaluating and amending sampling and analytical procedures, and accepting data acknowledging the level of uncertainty.

In the event that the final status survey data are processed by computer, the application program and each modification thereof will be verified to perform as intended before its initial use. A knowledgeable person will verify that the algorithms are as intended and will compare a computer-generated result and an independently derived result of the same process. Waste Management will document the application program, including its algorithms and a listing or copy of the program.

### 13.6.4 Sample Chain-of-Custody

One of the most important aspects of sample management is to ensure that the integrity of the sample is maintained, that is, that there is an accurate record of sample collection, transport, analysis, and disposal. This ensures that samples are neither lost nor tampered with, and that the sample analyzed in the laboratory is actually and verifiably the sample taken from a specific location in the field.

Sample custody will be assigned to one individual at a time. This will prevent confusion as to who is responsible. Custody is maintained when (1) the sample is under direct surveillance by the assigned individual, (2) the sample is maintained in a tamper-free container, or (3) the sample is within a controlled-access facility.

The individual responsible for sample collection will initiate a Chain-of-Custody Record using a standard form provided by the Decommissioning Contractor. A copy of this form will accompany the samples throughout transportation and analyses; and any breach in custody or evidence of tampering will be documented.

## 13.7 Audits and Surveillances

Periodic audits will be performed by the Decommissioning PM, the RSO, the HSO, and/or persons so designated to verify that decommissioning activities comply with established procedures and other aspects of the QAPP (such as scope, status, adequacy, and compliance) and to evaluate the overall effectiveness of the QA Program. S.C. Holdings and the Quality Assurance Officer will verify that qualified personnel are employed to conduct audits to ensure that the applicable procedures are being properly implemented. The audits will be conducted on at least a quarterly basis, in accordance with written guidelines or checklists. Health and safety personnel will also conduct semiannual audits in their area of concern. External program audits may also be used at the discretion of S.C. Holdings or the Decommissioning Contractor. Audit results will be reported to both S.C. Holdings and the Decommissioning Contractor in writing, and actions to resolve identified deficiencies will be tracked and appropriately documented. The audit information will become part of the decommissioning record for the site.

# Section 14
# Facility Radiation Surveys

## 14.1 Classification of Areas

As discussed in previous sections (particularly Section 4), the operating history for various parts of the SCA Hartley & Hartley Landfill Site has resulted in different levels of potential exposure to radiological constituents. Therefore, these areas require different levels of survey coverage to evaluate their radiological character. For purposes of this Decommissioning Plan, S.C. Holdings has classified the areas into three categories: Class 1, Class 2, and Class 3. Class 1 areas have the greatest potential for contamination, and therefore will receive the highest degree of survey effort for the Final Status Survey using the graded approach, followed by Class 2, and then Class 3 areas. Areas of the SCA Hartley & Hartley Landfill Site have been classified based on site operating history and site characterization data.

The survey units shown on Figure 8-1 will be the fundamental elements for demonstrating compliance with the DCGLs using the statistical tests (see Subsections 14.2 and 14.3).

Class 1 areas are those that have, or that had prior to decommissioning field activities, a potential for radioactive contamination or known contamination greater than the DCGLs (above background levels). There are three Class 1 survey units at the site: the Northwest Landfill, Slag Pile A, and Slag Pile B. These areas are designated Survey Units 1C, 1A, and 1B, respectively. Each of these areas is known to contain the thorium-bearing slag generated at the Wellman Dynamics facility in Bay City, Michigan.

Class 2 areas are those areas that have a potential for radioactive contamination, but are not expected to contain radiation greater than the DCGLs (above background levels). The area surrounding the Northwest Landfill has been designated a Class 2 survey unit; however, no Class 2 survey units exist around Slag Piles A and B. Because Slag Piles A and B (Survey Units 1A and 1B) are of such limited area (0.2 and 0.1 acre, respectively), these areas will be over-excavated (that is, extra material, laterally and vertically, will be removed), based on visually observation, and then tested to ensure that all radiologically contaminated material is removed from these areas. Survey Units 2A and 2B were assigned their classifications based on S.C. Holdings' plans to excavate the material in Slag Piles A and B and reconsolidate these materials into the Northwest Landfill, not because there is a history or other evidence of radiological contamination in these areas. Because radiologically contaminated material could be deposited along the haul roads between the slag piles and the Northwest Landfill in the course of transporting the excavated material from the two slag piles to the Northwest Landfill, the haul roads between the slag piles and the Northwest Landfill are designated Class 2 survey units. This designation will provide more intensive sampling for the Final Status Survey to ensure that radiological contamination was not inadvertently spread during the course of decommissioning fieldwork.

Class 3 areas are those that are not expected to contain residual radioactivity above background or that are expected to contain levels of residual radioactivity at a small fraction of the DCGLs, based on operating history and previous radiation surveys. Class 3 areas at the SCA Hartley & Hartley Landfill Site include all areas that are not designated as Class 1 or Class 2. The East Landfill is also a Class 3 area based upon historical process knowledge, which indicates that industrial and municipal solid wastes were disposed in this portion of the site, but not the thorium-bearing slag from Wellman Dynamics. This designation is supported by site characterization data for the East Landfill (see Appendix B-3), which does not indicate the presence of radioactive slag material in this area.

The following radiological survey unit designations have been made at this site:

| SURVEY UNIT ID | CLASSIFICATION | DESCRIPTION |
|---|---|---|
| 1A | 1 | Slag Pile A |
| 1B | 1 | Slag Pile B |
| 1C | 1 | Northwest Landfill |
| 2A | 2 | Haul road between Slag Pile A and the Northwest Landfill |
| 2B | 2 | Haul road between Slag Pile B and the Northwest Landfill |
| 2C | 2 | Area surrounding the Northwest Landfill |
| 3 | 3 | All other areas of the site, including the East Landfill |

## 14.2 Final Status Survey Design

The objective of the Final Status Survey is to collect sufficient information to demonstrate, to a reasonable degree of statistical certainty, that the concentrations of radiological constituents at the site do not exceed the established DCGLs (see Section 5), and that the license termination for unrestricted release has been met.

As described in Subsection 8.3.3, the Final Status Survey will be conducted in two phases to optimize equipment scheduling and to minimize the likelihood that radiologically contaminated soil is identified after the engineering barrier is constructed over the Northwest Landfill. The following sequence of field decommissioning actions and Final Status Survey sampling will be conducted:

1. The first phase of the Final Status Survey is the collection of samples of the surface soil in the Class 2 survey unit surrounding the Northwest Landfill (Survey Unit 2C) and in the Class 3 areas except for the East Landfill. These soil samples will be analyzed for the radiological parameters associated with the thorium-bearing slag. The new analytical data, in conjunction with the historical radiological data for these areas, will be used to verify that the slag in the Northwest Landfill is contained within the slurry wall. Samples will not be collected in the East Landfill because historical data for the East Landfill (Appendix B-3) is sufficient for the Final Status Survey.
2. Erosion control and sediment control systems will be installed to prevent the off-site migration of regulated material during construction activities and to control the runon of precipitation into the work area.
3. Approximately 5 weeks after the samples are collected for the first phase of the Final Status Survey (to allow time for analysis and data validation), the regulated materials in Slag Piles A and B (Survey Units 1A and 1B, respectively) will be excavated and placed in the Northwest Landfill (Survey Unit 1C). The slag piles will be over-excavated based on visual observation to negate the need for Class 2 survey units around these limited areas of known radiologically contaminated material (*i.e.*, the two slag piles).
4. The second phase of the Final Status Survey is the collection of samples of the residual surface soil in the areas where Slag Piles A and B were excavated (Survey Units 1A and 1B, respectively), and the collection of surface soil samples along the haul roads used to transport material from Slag Piles A and B to the Northwest Landfill (Survey Units 2A and 2B, respectively). These soil samples will be analyzed for the radiological parameters associated with the thorium-bearing slag.
5. A leachate collection system will be installed in the Northwest Landfill.
6. An engineered barrier will be constructed over the Northwest Landfill.

Existing documentation of the source term for the licensed material (ORAU, 1985a) is appropriate and adequate to determine the necessary thickness of cover material needed to provide protection from radiological exposures to the buried thorium-bearing slag in the Northwest Landfill. This determination was made using the RESRAD computer code, and site-specific input parameters for a potential future industrial worker on the site. Consequently, documentation of the placement of the engineered barrier over the Northwest Landfill, in accordance with a Construction Quality Assurance Plan (to be developed as part of the decommissioning workplan) will serve as the Final Status Survey for the Northwest Landfill

(Survey Unit 1C). No additional samples of the waste or the new landfill cover materials will be collected.

Samples collected from background areas in December 2002 showed no evidence of elevated readings for radionuclides of concern. The results for the background study were presented in Subsection 4.3 of this Decommissioning Plan. Data from the Final Status Survey will be compared with the DCGLs for the site plus background using the statistical tests described in the following subsection.

A Final Status Survey Report will be prepared and submitted with S.C. Holdings' application to terminate License No. SUC-1564.

## 14.3 Statistical Tests

Because the radionuclides of concern at the SCA Hartley & Hartley Landfill Site (thorium, uranium, and radium isotopes) exist in the natural background, all measurement results acquired during the Final Status Survey will be compared with the DCGLs developed for the site plus background, using the Wilcoxon Rank Sum test, as described in MARSSIM (USNRC, 2000b). If an area exhibits residual radioactivity in excess of the applicable criterion, either additional decommissioning actions will be implemented in that area, or technical/regulatory justification for no further action will be developed and included in the Final Status Survey Report. If additional field decommissioning activities are necessary, follow-up measurements will be performed to demonstrate their effectiveness.

### 14.3.1 Data Quality Objectives

The final status survey design process begins with the development of data quality objectives (DQOs) (USEPA, 1994). The DQOs are used in conjunction with the radiological conditions at the site to calculate the number and locations of measurement and sampling points to demonstrate compliance with the release criterion. Survey techniques and analytical methodologies are selected to generate the required analytical data. Once the analytical data are received from the laboratory and validated, they are evaluated using statistical techniques to test the hypothesis stated in this section. A Final Status Survey sampling plan will be developed prior to performing the Final Status Survey.

#### *Statement of Cleanup Objective*

After decommissioning is completed, residual radioactivity in materials at the SCA Hartley & Hartley Landfill Site will be low enough that an on-site industrial worker will not be exposed to more than 25 mrem/yr for a period of

1,000 years. The selected decommissioning alternative for the SCA Hartley & Hartley Landfill Site is consolidating the material in the two slag piles outside the Northwest Landfill into the Northwest Landfill, and then placing an engineered cover over the Northwest Landfill to eliminate direct contact with the thorium-bearing slag.

### *Hypothesis to be Tested*

Following remediation of the two slag piles, it must be determined whether the site-specific cleanup guideline has been met, or if further remediation is required. Therefore, the decision to be made is: "Does the soil outside of the Northwest Landfill contain radiation less than the DCGLs listed in Table 5-5 of this Decommissioning Plan?" The null hypothesis (Ho) for the statistical test is that the site does not meet the release criteria, as outlined in MARSSIM (USNRC, 2000b): "The concentration in the survey unit exceeds the concentration in the reference area by more than the DCGLw."

### *Inputs to the Decision*

Inputs to the decision include the type, quality, and quantity of data that will be sufficient to make decisions. The type refers to the radiological data needed for the survey unit soil. Quality refers to various aspects of the analytical data collected, such as precision, accuracy, representativeness, comparability, completeness, required and achieved detection limits, and data validation documentation requirements. Validation that the resulting data meet these values will ensure the *quality* of the information and allow the results to be used in testing the site cleanup hypothesis. Quantity refers to the amount of data necessary to confirm compliance with the release criteria, and is determined as part of the design process. Data quality requirements are provided below.

### *Precision*

Precision refers to the level of agreement among repeated measurements of the same parameter. The overall precision of a piece of data is a mixture of sampling and analytical factors. The analytical precision is much easier to control and quantify because the laboratory is a controlled, and therefore a measurable environment. Laboratory sampling precision will be checked by obtaining a minimum of one replicate sample for every 10 physical soil samples collected in a given survey unit. Precision will be evaluated by calculating the relative percent difference (RPD) for each replicate pair. The soil field replicate pairs are expected to have RPDs in the range of ±50 percent. At a minimum, one replicate sample or the recount of a previously sampled location will be performed for every sample batch. A sample batch is defined as a group of samples that behave similarly with respect to the sampling or testing procedures being employed. For quality control (QC) purposes, a group of 10 samples of similar physical media collected within 1 work week, or all such samples collected in a work week (if less than 10), whichever occurs first, is considered a batch. The RPD for each analytical parameter will be calculated and compared with a method-specific precision criteria derived from historical performance data. If these criteria are not met, a careful examination of the sampling techniques, sample media, and analytical procedure will be conducted to identify the cause of the high RPD and to define the usability of the data.

*Accuracy*

Accuracy refers to the difference between a measured value for a parameter and the true value for the parameter. It is an indicator of the bias in the measurement system. Field instrument accuracy will be evaluated by comparing the static count measurement at each soil sample location with the laboratory result. Laboratory accuracy will be evaluated by the analysis of one method blank per sample batch and one spiked sample (matrix spike/matrix spike duplicate [MS/MSD]) per sample batch (or one MS/MSD for every 20 samples) as applicable for radionuclides.

*Representativeness*

Representativeness is a measure of the degree to which the measured results accurately reflect the medium being sampled and the overall situation at the site. It is a qualitative parameter that is addressed through the proper design of the sampling program in terms of sample location, number of samples, selection, preparation, and handling of the samples.

The final status survey unit sampling program will be designed in accordance with the guidance given in MARSSIM (USNRC, 2000b), to ensure that the appropriate statistically derived number of samples is collected during final status surveys. Sampling protocols will be developed and used in the field to ensure that samples collected are representative of the media. Field handling protocols (*e.g.*, storage, handling in the field, and shipping) will be designed to preserve the integrity of the collected samples. Proper field documentation and

QC efforts will be used to establish that protocols have been followed and that sample identification and integrity have been maintained.

### *Comparability*

Comparability expresses the confidence with which one data set can be compared with another. When comparing data, it is important to compare data collected under the same set of conditions. Seasonal trends, depth of sample collection, analytical protocol, method detection limits, and any other sampling/analytical variables must be taken into account when comparing data sets. This is accomplished by the Decommissioning Contractor and by using standardized methods for collecting the samples.

### *Completeness*

Completeness is a measure of the amount of information that must be collected during the Final Status Survey to allow for successful achievement of the project objectives. The overall objective of the remediation at the site is to remove contaminants exceeding the cleanup criteria presented in Section 5 of this plan. A certain amount and type of data must be collected for each Final Status Survey unit to be valid. The statistically-derived number of samples will be calculated in accordance with MARSSIM (USNRC, 2000b). Missing data may reduce the precision of estimates or introduce bias, thus lowering the confidence level of the conclusions. The completeness goal for each Final Status Survey will be 95 percent (areal) for the field sampling and 95 percent (number) for the laboratory analyses. The importance of any lost or suspect data will be evaluated in terms of the sample location, analytical parameter, nature of the problem, decision to be made, and the consequence of an erroneous decision. Critical locations or parameters for which data are determined to be inadequate may be resampled.

### *Sensitivity*

Sensitivity refers to the ability to detect a minimal amount of a substance, and is typically expressed as the Method Detection Limit, Practical Quantitation Limit, or Reporting Limit. Radiological analyses must indicate if the soil remaining at the site has met the cleanup criteria. Therefore, the required off-site analytical laboratory minimum detectable level (MDL) has been set at 1 pCi/g of U-238 and 1 pCi/g of Th-232.

### 14.3.2 Decision Rules

If the concentrations of residual U-238, Th-232, and radioactive progeny of the parents in the soil of a given survey unit are below the concentrations listed in Table 5-5 of this Plan, the survey unit is in compliance with the release criteria. The MARSSIM process specifically includes the use of elevated measurements as a component of radiation surveys and site investigations. Areas with elevated levels of radioactivity should be rare because remediation activities will be rigorously conducted. "Hot spot criteria" will be a multiple of the cleanup criteria. Any such "hot spots" identified during the gamma scanning cross-walk of the final excavation surface will be plotted on survey unit maps. All survey unit maps will be evaluated to identify areas that may require additional evaluation based on spatial distribution of the elevated measurements. Any areas with elevated levels of radioactivity will be evaluated following the criteria in Subsection 14.11.

*Acceptable Decision Errors*

The data evaluation approach described in MARSSIM specifies that failure to meet the release criteria should be assumed as the null hypothesis; the data are then analyzed to demonstrate that the release criteria are met. The null hypothesis can be stated thus: "The median concentration in the survey unit exceeds that in the reference area by more than the DCGLw." The data then are analyzed to demonstrate that the null hypothesis is false. Site measurement data are used to estimate the actual site conditions within a specified margin of error. The sample collection and data analysis process described in MARSSIM attempts to control decision error by defining the types of errors and incorporating them into the interpretation of survey results. The possible types of decision errors include the following:

- Type I errors ($\alpha$) - Concluding that residual radiological contamination does not exceed the cleanup criteria when it actually exceeds the criteria.
- Type II errors ($\beta$) - Concluding that residual radiological contamination exceeds the cleanup criteria when it actually is below the criteria.

Type I and Type II errors can have distinct consequences. Type I errors may have human health consequences, political consequences (state and federal officials may face undue pressure if it is discovered that the site may not have been adequately cleaned up), and cost consequences (the cost of excavating selected portions of the site after remediation is complete would be significant).

On a preliminary basis, the probability of a Type I error will be less than 5 percent ($\alpha \leq 0.05$).

Type II errors do not have residual risks, but rather have cost and resource consequences (the manpower, equipment, and disposal costs associated with excavating and disposing material that already meets the cleanup criteria are unnecessary expenses). On a preliminary basis, the probability of a Type II error will be less that 10 percent ($\beta \leq 0.10$).

## 14.4 Scanning Instrument Description

All instrumentation used for the Final Status Survey, including scanning measurements, will be appropriate for the type of radiation expected, of sufficient sensitivity and accuracy to detect the radioactive materials of interest, and of sufficient quantity to support planned activities. Many of the radionuclides of concern and/or their progeny emit high-energy photons and are easily detected using survey instruments equipped with sodium iodide (NaI) scintillation crystal detectors. Scanning for gross gamma activity will be used as part of the open land area status survey to ensure that elevated areas of activity are not missed. The survey instruments (or equivalents) in Table 14-1 will be used to scan soil media.

The use of these field instruments or acceptable equivalents will be evaluated against the goal of achieving a minimum detectable concentration (MDC) of less than the $DCGL_W$ for direct measurements and/or scanning measurements. The MDC will be calculated for scanning instruments using the method provided in MARSSIM (USNRC, 2000b) for calculating MDCs that controls both Type I ($\alpha$) and Type II ($\beta$) errors (*i.e.*, elimination of false negatives and false positives) as follows:

$$\text{Scan MDCR}^{\text{surveyor}} = \frac{MDCR}{\sqrt{\rho \in_i}},$$

where

| | | |
|---|---|---|
| MDCR | = | the minimum detectable count rate in counts per minute (cpm), and |
| $\in_I$ | = | the conversion factor for gamma energies provided by the manufacturer for 2-inch by 2-inch NaI detectors (cpm/microRoentgens per hour). |
| P | = | the efficiency of the technician performing the survey, which is based on empirical studies; to be conservative, "p" is assumed to be 0.5 (USNRC, 1997). Values for $\in_i$ are radionuclide-specific and are provided by MARSSIM for 2-inch by 2-inch NaI detectors. Some of |

the values are listed in Table 14-2. The Minimum Detectable Count Rate (MDCR) is defined by the USNRC as follows:

MDCR = $s_i \times (60/i)$,

where

$s_i$ = the minimal number of net source counts required for a specified level of performance for the interval i, in seconds.

and

$s_i$ = $d' \sqrt{b_i}$,

where

d' = the value selected from MARSSIM Table 6.5 (USNRC, 2000b) based on the required true-positive and false-positive rates,

$b_i$ = the number of background counts in the interval.

The value of d' used to calculate the detector sensitivity corresponds to a Type I error of 0.05 and Type II error of 0.40; the value was 1.38. This value of d' will result in less than 5 percent false negatives and about 40 percent false positives. MDC calculations are summarized in Table 14-2. The scan MDC value in µR/hr can be converted to pCi/g for specific radionuclides using a conversion factor derived using the guidance provided in MARSSIM and the shielding code Microshield (USNRC, 2000b). Examples of the conversion factors are provided in Table 14-3.

## 14.5 Surface Soil Scan

An area will be scanned according to the area classification, Class 1, 2, or 3. Scanning coverage will range from 0 to 100 percent. When scanning soil, the detector will be held close to the ground, within 6 centimeters (<3 inches), and will be moved in a serpentine pattern. A scan rate of 0.5 meter per second is standard for scanning gamma emitters in surface soil. The scan rate may be adjusted by the Radiation Safety Officer according to the required scan MDC. Additional factors that may reduce the effectiveness of scanning (*e.g.*, increased moisture content of the soil or depth of contamination) will be considered when establishing a scan rate in the field. In the scanning mode, the audio response will be used to improve the likelihood of detection of an elevated area and avoid a false-negative response resulting from the lag time of the meter (analog needle) response.

Discrete fixed-point measurements will also be recorded in Class 1, 2, and 3 areas. This measurement provides a lower detection limit than the scanning mode. A fixed gross gamma measurement will be taken at specific coordinates or at a predetermined interval. The discrete radiation measurements will be recorded over a duration sufficient to achieve the required MDC. The survey time will be adjusted according to the instrument background.

## 14.6 Instrument Response Check

The sensitivity of each counting system and instrument for each medium and radionuclide will be determined prior to the start of the measurement campaign, with the results documented in the Final Status Survey Report. For all counting systems and instruments used as part of the analyses, at a minimum, the following QA/QC principles will be applied:

- Counting systems and instruments will be used in accordance with approved procedures. Each day that a counting system and instrument is used, the response will be checked using an appropriate radiation source before use. Additional response checks may be necessary depending on the counting system used, for example:
  - For laboratory counting systems, source check acceptance criteria (*e.g.*, $\pm 2\sigma$ of the average response determined after the most recent calibration, or otherwise linking the response to the current calibration) will be established prior to using the counting system. Control charts will be used to evaluate the data.
  - For field instrumentation, source check acceptance criteria (*e.g.*, $\pm 2\sigma$ for direct [integrated] measurements and $\pm 20$ percent for rate measurements) will be established prior to beginning the project.
- All source check results will be documented. Failed source checks will be repeated. Consecutive failure will result in additional testing of the counting system, in accordance with the applicable procedure, and ultimately in removing the counting system from service.
- Survey data acquired prior to an instrument failing a source check will be reviewed by the Radiation Safety Officer to determine the validity of the data. This review will be documented.
- All instrument failures in the field will be followed by an investigation by the Project Manager of suspect data. All investigations will be documented.

