4.0 RADIOLOGICAL STATUS OF FACILITY

A substantial volume of radiological data, in addition to the historical information (HLA 1998a) and other technical data, are available for the Site. From these data, it is evident that there are no radiologically contaminated structures, no contaminated systems or equipment, and no residual radioactivity in excess of background concentrations in surface soil on the site. There are, however, deposits of foundry slag containing naturally occurring, but elevated concentrations, of thorium in subsurface soils.

The source of residual radioactivity at the site is known to be associated with the disposition of foundry slag generated at a site in nearby Bay City, Michigan. The foundry-generated slag came from operations involving magnesium alloys. Some, but not all, of these slag materials contained thorium as a natural composition of the ores from which the metals were derived. A review of historical documents indicates that the disposition of thorium-bearing slag materials at the site likely began sometime after a decision was made by Dow Chemical to discontinue the practice of stockpiling thoriated slag on its property, forcing then operator of the foundry, Wellman Dynamics, to look for alternative disposal options.

Prior to any known disposal of slag materials at the MDNR site, other industrial wastes were being disposed of on the ground surface and in surface depressions believed to have been created by the excavation of sand deposits. In response to regulatory pressure from the State of Michigan, the former landfill owner, Hartley & Hartley, covered a significant portion of the site with sand. Some limited disposal is known to have occurred following the placement of the sand cover.

Placement of radioactive magnesium-thorium slag on top of the sand cover is believed to have begun in September of 1970.

4.1 CONTAMINATED STRUCTURES

The only structure present at the site is the LCTS building. The building is a simple, small, shed-sized, rectangular concrete slab-on-grade building designed to house the LCTS operational components. The LCTS was never operated, and none of the above-grade piping, including that present within the LCTS building, has ever contained radioactivity from the site. Given that the LCTS was never used, and that the building was constructed on a slab set on top of the engineered clay cover (and thus isolated from contact with the radioactive slag beneath the cover), it is reasonable to conclude that the building has not been radiologically impacted by historical operations at the site.

However, the building has been used, and is currently used, to provide protection from the elements for a steel drum containing sample-derived waste from recent characterization activities at the site. While the waste is completely and effectively contained within the drum, and routine radiological surveys confirm the integrity of the

containment, a portion of the building where the drum is stored is posted as a Radioactive Materials Area (RMA) in accordance with NRC requirements. For this reason, the MDNR cannot completely rule out the possibility that the LCTS building might be radiologically impacted. Still, the potential for the presence of residual radioactivity in the LCTS building is judged to be very small.

4.2 CONTAMINATED SYSTEMS AND EQUIPMENT

The Leachate Collection and Treatment System (LCTS) is the only system in place at the site. The LCTS consists of a network of collection pipes embedded within the disposal cell from which leachate was to have been extracted. The extracted leachate was to have been directed through a piping system to a collection tank within the LCTS building where it would be treated before being discharged. As discussed above, the LCTS system has never been operated and has never contained radioactivity from the site. The collection and distribution piping located above the level of the radioactive waste layer (>5 bgs) as well as the process treatment equipment and components remaining in the LCTS building are, therefore, radiologically unimpacted.

4.3 SURFACE SOIL CONTAMINATION

Surface soils at the site consist of high clay-content native materials imported to construct the engineered clay cover for the cell. The clay materials were apparently obtained from a borrow pit not in the immediate area of the disposal site, leading to the conclusion that the material is not potentially radiologically impacted.

The subsurface soil characterization effort undertaken by the MDNR in 2000, after the installation of the clay cover material, necessitated the placement of a number of coreholes through the cover and into the disposed materials below the cover. The method used to access the subsurface soils was a direct-push GeoProbe® coring device. Substantial measures were employed during core extraction to preclude the contaminating the surface soils. Barrier materials were placed on the ground around the corehole. Core samples and downhole equipment were laid out on plastic during sample processing, and all equipment was decontaminated between corings. Core materials that were not needed for subsequent sampling were returned to the corehole. The cover was then repaired by filling the hole with commercially supplied bentonite clay. Once placed, the bentonite clay material hydrates and expands to form a solid and competent seal, restoring the cover to its original integrity.