### 14.6.1 Background Determination

On each day that an analysis is performed, the ambient background radiation will be determined and documented at least once daily, depending on the counting system and instrument used and the variability in the background.

### 14.6.2 Calibration

All counting systems and instruments will be calibrated with a National Institute of Standards and Technology (NIST) traceable source at intervals not exceeding 12 months for laboratory counting systems and at intervals not exceeding 6 months for portable field survey instruments. The source used will be appropriate for the type and the energy of the radiation to be detected. All calibrations will be documented and will include the source data.

### 14.6.3 *In Situ* Measurement Instrumentation Description

No *in situ* measurements of radionuclide concentration in soil or other solid materials will be made during this decommissioning effort. Instead, samples will be collected and forwarded to a commercial analytical laboratory for analysis.

### 14.6.4 Analytical Instrument Description

Prior to submitting any samples to a commercial analytical laboratory, S.C. Holdings will write a letter of specification to the laboratory. This letter will include the necessary measurement results and relevant detection sensitivities. At that time, the laboratory will be asked to declare the analytical methods and measurement devices they intend to use in order to meet S.C. Holdings' specifications.

Each commercial laboratory that provides analytical results as part of the decommissioning effort will be asked to provide a copy of their quality assurance documents, including quality assurance procedures designed to ensure that the necessary calibrations and detection sensitivity requirements are met.

In addition to the analytical requirements, the letter of specification will describe the following criteria:

- **Sample disposition** - turnaround time required to support the project; and proper maintenance, storage, and archiving of samples after transfer to laboratory.
- **Analytical QC** - the number of samples for a specific laboratory analysis that will be submitted for the purposes of QA/QC, as specified in the QAPP. These QC samples will include duplicate samples, equipment rinsate samples (decontamination blanks), and spiked samples with site media (soil or water) containing a known quantity of one or more radionuclides. Samples selected for QC analyses will be determined by the Project Manager. The results of these QA/QC samples will be reviewed by the Project Manager to assess the accuracy and precision of the laboratory counting system as follows:

- The results of duplicate samples, equipment rinsate samples, and spiked samples will be reviewed against the original analysis results.
- The results of the background analysis will be reviewed against the desired MDCs for the specified radionuclides. The MDCs reported should be less than the desired MDCs. The results of the QC samples and their review will be included in the Final Status Survey Report.

## 14.7 Sample Collection

Surface soil samples will be collected with a dedicated precleaned stainless-steel scoop or spatula. Samples will be placed in appropriately-sized containers that have been provided by, or that are specified by, the analytical laboratory. Each will be labeled with a unique sample number.

All sampling activities will be recorded on field logs and will include sample-specific information such as date/time of sampling, sample location, and sample number. Samples will remain in the custody of sampling personnel or will be locked in a controlled, limited access location until they are packaged for shipment to the commercial laboratory. A sample Chain-of-Custody/Request for Analysis Form will be completed for all samples and will accompany the sample shipment to the analytical laboratory. Samples will be field-screened to approximate the total radioactivity present and to ensure that the sample shipment conforms to applicable Department of Transportation shipping regulations.

Soil samples will be collected in accordance with written procedures. Sampling tools will be cleaned and monitored, as appropriate, after each use. Samples will be collected in clean/unused sealable containers. Equipment rinsate samples will be collected in accordance with the QAPP.

Sample containers will be permanently labeled/marked in the field at the time of collection by the technician collecting the sample. At a minimum, the following information will be recorded on the sample container: sample date/time, sample identification, sample location, and name of person collecting the sample. Sample identifications will consist of an alphanumeric code that further defines the sample type, location, and depth at which the sample was taken. All samples that may contain radionuclide levels in excess of 100 times the background concentration, or which, because of their form, may be of potential laboratory contamination concern, will be identified on the outside of the container with a "radioactive material" caution label. An approved procedure will be used for strict Chain-of-Custody to ensure that the integrity of the sample is maintained throughout sampling, transportation, analysis, and archiving.

## 14.8 Data Assessment

Data will be reviewed by the Project Manager or as designated to verify that the requirements stated in the survey plan are implemented as prescribed and that the results of the data collection activities support the objectives of the survey, or permit a determination that these objectives should be modified. The Project Manager will determine if the data are of the appropriate type, quality, and quantity to demonstrate compliance with the plan objective. The review will check that the appropriate number of samples were taken from the correct locations and that they were analyzed with measurement systems having the appropriate sensitivity. After the data are analyzed, a sample estimate of the data variability, namely the sample standard deviation ($\sigma$) and the actual number of valid measurements, will be used to determine that the sampling design provides adequate power to conclude that the objectives of the survey design are met.

## 14.9 Preliminary Data Review

The Project Manager will review the QA/QC reports, prepare graphs of the data, and calculate basic statistical quantities to analyze the structure of the data, and to identify patterns, relationships, or potential anomalies. The survey data will be reviewed as they are collected. The preliminary data examination will include the following:

- Evaluation of data completeness
- Verification of instrument calibration
- Verification of sample identification and traceability to sampling location
- Measurement of analytical precision using duplicate samples
- Measurement of analytical bias using spiked samples
- Evaluation of the potential for cross contamination with equipment rinsate blanks
- Assessment of adherence to method specifications and QC limits
- Evaluation of method specifications and QC limits
- Evaluation of method performance in the sample matrix
- Applicability and validation of analytical procedures for site-specific measurements
- Assessment of external QC measurement results and QA assessments

## 14.10 Investigation Levels

The Project Manager will use radionuclide-specific investigation levels to determine when additional investigations may be necessary. Investigation levels will also serve as a QC check to assess whether a measurement process is beginning to get out of control. A measurement that exceeds the investigation level may indicate that the survey unit has been improperly classified, or it may indicate a failing instrument. When an investigation level is exceeded, the first step will be to confirm that the initial measurement/sample actually exceeds the particular investigation level. This may involve taking further measurements to determine that the area and level of the elevated residual radioactivity are such that the resulting dose or risk meets the release criterion. Depending on the results of the investigation actions, the survey unit may require reclassification, additional field decommissioning activities, and/or resurveying. Table 14-4 lists the investigation levels that will be used by the Project Manager.

If the data suggest that the survey unit was improperly classified, then the original DQOs will be redeveloped for the proper classification. The sampling design and data collection documentation will be reviewed for consistency with the DQOs.

## 14.11 Data Evaluation and Conversion

### 14.11.1 Conversion of Data to DCGL Units

For comparison of survey data with DCGLs, the survey data from field and laboratory measurements will be converted to DCGL units. The Project Manager will ensure that data measurements retain traceability to NIST and that conversion factors are appropriate for the radiation quantity. The preliminary data reports will be reviewed to ensure that adequate measurement sensitivity is being achieved and to resolve any detector sensitivity problems.

An evaluation will be made to confirm that the data are consistent with the underlying assumptions made for survey plan statistical procedures. The basic statistical quantities that will be calculated for the survey unit are as follows:

- Mean
- Standard deviation
- Median
- Minimum
- Maximum

The value of the sample standard deviation will be used to determine if a sufficient number of samples were collected to achieve the desired power of the statistical test. A verification that the sample sizes determined for the tests are sufficient to achieve the DQOs set for the Type I ($\alpha$) and Type II ($\beta$) error rates will be completed. If an insufficient number of samples was collected, another survey will be performed. A resurvey will be performed only if the sample size must be increased by more than 20 percent, since MARSSIM Tables 5-3 and 5-5 include a correction factor of 20 percent to allow for loss or unusable data (USNRC, 2000d). If it is not possible to show that the DQOs were met with reasonable assurance, then a resurvey may be performed.

### 14.11.2 Data Analysis

During the Final Status Survey, the survey data will be evaluated to determine whether the levels of radioactivity in each medium in a survey unit are greater than the levels of radioactivity in the corresponding medium in the background area. Data evaluation will be performed using the tests specified in MARSSIM (USNRC, 2000b), as summarized in Table 14-5.

*Wide-Area Measurements*

Wide-area measurements will be performed in which the mean measurement for a survey unit will be compared with the mean background plus the $DCGL_W$. The $DCGL_W$ is the DCGL to be used for statistical tests (the W subscript is for the Wilcoxon Rank Sum test). In a "hot spot," Elevated Measurement Comparisons (EMCs) will be performed where specific measurements exceed the $DCGL_{EMC}$. The $DCGL_{EMC}$ is derived separately, based on the characteristics of the "hot spot" (USNRC, 2000a).

The first level of comparison will be to assess whether the difference between the maximum value in the survey unit and the minimum value in the reference area is less than the $DCGL_W$. If the difference is less than the $DCGL_W$, then the unit passes.

A second level of comparison is to assess whether the difference between the mean of the values in the survey unit and the mean of the values in the reference area is greater than the $DCGL_W$. If the difference is greater than the $DCGL_W$, then the unit fails.

In the intermediate case, where the maximum difference is greater than the $DCGL_W$, but the difference of the means is less than the $DCGL_W$, the Wilcoxon Rank Sum (WRS) test will be used. The WRS test will be used because all of the analytes of concern are present in background. The WRS test is a nonparametric test that can used to determine if the mean concentration in the survey unit is significantly greater than the mean concentration in the background.

*Areas with Isolated Elevated Measurements*

Both the measurements at discrete locations and the scans will be subject to the Elevated Measurement Comparison (EMC). The result of the EMC will be used as a trigger for further investigation. If a measurement at any location exceeds the $DCGL_{EMC}$, the investigation may involve taking further measurements to determine that the area and level of the elevated residual radioactivity are such that the resulting dose or risk meets the release criteria. The investigation will provide adequate assurance, using the process outlined in MARSSIM, that there are no other undiscovered areas of elevated residual radioactivity in the survey unit that might otherwise result in a dose or risk exceeding the release criteria. In some cases, this may lead to reclassifying all or part of a survey unit, unless the results of the investigation indicate that reclassification is not necessary.

## 14.12 Final Status Survey Report

Much of the information contained in the Final Status Survey Report will be available from other decommissioning documents compiled and retained by S.C. Holdings. The Final Status Survey Report will be a stand-alone document, with the amount of information incorporated by reference being kept to a minimum. The report will be reviewed and approved by personnel capable of evaluating all aspects of the report prior to its release. The required report elements are as follows:

- Site description
- Site conditions at the time of the survey
- Survey objectives
- Derived concentration guideline levels
- Classification of areas
- Selection of instruments and survey techniques
- Survey plan and procedures
- Determination of background
- Scanning survey measurements
- Discrete samples
- Detection sensitivity
- Sample collection and analysis
- Data interpretation

The following construction-related items will be included in the report as well:

- A brief description of the outstanding construction items from the final inspection and an indication that the items were satisfactorily resolved
- A synopsis of the work defined in the decommissioning workplan and certification that this work was performed
- An explanation of any changes to the work defined in the decommissioning workplan, including as-built drawings of the constructed facilities, and why the changes were necessary or beneficial for the project
- Certification that the decommissioning activities are complete and that the engineered barrier placed over the Northwest Landfill meets the applicable construction quality assurance criteria

Additionally, the Final Status Survey Report will contain the following:

- A discussion of any changes that were made in the Final Status Survey from what was proposed in the Plan or other submittals
- A description of the method by which the number of samples was determined for each survey unit
- A summary of the values used to determine the number of samples and a justification for these values

Furthermore, the survey results reported for each survey unit will include the following, as applicable:

- The number of samples collected from the survey unit.
- A drawing of the survey unit showing the reference system and random start systematic sample locations for Class 1 and 2 survey units and random locations shown for Class 3 survey units and reference areas
- The measured sample concentrations
- The statistical evaluation of the measured concentrations
- Judgmental and miscellaneous sample data sets reported separately from those samples collected for performing the statistical evaluation
- A discussion of anomalous data, including any areas of elevated direct radiation detected during scanning that exceeded the investigation level or measurement
- Locations in excess of the $DCGL_W$
- A statement that a given survey unit satisfied the $DCGL_W$ and the elevated measurement comparison if any sample points exceeded the $DCGL_W$

Finally, the Final Status Survey Report will contain the following, as necessary:

- A description of any changes in initial survey unit assumptions relative to the extent of residual radioactivity
- If a survey unit fails, a description of the investigation conducted to ascertain the reason for the failure and a discussion of the impact that failure has on the conclusion that the facility is ready for final radiological surveys
- If a survey unit fails, a discussion of the impact that the reason for the failure has on other survey unit information

# Section 15
# Financial Assurance

## 15.1 Cost Estimate

The estimated cost to decommission the SCA Hartley & Hartley Landfill Site is $1,900,000. This estimate was developed for the selected decommissioning alternative, which is on-site consolidation of radiologically contaminated materials in the Northwest Landfill and improvement of the cover over the Northwest Landfill. Additional details about the selected decommissioning alternative are presented in Subsection 8.3, and the estimated costs are documented in Table 6-1.

## 15.2 Financial Assurance Mechanism

S. C. Holdings will maintain financial assurance for decommissioning the SCA Hartley & Hartley Landfill Site consistent with the existing financial assurance mechanism for this site. S.C. Holdings currently maintains (through annual renewals) a $5,000,000 insurance policy for decommissioning this site. The policy is underwritten by National Guaranty Insurance Company of Vermont (Policy No. CPCH95-0002). The current endorsement, which was issued on February 25, 2003, extends the policy through March 31, 2004 (see Appendix E). The amount of the financial assurance currently in place exceeds the estimated cost of the remaining decommissioning activities by $3,100,000. Consequently, S.C. Holdings plans to reduce the insured amount to $1,900,000 beginning April 1, 2004.

# Section 16
# Restricted Use/Alternative Criteria

S.C. Holdings proposed to terminate Source Materials License No. SUC-1565 for the SCA Hartley & Hartley Landfill for unrestricted release (refer to Section 8 for details). Consequently, this section is not applicable to this Decommissioning Plan.

# Section 17
# References

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**Table 2-1**
**Licensed Radionuclides[1]**
**SCA Hartley & Hartley Landfill Site**
**Kawkawlin Township, Michigan**

| SOURCE MATERIAL | CHEMICAL AND/OR PHYSICAL FORM | MAXIMUM AMOUNT |
|---|---|---|
| Thorium | Contaminated soil, sludge, sediment, trash, building rubble, structures, and any other material contaminated in excess of background levels | 40 metric tons |
| Uranium | Contaminated soil, sludge, sediment, trash, building rubble, structures, and any other material contaminated in excess of background levels | 5 metric tons |

(1) From USNRC License No. SUC-1565.

## Table 2-2
## Laboratory Hydraulic Conductivity Measurements for the Landfill Containment Structures[1]
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| AREA | AVERAGE HYDRAULIC CONDUCTIVITY (cm/s) | NUMBER OF SAMPLES |
|---|---|---|
| **East Landfill** | | |
| Clay dike | $2.21 \times 10^{-8}$ | 8 |
| Clay cap | $6.85 \times 10^{-8}$ | 3 |
| **Northwest Landfill** | | |
| Slurry wall | $1.67 \times 10^{-8}$ | 6 |
| Clay cap | $1.86 \times 10^{-6}$ | 3 |

(1) From "Site Closure Integrity Investigation" (Dell Engineering, 1990).

## Table 3-1
## Location of Nearby Residences and Other Properties of Interest
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| POPULATION AREA/LOCATION | APPROXIMATE DISTANCE (miles) | BEARING FROM SITE |
|---|---|---|
| MDNR Tobico Marsh SGA Landfill | 0.0 | North |
| Bangor Township Landfill | 0.0 | East |
| Nearest Two Mile Road residence | 0.25 | South |
| Spring Valley Golf Course (club house) | 0.25 | Southwest |
| East Beaver Road (nearest residences) | 0.25 | South |
| Bay City State Recreation Area | 0.25 | East |
| Nearest Jose Road residence | 0.40 | West |
| Nearest Old Kawkawlin Road residence | 0.50 | West |
| Nearest Carrier Lane residence | 0.60 | East |
| Nearest South Huron Road residence | 0.60 | West |
| Highway 13 (South Huron Road) | 0.60 | West |
| Nearest Oak Lane residence | 0.65 | West |
| Nearest Scott Drive residence | 0.70 | South |
| Little Killarney Beach | 0.75 | Northeast |
| Nearest Lauria Road residence | 0.75 | South |
| Nearest Tobico Beach Road residence | 0.80 | East |
| Nearest Killarney Beach Road residence | 0.85 | South |
| Nearest Schmidt Road residences | 0.9 | West |
| Killarney Beach | 0.95 | Northeast |
| Tobico Beach | 0.95 | East |
| Kawkawlin Township | 1.30 | South |
| Lagoon Beach | 1.90 | Southeast |
| Donahue Beach | 3.0 | Southeast |
| Bay City | 4.9 | South |

Source:
USGS Map (1973).

## Table 3-2
## Bay County Past and Current Population
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| YEAR | POPULATION |
|---|---|
| 1950 | 88,461 |
| 1960 | 107,042 |
| 1970 | 117,339 |
| 1980 | 119,881 |
| 1990 | 111,723 |
| 2000 | 110,157 |

Source:
U.S. Bureau of Census, 1995;
1960-1990 http://www.census.gov/population/cencounts/mi190090.txt
U.S. Bureau of Census, 2000;
2000 - http://www.quickfacts.census.gov/gfd/states/26/26017.html

## Table 3-3
## Bay County Future Population Projections
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| YEAR | POPULATION |
|---|---|
| 2005 | 110,700 |
| 2010 | 109,400 |
| 2015 | 107,700 |
| 2020 | 105,800 |

Source:
Michigan State Budget Office, 1996;
http://www.michigan.gov/documents/8510_26104_7.pdf

## Table 3-4
## Population Ethnicity Demographics by Region, Census Tract, and Block Group
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| Location | Total Population | ETHNICITY BY PERCENTAGE OF TOTAL POPULATION | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | White | Hispanic or Latino | African American | American Indian | Asian | Hawaiian, Pacific Islander | Other Race | Mixed Ethnicity |
| Greater Saginaw, Bay City, Midland Area | 403,070 | 84.8 | 4.9 | 10.3 | 0.4 | 0.9 | 0.0 | 1.9 | 1.7 |
| Bay County, Michigan | 110,157 | 92.7 | 3.9 | 1.2 | 0.5 | 0.5 | 0.0 | 0.0 | 1.2 |
| Block Group 1, Census Tract 2861 | 1,603 | 96.2 | 1.4 | 0.2 | 0.3 | 0.1 | 0.0 | 0.0 | 1.7 |
| Block Group 2, Census Tract 2861 | 861 | 94.5 | 4.2 | 0.5 | 0.3 | 0.0 | 0.0 | 0.0 | 0.5 |
| Block Group 3, Census Tract 2861 | 913 | 94.9 | 2.5 | 0.0 | 0.5 | 0.4 | 0.1 | 0.0 | 1.5 |
| Block Group 4, Census Tract 2861 (Site location) | 1,727 | 94.6 | 2.0 | 0.9 | 0.6 | 0.2 | 0.0 | 0.0 | 1.6 |
| Block Group 5, Census Tract 2861 | 1,257 | 97.5 | 2.1 | 0.0 | 0.2 | 0.2 | 0.0 | 0.0 | 0.1 |
| Block Group 6, Census Tract 2861 | 1,549 | 98.1 | 1.0 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.6 |
| Block Group 1, Census Tract 2860 | 1,077 | 96.3 | 1.8 | 0.0 | 0.3 | 0.1 | 0.0 | 0.0 | 1.6 |
| Block Group 2, Census Tract 2860 | 1,185 | 98.1 | 1.3 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.2 |
| Block Group 3, CT 2860 | 1,557 | 96.6 | 2.1 | 0.3 | 0.3 | 0.5 | 0.0 | 0.0 | 0.3 |
| Block Group 1, Census Tract 2857 | 1,724 | 95.8 | 2.6 | 0.2 | 0.3 | 0.2 | 0.0 | 0.0 | 0.9 |
| Block Group 2, Census Tract 2857 | 705 | 96.5 | 1.6 | 0.0 | 0.4 | 0.7 | 0.0 | 0.0 | 0.9 |
| Block Group 3, Census Tract 2857 | 534 | 96.4 | 0.9 | 0.6 | 0.6 | 0.2 | 0.0 | 0.0 | 1.3 |
| Block Group 4, Census Tract 2857 | 914 | 96.3 | 2.0 | 0.0 | 0.1 | 0.5 | 0.0 | 0.0 | 1.1 |
| Block Group 2, Census Tract 2862 | 546 | 96.0 | 0.2 | 2.7 | 0.2 | 0.0 | 0.0 | 0.0 | 0.9 |
| Block Group 4, Census Tract 2862 | 1,008 | 94.9 | 1.5 | 0.7 | 0.5 | 0.8 | 0.0 | 0.0 | 1.6 |
| Block Group 5, Census Tract 2862 | 959 | 97.2 | 1.6 | 0.0 | 0.4 | 0.3 | 0.0 | 0.0 | 0.5 |

Source:
U.S. Bureau of Census, 2000; http://factfinder.census.gov

## Table 3-5
## Comparison of Poverty Level Statistics by Region and Block Group
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| LOCATION | POPULATION | POPULATION BELOW POVERTY LEVEL | PERCENTAGE BELOW POVERTY LEVEL |
|---|---|---|---|
| Greater Saginaw, Bay City, Midland Area | 403,070 | 46,751 | 12 |
| Bay County, Michigan | 110,157 | 10,605 | 9.7 |
| Block Group 1, Census Tract 2861 | 1,764 | 62 | 3.5 |
| Block Group 2, Census Tract 2861 | 930 | 26 | 2.8 |
| Block Group 3, Census Tract 2861 | 747 | 72 | 9.6 |
| Block Group 4, Census Tract 2861 (Site location) | 1,591 | 89 | 5.6 |
| Block Group 5, Census Tract 2861 | 1,250 | 46 | 3.7 |
| Block Group 6, Census Tract 2861 | 1,550 | 105 | 6.8 |
| Block Group 1, Census Tract 2860 | 1,085 | 77 | 7.1 |
| Block Group 2, Census Tract 2860 | 1,160 | 49 | 4.2 |
| Block Group 3, Census Tract 2860 | 1,525 | 43 | 2.8 |
| Block Group 1, Census Tract 2857 | 1,727 | 130 | 7.5 |
| Block Group 2, Census Tract 2857 | 735 | 52 | 7.1 |
| Block Group 3, Census Tract 2857 | 524 | 32 | 6.1 |
| Block Group 4, Census Tract 2857 | 891 | 70 | 7.9 |
| Block Group 2, Census Tract 2862 | 524 | 25 | 4.8 |
| Block Group 4 Census Tract 2862 | 1,026 | 107 | 10.4 |
| Block Group 5, Census Tract 2862 | 977 | 86 | 8.8 |

Source:
U.S. Bureau of Census, 2000; http://factfinder.census.gov

## Table 3-6
## 30-Year Monthly Average Temperature and Precipitation for Bay County (1951 to 1980)
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| MONTH | HIGH TEMPERATURE (°F) | LOW TEMPERATURE (°F) | MEAN TEMPERATURE (°F) | PRECIPITATION (inches) | SNOWFALL (inches) |
|---|---|---|---|---|---|
| January | 28.6 | 14.6 | 21.6 | 1.51 | 11.3 |
| February | 31.1 | 15.6 | 23.4 | 1.18 | 7.9 |
| March | 40.4 | 24.6 | 32.5 | 2.15 | 6.0 |
| April | 55.5 | 36.2 | 45.9 | 2.62 | 1.3 |
| May | 67.9 | 46.4 | 57.2 | 2.62 | 0.0 |
| June | 78.0 | 56.5 | 67.3 | 2.87 | 0.0 |
| July | 82.0 | 60.9 | 71.5 | 2.58 | 0.0 |
| August | 79.9 | 59.2 | 69.6 | 2.93 | 0.0 |
| September | 72.1 | 52.0 | 62.1 | 2.78 | 0.0 |
| October | 60.5 | 41.8 | 51.2 | 2.57 | 0.2 |
| November | 46.2 | 31.8 | 39.0 | 2.28 | 3.1 |
| December | 33.6 | 20.7 | 27.2 | 1.83 | 9.0 |

Source:

U.S. Army Corps of Engineers – Detroit District, 2003;
http://www.lre.usace.army.mil/index.cfm?chn_ID=1383&lake_id=2

## Table 3-7
## Severe Weather Phenomena 30-Year High and Low Temperature (1951 to 1980)
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| MONTH | HIGH TEMPERATURE (°F) | YEAR | LOW TEMPERATURE (°F) | YEAR |
|---|---|---|---|---|
| January | 62 | 1966 | -14 | 1977* |
| February | 58 | 1976 | -15 | 1979 |
| March | 78 | 1963 | -9 | 1962 |
| April | 85 | 1980* | 12 | 1954 |
| May | 93 | 1977* | 22 | 1966 |
| June | 99 | 1971* | 36 | 1971 |
| July | 98 | 1977* | 41 | 1965 |
| August | 100 | 1955 | 37 | 1971 |
| September | 98 | 1953 | 28 | 1976 |
| October | 87 | 1951 | 17 | 1976 |
| November | 76 | 1978 | -6 | 1977 |
| December | 68 | 1971 | -9 | 1951 |

Note:
* Indicates the last (of more than one) occurrence of the minimum or maximum temperature within the 30-year elevation period.

Source:
U.S. Army Corps of Engineers – Detroit District, 2003;
http://www.lre.usace.army.mil/index.cfm?chn_ID=1383&lake_id=2

## Table 3-8
## Severe Weather Phenomena 30-Year Maximum Precipitations (1951 to 1980)
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| MONTH | MAXIMUM RAINFALL (inches, year) | MAXIMUM SNOWFALL (inches, year) | MAXIMUM DAILY SNOW AMOUNT (inches, year) | MAXIMUM TOTAL SNOW DEPTH (inches, year) |
|---|---|---|---|---|
| January | 2.02 - 1974 | 29.0 - 1979 | 12.0 - 1967 | 25 - 1979 |
| February | 1.28 - 1974 | 19.5 - 1956 | 6.7 - 1962 | 21 - 1959 |
| March | 4.35 - 1973 | 14.7 - 1965 | 11.0 - 1968 | 13 - 1978 |
| April | 2.31 - 1967 | 13.0 - 1975 | 9.0 - 1970 | 12 - 1975 |
| May | 2.17 - 1978 | Trace - 1961* | Trace - 1961* | Trace - 1957 |
| June | 2.95 - 1973 | 0.0 | 0.0 | 0.0 |
| July | 2.81 - 1980 | 0.0 | 0.0 | 0.0 |
| August | 2.50 - 1951 | 0.0 | 0.0 | 0.0 |
| September | 2.20 - 1957 | 0.0 | 0.0 | 0.0 |
| October | 2.90 - 1954 | 3.5 - 1974 | 3.5 - 1967 | 3 - 1967 |
| November | 1.62 - 1965 | 17.9 - 1974 | 8.0 - 1951 | 4 - 1977* |
| December | 1.69 - 1979 | 21.0 - 1974 | 8.0 - 1957* | 12 - 1962 |

Note:
* Indicates the last (of more than one) occurrence of the minimum or maximum temperature within the 30-year elevation period.

Source
U.S. Army Corps of Engineers – Detroit District, 2003;
http://www.lre.usace.army.mil/index.cfm?chn_ID=1383&lake_id=2

## Table 3-9
## Seismic Activity Greater Than Magnitude 3
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| LOCATION | DATE | TIME OF EVENT (hr:min:sec) | MAGNITUDE | LATITUDE | LONGITUDE |
|---|---|---|---|---|---|
| Westcentral Ohio | 6/18/1875 | 12:43 | 4.7 | 4.20 | -84.00 |
| Westcentral Ohio | 9/19/1884 | 19:14 | 4.8 | 40.70 | -84.10 |
| Northeastern Ohio | 4/9/1900 | 14:00 | 3.4 | 41.40 | -81.90 |
| Westcentral Ohio | 9/30/1930 | 20:40 | 4.2 | 40.30 | -84.30 |
| Westcentral Ohio | 9/20/1931 | 23:05:03.4 | 4.7 | 40.43 | -84.27 |
| Westcentral Ohio | 3/2/1937 | 14:47:33.3 | 5.0 | 40.49 | -84.27 |
| Westcentral Ohio | 3/9/1937 | 54:43:5.5 | 5.4 | 40.47 | -84.28 |
| Northeastern Ohio | 3/9/1943 | 32:52:4.9 | 4.5 | 41.63 | -81.31 |
| Southcentral Michigan | 8/10/1947 | 24:64:1.3 | 4.6 | 41.63 | -85.00 |
| Lake Erie | 2/2/1976 | 21:14:02 | 3.4 | 41.96 | -82.67 |
| Westcentral Ohio | 6/17/1977 | 15:39:47.3 | 3.2 | 40.71 | -84.58 |
| Westcentral Ohio | 6/17/1977 | 15:39:46.9 | 3.2 | 40.71 | -84.71 |
| Lake Erie | 8/20/1980 | 93:45:2.3 | 3.2 | 41.94 | -83.01 |
| Southern Ontario | 8/28/1981 | 10:51:32 | 3.3 | 43.21 | -80.57 |
| Southern Ontario | 9/5/1981 | 54:92:0 | 3.1 | 42.73 | -81.35 |
| Northeastern Ohio | 1/31/1986 | 16:46:43.33 | 5.0 | 41.65 | -81.16 |
| Northeastern Ohio | 1/31/1986 | 16:46:42.3 | 5.0 | 41.65 | -81.16 |
| Westcentral Ohio | 7/12/1986 | 81:93:7.95 | 4.5 | 40.54 | -84.37 |
| Westcentral Ohio | 7/12/1986 | 81:93:7.9 | 4.6 | 40.54 | -84.37 |
| Northeastern Ohio | 7/13/1987 | 54:91:7.43 | 3.8 | 41.90 | -80-77 |
| Northeastern Ohio | 1/26/1991 | 32:12:2.61 | 3.4 | 41.54 | -81.45 |
| Lake Erie | 3/15/1992 | 61:35:5.22 | 3.5 | 41.91 | -81.25 |
| Northeastern Ohio | 10/16/1993 | 63:00:5.32 | 3.6 | 41.70 | -81.01 |
| Central Michigan | 9/2/1994 | 21:23:06.52 | 3.5 | 42.80 | -84.60 |
| Western Pennsylvania | 9/25/1998 | 19:52:52.07 | 5.2 | 41.49 | -80.39 |
| Lake Erie | 1/26/2001 | 30:32:0.06 | 4.4 | 41.94 | -80.80 |
| Northeastern Ohio | 6/3/2001 | 22:36:46.46 | 3.4 | 41.90 | -80.77 |
| Lake Erie | 6/30/2003 | 19:21:17.2 | 3.4 | 41.80 | -81.20 |

Source:
United States Geological Survey (USGS) Earthquake Hazards Program (http://neic.usgu.gov/neis/epic) (USGS, 2003b)

**Table 3-10**
**Lake Huron Physical Characteristics**
**SCA Hartley & Hartley Landfill Site**
**Kawkawlin Township, Michigan**

| CHARACTERISTIC | VALUE |
|---|---|
| Low water datum (LWD) | 576.8 ft |
| Length | 206 mi |
| Breadth | 183 mi |
| Shoreline length | 3,180 mi |
| Total surface area | 23,000 $mi^2$ |
| Surface area in U.S. | 9,100 $mi^2$ |
| Volume at LWD3 | 3,538,760 $yd^3$ |
| Average depth below LWD | 195 ft |
| Maximum depth below LWD | 750 ft |
| Average surface elevation (IGLD)(1) | 578.7 ft |
| Maximum surface elevation (IGLD) | 581.9 ft |
| Minimum surface elevation (IGLD) | 575.3 ft |

(1) International Great Lakes Datum (IGLD) of 1985 is equivalent to the North American Vertical Datum of 1988 (NAVD88);
[(Zilboski, D., Richards, J. and Young G. 1992) and (Beranek, Dwight A. 1992)]

**Table 3-11**
**Kawkawlin River Stream Flow Data Table**
**SCA Hartley & Hartley Landfill Site**
**Kawkawlin Township, Michigan**

| YEAR | GAGE HEIGHT (feet) | PEAK STREAM FLOW DATE | PEAK STREAM FLOW (cfs) | ANNUAL MEAN STREAM FLOW (cfs) |
|---|---|---|---|---|
| 1951 | -- | April 27 | 520 | -- |
| 1952 | -- | April 15 | 990 | 84.3 |
| 1953 | -- | May 4 | 506 | 37.4 |
| 1954 | -- | June 22 | 1,090 | 76.3 |
| 1955 | -- | March 13 | 1,100 | 51.3 |
| 1956 | -- | May 8 | 855 | 52.5 |
| 1957 | -- | April 8 | 415 | 56.5 |
| 1958 | -- | May 6 | 714 | 34.9 |
| 1959 | -- | April 3 | 1,220 | 78.2 |
| 1960 | -- | April 1 | 1,540 | 64.1 |
| 1961 | 7.05 | March 27 | 390 | 37.7 |
| 1962 | 9.97 | May 4 | 1,120 | 58.1 |
| 1963 | 7.28 | March 29 | 396 | 33.2 |
| 1964 | 5.60 | May 4 | 128 | 9.50 |
| 1965 | 10.33 | April 13 | 1,540 | 63.7 |
| 1966 | 7.45 | March 25 | 472 | 51.8 |
| 1967 | 9.09 | March 28 | 1,020 | 75.7 |
| 1968 | 9.38 | May 30 | 906 | 48.2 |
| 1969 | 8.44 | May 11 | 719 | 70.4 |
| 1970 | 7.81 | April 9 | 518 | 64.0 |
| 1971 | 8.76 | April 4 | 846 | 41.1 |
| 1972 | -- | April 14 | 542 | 47.1 |
| 1973 | 8.98 | January 22 | 840 | 94.0 |
| 1974 | 10.92 | May 18 | 1,610 | 96.2 |
| 1975 | 8.42 | September 3 | 516 | 80.4 |
| 1976 | 10.44 | March 22 | 1,420 | 116 |
| 1977 | 4.58 | March 13 | 87.0 | 19.1 |
| 1978 | 8.75 | March 31 | 805 | 44.5 |
| 1979 | 8.19 | April 2 | 548 | 49.1 |
| 1980 | 6.54 | April 12 | 306 | 43.9 |
| 1981 | 9.44 | February 25 | 1,010 | 91.9 |
| 1982 | 9.27 | March 26 | 957 | -- |

Source:
USGS, 2003; http://waterdata.usgs.gov/mi/nwis/annual

**Table 3-12**
**Existing Monitoring Well/Piezometer Inventory**
**SCA Hartley & Hartley Landfill Site**
**Kawkawlin Township, Michigan**

| WELL/ PIEZOMETER | GROUND ELEVATION (M.S.L.) | TOP OF CASING ELEVATION (M.S.L.) | WATER LEVEL ELEVATION (July 2000) | SCREEN LENGTH (feet) | BORING DEPTH (feet) | SCREEN INTERVAL (M.S.L.) | INSIDE DIAMETER (inches) | WELL MATERIAL | OUTSIDE /INSIDE CONTAINMENT |
|---|---|---|---|---|---|---|---|---|---|
| INS-01 | 588.80 | 590.82 | 586.38 | 10.0 | 11.0 | 577.80-587.80 | 2.0 | SS | Inside |
| INS-02 | 589.50 | 591.04 | 586.70 | 10.0 | 12.0 | 578.50-588.50 | 2.0 | SS | Inside |
| INS-03 | 588.80 | 590.46 | 586.66 | 10.0 | 11.4 | 577.80-587.80 | 2.0 | SS | Inside |
| MW-47* | 590.90 | 596.00 | 589.03 | NA | 11.3 | NA | 2.0 | PVC | Inside |
| PZ-1 (MW-18A) | 588.00 | 591.20 | 586.39 | 3.0 | 9.0 | 582.5-579.5 | 2.0 | SS | Inside |
| PZ-2 | 591.20 | 594.78 | 593.98 | 3.0 | 15.0 | 579.7-576.7 | 2.0 | SS | Inside |
| PZ-3 | 589.40 | 592.39 | 584.08(1) | 3.0 | 13.5 | 579.9-576.9 | 2.0 | SS | Outside |
| UP-01* | 586.30 | 588.38 | 585.36 | 10.0 | 11.0 | 575.30-585.30 | 2.0 | PVC | Outside |
| DWN-02* | 587.20 | 588.49 | 585.35 | 10.0 | 11.4 | 576.20-586.20 | 2.0 | PVC | Outside |
| DWN-03* | 587.70 | 589.30 | 585.12 | 10.0 | 11.2 | 576.70-586.70 | 2.0 | PVC | Outside |
| MW-39 | 589.20 | 591.72 | 583.78 | 2.0 | 10.0 | 579.17-581.17 | 2.0 | SS | Outside |
| MW-40A | 586.30 | 589.41 | 586.36 | NA | 9.0 | NA | 2.0 | PVC | Outside |
| MW-43A | 586.40 | 589.55 | 583.58(1) | NA | 7.0 | NA | 2.0 | PVC | Outside |
| MW-48 | NA | NA | 583.77 | NA | NA | NA | NA | NA | Outside |

(1) Water level in October 1994.

Notes:
* = utilized in current monitoring program.
NA = not available.
M.S.L. = mean sea level.
SS = stainless steel.
PVC = polyvinyl chloride.
() = alternative identification.

Source:
(REI, 1996; Dell, 1990)

## Table 3-13
## Inorganic Chemicals in Groundwater Exceeding the Michigan Part 201 Generic Residential Cleanup Criteria
## SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| ANALYTE | MICHIGAN PART 201 GENERIC RESIDENTIAL CLEANUP CRITERION[1] | UNITS | MAXIMUM ON-SITE CONCENTRATION | DATE OF SAMPLE | WELL LOCATION FOR MAXIMUM ON-SITE CONCENTRATION |
|---|---|---|---|---|---|
| Arsenic, total | 50 | µg/L | 72.2 | 07/22/00 | MWM-12 |
| Cadmium, dissolved | 5 | µg/L | 6 | 05/02/85 | UP-1 |
| Chloride | 250 | mg/L | 4,240 | 05/04/99 | MW-12 |
| Chromium, dissolved | 100 | µg/L | 110 | 11/01/89 | UP-1 |
| Iron, total | 300 | µg/L | 53,000 | 07/22/00 | MWM-12 |
| Lead, total | 4 | µg/L | 44 | 11/03/85 | MW-12 |
| Manganese, dissolved | 50 | µg/L | 620 | 07/20/00 | MWM-24 |
| Sodium, dissolved | 120,000 | µg/L | 778,000 | 07/22/00 | MWH-8 DUP |

(1) Rule R299.5744 of the Michigan Administrative Code. December 13, 2002.

# Table 3-14
## Summary of Water Quality Data in Saginaw Formation for Bay County, Michigan
## SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| WELL | SPECIFIC CONDUCTANCE (uS) | TOTAL DISSOLVED SOLIDS (mg/L) | IRON (µg/L) | MANGANESE (µg/L) | SODIUM (mg/L) | CHLORIDE (mg/L) | SULFATE (mg/L) |
|---|---|---|---|---|---|---|---|
| **Data from Wells in the Saginaw Formation in Townships Around Kawkawlin** | | | | | | | |
| **USGS Investigative Wells (Twenter & Cummings, 1985)** | | | | | | | |
| B1F | 24,400 | 15,100 | 2,300 | 200 | 5,100 | 9,400 | 18 |
| B5F | 8,380 | 4,680 | 440 | 20 | 1,700 | 2,700 | 19 |
| B7F | 12,800 | 6,590 | 1,500 | 70 | 2,400 | 4,000 | 3.5 |
| B9F | 33,600 | 19,500 | 1,000 | 110 | 7,500 | 11,000 | 500 |
| B11F | 4,500 | 2,290 | 19,000 | 500 | 670 | 1,200 | 130 |
| B17F | 158,000 | 80,200 | 6,400 | 700 | 28,000 | 50,000 | 160 |
| B20F | 4,750 | 2,520 | 290 | 20 | 870 | 1,400 | 5.4 |
| **Private Wells (Twenter & Cummings, 1985)** | | | | | | | |
| 511 Delta Road | NA | NA | NA | NA | 130 | 96 | 41 |
| 6331 Eight Mile Road | NA | NA | NA | NA | 650 | 1,100 | 640 |
| 1417 Weiss Road | NA | NA | NA | NA | 370 | 540 | 2.1 |
| 2323 E Amlethe Road | NA | NA | NA | NA | 500 | 920 | 6.3 |
| 2323 E Amlethe Road | NA | NA | NA | NA | 420 | 800 | 22 |
| 2901 E Schwab Road | NA | NA | NA | NA | 670 | 990 | 86 |
| 6815 Three Mile Rd | NA | NA | NA | NA | 370 | 490 | 13 |
| 2905 E Amlethe Road | NA | NA | NA | NA | 1,000 | 1,700 | 20 |
| 2916 Englehart Road | NA | NA | NA | NA | 530 | 410 | 4 |
| 2412 E Amlethe Road | NA | NA | NA | NA | 510 | 860 | 26 |
| 7115 Bentwood Road | NA | NA | NA | NA | 400 | 600 | 61 |
| 7116 Bentwood Road | NA | NA | NA | NA | 430 | 690 | 60 |
| 1084 Amlethe Road | NA | NA | NA | NA | 540 | 930 | 2.1 |
| 367 River Road | NA | NA | NA | NA | 300 | 260 | 130 |
| 1987 Eight Mile Road | NA | NA | NA | NA | 300 | 430 | 300 |
| 1578 Fraser Road | NA | NA | NA | NA | 520 | 750 | 190 |
| 2055 Seven Mile Road | NA | NA | NA | NA | 1,300 | 2,300 | 300 |
| 2976 Moser Road | NA | NA | NA | NA | 790 | 1,300 | 300 |
| 769 W. Brown Road | NA | NA | NA | NA | 640 | 690 | 280 |
| 1300 E Chip Road | NA | NA | NA | NA | 620 | 1,000 | 62 |
| 3939 Fraser Road | NA | NA | NA | NA | 2,100 | 2,800 | 100 |
| 5864 Seven Mile Road | NA | NA | NA | NA | 10 | 15 | 42 |
| 5904 Seven Mile Road | NA | NA | NA | NA | 610 | 870 | 1,200 |
| 1467 Hotchkiss Road | NA | NA | NA | NA | 860 | 1,500 | 7.5 |
| **Mean Value** | **35,204** | **18,697** | **4,419** | **231** | **1,962** | **3,282** | **153** |

## Table 3-14 *(continued)*
## Summary of Water Quality Data in Saginaw Formation for Bay County, Michigan
## SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| WELL | SPECIFIC CONDUCTANCE (uS) | TOTAL DISSOLVED SOLIDS (mg/L) | IRON (µg/L) | MANGANESE (µg/L) | SODIUM (mg/L) | CHLORIDE (mg/L) | SULFATE (mg/L) |
|---|---|---|---|---|---|---|---|
| **Data from Private Wells in Saginaw Formation in Wells in Bay County (Dannemiller & Baltusis, 1990)** | | | | | | | |
| 1 | 2,900 | 1920 | 740 | 57 | 420 | 520 | 660 |
| 2 | 3,300 | NA | NA | 160 | 420 | 590 | 900 |
| 3 | 1,800 | 2,330 | 1,200 | NA | NA | NA | NA |
| 4 | 1,350 | 800 | 220 | 12 | 220 | 270 | 100 |
| 5 | 1,090 | 739 | 500 | 22 | 92 | 100 | 280 |
| 6 | 5,500 | NA | NA | NA | NA | NA | NA |
| 7 | 928 | 682 | 500 | 36 | 50 | 4.2 | 370 |
| 8 | 1,780 | 1,530 | 1,700 | 97 | 85 | 36 | 920 |
| **Mean Value** | **2,331** | **1,334** | **810** | **64** | **215** | **253** | **538** |
| **MI Part 201 Generic Residential Groundwater Cleanup Criteria** | | | **300** | **50** | **120** | **250** | **250** |

Note:
NA = data not available.