Radiation surveys routinely performed over the cover area to date are not sensitive enough to definitively demonstrate that radioactivity was not brought to the surface during the characterization survey process. However, the routine gamma radiation surveys over the cover are sensitive enough to detect significant amounts of the gamma-emitting Th-232 radioactivity if it were present. As a benchmark for the sensitivity of the gamma measurements, the natural radioactivity present in the granite markers placed on the cover is easily detected. These markers are consistently recorded as the locations with the highest radiation level on site.

Given the controls that were in place to prevent the spread of radioactive contamination during the characterization survey process, and the evidence supplied in the post-characterization survey routine site radiation surveys, it is reasonable to conclude that the surface soil at the site does not have significant amounts of residual radioactivity owing to the characterization survey process. Nonetheless, there is some potential for the presence of relatively minor concentrations of residual radioactivity to be present in the surface soils in the immediate vicinity of the characterization coreholes.

In November and December of 2003, MACTEC performed a scoping survey of the surface soils on the cover to assess whether measurable concentrations of radioactivity might be present in the vicinity of the former corehole penetrations. Scan surveys were performed within the area circumscribed by a 1-meter radius about a number of former corehole sites. The radiological scans were performed using standard "pancake" frisker GM detectors sensitive to the beta and gamma radiation signals associated with the thoriated slag. The coreholes surveyed were those found along the former access road through the approximate centerline of the site. These were chosen because the site characterization survey (Cabrera 2001) indicated that the majority of subsurface radioactivity was located along this axis. Thus, the surface soils around these coreholes would represent those most likely to be impacted in the hypothesized fashion. No radioactivity concentrations distinguishable from background could be found. The absence of measurable radioactivity in the surface soils during this scoping survey strongly supports the conclusion that significant concentrations of radioactivity are not present on the surface.

4.4 SUBSURFACE SOIL CONTAMINATION

Subsurface soils are typically defined as those lying deeper than 15 cm (6 inches) below the ground surface. However, given that the clay cover material at the Tobico SGA Site is typically 1.5 meters (5 ft.) thick, potentially contaminated subsurface soils is restricted to soils immediately beneath the engineered clay cover layer.

4.4.1 Location of Residual Radioactivity in Subsurface Soils

Radiological surveys performed after MDNR's acquisition of the property in 1974, along with both aerial and ground-level photographs of the site taken in 1983 prior to installation of the engineered slurry wall and cap, indicate that slag was placed in piles on top of the sand cover along the route of the former access road through the center of the site. It is logical that the slag was deposited near and along the both sides of the former road, because vehicles venturing very far to the east or west of the road would have readily sunk into the saturated wetland soils.

A series of radiological surveys have been performed at the site over the years that confirm the limited distribution of subsurface radioactive waste deposits. These radiological surveys corroborate the historical, photographic, and physical evidence that the slag deposits are located along the route of the former access road through the site. The Radiological Scoping Survey (HLA 1998b) and the subsurface soil Characterization

Survey (Cabrera 2001) were both performed after placement of the clay cover and slurry walls. Both of these surveys confirmed that surface and near-surface soils at the site are not contaminated with residual radioactivity. They further confirmed that concentrations of radioactivity in soil (both surface and subsurface) outside the footprint of the slurry wall are consistent with concentrations expected for naturally occurring background levels in native soils.

4.4.1.1 MDNR Survey Report

In April 1983, after the surface was covered with sand but prior to construction of the clay cap and slurry walls, the MDNR surveyed a portion of the Site (MDPH 1983), accompanied by representatives of the USEPA and the State of Michigan Department of Public Health.

A survey line, down the center of the visible road trace (former access road), was established as a reference point. Exposure rates were measured at waist height (approximately 1 meter) using a micro-R meter along the length of this survey line. The survey was repeated moving incrementally to the east and west of the centerline until background radiation levels were consistently encountered. The survey area extended beyond (in most cases, well beyond) the boundaries of the areas of elevated radiation levels, covering an area approximately 450 feet long by 200 feet wide. The survey recorded 20 μR per hour exposure-rate contours indicating the areal extent of residual radioactivity as measured by gamma radiation emission.