## Table 4-1
## Mean Background Activity Levels
## of Radioisotopes of Potential Concern
## SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| MEDIUM | ANALYSIS | BACKGROUND MEAN ACTIVITY LEVEL[1] | STANDARD DEVIATION[2] | 95 % UPPER CONFIDENCE LIMIT ABOVE THE MEAN[3] |
|---|---|---|---|---|
| Groundwater (values reported as pCi/L) | Cs-137 | 0.397 | 0.084 | 0.566 |
| | Ra-226 | 0.311 | 0.108 | 0.528 |
| | Ra-228 | 0.393 | 0.647 | 1.686 |
| | Sr-90 | 3.717 | 2.682 | 9.082 |
| | Th-228 | 0.478 | 0.506 | 1.489 |
| | Th-230 | 0.550 | 0.336 | 1.221 |
| | Th-232 | 0.305 | 0.116 | 0.536 |
| | U-234 | 0.539 | 0.260 | 1.059 |
| | U-235 | 0.111 | 0.057 | 0.224 |
| | U-238 | 0.246 | 0.129 | 0.504 |
| Surface water (values reported as pCi/L) | Cs-137 | 0.434 | 0.070 | 0.575 |
| | Ra-226 | 0.332 | 0.169 | 0.670 |
| | Ra-228 | 2.349 | 2.359 | 7.067 |
| | Sr-90 | 6.963 | 6.656 | 20.275 |
| | Th-228 | 0.232 | 0.170 | 0.572 |
| | Th-230 | 0.437 | 0.249 | 0.934 |
| | Th-232 | 0.175 | 0.172 | 0.519 |
| | U-234 | 0.973 | 0.677 | 2.327 |
| | U-235 | 0.179 | 0.155 | 0.488 |
| | U-238 | 0.614 | 0.475 | 1.564 |
| Sediment (values reported as pCi/g) | Cs-137 | 0.629 | 0.606 | 1.841 |
| | Ra-226 | 0.528 | 0.310 | 1.148 |
| | Ra-228 | 0.675 | 0.290 | 1.255 |
| | Sr-90 | 0.202 | 0.108 | 0.419 |
| | Th-228 | 0.200 | 0.098 | 0.395 |
| | Th-230 | 0.333 | 0.274 | 0.880 |
| | Th-232 | 0.220 | 0.090 | 0.400 |
| | Th-234 | 1.489 | 0.959 | 3.407 |
| | U-234 | 0.733 | 0.557 | 1.847 |
| | U-235 | 0.081 | 0.053 | 0.186 |
| | U-238 | 0.682 | 0.533 | 1.749 |

## Table 4-1(continued)
## Mean Background Activity Levels
## of Radioisotopes of Potential Concern
## SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| MEDIUM | ANALYSIS | BACKGROUND MEAN ACTIVITY LEVEL[1] | STANDARD DEVIATION[2] | 95 % UPPER CONFIDENCE LIMIT ABOVE THE MEAN[3] |
|---|---|---|---|---|
| Upland soil (values reported as pCi/g) | Cs-137 | 0.647 | 0.190 | 1.028 |
| | Ra-226 | 0.261 | 0.147 | 0.555 |
| | Ra-228 | 0.424 | 0.187 | 0.798 |
| | Sr-90 | 0.210 | 0.129 | 0.468 |
| | Th-228 | 0.074 | 0.034 | 0.141 |
| | Th-230 | 0.330 | 0.145 | 0.620 |
| | Th-232 | 0.103 | 0.048 | 0.198 |
| | Th-234 | 1.199 | 0.994 | 3.188 |
| | U-234 | 0.103 | 0.085 | 0.273 |
| | U-235 | 0.023 | 0.017 | 0.057 |
| | U-238 | 0.056 | 0.042 | 0.140 |
| Wetland soil (values reported as pCi/g) | Cs-137 | 1.402 | 1.186 | 3.773 |
| | Ra-226 | 0.261 | 0.147 | 0.555 |
| | Ra-228 | 0.424 | 0.187 | 0.798 |
| | Sr-90 | 0.143 | 0.030 | 0.202 |
| | Th-228 | 0.161 | 0.159 | 0.478 |
| | Th-230 | 0.225 | 0.250 | 0.726 |
| | Th-232 | 0.138 | 0.132 | 0.401 |
| | Th-234 | 2.115 | 1.835 | 5.785 |
| | U-234 | 0.452 | 0.344 | 1.139 |
| | U-235 | 0.052 | 0.037 | 0.126 |
| | U-238 | 0.403 | 0.376 | 1.155 |

(1) The mean is calculated for the 10 samples of each medium collected in December 2002, by RMT, Inc. The analytical results are presented in Appendix B-1.

(2) Calculated based on n = 10 samples.

(3) The 95 percent Upper Confidence Limit above the mean is calculated as the mean plus two standard deviations.

## Table 4-2
## Samples Collected in May 2003 to Confirm Anomalously High Historical Results
## SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| | | Media to be Sampled | | | Analytical Program(s) | |
|---|---|---|---|---|---|---|
| Sample[1] | General Location | SOW | SD | SW | Rad.[2] | Chem. |
| SD-A96C<br>SW-A96C | Pond west of MDNR Landfill | | ✓ | ✓ | ✓ | |
| SD-Q13C<br>SW-Q13 | Pond west of East Landfill | | ✓ | ✓ | ✓ | |
| SD-R16C<br>SW-R16 | Pond west of East Landfill | | ✓ | ✓ | ✓ | |
| SD-Q14<br>SW-Q14 | Pond west of East Landfill | | ✓ | ✓ | ✓ | |
| SD-S13<br>SW-S13 | Pond west of East Landfill | | ✓ | ✓ | ✓ | |
| SD-T23C<br>SW-T23 | Pond west of East Landfill | | ✓ | ✓ | ✓ | |
| SD-W23C<br>SW-W23 | Pond west of East Landfill | | ✓ | ✓ | ✓ | |
| SOW-M24C | West Marsh Area | ✓ | | | ✓ | |
| SOW-N20C | West Marsh Area | ✓ | | | ✓ | |
| SOW-Q26C | West Marsh Area | ✓ | | | ✓ | |
| SOW-G11C | West Marsh Area | ✓ | | | ✓ | |
| SOW-U97C | Off-site, north of Cell A | ✓ | | | ✓ | |
| SOW-X96C | Off-site, north of Cell A | ✓ | | | ✓ | |
| SOW-R99C | Off-site, northwest of Cell A and north of North Pond Area | ✓ | | | ✓ | |
| SOW-Y99C | Off-site, north of Cell A and northeast and Marsh Area | ✓ | | | ✓ | |
| SOW-H8C | Wetland, south of Northwest Landfill | ✓ | | | ✓ | |
| SOW-H7 | Wetland, south of Northwest Landfill | ✓ | | | ✓ | |
| SOW-ITD3C | Drainage ditch south of site | ✓ | | | | B2EHP |
| | Total Number of Samples | 11 | 7 | 7 | | |

(1) Sample locations are shown on Figure 4-2.
(2) See Table 4-3 for a list of the radiological parameters tested.

Notes:
B2EHP = bis-2 ethylhexyl phthalate.
SOW designates wetland soil.
SD designates sediment.
SW designates surface water.

## Table 4-3
## Analytical Methods Used in the May 2003 Sampling Event
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| Radiological Analyses(1) | | | |
|---|---|---|---|
| Parameter | Matrix | Method | Contract-Required Detection Limit |
| Isotopic uranium | Soil/Sediment | Alpha spectroscopy LANL ER290 | 0.1 pCi/g |
| Isotopic thorium | Soil/Sediment | Alpha spectroscopy LANL ER200 | 0.1 pCi/g |
| Radium (as Bi-214 and Ac-228) | Soil/Sediment | Gamma spectroscopy HASL 300 | 0.1 pCi/g |
| Isotopic uranium | Water | Alpha spectroscopy LANL ER290 | 0.1 pCi/L |
| Isotopic thorium | Water | Alpha spectroscopy LANL ER200 | 0.1 pCi/L |
| Radium-228 | Water | EPA 904/9320 | 0.1 pCi/L |
| Radium-226 | Water | SM 7500 | 0.1 pCi/L |

Footnote:

(1) All samples, except SOW-ITD3C, were analyzed for the radioisotopes in this table.

| Chemical Analyses(2) | | | |
|---|---|---|---|
| Parameter | Matrix | Method | Contract-Required Detection Limit |
| PCBs(3) | Soil | CLP 3/90 SOW, as modified | 330 μg/kg |
| Bis(2-ethylhexyl) phthalate(4) | Soil | CLP 3/90 SOW, as modified | 330 μg/kg |
| Chromium (total)(5) | Soil | CLP 3/90 SOW, as modified | 50 μg/kg |

(2) Certain wetland soil samples were analyzed for chemical parameters, in addition to the radiological analyses.

(3) The following five samples were analyzed for PCBs: SOW-NWLF13, SOW-H9, SOW-J8, SOW-N9, and SOW-O10.

(4) Sample SOW-ITD3C was analyzed for bis-2 ethylhexyl phthalate.

(5) Samples SOW-NWLF9 and SOW-NWLF10 were analyzed for chromium (total).

## Table 4-4
## Samples Used to Delineate Class 1/Class 2 Survey Unit Boundaries, May 2003 Sampling Event
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| | | Analytical Program(s) | |
|---|---|---|---|
| Sample ID[1] | General Location | Rad.[2] | Chem. |
| SOW-NWLF1 | North of Northwest Landfill | ✓ | |
| SOW-NWLF2 | North of Northwest Landfill | ✓ | |
| SOW-NWLF3 | North of Northwest Landfill | ✓ | |
| SOW-NWLF4 | North of Northwest Landfill | ✓ | |
| SOW-NWLF5 | North of Northwest Landfill | ✓ | |
| SOW-NWLF6 | West of Northwest Landfill | ✓ | |
| SOW-NWLF7 | West of Northwest Landfill | ✓ | |
| SOW-NWLF8 | West of Northwest Landfill | ✓ | |
| SOW-NWLF9 | Northeast of Northwest Landfill | ✓ | Cr |
| SOW-NWLF10 | Northeast of Northwest Landfill | ✓ | Cr |
| SOW-NWLF11 | Northeast of Northwest Landfill | ✓ | |
| SOW-NWLF12 | Northeast of Northwest Landfill | ✓ | |
| SOW-NWLF13 | South of Northwest Landfill | ✓ | PCBs |
| SOW-NWLF14 | South of Northwest Landfill | ✓ | |
| SOW-H9 | Northern edge of West Marsh Area (just outside of a sediment excavation area as part of the Part 201 response activities) | ✓ | PCBs |
| SOW-J8 | Northern edge of West Marsh Area (just outside of a sediment excavation area as part of the Part 201 response activities) | ✓ | PCBs |
| SOW-N9 | Northeastern edge of West Marsh Area (just outside of a sediment excavation area as part of the Part 201 response activities) | ✓ | PCBs |
| SOW-O10 | Northeastern edge of West Marsh Area (just outside of a sediment excavation area as part of the Part 201 response activities) | ✓ | PCBs |

(1) A total of 19 samples were collected. Sample locations are shown on Figure 4-2. All samples consisted of wetland soil. Samples SOW-NWLF1 through SOW-NWLF14 were collected outside of the slurry wall around the Northwest Landfill.
(2) See Table 4-3 for a list of the radiological parameters tested.

Note:
Cr = chromium (total).

## Table 4-5
## Summary of the May 2003 Sampling Program
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| | Number of Samples | | | | |
|---|---|---|---|---|---|
| | | QC Samples[1] | | | |
| Medium | Field Sample | Field Duplicate | Equipment Rinseate Blank | Matrix Spike/ Matrix Spike Duplicate (MS/MSD) | Total Number of Samples |
| Wetland soil (SOW) | 30 | 3 | 3 | 1 | 37 |
| Sediment (SD) | 7 | 1 | 1 | 1 | 10 |
| Surface water (SW) | 7 | 1 | 1 | 1 | 10 |
| Slag/Waste (WST) | 10 | 1 | 1 | 1 | 13 |
| Total | 54 | 6 | 6 | 4 | 70 |

(1) One of each type of QC sample (duplicate, equipment rinseate blank, and MS/MSD) was also analyzed for PCBs, chromium, and bis(2-ethylhexyl)phthalate.

**Table 4-6**
**Comparison of the December 2002 and May 2003 Resampling Results with the Corresponding Historical Results**
**SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan**

| PARAMETER | UNITS | HISTORICAL SAMPLE SD-A96 SAMPLE DATE: JULY 20, 2000 LABORATORY: THERMONUCLEAR | | | | CONFIRMATION SAMPLE SD-A96C SAMPLE DATE: MAY 20, 2003 LABORATORY: OUTREACH | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | RESULT | QUAL | ERROR | DL | RESULT | QUAL | ERROR | DL |
| Cesium-137 | pCi/g | NA | NA | NA | NA | 0.094 | | 0.013 | 0.025 |
| Radium-226 | pCi/g | 4.55 | | 1.53 | 3.298 | 0.075 | | 0.010 | 0.041 |
| Radium-228 | pCi/g | -0.55 | U | 1.59 | 2.881 | 0.055 | U | 0.034 | 0.102 |
| Strontium-90 | pCi/g | 0.18 | U | 0.36 | 0.619 | NA | NA | NA | NA |
| Thorium-228 | pCi/g | 0.27 | BU | 0.21 | 0.262 | 0.076 | | 0.032 | 0.024 |
| Thorium-230 | pCi/g | 0.7 | BU | 0.35 | 0.25 | 0.091 | U | 0.071 | 0.142 |
| Thorium-232 | pCi/g | 0.63 | | 0.33 | 0.249 | 0.107 | | 0.040 | 0.037 |
| Thorium-234 | pCi/g | 0.46 | U | 0.98 | 0.845 | 0.045 | U | 0.139 | 0.359 |
| Uranium-234 | pCi/g | NA | NA | NA | NA | 0.171 | | 0.045 | 0.022 |
| Uranium-235 | pCi/g | NA | NA | NA | NA | 0.023 | | 0.018 | 0.019 |
| Uranium-238 | pCi/g | NA | NA | NA | NA | 0.116 | | 0.036 | 0.015 |

| PARAMETER | UNITS | HISTORICAL SAMPLE SW-A96 SAMPLE DATE: JULY 20, 2000 LABORATORY: THERMONUCLEAR | | | | CONFIRMATION SAMPLE SW-A96C SAMPLE DATE: MAY 20, 2003 LABORATORY: OUTREACH | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cesium-137 | pCi/L | NA | NA | NA | NA | NA | NA | NA | NA |
| Radium-226 | pCi/L | 1.49 | BU | 1.16 | 1.312 | 0.10 | U | 0.083 | 0.134 |
| Radium-228 | pCi/L | -3.02 | U | 3.63 | 6.817 | 0.554 | | 0.049 | 0.133 |
| Strontium-90 | pCi/L | 3.62 | | 1.94 | 2.968 | NA | NA | NA | NA |
| Thorium-228 | pCi/L | -0.05 | U | 0.05 | 0.54 | 0.049 | U | 0.055 | 0.079 |
| Thorium-230 | pCi/L | 0.6 | BU | 0.49 | 0.486 | 0.794 | | 0.162 | 0.232 |
| Thorium-232 | pCi/L | -0.02 | U | 0.03 | 0.414 | 0.120 | | 0.062 | 0.065 |
| Thorium-234 | pCi/L | 60.09 | U | 122.3 | 160.8 | NA | NA | NA | NA |
| Uranium-234 | pCi/L | NA | NA | NA | NA | 0.258 | | 0.084 | 0.054 |
| Uranium-235 | pCi/L | NA | NA | NA | NA | 0.050 | | 0.043 | 0.044 |
| Uranium-238 | pCi/L | NA | NA | NA | NA | 0.063 | U | 0.055 | 0.068 |

## Table 4-6 (continued)
## Comparison of the December 2002 and May 2003 Resampling Results with the Corresponding Historical Results
## SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| | | HISTORICAL SAMPLE | | | | CONFIRMATION SAMPLE | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | SOW-A97 SAMPLE DATE: JULY 20, 2000 LABORATORY: THERMONUCLEAR | | | | SOW-A97C SAMPLE DATE: DECEMBER 11, 2002 LABORATORY: OUTREACH | | | |
| PARAMETER | UNITS | RESULT | QUAL | ERROR | DL | RESULT | QUAL | ERROR | DL |
| Cesium-137 | pCi/g | NR | NR | NR | NR | 1.58 | | 0.215 | 0.493 |
| Radium-226 | pCi/g | 0.68 | U | 0.56 | 0.962 | 0.54 | U | 0.246 | 0.774 |
| Radium-228 | pCi/g | 0.64 | U | 1.76 | 3.072 | 0 | U | | 1.8 |
| **Strontium-90** | **pCi/g** | **47.12** | | **2.44** | **1.305** | **0.119** | **U** | **0.171** | **0.29** |
| Thorium-228 | pCi/g | 0.53 | | 0.38 | 0.395 | 0.173 | U | 0.08 | 0.092 |
| Thorium-230 | pCi/g | 1.19 | | 0.58 | 0.418 | 0.566 | U | 0.159 | 0.25 |
| Thorium-232 | pCi/g | 0.61 | | 0.39 | 0.261 | 0.257 | | 0.106 | 0.133 |
| Thorium-234 | pCi/g | 2.83 | U | 11.04 | 8.614 | 5.36 | | 1.24 | 4.96 |
| Uranium-234 | pCi/g | NA | NA | NA | NA | 0.606 | | 0.105 | 0.036 |
| Uranium-235 | pCi/g | NA | NA | NA | NA | 0.071 | | 0.042 | 0.046 |
| Uranium-238 | pCi/g | NA | NA | NA | NA | 0.481 | | 0.095 | 0.046 |

| | | HISTORICAL SAMPLE | | | | CONFIRMATION SAMPLE | | | |
|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | UNITS | SOW-F8 SAMPLE DATE: JULY 21, 2000 LABORATORY: THERMONUCLEAR | | | | SOW-F8C SAMPLE DATE: DECEMBER 10, 2002 LABORATORY: OUTREACH | | | |
| Cesium-137 | pCi/g | 0.91 | | 0.67 | 0.664 | 2.64 | | 0.401 | 0.85 |
| Radium-226 | pCi/g | 1.53 | | 1.01 | 0.947 | 1.09 | U | 0.418 | 1.25 |
| Radium-228 | pCi/g | -5.11 | U | 4.75 | 9.001 | 0 | U | | 2.22 |
| **Strontium-90** | **pCi/g** | **79.98** | | **3.89** | **1.974** | **0.231** | | **0.137** | **0.225** |
| Thorium-228 | pCi/g | 0.44 | U | 0.47 | 0.657 | 0.085 | J | 0.072 | 0.07 |
| Thorium-230 | pCi/g | 0.72 | | 0.59 | 0.703 | 0.033 | U | 0.101 | 0.223 |
| Thorium-232 | pCi/g | 0.52 | U | 0.51 | 0.702 | 0.011 | U | 0.049 | 0.08 |
| Thorium-234 | pCi/g | -2.74 | U | 4.78 | 8.939 | 2.56 | J | 3.02 | 0.929 |
| Uranium-234 | pCi/g | NA | NA | NA | NA | 0.463 | | 0.073 | 0.036 |
| Uranium-235 | pCi/g | NA | NA | NA | NA | 0.022 | U | 0.024 | 0.038 |
| Uranium-238 | pCi/g | NA | NA | NA | NA | 0.408 | | 0.067 | 0.022 |

Table 4-6 (continued)
Comparison of the December 2002 and May 2003 Resampling Results with the Corresponding Historical Results
SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| PARAMETER | UNITS | HISTORICAL SAMPLE SOW-G11 SAMPLE DATE: JULY 21, 2000 LABORATORY: THERMONUCLEAR | | | | CONFIRMATION SAMPLE SOW-G11C SAMPLE DATE: MAY 20, 2003 LABORATORY: OUTREACH | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | RESULT | QUAL | ERROR | DL | RESULT | QUAL | ERROR | DL |
| Cesium-137 | pCi/g | 2.97 | | 0.6 | 0.342 | 1.34 | | 0.066 | 0.072 |
| Radium-226 | pCi/g | 2.07 | | 0.87 | 0.66 | 0.036 | U | 0.019 | 0.051 |
| Radium-228 | pCi/g | -2.84 | U | 2.24 | 4.318 | 0 | U | | 0.126 |
| Strontium-90 | pCi/g | 5.54 | | 1.17 | 1.39 | NA | NA | NA | NA |
| Thorium-228 | pCi/g | 0.48 | U | 0.61 | 0.773 | 0.116 | | 0.039 | 0.029 |
| Thorium-230 | pCi/g | 1.59 | | 1.14 | 1.009 | 0 | U | 0.074 | 0.222 |
| Thorium-232 | pCi/g | 0.61 | U | 0.69 | 0.905 | 0.114 | | 0.039 | 0.026 |
| Thorium-234 | pCi/g | -2.16 | U | 2.57 | 4.72 | 0.116 | U | 0.081 | 0.296 |
| Uranium-234 | pCi/g | NA | NA | NA | NA | 0.458 | | 0.139 | 0.112 |
| Uranium-235 | pCi/g | NA | NA | NA | NA | 0.073 | | 0.052 | 0.034 |
| Uranium-238 | pCi/g | NA | NA | NA | NA | 0.315 | | 0.106 | 0.055 |

| PARAMETER | UNITS | HISTORICAL SAMPLE GW-H8 SAMPLE DATE: JULY 22, 2000 LABORATORY: THERMONUCLEAR | | | | CONFIRMATION SAMPLE GW-H8C SAMPLE DATE: DECEMBER 11, 2002 LABORATORY: OUTREACH | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cesium-137 | pCi/L | NR | NR | NR | NR | 0.29 | U | 0.196 | 0.59 |
| Radium-226 | pCi/L | 18.57 | | 10.28 | 13.25 | 0.345 | | 0.183 | 0.285 |
| Radium-228 | pCi/L | 26.48 | | 15.01 | 23.138 | 0 | U | 0.093 | 0.266 |
| Strontium-90 | pCi/L | 2.01 | U | 1.63 | 2.624 | 1.03 | U | 0.806 | 1.29 |
| Thorium-228 | pCi/L | 0.54 | U | 0.5 | 0.582 | 1.08 | | 0.424 | 0.313 |
| Thorium-230 | pCi/L | 0.64 | BU | 0.53 | 0.524 | 0 | U | 0.515 | 1.19 |
| Thorium-232 | pCi/L | 0.27 | U | 0.34 | 0.447 | 0.194 | U | 0.298 | 0.424 |
| Thorium-234 | pCi/L | NA | NA | NA | NA | NA | NA | NA | NA |
| Uranium-234 | pCi/L | -104.2 | U | 130.9 | 215.4 | 0.102 | U | 0.24 | 0.359 |
| Uranium-235 | pCi/L | NA | NA | NA | NA | 0.22 | U | 0.308 | 0.438 |
| Uranium-238 | pCi/L | NA | NA | NA | NA | 0.187 | U | 0.342 | 0.517 |