All elevated readings were found on or within approximately 50 feet of the road trace in areas where the ground surface had been disturbed or exposed. Elevated readings were not found in areas where there was no evidence of disturbance. The area of elevated measurements from the 1983 survey is presented in Figure 4-1.

4.4.1.2 ORAU Radiological Assessment Survey

Under contract to NRC Region III, Oak Ridge Associated Universities (ORAU) conducted a survey to assess the radiological conditions of the MDNR's portion of the former Hartley & Hartley landfill (Tobico Marsh Site). ORAU actually conducted two surveys; one in July 1984 just prior to installation of the clay cap and slurry walls, and another in June 1985 after their installation (ORAU 1985). The first of the two surveys is of interest in determining the deposition of subsurface radioactive materials.

The first survey was designed to systematically identify the areal extent of elevated concentrations of residual radioactivity. A 20-meter grid system was established over the sand cover area, extending approximately 20 meters into the marsh on either side of this area. The area was subdivided into 10-meter grids within the sand cover area. A walkover scan was conducted using NaI(Tl) gamma scintillation detectors at 1- to 2-meter intervals over accessible portions of the property and at 5- to 10-meter intervals in the marsh areas. Locations where elevated radiation levels were measured at the ground surface were noted. Gamma exposure-rate measurements were then made both at the