## Table 4-6 (continued)
## Comparison of the December 2002 and May 2003 Resampling Results with the Corresponding Historical Results
## SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| | | HISTORICAL SAMPLE | | | | CONFIRMATION SAMPLE | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | SOW-H8<br>SAMPLE DATE: JULY 21, 2000<br>LABORATORY: THERMONUCLEAR | | | | SOW-H8C<br>SAMPLE DATE: MAY 20, 2003<br>LABORATORY: OUTREACH | | | |
| PARAMETER | UNITS | RESULT | QUAL | ERROR | DL | RESULT | QUAL | ERROR | DL |
| Cesium-137 | pCi/g | 0.72 | | 0.45 | 0.378 | 1.12 | | 0.071 | 0.121 |
| Radium-226 | pCi/g | 2.08 | | 0.93 | 0.79 | 0.01 | U | 0.014 | 0.103 |
| Radium-228 | pCi/g | -0.09 | U | 2.54 | 4.515 | 0.142 | U | 0.057 | 0.227 |
| Strontium-90 | pCi/g | 10.91 | | 1.57 | 1.59 | NA | NA | NA | NA |
| Thorium-228 | pCi/g | 0.27 | U | 0.37 | 0.658 | 0.288 | | 0.074 | 0.033 |
| Thorium-230 | pCi/g | 0.68 | U | 0.59 | 0.879 | 0.039 | U | 0.123 | 0.280 |
| Thorium-232 | pCi/g | 0.22 | U | 0.32 | 0.535 | 0.260 | | 0.074 | 0.053 |
| Thorium-234 | pCi/g | -1.07 | U | 3.31 | 6.564 | 0.408 | U | 0.143 | 0.622 |
| Uranium-234 | pCi/g | NA | NA | NA | NA | 0.228 | | 0.065 | 0.054 |
| Uranium-235 | pCi/g | NA | NA | NA | NA | 0.017 | U | 0.018 | 0.019 |
| Uranium-238 | pCi/g | NA | NA | NA | NA | 0.145 | | 0.048 | 0.028 |

| | | HISTORICAL SAMPLE | | | | CONFIRMATION SAMPLE | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | SOW-J18<br>SAMPLE DATE: JULY 20, 2000<br>LABORATORY: THERMONUCLEAR | | | | SOW-J18C<br>SAMPLE DATE: DECEMBER 10, 2002<br>LABORATORY: OUTREACH | | | |
| Cesium-137 | pCi/g | NR | NR | NR | NR | 1.9 | | 0.15 | 0.193 |
| Radium-226 | pCi/g | 2.24 | | 1.08 | 0.678 | 0.514 | | 0.083 | 0.192 |
| Radium-228 | pCi/g | 2.47 | U | 1.85 | 2.97 | 0 | U | | 1.02 |
| Strontium-90 | pCi/g | 269.14 | | 6.05 | 1.328 | 0 | U | 0.141 | 0.275 |
| Thorium-228 | pCi/g | 0.72 | | 0.53 | 0.504 | 0.164 | | 0.068 | 0.065 |
| Thorium-230 | pCi/g | 4.43 | | 1.5 | 0.619 | 0.219 | | 0.103 | 0.173 |
| Thorium-232 | pCi/g | 0.9 | | 0.58 | 0.386 | 0.223 | | 0.082 | 0.083 |
| Thorium-234 | pCi/g | -0.11 | U | 0.15 | 0.294 | 0 | U | | 1.86 |
| Uranium-234 | pCi/g | NA | NA | NA | NA | 0.305 | J | 0.142 | 0.101 |
| Uranium-235 | pCi/g | NA | NA | NA | NA | 0.065 | U | 0.096 | 0.132 |
| Uranium-238 | pCi/g | NA | NA | NA | NA | 0.167 | J | 0.122 | 0.132 |

**Table 4-6 (continued)**
**Comparison of the December 2002 and May 2003 Resampling Results with the Corresponding Historical Results**
**SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan**

| | | HISTORICAL SAMPLE | | | | CONFIRMATION SAMPLE | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | SOW-M24 SAMPLE DATE: JULY 20, 2000 LABORATORY: THERMONUCLEAR | | | | SOW-M24C SAMPLE DATE: MAY 21, 2003 LABORATORY: OUTREACH | | | |
| PARAMETER | UNITS | RESULT | QUAL | ERROR | DL | RESULT | QUAL | ERROR | DL |
| Cesium-137 | pCi/g | 2.85 | | 1.36 | 1.216 | 0.040 | | 0.008 | 0.028 |
| **Radium-226** | **pCi/g** | **10.63** | | **3.2** | **1.617** | **0.087** | | **0.014** | **0.047** |
| Radium-228 | pCi/g | -0.12 | U | 3.58 | 6.354 | 0.123 | | 0.021 | 0.105 |
| Strontium-90 | pCi/g | 2.25 | | 1 | 1.48 | NA | NA | NA | NA |
| Thorium-228 | pCi/g | 0.55 | | 0.41 | 0.319 | 0.273 | | 0.052 | 0.031 |
| **Thorium-230** | **pCi/g** | **2.94** | | **1.08** | **0.374** | **0** | **U** | **0.057** | **0.195** |
| Thorium-232 | pCi/g | 1.23 | | 0.63 | 0.319 | 0.210 | | 0.047 | 0.033 |
| Thorium-234 | pCi/g | -6.49 | U | 9.46 | 18.74 | 0.037 | U | 0.041 | 0.209 |
| Uranium-234 | pCi/g | NA | NA | NA | NA | 0.094 | | 0.037 | 0.028 |
| Uranium-235 | pCi/g | NA | NA | NA | NA | 0.020 | U | 0.019 | 0.022 |
| Uranium-238 | pCi/g | NA | NA | NA | NA | 0.125 | | 0.041 | 0.022 |

| | | HISTORICAL SAMPLE | | | | CONFIRMATION SAMPLE | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | SOW-N20 SAMPLE DATE: JULY 20, 2000 LABORATORY: THERMONUCLEAR | | | | SOW-N20C SAMPLE DATE: MAY 21, 2003 LABORATORY: OUTREACH | | | |
| Cesium-137 | pCi/g | NA | NA | NA | NA | 0.336 | | 0.027 | 0.061 |
| **Radium-226** | **pCi/g** | **3.94** | | **1.52** | **0.381** | **0.180** | | **0.026** | **0.070** |
| Radium-228 | pCi/g | -2.78 | U | 2.76 | 5.236 | 0.136 | | 0.033 | 0.119 |
| Strontium-90 | pCi/g | 1.52 | | 0.92 | 1.436 | NA | NA | NA | NA |
| Thorium-228 | pCi/g | 1.74 | | 0.81 | 0.513 | 0.169 | | 0.057 | 0.022 |
| **Thorium-230** | **pCi/g** | **6.33** | | **1.81** | **0.514** | **0** | **U** | **0.080** | **0.271** |
| **Thorium-232** | **pCi/g** | **1.74** | | **0.79** | **0.398** | **0.131** | | **0.052** | **0.033** |
| Thorium-234 | pCi/g | -4.71 | U | 11.04 | 22.28 | 0.287 | U | 0.103 | 0.478 |
| Uranium-234 | pCi/g | NA | NA | NA | NA | 0.656 | | 0.207 | 0.126 |
| Uranium-235 | pCi/g | NA | NA | NA | NA | 0.052 | U | 0.075 | 0.091 |
| Uranium-238 | pCi/g | NA | NA | NA | NA | 0.395 | | 0.159 | 0.091 |

## Table 4-6 (continued)
## Comparison of the December 2002 and May 2003 Resampling Results with the Corresponding Historical Results
## SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| | | HISTORICAL SAMPLE | | | | CONFIRMATION SAMPLE | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | SD-Q13 SAMPLE DATE: JULY 19, 2000 LABORATORY: THERMONUCLEAR | | | | SD-Q13C SAMPLE DATE: MAY 19, 2003 LABORATORY: OUTREACH | | | |
| PARAMETER | UNITS | RESULT | QUAL | ERROR | DL | RESULT | QUAL | ERROR | DL |
| Cesium-137 | pCi/g | NA | NA | NA | NA | 0.044 | | 0.013 | 0.040 |
| Radium-226 | pCi/g | 1.53 | | 0.46 | 0.201 | 0.156 | | 0.026 | 0.068 |
| Radium-228 | pCi/g | 0.33 | U | 0.67 | 1.156 | 0.091 | U | 0.032 | 0.142 |
| Strontium-90 | pCi/g | -0.2 | U | 0.37 | 0.679 | NA | NA | NA | NA |
| Thorium-228 | pCi/g | 0.28 | BU | 0.18 | 0.208 | 0.165 | | 0.048 | 0.037 |
| Thorium-230 | pCi/g | 0.79 | BU | 0.32 | 0.208 | 0.549 | | 0.096 | 0.126 |
| Thorium-232 | pCi/g | 0.49 | | 0.23 | 0.175 | 0.164 | | 0.047 | 0.031 |
| Thorium-234 | pCi/g | 0.91 | | 0.67 | 0.637 | 0.352 | | 0.071 | 0.344 |
| Uranium-234 | pCi/g | NA | NA | NA | NA | 0.149 | | 0.045 | 0.030 |
| Uranium-235 | pCi/g | NA | NA | NA | NA | 0.027 | U | 0.029 | 0.044 |
| Uranium-238 | pCi/g | NA | NA | NA | NA | 0.083 | | 0.035 | 0.028 |

| | | HISTORICAL SAMPLE | | | | CONFIRMATION SAMPLE | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | SOW-Q26 SAMPLE DATE: JULY 20, 2000 LABORATORY: THERMONUCLEAR | | | | SOW-Q26C SAMPLE DATE: MAY21, 2003 LABORATORY: OUTREACH | | | |
| Cesium-137 | pCi/g | 4.92 | | 1.51 | 1.111 | 0.270 | | 0.025 | 0.059 |
| Radium-226 | pCi/g | 4.59 | | 1.77 | 1.447 | 0.159 | | 0.027 | 0.093 |
| Radium-228 | pCi/g | -0.64 | U | 2.94 | 5.305 | 0.105 | U | 0.032 | 0.152 |
| Strontium-90 | pCi/g | 1.2 | U | 0.97 | 1.577 | NA | NA | NA | NA |
| Thorium-228 | pCi/g | 1.41 | | 0.72 | 0.537 | 0.136 | | 0.059 | 0.061 |
| Thorium-230 | pCi/g | 3.61 | | 1.24 | 0.394 | 0 | U | 0.066 | 0.267 |
| Thorium-232 | pCi/g | 1.66 | | 0.77 | 0.336 | 0.131 | | 0.057 | 0.056 |
| Thorium-234 | pCi/g | -5.22 | U | 9.96 | 19.9 | 0.268 | U | 0.090 | 0.362 |
| Uranium-234 | pCi/g | NA | NA | NA | NA | 0.198 | | 0.058 | 0.020 |
| Uranium-235 | pCi/g | NA | NA | NA | NA | 0.032 | | 0.024 | 0.020 |
| Uranium-238 | pCi/g | NA | NA | NA | NA | 0.085 | | 0.041 | 0.034 |

## Table 4-6 (continued)
## Comparison of the December 2002 and May 2003 Resampling Results with the Corresponding Historical Results
## SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| PARAMETER | UNITS | HISTORICAL SAMPLE SD-R16 SAMPLE DATE: JULY 19, 2000 LABORATORY: THERMONUCLEAR | | | | CONFIRMATION SAMPLE SD-R16C SAMPLE DATE: MAY 19, 2003 LABORATORY: OUTREACH | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | RESULT | QUAL | ERROR | DL | RESULT | QUAL | ERROR | DL |
| Cesium-137 | pCi/g | 0.08 | | 0.05 | 0.044 | 0.049 | | 0.016 | 0.049 |
| **Radium-226** | **pCi/g** | **1.94** | | **0.66** | **0.36** | **0.145** | | **0.020** | **0.074** |
| Radium-228 | pCi/g | 1.42 | U | 0.97 | 1.56 | 0.151 | U | 0.035 | 0.169 |
| Strontium-90 | pCi/g | 0.45 | U | 0.47 | 0.773 | NA | NA | NA | NA |
| Thorium-228 | pCi/g | 0.25 | BU | 0.17 | 0.186 | 0.184 | | 0.042 | 0.020 |
| Thorium-230 | pCi/g | 0.87 | BU | 0.33 | 0.106 | 0.050 | U | 0.051 | 0.114 |
| Thorium-232 | pCi/g | 0.54 | | 0.25 | 0.124 | 0.130 | | 0.035 | 0.020 |
| Thorium-234 | pCi/g | 0.42 | U | 0.89 | 0.673 | 0 | U | | 0.651 |
| Uranium-234 | pCi/g | NA | NA | NA | NA | 0.285 | | 0.065 | 0.028 |
| Uranium-235 | pCi/g | NA | NA | NA | NA | 0.040 | | 0.028 | 0.031 |
| Uranium-238 | pCi/g | NA | NA | NA | NA | 0.076 | | 0.034 | 0.018 |

| | | HISTORICAL SAMPLE SOW-R99 SAMPLE DATE: JULY 21, 2000 LABORATORY: THERMONUCLEAR | | | | CONFIRMATION SAMPLE SOW-R99C SAMPLE DATE: MAY 21, 2003 LABORATORY: OUTREACH | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cesium-137 | pCi/g | 0.98 | | 0.29 | 0.261 | 0.427 | | 0.045 | 0.103 |
| **Radium-226** | **pCi/g** | **1.68** | | **0.93** | **0.857** | **0.058** | **U** | **0.028** | **0.106** |
| Radium-228 | pCi/g | -1.76 | U | 2.48 | 4.615 | 0 | U | | 0.156 |
| Strontium-90 | pCi/g | 2.39 | | 0.75 | 1.035 | NA | NA | NA | NA |
| Thorium-228 | pCi/g | 0.36 | U | 0.35 | 0.521 | 0.079 | | 0.038 | 0.038 |
| Thorium-230 | pCi/g | 1.14 | | 0.59 | 0.553 | 0 | U | 0.065 | 0.240 |
| Thorium-232 | pCi/g | 0.15 | U | 0.24 | 0.467 | 0.093 | | 0.041 | 0.038 |
| Thorium-234 | pCi/g | -1.26 | U | 2.02 | 3.694 | 0 | U | | 0.644 |
| Uranium-234 | pCi/g | NA | NA | NA | NA | 0.231 | | 0.079 | 0.037 |
| Uranium-235 | pCi/g | NA | NA | NA | NA | 0.023 | U | 0.033 | 0.044 |
| Uranium-238 | pCi/g | NA | NA | NA | NA | 0.165 | | 0.067 | 0.037 |

## Table 4-6 (continued)
## Comparison of the December 2002 and May 2003 Resampling Results with the Corresponding Historical Results
## SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| PARAMETER | UNITS | HISTORICAL SAMPLE SD-T23 SAMPLE DATE: JULY 19, 2000 LABORATORY: THERMONUCLEAR | | | | CONFIRMATION SAMPLE SD-T23C SAMPLE DATE: MAY 20, 2003 LABORATORY: OUTREACH | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | RESULT | QUAL | ERROR | DL | RESULT | QUAL | ERROR | DL |
| Cesium-137 | pCi/g | NA | NA | NA | NA | 0.181 | | 0.009 | 0.027 |
| Radium-226 | pCi/g | 2.24 | | 0.57 | 0.332 | 0.103 | | 0.018 | 0.065 |
| Radium-228 | pCi/g | 0.79 | U | 0.68 | 1.118 | 0.036 | U | 0.010 | 0.082 |
| Strontium-90 | pCi/g | 0.04 | U | 0.45 | 0.797 | NA | NA | NA | NA |
| Thorium-228 | pCi/g | 0.57 | | 0.26 | 0.166 | 0.078 | | 0.035 | 0.028 |
| Thorium-230 | pCi/g | 0.88 | BU | 0.33 | 0.166 | 0 | U | 0.052 | 0.224 |
| Thorium-232 | pCi/g | 0.42 | | 0.21 | 0.104 | 0.051 | U | 0.038 | 0.054 |
| Thorium-234 | pCi/g | -0.1 | U | 0.42 | 0.792 | 0 | U | | 0.388 |
| Uranium-234 | pCi/g | NA | NA | NA | NA | 0.151 | | 0.084 | 0.078 |
| Uranium-235 | pCi/g | NA | NA | NA | NA | 0.009 | U | 0.030 | 0.047 |
| Uranium-238 | pCi/g | NA | NA | NA | NA | 0.111 | | 0.064 | 0.035 |

| | | HISTORICAL SAMPLE SOW-U97 SAMPLE DATE: JULY 21, 2000 LABORATORY: THERMONUCLEAR | | | | CONFIRMATION SAMPLE SOW-U97C SAMPLE DATE: MAY 21, 2003 LABORATORY: OUTREACH | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cesium-137 | pCi/g | 1.19 | | 0.39 | 0.356 | 0.314 | | 0.029 | 0.050 |
| Radium-226 | pCi/g | 2.35 | | 1.17 | 1.183 | 0.036 | U | 0.020 | 0.052 |
| Radium-228 | pCi/g | -2.46 | U | 2.77 | 5.207 | 0.041 | U | 0.030 | 0.119 |
| Strontium-90 | pCi/g | 3.58 | | 1.24 | 1.799 | NA | NA | NA | NA |
| Thorium-228 | pCi/g | 0.77 | | 0.58 | 0.711 | 0.044 | U | 0.049 | 0.070 |
| Thorium-230 | pCi/g | 1.65 | | 0.83 | 0.712 | 0 | U | 0.079 | 0.297 |
| Thorium-232 | pCi/g | 0.62 | U | 0.51 | 0.659 | 0.076 | | 0.047 | 0.045 |
| Thorium-234 | pCi/g | -1.44 | U | 1.86 | 3.524 | 0 | U | | 0.340 |
| Uranium-234 | pCi/g | NA | NA | NA | NA | 0.290 | | 0.087 | 0.036 |
| Uranium-235 | pCi/g | NA | NA | NA | NA | 0.045 | U | 0.046 | 0.058 |
| Uranium-238 | pCi/g | NA | NA | NA | NA | 0.110 | | 0.058 | 0.048 |

## Table 4-6 (continued)
## Comparison of the December 2002 and May 2003 Resampling Results with the Corresponding Historical Results
## SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| | | HISTORICAL SAMPLE | | | | CONFIRMATION SAMPLE | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | SD-W23<br>SAMPLE DATE: JULY 19, 2000<br>LABORATORY: THERMONUCLEAR | | | | SD-W23C<br>SAMPLE DATE: MAY 20, 2003<br>LABORATORY: OUTREACH | | | |
| PARAMETER | UNITS | RESULT | QUAL | ERROR | DL | RESULT | QUAL | ERROR | DL |
| Cesium-137 | pCi/g | NA | NA | NA | NA | 0.073 | | 0.014 | 0.041 |
| Radium-226 | pCi/g | 1.05 | | 0.38 | 0.262 | 0.160 | | 0.023 | 0.060 |
| **Radium-228** | pCi/g | 3.69 | | 0.94 | 1.3 | 0.122 | | 0.025 | 0.096 |
| Strontium-90 | pCi/g | 0.07 | U | 0.43 | 0.766 | NA | NA | NA | NA |
| Thorium-228 | pCi/g | 0.39 | | 0.19 | 0.104 | 0.192 | | 0.049 | 0.028 |
| Thorium-230 | pCi/g | 0.68 | BU | 0.26 | 0.126 | 0 | U | 0.057 | 0.217 |
| Thorium-232 | pCi/g | 0.32 | | 0.17 | 0.089 | 0.108 | | 0.038 | 0.028 |
| Thorium-234 | pCi/g | 0.12 | U | 0.69 | 0.614 | 0.375 | U | 0.408 | 0.427 |
| Uranium-234 | pCi/g | NA | NA | NA | NA | 0.256 | | 0.087 | 0.030 |
| Uranium-235 | pCi/g | NA | NA | NA | NA | 0.033 | U | 0.045 | 0.061 |
| Uranium-238 | pCi/g | NA | NA | NA | NA | 0.204 | | 0.080 | 0.048 |

| | | HISTORICAL SAMPLE | | | | CONFIRMATION SAMPLE | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | SOW-X96<br>SAMPLE DATE: JULY 21, 2000<br>LABORATORY: THERMONUCLEAR | | | | SOW-X96C<br>SAMPLE DATE: MAY 21, 2003<br>LABORATORY: OUTREACH | | | |
| Cesium-137 | pCi/g | 1.22 | | 0.25 | 0.198 | 0.369 | | 0.038 | 0.095 |
| **Radium-226** | pCi/g | 1.63 | | 0.97 | 0.744 | 0.025 | U | 0.013 | 0.097 |
| Radium-228 | pCi/g | -0.79 | U | 2.69 | 4.878 | 0.077 | U | 0.056 | 0.187 |
| Strontium-90 | pCi/g | 4.69 | | 0.84 | 0.981 | NA | NA | NA | NA |
| Thorium-228 | pCi/g | 1.42 | | 0.96 | 1.023 | 0.211 | | 0.060 | 0.036 |
| **Thorium-230** | pCi/g | 3.32 | | 1.54 | 1.227 | 0 | U | 0.068 | 0.248 |
| **Thorium-232** | pCi/g | 2.13 | | 1.14 | 0.655 | 0.141 | | 0.048 | 0.025 |
| Thorium-234 | pCi/g | 0.03 | U | 1.65 | 3.29 | 0.437 | U | 0.125 | 0.534 |
| Uranium-234 | pCi/g | NA | NA | NA | NA | 0.408 | | 0.125 | 0.050 |
| Uranium-235 | pCi/g | NA | NA | NA | NA | 0.062 | | 0.057 | 0.060 |
| Uranium-238 | pCi/g | NA | NA | NA | NA | 0.275 | | 0.103 | 0.050 |

## Table 4-6 (continued)
## Comparison of the December 2002 and May 2003 Resampling Results with the Corresponding Historical Results
## SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| PARAMETER | UNITS | HISTORICAL SAMPLE SOW-Y99 SAMPLE DATE: JULY 21, 2000 LABORATORY: THERMONUCLEAR | | | | CONFIRMATION SAMPLE SOW-Y99C SAMPLE DATE: MAY 20, 2003 LABORATORY: OUTREACH | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | RESULT | QUAL | ERROR | DL | RESULT | QUAL | ERROR | DL |
| Cesium-137 | pCi/g | NA | NA | NA | NA | 0.252 | | 0.025 | 0.054 |
| **Radium-226** | pCi/g | **1.54** | | **0.95** | **1.434** | **0** | **U** | | **0.096** |
| Radium-228 | pCi/g | -2.07 | U | 2.1 | 3.97 | 0 | U | | 0.145 |
| Strontium-90 | pCi/g | 0.79 | U | 0.76 | 1.254 | NA | NA | NA | NA |
| Thorium-228 | pCi/g | 0.24 | U | 0.27 | 0.399 | 0.079 | | 0.047 | 0.050 |
| Thorium-230 | pCi/g | 1.66 | | 0.69 | 0.423 | 0 | U | 0.080 | 0.283 |
| Thorium-232 | pCi/g | 0.22 | U | 0.23 | 0.264 | 0.104 | | 0.050 | 0.043 |
| Thorium-234 | pCi/g | -1.02 | U | 1.94 | 3.623 | 0 | U | | 0.665 |
| Uranium-234 | pCi/g | NA | NA | NA | NA | 0.142 | | 0.060 | 0.039 |
| Uranium-235 | pCi/g | NA | NA | NA | NA | 0.023 | U | 0.028 | 0.033 |
| Uranium-238 | pCi/g | NA | NA | NA | NA | 0.072 | | 0.042 | 0.025 |

General Notes:
NA = not analyzed.
NR = not reported.
U = not detected.
J = estimated value.
DL = detection limit.
QUAL = data validation qualifier.
GW = groundwater.
SD = sediment.
SOW = wetland soil.
SW = surface water.
BOLD = constituents and activity levels of primary concern in resampling.
[shaded box] highlights suspect historical result and corresponding resample result.

Created by: CS, 7/1/03
Checked by: CA, 7/1/03

Table 4-7
Results for Samples Collected in May 2003
to Delineate Class 1/Class 2 Survey Unit Boundaries
SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| Sample[1] | Parameter | Activity Level or Concentration[2][3] | Units |
|---|---|---|---|
| SOW-NWLF-1 | Radium-226 | 0.197 | pCi/g |
| SOW-NWLF-1 | Radium-228 | 0.151 | pCi/g |
| SOW-NWLF-1 | Thorium-228 | 0.165 | pCi/g |
| SOW-NWLF-1 | Thorium-230 | 0 U | pCi/g |
| SOW-NWLF-1 | Thorium-232 | 0.116 | pCi/g |
| SOW-NWLF-1 | Uranium-234 | 0.153 | pCi/g |
| SOW-NWLF-1 | Uranium-238 | 0.063 | pCi/g |
| SOW-NWLF-2 | Radium-226 | 0.197 | pCi/g |
| SOW-NWLF-2 | Radium-228 | 0.203 U | pCi/g |
| SOW-NWLF-2 | Thorium-228 | 0.326 | pCi/g |
| SOW-NWLF-2 | Thorium-230 | 0.264 | pCi/g |
| SOW-NWLF-2 | Thorium-232 | 0.232 | pCi/g |
| SOW-NWLF-2 | Uranium-234 | 0.216 | pCi/g |
| SOW-NWLF-2 | Uranium-238 | 0.109 | pCi/g |
| SOW-NWLF-3 | Radium-226 | 0.058 U | pCi/g |
| SOW-NWLF-3 | Radium-228 | 0.088 U | pCi/g |
| SOW-NWLF-3 | Thorium-228 | 0.104 | pCi/g |
| SOW-NWLF-3 | Thorium-230 | 0 U | pCi/g |
| SOW-NWLF-3 | Thorium-232 | 0.070 | pCi/g |
| SOW-NWLF-3 | Uranium-234 | 0.111 | pCi/g |
| SOW-NWLF-3 | Uranium-238 | 0.048 | pCi/g |
| SOW-NWLF-4 | Radium-226 | 0.080 U | pCi/g |
| SOW-NWLF-4 | Radium-228 | 0.161 U | pCi/g |
| SOW-NWLF-4 | Thorium-228 | 0.336 | pCi/g |
| SOW-NWLF-4 | Thorium-230 | 0 U | pCi/g |
| SOW-NWLF-4 | Thorium-232 | 0.189 | pCi/g |
| SOW-NWLF-4 | Uranium-234 | 0.213 | pCi/g |
| SOW-NWLF-4 | Uranium-238 | 0.131 | pCi/g |
| SOW-NWLF-5 | Radium-226 | 0.267 | pCi/g |
| SOW-NWLF-5 | Radium-228 | 0.345 | pCi/g |
| SOW-NWLF-5 | Thorium-228 | 0.239 | pCi/g |
| SOW-NWLF-5 | Thorium-230 | 0.107 U | pCi/g |
| SOW-NWLF-5 | Thorium-232 | 0.297 | pCi/g |
| SOW-NWLF-5 | Uranium-234 | 0.451 | pCi/g |
| SOW-NWLF-5 | Uranium-238 | 0.375 | pCi/g |

Table 4-7 *(continued)*
Results for Samples Collected in May 2003
to Delineate Class 1/Class 2 Survey Unit Boundaries
SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| Sample[1] | Parameter | Activity Level or Concentration[2][3] | Units |
|---|---|---|---|
| SOW-NWLF-6 | Radium-226 | 0.259 | pCi/g |
| SOW-NWLF-6 | Radium-228 | 0.281 | pCi/g |
| SOW-NWLF-6 | Thorium-228 | 0.311 | pCi/g |
| SOW-NWLF-6 | Thorium-230 | 0.268 | pCi/g |
| SOW-NWLF-6 | Thorium-232 | 0.275 | pCi/g |
| SOW-NWLF-6 | Uranium-234 | 0.318 | pCi/g |
| SOW-NWLF-6 | Uranium-238 | 0.096 | pCi/g |
| SOW-NWLF-7 | Radium-226 | 0.228 | pCi/g |
| SOW-NWLF-7 | Radium-228 | 0.351 | pCi/g |
| SOW-NWLF-7 | Thorium-228 | 0.334 | pCi/g |
| SOW-NWLF-7 | Thorium-230 | 0.527 | pCi/g |
| SOW-NWLF-7 | Thorium-232 | 0.236 | pCi/g |
| SOW-NWLF-7 | Uranium-234 | 0.184 | pCi/g |
| SOW-NWLF-7 | Uranium-238 | 0.127 | pCi/g |
| SOW-NWLF-8 | Radium-226 | 0.509 | pCi/g |
| SOW-NWLF-8 | Radium-228 | 0.494 | pCi/g |
| SOW-NWLF-8 | Thorium-228 | 0.228 | pCi/g |
| SOW-NWLF-8 | Thorium-230 | 0.122 U | pCi/g |
| SOW-NWLF-8 | Thorium-232 | 0.222 | pCi/g |
| SOW-NWLF-8 | Uranium-234 | 0.597 | pCi/g |
| SOW-NWLF-8 | Uranium-238 | 0.249 | pCi/g |
| SOW-NWLF-9 | Chromium | 11.2 E | mg/kg |
| SOW-NWLF-9 | Radium-226 | 0.386 | pCi/g |
| SOW-NWLF-9 | Radium-228 | 0.376 | pCi/g |
| SOW-NWLF-9 | Thorium-228 | 0.300 | pCi/g |
| SOW-NWLF-9 | Thorium-230 | 0 U | pCi/g |
| SOW-NWLF-9 | Thorium-232 | 0.286 | pCi/g |
| SOW-NWLF-9 | Uranium-234 | 0.521 | pCi/g |
| SOW-NWLF-9 | Uranium-238 | 0.577 | pCi/g |
| SOW-NWLF-10 | Chromium | 17.9 E | mg/kg |
| SOW-NWLF-10 | Radium-226 | 0.400 | pCi/g |
| SOW-NWLF-10 | Radium-228 | 0.559 | pCi/g |
| SOW-NWLF-10 | Thorium-228 | 0.371 | pCi/g |
| SOW-NWLF-10 | Thorium-230 | 0.225 | pCi/g |
| SOW-NWLF-10 | Thorium-232 | 0.357 | pCi/g |

## Table 4-7 *(continued)*
## Results for Samples Collected in May 2003
## to Delineate Class 1/Class 2 Survey Unit Boundaries
## SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| Sample[1] | Parameter | Activity Level or Concentration[2][3] | Units |
|---|---|---|---|
| SOW-NWLF-10 | Uranium-234 | 0.769 | pCi/g |
| SOW-NWLF-10 | Uranium-238 | 0.608 | pCi/g |
| SOW-NWLF-11 | Radium-226 | 0.471 | pCi/g |
| SOW-NWLF-11 | Radium-228 | 0.316 | pCi/g |
| SOW-NWLF-11 | Thorium-228 | 0.223 | pCi/g |
| SOW-NWLF-11 | Thorium-230 | 0.320 | pCi/g |
| SOW-NWLF-11 | Thorium-232 | 0.316 | pCi/g |
| SOW-NWLF-11 | Uranium-234 | 0.141 | pCi/g |
| SOW-NWLF-11 | Uranium-238 | 0.079 | pCi/g |
| SOW-NWLF-12 | Radium-226 | 0.138 | pCi/g |
| SOW-NWLF-12 | Radium-228 | 0.115 | pCi/g |
| SOW-NWLF-12 | Thorium-228 | 0.095 | pCi/g |
| SOW-NWLF-12 | Thorium-230 | 0.126 U | pCi/g |
| SOW-NWLF-12 | Thorium-232 | 0.134 | pCi/g |
| SOW-NWLF-12 | Uranium-234 | 0.340 | pCi/g |
| SOW-NWLF-12 | Uranium-238 | 0.117 | pCi/g |
| SOW-NWLF-13 | Aroclor-1016 | 59 U | µg/kg |
| SOW-NWLF-13 | Aroclor-1221 | 59 U | µg/kg |
| SOW-NWLF-13 | Aroclor-1232 | 59 U | µg/kg |
| SOW-NWLF-13 | Aroclor-1242 | 59 U | µg/kg |
| SOW-NWLF-13 | Aroclor-1248 | 59 U | µg/kg |
| SOW-NWLF-13 | Aroclor-1254 | 80 | µg/kg |
| SOW-NWLF-13 | Aroclor-1260 | 59 U | µg/kg |
| SOW-NWLF-13 | Aroclor-1262 | 59 U | µg/kg |
| SOW-NWLF-13 | Aroclor-1268 | 59 U | µg/kg |
| SOW-NWLF-13 | Radium-226 | 0.244 | pCi/g |
| SOW-NWLF-13 | Radium-228 | 0.214 U | pCi/g |
| SOW-NWLF-13 | Thorium-228 | 0.277 | pCi/g |
| SOW-NWLF-13 | Thorium-230 | 0.119 U | pCi/g |
| SOW-NWLF-13 | Thorium-232 | 0.247 | pCi/g |
| SOW-NWLF-13 | Uranium-234 | 0.188 | pCi/g |
| SOW-NWLF-13 | Uranium-238 | 0.058 | pCi/g |
| SOW-NWLF-14 | Radium-226 | 0.127 | pCi/g |
| SOW-NWLF-14 | Radium-228 | 0.118 U | pCi/g |
| SOW-NWLF-14 | Thorium-228 | 0.124 | pCi/g |

Table 4-7 *(continued)*
**Results for Samples Collected in May 2003 to Delineate Class 1/Class 2 Survey Unit Boundaries SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan**

| Sample[1] | Parameter | Activity Level or Concentration[2][3] | Units |
|---|---|---|---|
| SOW-NWLF-14 | Thorium-230 | 0 U | pCi/g |
| SOW-NWLF-14 | Thorium-232 | 0.096 | pCi/g |
| SOW-NWLF-14 | Uranium-234 | 0.196 | pCi/g |
| SOW-NWLF-14 | Uranium-238 | 0.089 | pCi/g |
| SOW-H9 | Aroclor-1016 | 120 U | µg/kg |
| SOW-H9 | Aroclor-1221 | 120 U | µg/kg |
| SOW-H9 | Aroclor-1232 | 120 U | µg/kg |
| SOW-H9 | Aroclor-1242 | 120 U | µg/kg |
| SOW-H9 | Aroclor-1248 | 120 U | µg/kg |
| SOW-H9 | Aroclor-1254 | 120 U | µg/kg |
| SOW-H9 | Aroclor-1260 | 120 U | µg/kg |
| SOW-H9 | Aroclor-1262 | 120 U | µg/kg |
| SOW-H9 | Aroclor-1268 | 120 U | µg/kg |
| SOW-H9 | Radium-226 | 0.129 | pCi/g |
| SOW-H9 | Radium-228 | 0.125 U | pCi/g |
| SOW-H9 | Thorium-228 | 0.122 | pCi/g |
| SOW-H9 | Thorium-230 | 0 U | pCi/g |
| SOW-H9 | Thorium-232 | 0.146 | pCi/g |
| SOW-H9 | Uranium-234 | 0.141 | pCi/g |
| SOW-H9 | Uranium-238 | 0.081 | pCi/g |
| SOW-J8 | Aroclor-1016 | 860 U | µg/kg |
| SOW-J8 | Aroclor-1221 | 860 U | µg/kg |
| SOW-J8 | Aroclor-1232 | 860 U | µg/kg |
| SOW-J8 | Aroclor-1242 | 860 U | µg/kg |
| SOW-J8 | Aroclor-1248 | 2700 | µg/kg |
| SOW-J8 | Aroclor-1254 | 3000 | µg/kg |
| SOW-J8 | Aroclor-1260 | 860 U | µg/kg |
| SOW-J8 | Aroclor-1262 | 860 U | µg/kg |
| SOW-J8 | Aroclor-1268 | 860 U | µg/kg |
| SOW-J8 | Radium-226 | 0.075 | pCi/g |
| SOW-J8 | Radium-228 | 0.134 | pCi/g |
| SOW-J8 | Thorium-228 | 0.173 | pCi/g |
| SOW-J8 | Thorium-230 | 0 U | pCi/g |
| SOW-J8 | Thorium-232 | 0.324 | pCi/g |
| SOW-J8 | Uranium-234 | 0.156 | pCi/g |

Table 4-7 *(continued)*
**Results for Samples Collected in May 2003**
**to Delineate Class 1/Class 2 Survey Unit Boundaries**
**SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan**

| Sample[1] | Parameter | Activity Level or Concentration[2][3] | Units |
|---|---|---|---|
| SOW-J8 | Uranium-238 | 0.116 | pCi/g |
| SD-N9 | Aroclor-1016 | 260 | µg/kg |
| SD-N9 | Aroclor-1221 | 44 U | µg/kg |
| SD-N9 | Aroclor-1232 | 44 U | µg/kg |
| SD-N9 | Aroclor-1242 | 44 U | µg/kg |
| SD-N9 | Aroclor-1248 | 56 | µg/kg |
| SD-N9 | Aroclor-1254 | 44 U | µg/kg |
| SD-N9 | Aroclor-1260 | 44 U | µg/kg |
| SD-N9 | Aroclor-1262 | 44 U | µg/kg |
| SD-N9 | Aroclor-1268 | 44 U | µg/kg |
| SD-N9 | Radium-226 | 0.077 | pCi/g |
| SD-N9 | Radium-228 | 0 U | pCi/g |
| SD-N9 | Thorium-228 | 0.065 | pCi/g |
| SD-N9 | Thorium-230 | 0.037 U | pCi/g |
| SD-N9 | Thorium-232 | 0.092 | pCi/g |
| SD-N9 | Uranium-234 | 0.253 | pCi/g |
| SD-N9 | Uranium-238 | 0.17 | pCi/g |
| SOW-N9 | Radium-226 | 0.072 | pCi/g |
| SOW-N9 | Radium-228 | 0.148 | pCi/g |
| SOW-N9 | Thorium-228 | 0.152 | pCi/g |
| SOW-N9 | Thorium-230 | 0 U | pCi/g |
| SOW-N9 | Thorium-232 | 0.132 | pCi/g |
| SOW-N9 | Uranium-234 | 0.198 | pCi/g |
| SOW-N9 | Uranium-238 | 0.131 | pCi/g |
| SD-O10 | Aroclor-1016 | 960 | µg/kg |
| SD-O10 | Aroclor-1221 | 79 U | µg/kg |
| SD-O10 | Aroclor-1232 | 79 U | µg/kg |
| SD-O10 | Aroclor-1242 | 79 U | µg/kg |
| SD-O10 | Aroclor-1248 | 270 | µg/kg |
| SD-O10 | Aroclor-1254 | 79 U | µg/kg |
| SD-O10 | Aroclor-1260 | 79 U | µg/kg |
| SD-O10 | Aroclor-1262 | 79 U | µg/kg |
| SD-O10 | Aroclor-1268 | 79 U | µg/kg |
| SD-O10 | Radium-226 | 0.063 | pCi/g |
| SD-O10 | Radium-228 | 0.040 U | pCi/g |

Table 4-7 *(continued)*
**Results for Samples Collected in May 2003**
**to Delineate Class 1/Class 2 Survey Unit Boundaries**
**SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan**

| Sample[1] | Parameter | Activity Level or Concentration[2][3] | Units |
|---|---|---|---|
| SD-O10 | Thorium-228 | 0.051 | pCi/g |
| SD-O10 | Thorium-230 | 0 U | pCi/g |
| SD-O10 | Thorium-232 | 0.073 | pCi/g |
| SD-O10 | Uranium-234 | 0.334 | pCi/g |
| SD-O10 | Uranium-238 | 0.144 | pCi/g |
| SOW-O10 | Radium-226 | 0.040 U | pCi/g |
| SOW-O10 | Radium-228 | 0 U | pCi/g |
| SOW-O10 | Thorium-228 | 0.105 | pCi/g |
| SOW-O10 | Thorium-230 | 0 U | pCi/g |
| SOW-O10 | Thorium-232 | 0.137 U | pCi/g |
| SOW-O10 | Uranium-234 | 0.367 | pCi/g |
| SOW-O10 | Uranium-238 | 0.121 | pCi/g |

[1] Sample locations are shown on Figure 4-2.
SD = sediment.
SOW = wetland soil.
[2] Complete analytical results are included in Appendices B-3 and B-4.
[3] Data qualifier flags:
E = matrix interference.
J = estimated result.
U = not detected.

## Table 4-8
## Ratio of Thorium-230/Thorium-232 in Slag
## May 2003 Sampling Event
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| Sample | Th-230 Activity Level (pCi/g) | Th-232 Activity Level (pCi/g) | Ratio of Th-230/Th-232 |
|---|---|---|---|
| **Slag Pile A, West of Northwest Landfill** | | | |
| WST-SP-1 | 17.9 | 19.6 | 0.913 |
| WST-SP-2 | 21.0 | 13.2 | 1.591 |
| WST-SP-3 | 6.75 | 5.36 | 1.259 |
| WST-SP-4 | 3.40 | 2.79 | 1.219 |
| WST-SP-5 | 5.79 | 5.06 | 1.144 |
| WST-SP-6 | 6.27 | 4.27 | 1.468 |
| WST-SP-7 | 5.53 | 9.46 | 0.585 |
| Mean Slag Pile A | 9.52 | 8.53 | 1.168(2) |
| **Slag Pile B, Southwest of Cell A at East Landfill** | | | |
| WST-SP-8(3) | 0.425 | 0.217 | 1.959 |
| WST-SP-9(3) | 0.938 | 0.261 | 3.594 |
| WST-SP-10 | 6.05 | 4.60 | 1.315 |
| Mean of all samples of slag(1) | 9.09(2) | 8.04(2) | Mean of above ratios = 1.19<br>Ratio of mean Th-230/mean Th-232 = 1.13 |

Footnotes:
(1) These means do not include samples WST-SP-8 and WST-SP-9.
(2) Mean of above values.
(3) Did not contain elevated levels of radioactivity. Sample may not have been the targeted material.