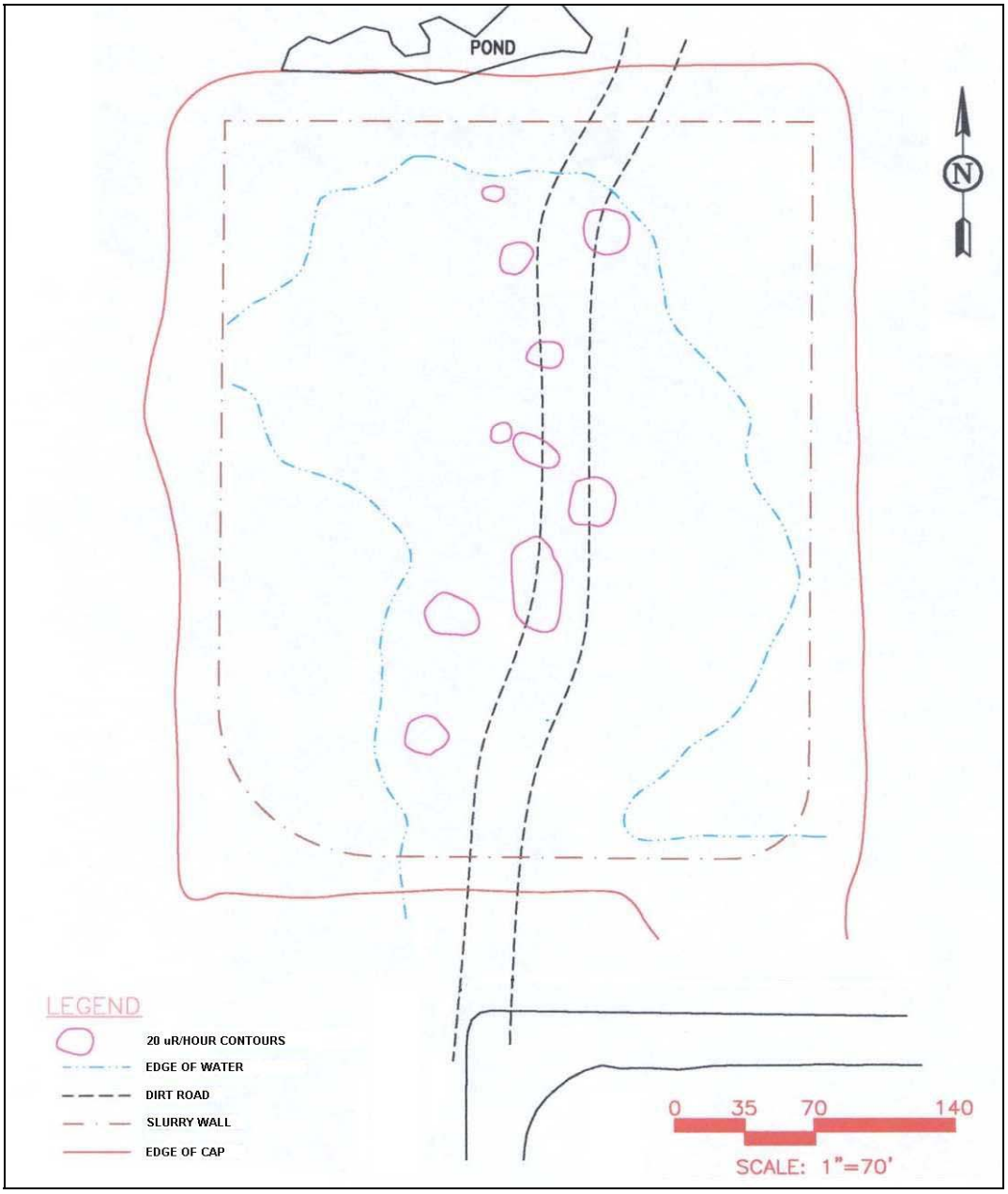

Figure 4-1 Extent of Elevated Radiation—1983 MDNR Radiological Survey

ground surface and at 1 meter above the surface at each grid-line intersection, and at locations identified as having elevated radiation levels during the walkover surface scan. All locations of elevated radiation levels identified by either the walkover scan or the grid-node gamma exposure-rate measurements were within a 10- to 15-meter wide path corresponding to the access road route.

In addition to direct gamma-radiation level measurements, ORAU collected surface soil samples (0 to 15 cm depth increment) at the grid nodes across the entire site and at various depths from selected locations where elevated gamma-radiation levels were measured at the ground surface.

Soil and sediment samples were analyzed by gamma spectrometry. Radionuclides of primary concern (given the analytical method and known source of the radioactivity) included Th-228 and -232, U-238, and Ra-226. Soil samples confirmed that elevated concentrations of residual radioactivity are approximately confined within this 10- to 15-meter-wide path corresponding to the former road. The areal locations of elevated measurements from the ORAU survey in 1984 (ORAU 1985) are presented in Figure 4-2.

4.4.1.3 Radiological Scoping Survey

A radiological scoping survey (RSS) was conducted by Harding Lawson Associates (HLA) in 1998 under contract to the MDNR (HLA 1998b). The primary objectives of the scoping survey were to determine the presence of radionuclides identified in the HSA as potential constituents of concern; evaluate the relative ratios of identified radionuclides in the affected areas of the site; and determine the general levels and extent of radionuclide distribution.

The RSS covered the area within the slurry wall and a 20-meter-wide strip around the outside of the slurry wall[1]. A 10-meter grid system was established and mapped using a global positioning system. A walkover scan of the ground surface was again conducted using NaI(Tl) gamma scintillation detectors over the entire grid system (essentially 100-percent scan coverage except for grids covered by water). Sodium Iodide walkover surveys did not identify any areas with elevated gamma-radiation levels.

[1] The clay cap over the cell generally extends 5 to 10 meters beyond the slurry wall itself.

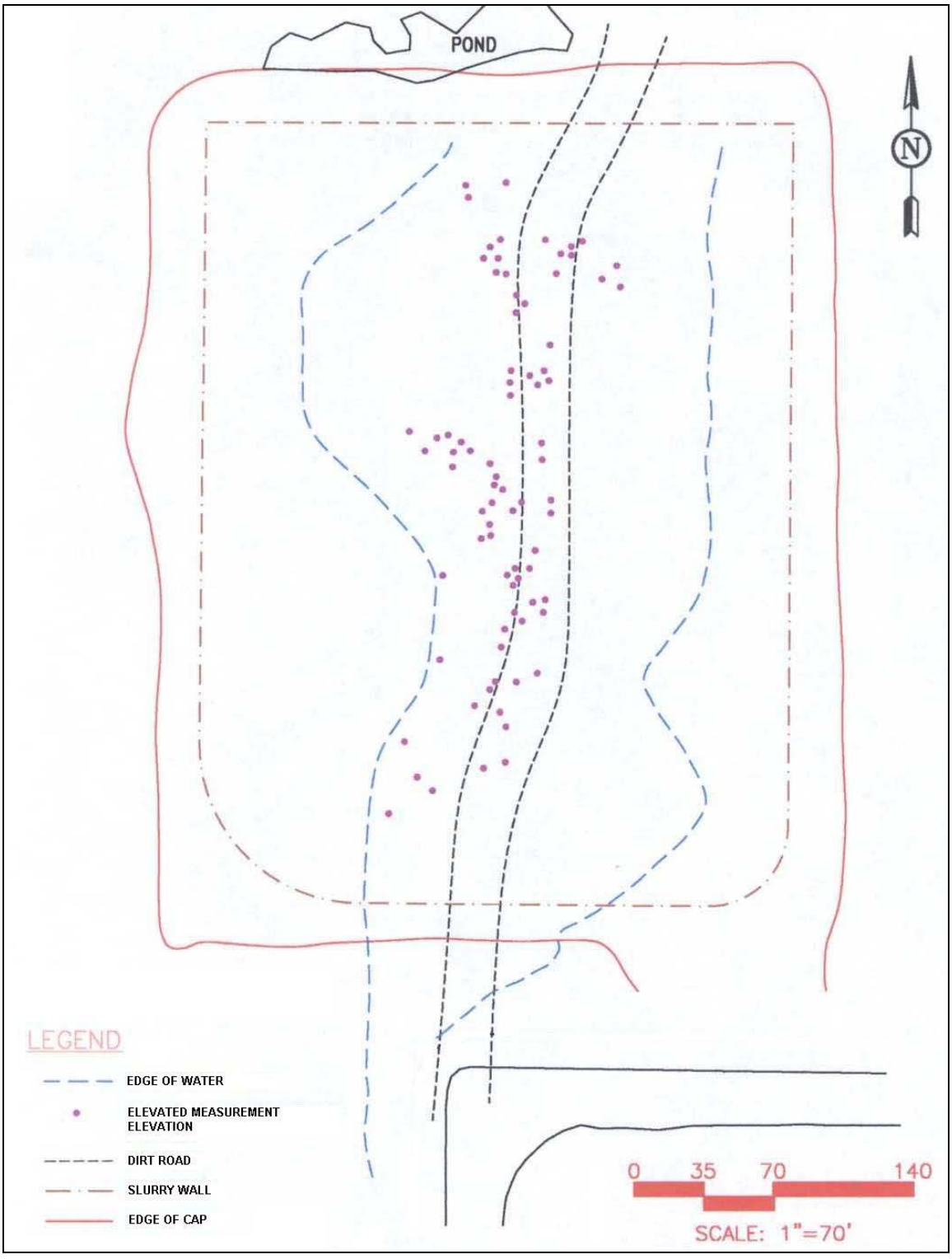

Figure 4-2 Extent of Elevated Radiation—1984 ORAU Radiological Survey

Surface soil sampling to a depth of 1 foot was performed in the outermost grids beyond the edge of the clay cap to detect if residual radioactivity is present in soils beyond the footprint of the slurry wall and clay cover. Sediment sampling was conducted in the ponded water area located to the north of the Site. GeoProbe® soil cores were obtained from 36 grids within the slurry walls and in each of the 10-meter grids surrounding the outside of the slurry walls where the clay cover prevented conventional surface soil sampling techniques. The core samples were screened with a gamma survey instrument to identify the segment of the core having the highest gamma-radiation signal. Samples were obtained from 18 of the 36 cores collected from within the slurry walls and from 18 of the 40 cores collected from grids surrounding the slurry walls. These soil samples were analyzed in the laboratory using alpha spectroscopy, gamma spectroscopy, and gross alpha/beta analyses. Sample results confirmed that elevated Th-232 concentrations were confined to the area circumscribed by the slurry walls and that elevated radioactivity, when detected, was consistently located near the former access road through the site. Measured Th-232 activity outside the slurry wall compares well with background concentrations (measurements ranged from 0.01 to 0.68 pCi/g).