Date of samples: May 20, 2003

Table 4-9
Summary Statistical Evaluation for Radionuclides of Potential Concern,
Comparison of Mean Radioactivity in On-Site Media to Corresponding Mean Background Media
SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| MEDIUM | ANALYTE[1] | SAMPLE COUNT FOR ON-SITE SAMPLES | MEAN FOR ON-SITE SAMPLES | STANDARD DEVIATION FOR ON-SITE SAMPLES | MEAN FOR BACKGROUND SAMPLES[2] | STANDARD DEVIATION FOR BACKGROUND SAMPLES | MEAN +2 STANDARD DEVIATIONS FOR BACKGROUND SAMPLES |
|---|---|---|---|---|---|---|---|
| Upland soil[3] (values reported as pCi/g) | Ra-226 | 7 | 0.159 | 0.117 | 0.261 | 0.147 | 0.555 |
| | Ra-228 | 7 | 0.155 | 0.046 | 0.424 | 0.187 | 0.798 |
| | Th-228[4] | 8 | 0.187 | 0.200 | 0.074 | 0.034 | 0.141 |
| | Th-230 | 8 | 0.073 | 0.042 | 0.330 | 0.145 | 0.620 |
| | Th-232 | 8 | 0.094 | 0.054 | 0.103 | 0.048 | 0.198 |
| Wetland soil (values reported as pCi/g) | Ra-226 | 46 | 0.331 | 0.438 | 0.261 | 0.274 | 1.083 |
| | Ra-228 | 46 | 0.365 | 0.428 | 0.424 | 0.300 | 1.312 |
| | Th-228 | 50 | 0.205 | 0.258 | 0.161 | 0.250 | 0.726 |
| | Th-230 | 49 | 0.146 | 0.215 | 0.225 | 0.132 | 0.401 |
| | Th-232 | 49 | 0.180 | 0.193 | 0.138 | 1.835 | 5.785 |
| | U-234 | 30 | 0.305 | 0.173 | 0.452 | 0.344 | 1.139 |
| | U-238 | 30 | 0.202 | 0.168 | 0.403 | 0.376 | 1.155 |
| Landfill cap soil - Both landfills (values reported as pCi/g) | Ra-226 | 23 | 0.861 | 0.465 | 0.535 | 0.274 | 1.083 |
| | Ra-228 | 24 | 0.771 | 0.565 | 0.712 | 0.300 | 1.312 |
| | Th-228 | 24 | 0.176 | 0.409 | 0.161 | 0.159 | 0.478 |
| | Th-230 | 24 | 0.041 | 0.017 | 0.225 | 0.250 | 0.726 |
| | Th-232 | 24 | 0.093 | 0.257 | 0.138 | 0.132 | 0.401 |
| Subsurface Soil (values reported as pCi/g) | Ra-226 | 39 | 0.285 | 0.214 | 0.261 | 0.147 | 0.555 |
| | Ra-228 | 39 | 0.324 | 0.241 | 0.424 | 0.187 | 0.798 |
| | Th-228 | 39 | 0.257 | 0.280 | 0.074 | 0.034 | 0.141 |
| | Th-230 | 39 | 0.094 | 0.188 | 0.330 | 0.145 | 0.620 |
| | Th-232 | 39 | 0.191 | 0.258 | 0.103 | 0.048 | 0.198 |

Table 4-9 *(continued)*
Summary Statistical Evaluation for Radionuclides of Potential Concern
Comparison of Mean Radioactivity in On-Site Media to Corresponding Mean Background Media
SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| MEDIUM | ANALYTE[1] | SAMPLE COUNT FOR ON-SITE SAMPLES | MEAN FOR ON-SITE SAMPLES | STANDARD DEVIATION FOR ON-SITE SAMPLES | MEAN FOR BACKGROUND SAMPLES[2] | STANDARD DEVIATION FOR BACKGROUND SAMPLES | MEAN +2 STANDARD DEVIATIONS FOR BACKGROUND SAMPLES |
|---|---|---|---|---|---|---|---|
| Surface water (values reported as pCi/L) | Ra-226 | 29 | 0.389 | 0.386 | 0.332 | 0.169 | 0.670 |
| | Ra-228 | 22 | 1.881 | 2.181 | 2.349 | 2.359 | 7.067 |
| | Th-228 | 29 | 0.200 | 0.191 | 0.232 | 0.170 | 0.572 |
| | Th-230 | 29 | 0.277 | 0.406 | 0.437 | 0.249 | 0.934 |
| | Th-232 | 29 | 0.165 | 0.128 | 0.175 | 0.172 | 0.519 |
| | U-234 | 7 | 0.455 | 0.160 | 0.973 | 0.677 | 2.327 |
| | U-238 | 7 | 0.229 | 0.122 | 0.614 | 0.475 | 1.564 |
| Sediment (values reported as pCi/g) | Ra-226 | 64 | 0.311 | 0.251 | 0.528 | 0.310 | 1.148 |
| | Ra-228 | 67 | 0.484 | 0.481 | 0.675 | 0.290 | 1.255 |
| | Th-228 | 69 | 0.140 | 0.247 | 0.200 | 0.098 | 0.395 |
| | Th-230 | 68 | 0.091 | 0.147 | 0.333 | 0.274 | 0.880 |
| | Th-232 | 69 | 0.109 | 0.227 | 0.220 | 0.090 | 0.400 |
| | U-234 | 10 | 0.284 | 0.134 | 0.733 | 0.557 | 1.847 |
| | U-238 | 10 | 0.174 | 0.116 | 0.682 | 0.533 | 1.749 |
| Groundwater (values reported as pCi/L) | Ra-226 | 17 | 0.316 | 0.208 | 0.311 | 0.108 | 0.528 |
| | Ra-228 | 17 | 2.141 | 3.065 | 0.393 | 0.647 | 1.686 |
| | Th-228 | 17 | 0.290 | 0.276 | 0.478 | 0.506 | 1.489 |
| | Th-230 | 17 | 0.215 | 0.159 | 0.550 | 0.336 | 1.221 |
| | Th-232 | 17 | 0.190 | 0.131 | 0.305 | 0.116 | 0.536 |
| | U-234 | 1 | 0.180 | NA | 0.539 | 0.260 | 1.059 |
| | U-238 | 1 | 0.259 | NA | 0.246 | 0.129 | 0.504 |

Table 4-9 *(continued)*
Summary Statistical Evaluation for Radionuclides of Potential Concern
Comparison of Mean Radioactivity in On-Site Media to Corresponding Mean Background Media
SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| MEDIUM | ANALYTE[1] | SAMPLE COUNT FOR ON-SITE SAMPLES | MEAN FOR ON-SITE SAMPLES | STANDARD DEVIATION FOR ON-SITE SAMPLES | MEAN FOR BACKGROUND SAMPLES[2] | STANDARD DEVIATION FOR BACKGROUND SAMPLES | MEAN +2 STANDARD DEVIATIONS FOR BACKGROUND SAMPLES |
|---|---|---|---|---|---|---|---|
| Leachate - Both landfills[5] (values reported as pCi/L) | Ra-226 | 9 | 0.224 | 0.156 | 0.311 | 0.108 | 0.528 |
| | Ra-228 | 9 | 1.704 | 2.629 | 0.393 | 0.647 | 1.686 |
| | Th-228 | 12 | 0.214 | 0.168 | 0.478 | 0.506 | 1.489 |
| | Th-230 | 12 | 0.225 | 0.187 | 0.550 | 0.336 | 1.221 |
| | Th-232 | 12 | 0.230 | 0.232 | 0.305 | 0.116 | 0.536 |
| | U-234 | 3 | 0.112 | 0.026 | 0.539 | 0.260 | 1.059 |
| | U-238 | 3 | 0.132 | 0.024 | 0.246 | 0.129 | 0.504 |
| Slag waste[6] (values reported as pCi/g) | Ra-226 | 22 | 0.673 | 0.623 | 0.535 | 0.147 | 0.555 |
| | Ra-228 | 23 | 9.093 | 15.8 | 0.712 | 0.187 | 0.798 |
| | Th-228 | 21 | 4.358 | 6.623 | 0.161 | 0.034 | 0.141 |
| | Th-230 | 21 | 3.675 | 5.845 | 0.225 | 0.145 | 0.620 |
| | Th-232 | 21 | 3.109 | 5.228 | 0.138 | 0.048 | 0.198 |
| | U-234 | 10 | 2.055 | 1.881 | 0.452 | 0.994 | 3.188 |
| | U-238 | 10 | 1.892 | 1.804 | 0.403 | 0.042 | 0.140 |
| Non-slag waste[6] (values reported as pCi/g) | Ra-226 | 16 | 0.450 | 0.341 | 0.535 | 0.274 | 1.083 |
| | Ra-228 | 16 | 0.478 | 0.293 | 0.712 | 0.300 | 1.312 |
| | Th-228 | 16 | 0.329 | 0.341 | 0.161 | 0.159 | 0.478 |
| | Th-230 | 16 | 0.543 | 1.404 | 0.225 | 0.250 | 0.726 |
| | Th-232 | 16 | 0.263 | 0.341 | 0.138 | 0.132 | 0.401 |

Notes:
(1) Isotopes not listed have no corresponding data.
(2) Sample numbers for all background is 10 samples.
(3) Upland soil mean background values were used to compare to on-site subsurface soil.
(4) Bolding indicates that mean for the on-site samples for this analyte exceeded the background mean for the corresponding medium.
(5) Groundwater mean background values were used to compare to on-site leachate.
(6) Wetland soil mean background values were used to compare to on-site landfill cap soil (clay), slag waste, and nonslag waste.

## Table 5-1
## Evaluation of Pathways for the Industrial Worker Exposure Scenario
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| PATHWAY | INCLUDED IN RADIATION DOSE ASSESSMENT | EXPLANATION |
|---|---|---|
| External gamma exposure | Yes | Direct exposure to external gamma radiation from the progeny of thorium and uranium is limiting when the thorium-bearing slag is uncovered or is present at the surface. |
| Inhalation of dust | Yes | There is a potential for contaminated dust inside of the building during hours of operation. |
| Radon inhalation | No | Pathway deleted by the USNRC for purposes of license termination. |
| Ingestion of plant foods | No | No plants are grown and ingested on the property. |
| Ingestion of meat | No | No animals are raised and ingested on the property. |
| Ingestion of milk | No | No dairy cows are assumed to be present on the property. |
| Ingestion of fish | No | No fish are caught and ingested from the ponds located at the property. |
| Ingestion of soil | Yes | There is a potential for contaminated dust inside of the building during hours of operation. |
| Ingestion of water | No | Potable water is provided from the local POTW. |

## Table 5-2
## Input Parameters for RESRAD
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| PARAMETER | RESRAD DEFAULT VALUE | SITE-SPECIFIC INPUT VALUE | BASIS FOR SITE-SPECIFIC INPUT VALUE |
|---|---|---|---|
| Area of contaminated zone (AREA) | 10,000 $m^2$ | 32,375 $m^2$ | Area of Northwest Landfill, as reported in the RI Report (Earth Tech, October 2001, pg. 1 and Figure 2-2). |
| Thickness of contaminated zone (THICK0) | 2 m | 4 m | Thickness of waste in Northwest Landfill, as reported in the RI Report (Earth Tech, October 2001, Figure 6-6). |
| Length parallel to aquifer flow (LCZPAQ) | 100 m | 335 m | Length (long axis) of Northwest Landfill, as reported in the RI Report (Earth Tech, October 2001, Figure 6-6). |
| Concentration of thorium-232 (S1) (1) | Not provided | 18.67 pCi/g | ORAU, 1985a. Sixty nine (69) observations with standard deviation ±67 pCi/g. Maximum observation of 443 pCi/g. |
| Concentration of radium-228 (S1) (2) | Not provided | 18.67 pCi/g | Assumed to be in equilibrium with parent, Th-232. |
| Concentration of thorium-228 (S1) (3) | Not provided | 17.96 pCi/g | ORAU, 1985a. Sixty nine (69) observations with standard deviation ±64 pCi/g. Maximum observation of 415 pCi/g. |
| Concentration of uranium-238 (S1) (4) | Not provided | 2.54 pCi/g | ORAU, 1985a. Sixty nine (69) observations with standard deviation ±3.8 pCi/g. Maximum observation of 22.1 pCi/g. |
| Concentration of uranium -234 (S1) (5) | Not provided | 2.54 pCi/g | Assumed to be in equilibrium with parent, U-238. |
| Concentration of thorium-230 (S1) (6) | Not provided | 2.54 pCi/g | Subsection 4.4.10 of this Plan. |

Table 5-2 (*continued*)
Input Parameters for RESRAD
SCA Hartley & Hartley Landfill Site
Kawkawlin Township, Michigan

| PARAMETER | RESRAD DEFAULT VALUE | SITE-SPECIFIC INPUT VALUE | BASIS FOR SITE-SPECIFIC INPUT VALUE |
|---|---|---|---|
| Concentration of radium-226 (S1) (7) | Not provided | 0.61 pCi/g | ORAU, 1985a. Sixty nine (69) observations with standard deviation ±0.5 pCi/g. Maximum observation of 2.5 pCi/g. |
| Concentration of lead 210 (S1) (8) | Not provided | 0.61 pCi/g | Assumed to be in equilibrium with Ra-226. |
| Cover depth (COVER0) | 0 m | 0.8 m | Thickness of the finished clay cover. Existing cover is 0.61 m (2 feet) as reported in the RI Report (Earth Tech, October 2001). |
| Density of cover material (DENSCV) | 1.5 g/cm³ | 2.3 g/cm³ | Site Closure Integrity Investigation (Dell, 1990). |
| Cover depth erosion rate (VCV) | 0.001 m/yr | 0.0006 m/yr | RESRAD value for the resident farmer scenario for a site with a 2 percent slope. |
| Density of the contaminated zone (DENSCZ) | 1.5 g/cm³ | 2.0 g/cm³ | ORAU, 1985a. |
| Density of saturated zone (DENSAQ) | 1.5 g/cm³ | 1.9 g/cm³ | Calculated based on 1.5 g/cm³ bulk density, 40 percent porosity, and 100 percent saturation. |
| Saturated zone total porosity (TPSZ) | 0.4 | 0.4 | Estimated from description of stratigraphy in RI Report (Earth Tech, October 2001) and values in Freeze & Cherry (2001, Table 2-4). |
| Well pumping rate (UW) | 250 m³/yr | 340 m ³/yr | Values in Driscoll, 1986, Table 24.5. |
| Number of unsaturated zone strata (NS) | 1 | 1 | Stratigraphy adjacent to Northwest Landfill, as reported in the RI Report (Earth Tech, October 2001, Figure 6-6). |

## Table 5-2 (*continued*)
## Input Parameters for RESRAD
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| PARAMETER | RESRAD DEFAULT VALUE | SITE-SPECIFIC INPUT VALUE | BASIS FOR SITE-SPECIFIC INPUT VALUE |
|---|---|---|---|
| Unsaturated Zone 1, thickness (H[1]) | 4 m | 1 m | Stratigraphy adjacent to Northwest Landfill as reported in the RI Report (Earth Tech, October 2001, Figure 6-6). |
| Unsaturated Zone 1, soil density (DENSUZ[1]) | 1.5 g/cm³ | 1.6 g/cm³ | Typical range of bulk densities for a silty sand. (Interpreted from "Principles of Geotechnical Engineering," Das, 1985). |
| Unsaturated Zone 1, total porosity (TPUZ[1]) | 0.4 | 0.4 | Estimated from description of stratigraphy in RI Report (Earth Tech, October 2001) and values in Freeze & Cherry (2001, Table 2-4). |
| Unsaturated Zone 1, effective porosity (EPUZ[1]) | 0.2 | 0.3 | Estimated from description of stratigraphy in RI Report (Earth Tech, October 2001) and values in Freeze & Cherry (2001, Table 2-4). |
| Unsaturated Zone 1, field capacity (FCUZ[1]) | 0.2 | 0.2 | Estimated from description of stratigraphy in RI Report (Earth Tech, October 2001) and values in Freeze & Cherry (2001, p. 61). |
| Unsaturated Zone 1, soil-specific "b" parameter (BUZ[1]) | 5.3 | 4.9 | Sandy loam from RI Report. Default value for sandy loam from the RESRAD Table E.2. |
| Unsaturated Zone 1, hydraulic conductivity (HCUZ[1]) | 10 m/yr | 1,090 m/yr | Sandy loam from RI Report. Default value for sandy loam from the RESRAD Table E.2. |
| Distribution coefficient for thorium-232 contaminated zone (DCNUCC[1]) | 60,000 mL/g | 5,800 mL/g | Shepard and Thibault, 1990. |

Table 5-2 (*continued*)
Input Parameters for RESRAD
SCA Hartley & Hartley Landfill Site
Kawkawlin Township, Michigan

| PARAMETER | RESRAD DEFAULT VALUE | SITE-SPECIFIC INPUT VALUE | BASIS FOR SITE-SPECIFIC INPUT VALUE |
|---|---|---|---|
| Distribution coefficient for thorium-232 unsaturated zone (DCNUCU[1]) | 60,000 mL/g | 5,800 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for thorium-232 saturated zone (DCNUCS[1]) | 60,000 mL/g | 3,200 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for radium-228 contaminated zone (DCNUCC[2]) | 70 mL/g | 9,100 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for radium-228 unsaturated zone (DCNUCU[2]) | 70 mL/g | 9,100 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for radium-228 saturated zone (DCNUCS[2]) | 70 mL/g | 500 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for thorium--228 contaminated zone (DCNUCC[3]) | 60,000 mL/g | 5,800 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for thorium-228 unsaturated zone (DCNUCU[3]) | 60,000 mL/g | 5,800 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for thorium-228 saturated zone (DCNUCS[3]) | 60,000 mL/g | 3,200 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for thorium-230 contaminated zone (DCNUCC[4]) | 60,000 mL/g | 5,800 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for thorium-230 unsaturated zone (DCNUCU[4]) | 60,000 mL/g | 5,800 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for thorium-230 saturated zone (DCNUCS[4]) | 60,000 mL/g | 3,200 mL/g | Shepard and Thibault, 1990. |

## Table 5-2 (*continued*)
## Input Parameters for RESRAD
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| PARAMETER | RESRAD DEFAULT VALUE | SITE-SPECIFIC INPUT VALUE | BASIS FOR SITE-SPECIFIC INPUT VALUE |
|---|---|---|---|
| Distribution coefficient for uranium-238 contaminated zone (DCNUCC[5]) | 50 | 1,600 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for uranium-238 unsaturated zone (DCNUCU[5]) | 50 | 1,600 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for uranium-238 saturated zone (DCNUCS[5]) | 50 | 35 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for uranium-234 contaminated zone (DCNUCC[5]) | 50 | 1,600 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for uranium-234 unsaturated zone (DCNUCU[5]) | 50 | 1,600 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for uranium-234 saturated zone (DCNUCS[5]) | 50 | 35 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for radium-226 contaminated zone (DCNUCC[7]) | 70 mL/g | 9,100 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for radium-226 unsaturated zone (DCNUCU[7]) | 70 mL/g | 9,100 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for Ra-226 saturated zone (DCNUCS[7]) | 70 mL/g | 500 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for Pb-210 contaminated zone (DCNUCC[8]) | 100 mL/g | 550 mL/g | Shepard and Thibault, 1990. |

## Table 5-2 (*continued*)
## Input Parameters for RESRAD
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| PARAMETER | RESRAD DEFAULT VALUE | SITE-SPECIFIC INPUT VALUE | BASIS FOR SITE-SPECIFIC INPUT VALUE |
|---|---|---|---|
| Distribution coefficient for Pb-210 unsaturated contaminated zone (DCNUCU[8]) | 100 mL/g | 550 mL/g | Shepard and Thibault, 1990. |
| Distribution coefficient for Pb-210 saturated zone (DCNUCC[8]) | 100 mL/g | 270 mL/g | Shepard and Thibault, 1990. |

## Table 5-3
## Probabilistic Input Parameters for RESRAD
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| PARAMETER | CODE | VALUE | DISTRIBUTION | RANGE AND FIT | REFERENCE |
|---|---|---|---|---|---|
| Priority 1 | | | | | |
| Distribution coefficient for thorium--232 | SOLUBKO(1) | 5,800 mL/g | Lognormal-n | μ = 8.68 s=3.62 | NUREG 6697, Appendix C, Table 3.9-1. |
| Distribution coefficient for radium-228 | SOLUBKO(2) | 9,100 mL/g | Lognormal-n | μ = 8.17 s=1.70 | NUREG 6697, Appendix C, Table 3.9-1. |
| Distribution coefficient for thorium--228 | SOLUBKO(3) | 5,800 mL/g | Lognormal-n | μ = 8.68 s=3.62 | NUREG 6697, Appendix C, Table 3.9-1. |
| Distribution coefficient for thorium--230 | SOLUBKO(4) | 5,800 mL/g | Lognormal-n | μ = 8.68 s=3.62 | NUREG 6697, Appendix C, Table 3.9-1. |
| Distribution coefficient for uranium-238 | SOLUBKO(5) | 1,600 mL/g | Lognormal-n | μ = 4.84 s=3.13 | NUREG 6697, Appendix C, Table 3.9-1. |
| Distribution coefficient for uranium-234 | SOLUBKO(6) | 5,800 mL/g | Lognormal-n | μ = 4.84 s=3.13 | NUREG 6697, Appendix C, Table 3.9-1. |
| Distribution coefficient for radium-226 | SOLUBKO(7) | 9,100 mL/g | Lognormal-n | μ = 8.17 s=1.70 | NUREG 6697, Appendix C, Table 3.9-1. |
| Distribution coefficient for Pb-210 | SOLUBKO(8) | 550 mL/g | Lognormal-n | μ = 7.78 s=2.76 | NUREG 6697, Appendix C, Table 3.9-1. |
| Density of cover material | DENSCV | 2.3 $g/cm^3$ | Truncated normal | μ = 1.52 s=0.23 | Site Closure Integrity Investigation (Dell, 1990). |
| Density of contaminated zone | DENSCZ | 2.0 $g/cm^3$ | Truncated normal | μ = 1.52 s=0.23 | ORAU, 1985. |

**Table 5-3 (*continued*)**
**Probabilistic Input Parameters for RESRAD**
**SCA Hartley & Hartley Landfill Site**
**Kawkawlin Township, Michigan**

| PARAMETER | CODE | VALUE | DISTRIBUTION | RANGE AND FIT | REFERENCE |
|---|---|---|---|---|---|
| Density of saturated zone | DENSAQ | 1.9 g/cm³ | Truncated normal | μ = 1.52 s=0.23 | Calculated based on 1.5 g/cm³ bulk density, 40 percent porosity, and 100 percent saturation. |
| Saturated zone total porosity | TPSZ | 0.4 | Truncated normal | μ = 0.425 s=0.0867 | Estimated from description of stratigraphy in RI Report (Earth Tech, October 2001) and values in Freeze & Cherry (2001, Table 2-4). |
| Saturated zone effective porosity | EPSZ | 0.2 | Truncated normal | μ = 0.425 s=0.0867 | Estimated from description of stratigraphy in RI Report (Earth Tech, October 2001) and values in Freeze & Cherry (2001, Table 2-4). |
| Saturated zone hydraulic conductivity | HCSZ | 100 m/yr | Bounded lognormal-n | μ = 2.3 s=2.11<br>Minimum 0.004<br>Maximum 9250 m/yr | RESRAD 6.2 Default. |

**Table 5-3 (*continued*)**
**Probabilistic Input Parameters for RESRAD**
**SCA Hartley & Hartley Landfill Site**
**Kawkawlin Township, Michigan**

| PARAMETER | CODE | VALUE | DISTRIBUTION | RANGE AND FIT | REFERENCE |
|---|---|---|---|---|---|
| Unsaturated zone thickness | H(1) | 1 m | Bounded lognormal-n | μ = 2.296 s=1.276<br>Minimum 0.18<br>Maximum 320 m | Stratigraphy adjacent to Northwest Landfill as reported in the RI Report (Earth Tech, October 2001, Figure 6-6). |
| Depth of roots | DROOT | 0.9 m | Uniform | Minimum 0.3 m<br>Maximum 4 m | RESRAD 6.2 Default. |
| Transfer factor for plants thorium | BRTF(90,1) | derived | Lognormal-n | μ = -6.91<br>s = 0.916 | RESRAD 6.2 Default. |
| Transfer factor for plants Radium | BRTF(88,1) | derived | Lognormal-n | μ = -3.22<br>s = 0.916 | RESRAD 6.2 Default. |
| Transfer factor for plants Uranium | BRTF(92,1) | derived | Lognormal-n | μ = -6.21<br>s = 0.916 | RESRAD 6.2 Default. |
| Transfer factor for plants Lead | BRTF(82,1) | derived | Lognormal-n | μ = -5.52<br>s = 0.916 | RESRAD 6.2 Default. |

## Table 5-3 (*continued*)
## Probabilistic Input Parameters for RESRAD
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| PARAMETER | CODE | VALUE | DISTRIBUTION | RANGE AND FIT | REFERENCE |
|---|---|---|---|---|---|
| Priority 2 | | | | | |
| Area of contaminated zone | Area | 32,375 m2 | Log uniform | Min = 16,000 m2<br>Max = 32,375m2 | Area of Northwest Landfill, as reported in the RI Report (Earth Tech, October 2001, pg. 1 and Figure 2-2). The slag is not uniformly distributed through the landfill. It is assumed that at least 50 percent of the landfill contains slag. |
| Thickness of contaminated zone | THICK0 | 4 m | Bounded lognormal-n | μ = 2 s=2<br>Minimum 0.4<br>Maximum 4 m | Thickness of waste in Northwest Landfill, as reported in the RI Report (Earth Tech, October 2001, Figure 6-6). The depth of the contaminated zone is not uniform. It assumed that the range of the thickness is at less 0.4 m and no more than 4 m thick. |
| Contaminated zone total porosity | TPCZ | 0.4 | Truncated normal | μ = 0.425 s= 0.0867 | RESRAD 6.2 Default. |

Table 5-3 (*continued*)
Probabilistic Input Parameters for RESRAD
SCA Hartley & Hartley Landfill Site
Kawkawlin Township, Michigan

| PARAMETER | CODE | VALUE | DISTRIBUTION | RANGE AND FIT | REFERENCE |
|---|---|---|---|---|---|
| Contaminated zone erosion rate | VCZ | 0.001 m/yr | Continuous logarithmic | μ = 0.001 s= 0.95 | RESRAD 6.2 Default. |
| Contaminated zone hydraulic conductivity | HCCZ | 10 m/yr | Bounded lognormal-n | μ = 2.3 s=2.11<br>Minimum 0.004<br>Maximum 9250 m/yr | RESRAD 6.2 Default. |
| Contaminated Zone B parameter | BCZ | 5.3 | Bounded lognormal-n | μ = 1.06 s=0.66<br>Minimum 0.5<br>Maximum 30 | RESRAD 6.2 Default Sandy loam from RI Report. Default value for sandy loam from the RESRAD Table E.2. |
| Saturated Zone B parameter | BSZ | 5.3 | Bounded lognormal-n | μ = 1.06 s=0.66<br>Minimum 0.5<br>Maximum 30 | RESRAD 6.2 Default Sandy loam from RI Report. Default value for sandy loam from the RESRAD Table E.2. |
| Unsaturated zone density | DENSUZ(1) | 1.6 g/cm$^3$ | Truncated normal | μ = 1.52 s= 0.23 | Typical range of bulk densities for a silty sand. (Interpreted from "Principles of Geotechnical Engineering," Das, 1985). |

**Table 5-3 (*continued*)**
**Probabilistic Input Parameters for RESRAD**
**SCA Hartley & Hartley Landfill Site**
**Kawkawlin Township, Michigan**

| PARAMETER | CODE | VALUE | DISTRIBUTION | RANGE AND FIT | REFERENCE |
|---|---|---|---|---|---|
| Unsaturated zone total porosity | TPUZ(1) | 0.4 | Truncated normal | $\mu$ = 0.425 s=0.0867 | Estimated from description of stratigraphy in RI Report (Earth Tech, October 2001) and values in Freeze & Cherry (2001, Table 2.4). |
| Unsaturated Zone B parameter | BUZ(1) | 5.3 | Bounded lognormal-n | $\mu$ = 1.06 s=0.66<br>Minimum 0.5<br>Maximum 30 | Sandy loam from RI Report. Default value for sandy loam from the RESRAD Table E.2. |
| Unsaturated zone hydraulic conductivity | HCUZ(1) | 1090 m/yr | Bounded lognormal-n | $\mu$ = 2.3 s=2.11<br>Minimum 0.004<br>Maximum 9250 m/yr | Sandy loam from RI Report. Default value for sandy loam from the RESRAD Table E.2. |

**Table 5-4**
**Derived Concentration Guideline Levels for the Northwest Landfill**
**SCA Hartley & Hartley Landfill Site**
**Kawkawlin Township, Michigan**

| ISOTOPE | CONCENTRATION PRESENT IN THE NORTHWEST LANDFILL (pCi/g) |
|---|---|
| Lead-210 | 0.61 |
| Radium-226 | 0.61 |
| Radium-228 | 18.67 |
| Thorium-228 | 17.96 |
| Thorium-230 | 2.54 |
| Thorium-232 | 18.67 |
| Uranium-234 | 2.54 |
| Lead-210 | 2.54 |

Source:
Oak Ridge Associated Universities. *Radiological Survey of the SCA Chemical Services, Inc., Landfill Site, Bay City, Michigan.* July 1985. (ORAU, 1985a)

## Table 5-5
## Derived Concentration Guideline Levels for the Surface Soil Outside the Northwest Landfill
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| ISOTOPE | CONCENTRATION[1] (pCi/gram) |
|---|---|
| Radium-226 | 108 |
| Radium-228 | 228 |
| Thorium-230 | 206 |
| Thorium-232 | 141 |
| Uranium-234 | 358 |
| Uranium-238 | 358 |

Note:

(1) The DCGLs for surface soil were derived from the concentrations of radioactive materials calculated by RESRAD, using the input parameters described in Section 5. These concentrations are estimated to result in less than 25 millirem per year to an industrial worker on the site over an exposure period of 1,000 years.

**Table 5-6**
**Calculated Radiation Exposures**
**SCA Hartley & Hartley Landfill Site**
**Kawkawlin Township, Michigan**

| LOCATION | DESCRIPTION | CALCULATED RADIATION EXPOSURE (mrem/year) |
|---|---|---|
| Northwest Landfill | Industrial worker | 1.4 |
| Northwest Landfill | No controls in place[1] | 312 |
| Surface soil | DCGLs in soil outside of the Northwest Landfill | 24.6 |
| | NRC limit for unrestricted release | 25 |

[1] Assumes the cover over the Northwest Landfill is removed, the slag is disturbed, and that a resident farm family uses groundwater as their source of drinking water.

## Table 6-1
## Estimated Costs for On-Site Consolidation of Radiologically Contaminated Material and to Improve the Cover Over the Northwest Landfill
## SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

| | UNIT | UNIT $ | QUANTITY[1,2] | TOTAL[3] |
|---|---|---|---|---|
| DIRECT CAPITAL COSTS:[4] | | | | |
| Mobilization, demobilization, bonding, H&S, Ins. (20% of capital costs) | LS | $153,600 | 1 | $154,000 |
| Strip vegetation from the Northwest Landfill For additional cover placement | Acre | $200 | 8 | $2,000 |
| Excavating and stockpiling low-permeability layer from Northwest Landfill for placement of slag waste(5) | CY | $6 | 1800 | $11,000 |
| Excavate, haul, and place slag and cover material into Northwest Landfill(6) | CY | $10 | 1400 | $14,000 |
| Excavate, haul, and place general fill in Northwest Landfill(7) | CY | $9 | 6000 | $51,000 |
| Install leachate extraction well, and associated piping and connect to existing transfer line[8] | EA | $4 | 17000 | $68,000 |
| Replace stripped low-permeability soil in Northwest Landfill(9) | CY | $9 | 1800 | $16,000 |
| Place additional 9.5 inches of low-permeability soil in Northwest Landfill(10) | CY | $15 | 15000 | $221,000 |
| Place vegetative layer over low-permeability soil in Northwest Landfill | CY | $15 | 6200 | $93,000 |
| Grade and backfill areas where slag was removed, prepare for seeding | LS | $8,000 | 1 | $8,000 |
| Seed, fertilize, and mulch Northwest Landfill and ex-slag areas | Acre | $3,500 | 9 | $32,000 |
| Final Status Survey Class 2 and 3[11] | Per | $1,600 | 144 | $230,000 |
| Final Status Survey Class 1 areas[12] | Per | $1,600 | 15 | $24,000 |
| Final Status Survey contingency | LS | $180,000 | 1 | $180,000 |
| Contingency (25%) | LS | $276,000 | 1 | $276,000 |
| SUBTOTAL DIRECT CAPITAL COSTS | | | | $1,380,000 |
| INDIRECT CAPITAL COSTS: | | | | |
| - Engineering design, and regulatory assistance | LS | $200,000 | 1 | $200,000 |
| - Construction documents (bidding documents including plans/specs) | LS | $25,000 | 1 | $25,000 |
| - Surveying | LS | $20,000 | 1 | $20,000 |
| - CQA[13] | LS | $90,000 | 1 | $90,000 |
| - Documentation Report | LS | $25,000 | 1 | $25,000 |
| Contingency (25%) | | | | $90,000 |
| SUBTOTAL INDIRECT CAPITAL COSTS | | | | $450,000 |
| TOTAL CAPITAL COSTS | | | | $1,830,000 |
| ANNUAL O&M COSTS | | | | |
| Standard OM&M for cover maintenance | Yr | $15,000 | 1 | $15,000 |
| | | | | $0 |
| SUBTOTAL O&M COSTS | | | | $15,000 |
| PRESENT WORTH OF ANNUAL COSTS[14] | | | | $65,000 |
| TOTAL COSTS (TOTAL CAPITAL PLUS PRESENT WORTH) | | | | $1,895,000 |

By: B.Peotter
Date: 10/2/03
Checked By: MJA

Table 6-1
Estimated Costs for On-Site Consolidation of Radiologically Contaminated Material and to Improve the Cover Over the Northwest Landfill
SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

Assumptions and Clarifications

1. Costs determined from Means Cost Estimating Books 2003 for similar services and equipment to be provided and RMTs experience.
2. All costs are based on preliminary design quantities and concepts. References for costs and quantities are attached.
3. Cost totals rounded to the nearest thousand dollars.
4. Areas of the Northwest Landfill and slag piles are as follows: Northwest Landfill=333,000 SF=7.6 acre, East Slag Pile=4225 SF=0.1 acre, West Slag Pile=8850 SF=0.2 acre
5. This includes designating the area to place waste, stripping final cover, and preparing for placement of waste.
6. Assume minimal decon will be needed on equipment.
7. This is to provide positive slopes for surface water drainage in the Northwest Landfill. Assume general fill comes from off-site.
8. Assumes a depth of 15 feet
9. This consists of placing, grading, compacting, and moisture conditioning previously removed low-permeability soil as necessary to achieve desired density and moisture
10. This consists of supplying, hauling, placing, grading, compacting, and moisture conditioning additional low-permeability soil to supplement the soil, which is currently in place over the Northwest Landfill. Assume additional low-permeability soil is off-site.
11. $1,600 based on previous sampling events, 100 samples for Class 2 samples (100-foot buffer around the Northwest Landfill and slag piles, 60-foot grid spacing for samples), and 20 samples for class 3.
12. Includes the following costs: $1600 per sample, 15 samples for Class 1 area at Slag Piles (on a 30-foot square grid), costs per sample based on previous sampling costs.
13. Assume on-site staff will include two IEM and one RMT personnel for CQA work. Work to be performed over 5-week period.
14. Assumes 5 years at 5 percent.

## Table 6-2
## Estimated Costs to Excavate Radiologically Contaminated Materials and to Transport These Materials to an Off-Site Facility
## SCA Hartley & Hartley Landfill, Kawkawlin Township, Michigan

| | UNIT | UNIT $ | QUANTITY[1,2] | TOTAL[3] |
|---|---|---|---|---|
| DIRECT CAPITAL COSTS: | | | | |
| Mobilization, demobilization, bonding, H&S, Ins. (20% of capital costs)[4] | LS | $3,978,200 | 1 | $3,978,000 |
| Wetland protection measures[5] | LS | $15,000 | 1 | $15,000 |
| Excavate and stockpile cover from Northwest Landfill and two slag piles[6] | CY | $6 | 32392 | $184,000 |
| Construction of rail spur onto site for removal of waste[7] | LS | $250,000 | 1 | $250,000 |
| Upgrade access roads for excavation activities[8] | CY | $23 | 592 | $14,000 |
| Sump system | LS | $50,000 | 1 | $50,000 |
| Excavation dewatering | Day | $100 | 80 | $8,000 |
| Spoil dewatering by lime addition[9] | TN | $790,693 | 1 | $791,000 |
| Excavate, haul, and place slag from Northwest Landfill and slag piles into railroad cars | CY | $7 | 106100 | $743,000 |
| Haul waste in rail cars to Envirocare[10] | LS | $16,800,000 | 1 | $16,800,000 |
| Disposal costs at Envirocare[11] | LS | $48,000,000 | 1 | $48,000,000 |
| Regrade areas where slag removed, prepare for seeding[12] | CY | $5 | 31000 | $155,000 |
| Seed, fertilize, and mulch Northwest Landfill and ex-slag areas | Acre | $3,500 | 7.8 | $27,000 |
| Final Status Survey[13] | LS | $854,400 | 1 | $854,000 |
| | | | | $0 |
| Contingency (25%) | LS | $17,967,250 | 1 | $17,967,000 |
| SUBTOTAL DIRECT CAPITAL COSTS | | | | $89,836,000 |
| | | | | |
| INDIRECT CAPITAL COSTS: | | | | |
| Engineering design, administrative assistance | LS | $1,000,000 | 1 | $1,000,000 |
| - CQA | LS | $300,000 | 1 | $300,000 |
| - Documentation Report[13] | LS | $50,000 | 1 | $50,000 |
| | | | | $0 |
| Contingency (35%) | | | | $473,000 |
| SUBTOTAL INDIRECT CAPITAL COSTS | | | | $1,823,000 |
| | | | | |
| TOTAL CAPITAL COSTS | | | | $91,659,000 |
| | | | | |
| ANNUAL O&M COSTS | | | | |
| Standard OM&M for cover maintenance | YR | $10,000 | 1 | $10,000 |
| | | | | $0 |
| SUBTOTAL O&M COSTS | | | | $10,000 |
| PRESENT WORTH OF ANNUAL COSTS[15] | | | | $43,000 |
| | | | | |
| TOTAL COSTS (TOTAL CAPITAL PLUS PRESENT WORTH) | | | | $91,702,000 |

By: B.Peotter
Date: 10/2/03
Checked By: MJA

Table 6-2
Estimated Costs to Excavate Radiologically Contaminated Materials
and to Transport These Materials to an Off-Site Facility
SCA Hartley & Hartley Landfill Site, Kawkawlin Township, Michigan

Assumptions and Clarifications

1. Costs determined from Means Cost Estimating Books, known costs for similar projects and services, and estimates given by contractors and venders based on conceptual design.
2. All costs are based on preliminary design quantities and concepts. References for costs and quantities are attached.
3. Cost totals rounded to the nearest thousand dollars.
4. Does not include costs for disposal at Envirocare.
5. Allowance for protection measures during and after construction.
6. This includes stripping final cover soils (assumes thickness of 2.5 feet), and preparing for removal of waste.
7. This includes all costs for constructing a 0.5-mile railway spur through the Tobico Marsh State Game Area. Includes obtaining ROW, railway permits, insurance, clear and grub trees, material for railroad tie subgrade, and construction of rail line.
8. Assumes 10-foot wide, 12-inch thick crushed gravel base, cost from R.S. Means 2003.
9. The costs associated with the addition and mixing of lime to solidify water in the waste mass.
10. Based on the following information: 88,400 cubic yards (waste) + 17,680 cubic yards (due to lime addition) = 106,100 cubic yards, 90 lb/cf, 1,800 miles, a cost of $12,000/per railcar with a capacity of 75 cubic yards.
11. From a phone conversation with Dana Simonsen at Envirocare, the disposal of 87,000 cubic yards of waste material is $35 to $40 million. If we assume a volume increase of 20 percent due to the addition of lime for dewatering purposes, the costs will increase by 20 percent, or for worst case pricing, $8 million.
12. This includes placing stripped cover material back in place and grading (24-inch clay, 6-inch topsoil, 37,000 square yards = 31,000 cubic yards). Costs from Means 2003.
13. Includes the following costs: $1,600 per sample, 390 samples for Class 1 Area (samples on a 30-foot square grid), 124 samples for Class 2 samples (100-foot perimeter around the Northwest Landfill and slag piles, 60-foot grid spacing for samples), and 20 samples for Class 3. Cost per sample based on previous sampling costs.
14. Assume on-site staff will include IEM and RMT for CQA work.
15. Assume 5 years at 5 percent.

## Table 12-1
## Volumes of Waste Material in the Northwest Landfill and the Two Slag Piles
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| | VOLUME OF THORIUM-BEARING SLAG[1] (cubic yards) | VOLUME OF NON-THORIUM-BEARING WASTE[2] (cubic yards) | TOTAL VOLUME OF WASTE MATERIAL (cubic yards) |
|---|---|---|---|
| NWLF | 21,750 - 65,250 | 21,750 - 65,250 | 87,000 |
| Slag Pile A | 165-210 | 0 | 165-210 |
| Slag Pile B | 245-390 | 0 | 245-390 |
| Total | 22,160 – 62,850 | 21,750 - 65,250 | 87,410 – 87,600 |

(1) The total volume of waste in the Northwest Landfill is approximately 87,000 cubic yards based on a surface area of 332,941 square feet and an average depth of 7 feet. The thorium-bearing slag slag was assumed to be in the range of 25 to 75 percent of the total volume of waste in the Northwest Landfill.

(2) Non–thorium-bearing waste includes non-thorium-bearing slag, soil debris, and other nonlicensed wastes.

**Table 14-1**
**Survey Instruments for Scanning Soil**
**SCA Hartley & Hartley Landfill Site**
**Kawkawlin Township, Michigan**

| MANUFACTURER AND METER | MANUFACTURER AND DETECTOR MODEL | DETECTOR TYPE | USE |
|---|---|---|---|
| Eberline E600 | Eberline SPA3<br>2" x 2" NaI scintillator(1) | NaI | Scans for gamma-emitting radionuclides |
| Ludlum 2221 | Ludlum 44-10<br>2" x 2" NaI scintillator | NaI | Scans for gamma-emitting radionuclides |

(1) NaI = Sodium iodide.

## Table 14-2
## Typical Minimum Detectable Concentrations
## Gross Gamma Scanning in Soil
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| Isotope | B (cpm) | I (sec) | p | $\epsilon_i$ (cpm/μR/hr) | d' | $S_i$ (counts) | MDCR (ncpm) | $MDCR_s$ (ncpm) | Scan MDCR (μR/hr) | CF (pCi/g/μR/hr) | Scan MDC (pCi/g) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ra-226 | 5,000 | 1 | 0.5 | 760 | 1.38 | 13 | 756 | 1,069 | 1.41 | 1.41 | 2.0 |
| | 10,000 | 1 | 0.5 | 760 | 1.38 | 18 | 1,069 | 1,512 | 1.99 | 1.41 | 2.8 |
| Uranium natural | 5,000 | 1 | 0.5 | 3990 | 1.38 | 13 | 756 | 1,069 | 0.27 | 211 | 57 |
| (in equilibrium) | 10,000 | 1 | 0.5 | 3990 | 1.38 | 18 | 1,069 | 1,512 | 0.38 | 211 | 80 |
| Th-232 | 5,000 | 1 | 0.5 | 830 | 1.38 | 13 | 756 | 1,069 | 1.29 | 0.99 | 1.3 |
| (in equilibrium) | 10,000 | 1 | 0.5 | 830 | 1.38 | 18 | 1,069 | 1,512 | 1.82 | 0.99 | 1.8 |

<u>Notes:</u>

B = background count rate (cpm).
cpm = counts per minute.
I = scan time interval.
P = surveyor efficiency (ranges from 0.5 to 0.75).
$\epsilon_i$ = instrument efficiency (from Table 6.4 NUREG-1507).
d' = value selected from Table 6.1, NUREG-1507.
$S_i$ = minimal number of net source counts.
MDCR = minimum detectable count rate.

MDCRs = surveyor MDCR.
MDCRs = surveyor MDCR.
MDC = minimum detectable concentration.
CF = conversion factor from NUREG-1507.
Ncpm = net counts per minute.
pCi/g = picocuries per gram.
μR/hr = microroentgen per hour.

**Table 14-3**
**Example Conversion Factors to Convert From Scanning Results to Emissions for Specific Radionuclides**
**SCA Hartley & Hartley Landfill Site**
**Kawkawlin Township, Michigan**

| RADIONUCLIDE | [illegible] (cpm/μR/hr) | CONVERSION FACTOR (pCi/g/μR/hr) |
|---|---|---|
| Ra-226 | 760 | 1.41 |
| Th-232 | 830 | 0.99 |
| U natural | 3,990 | 211 |

## Table 14-4
## Final Status Survey Investigation Levels
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| SURVEY UNIT CLASSIFICATION | INVESTIGATE DIRECT MEASUREMENT OR SAMPLE RESULT WHEN: | INVESTIGATE SCANNING MEASUREMENT WHEN: |
|---|---|---|
| Class 1 | >$DCGL_W$ or >statistical parameter based value | >$DCGL_W$ |
| Class 2 | >$DCGL_W$ | >$DCGL_W$ |
| Class 3 | > 0.8 $DCGL_W$ | >MDC |

$DCGL_W$ = DCGL for the Wilcoxon Rank Sum Test.

## Table 14-5
## Summary of Statistical Tests
## for Analytes that are Present in Background
## SCA Hartley & Hartley Landfill Site
## Kawkawlin Township, Michigan

| SURVEY RESULT | CONCLUSION |
|---|---|
| Difference between largest survey unit measurement and smallest reference area measurement is less than $DCGL_W$. | Survey unit meets release criterion. |
| Difference of survey unit average and reference area average is greater than $DCGL_W$. | Survey unit does not meet release criterion. |
| Difference between any survey unit measurement and any reference area measurement is greater than $DCGL_W$, and the difference of survey unit average and reference area average is less than $DCGL_W$. | Conduct WRS test and elevated measurement comparison. |