In-situ gamma-spectroscopy measurements were made at the ground surface at the grid nodes outside of the slurry walls that were not covered by the clay cap or surface water. Downhole in-situ gamma-spectroscopy measurements were made at various depths in the cased GeoProbe® holes both inside and outside of the slurry walls where the clay cover impeded a surface measurement. A total of 84 measurements were made within the 36 coreholes inside the slurry wall. A total of 49 measurements were made within 25 cased coreholes outside of the slurry wall. The casings were logged over their entire length using an NaI detector to identify depths with elevated radiation levels. In-situ gamma-spectroscopy measurements made outside of the footprint of the slurry walls again indicated that Th-232 concentrations are comparable to those in non-impacted background soils with concentrations ranging from 0.01 to 0.49 pCi/g.

The locations of elevated Th-232 concentrations measured during the scoping survey were consistent with those identified in the MDNR and ORAU surveys. No sample or survey measurements identified the presence of residual radioactivity in excess of background in the area outside of the slurry walls.

4.4.1.4 Characterization Survey

An extensive characterization survey of the Tobico Marsh SGA Site was performed by Cabrera Services in 2000 under contract to HLA and the MDNR (Cabrera 2001). The objectives of the characterization survey were to document the three-dimensional location and concentration of residual radioactivity at the site with sufficient detail to support site-specific dose assessment, development of this decommissioning plan, and an ALARA evaluation. The survey was also aimed at generating data of sufficient quantity and quality to support a final status decision and to focus future sampling events that might be required to terminate the MDNR's radioactive material license (NRC 1999).

The radiological-characterization survey employed a number of radio-analytical techniques including: 1) down-hole gross gamma logging, 2) downhole gamma spectrometry, 3) gamma spectrometry of discrete soil samples, and 4) alpha spectrometry of discrete soil samples. Subsurface soils at the site were accessed by inserting GeoProbe® casings and core sampling tools. Watertight casings used to make in-situ measurements were advanced to a depth equal to or greater than the upper boundary of the native clay-bearing till layer underlying the site. Soil cores were obtained at discrete depths immediately adjacent to the GeoProbe® casing.

The extremely dense configuration of the gross gamma-logging measurements made across the site (both laterally and vertically) provides a well-defined representation of the location of thorium-bearing slag[2]. As previous radiological surveys concluded, residual radioactivity in soils was shown to be confined within the slurry walls and distributed principally along the path defined by the former access road through the site. The areal extent of elevated concentrations of residual radioactivity as identified by gross gamma logging is presented in Figure 4-3.

In addition to the gross gamma logging measurements, down-hole gamma spectrometry was utilized to quantify the activity of Th-232. Again, a very dense measurement configuration was achieved.[3] Of the 2,518 gamma spectroscopy measurements performed, only 131 identified Th-232 concentrations distinguishable from background. These positive detections averaged 33 ± 106 (2σ) pCi/g of Th-232 and ranged from near background to approximately 800 pCi/g. The locations at which these positive detections occurred correlate well with the elevated-measurement locations identified using the gamma-logging technique. The areal extent of elevated concentrations of residual radioactivity as identified by down-hole in-situ gamma spectroscopy measurements superimposed over the elevated radiation contour lines determined by gross gamma logging is presented in Figure 4-4.

[2] A total of 5926 gamma logging measurements were made in 397 casing locations distributed across the site. A series of measurements were made in 1-foot increments down to or slightly into the underlying clay till interface.

[3] A total of 2518 in situ gamma spectrometry measurements were made in 397 casing locations distributed across the site. Spectral measurements were typically obtained at six locations (depths) within the casing. Depth selection was often biased to coincide with the depth at which the highest gross gamma logging measurements were observed.

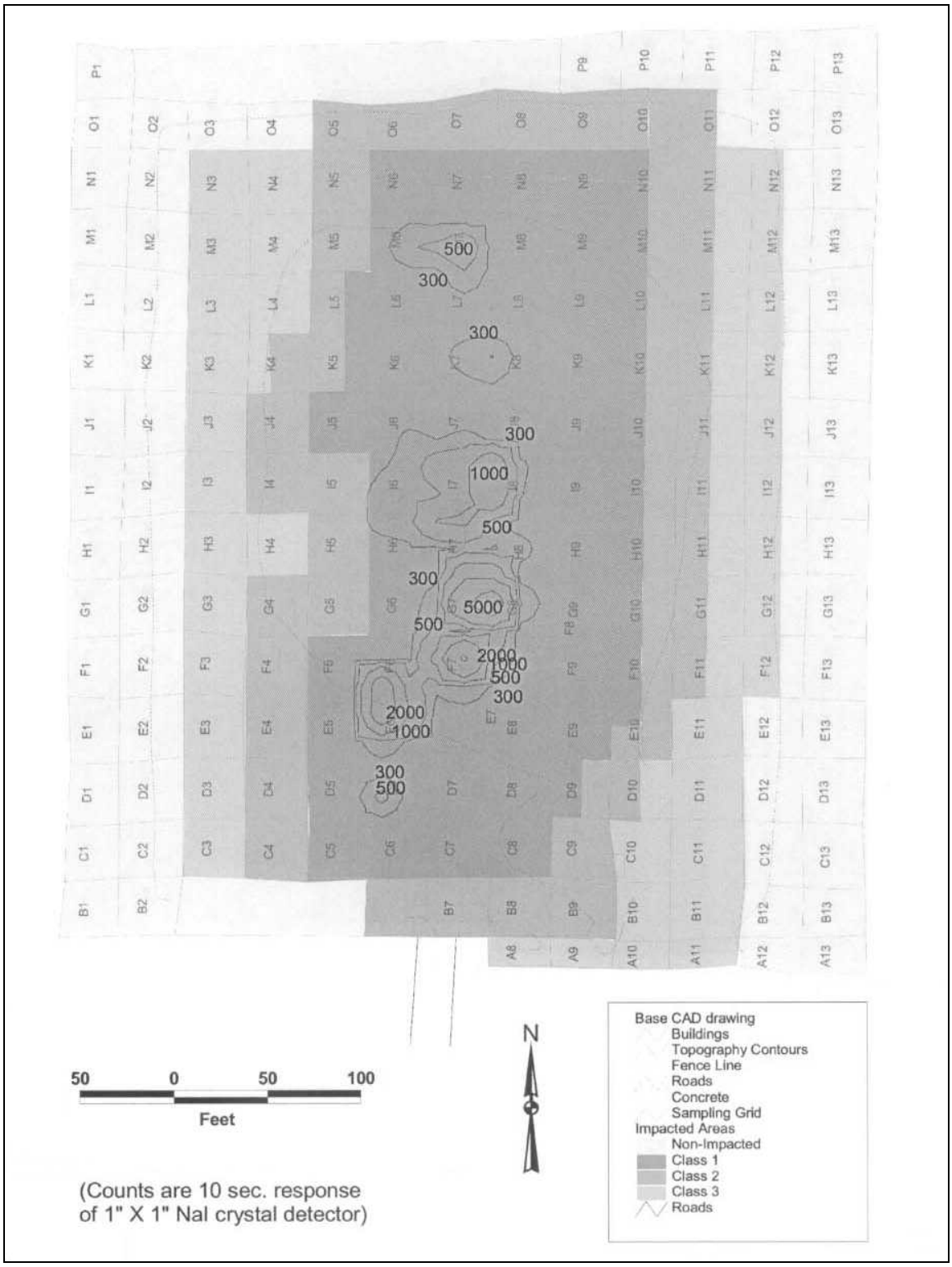

Figure 4-3 Extent of Elevated Radiation—Gamma Logging Survey

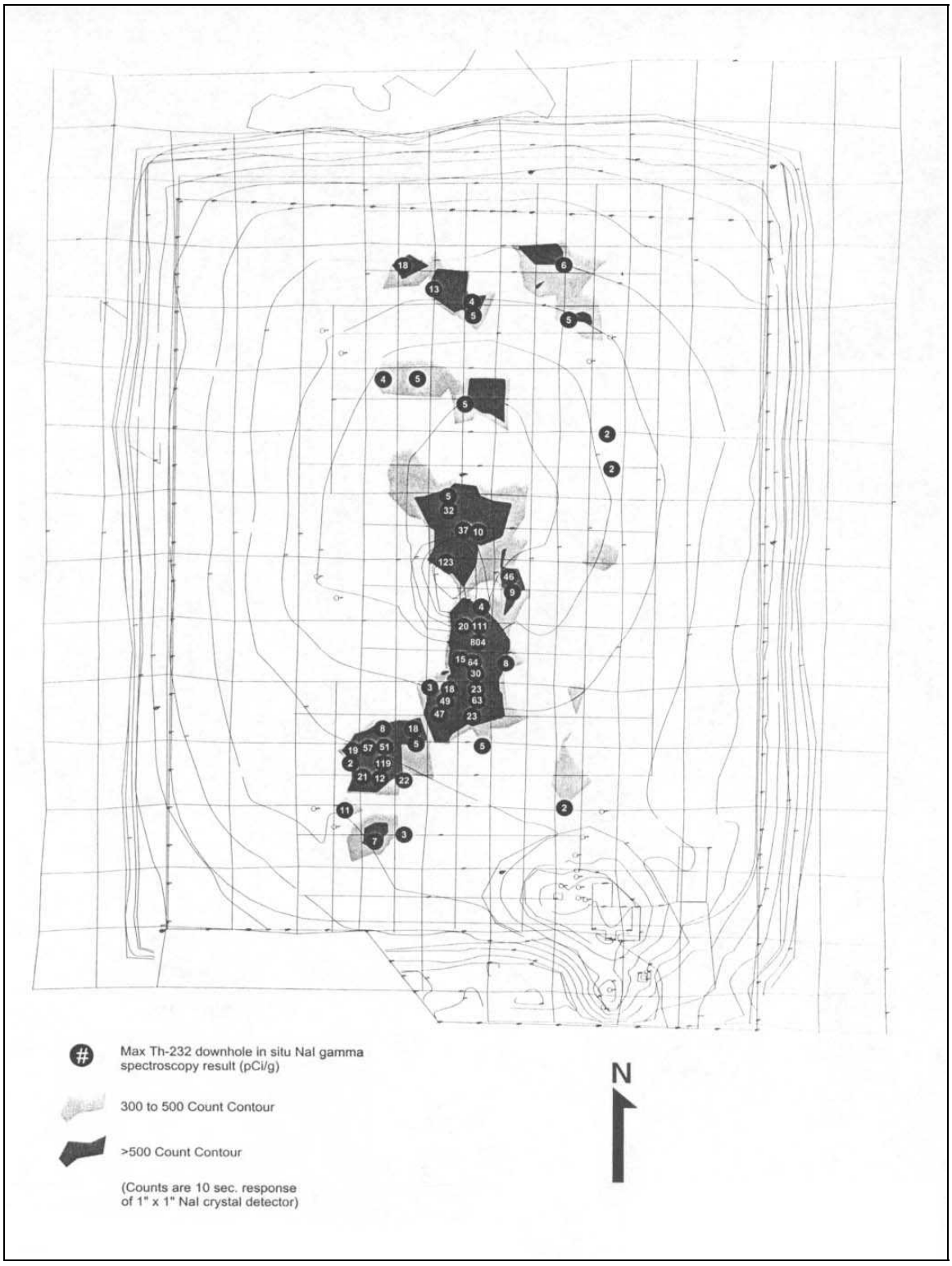

Figure 4-4 Extent of Elevated Radioactivity—In Situ Gamma Spectroscopy Survey

4.4.2 Summary of Background Radioactivity

Three different surveys have been undertaken to assess and quantify the presence of naturally occurring background radioactivity in surrounding environs of the MDNR site. The first quantitative assessment of background radioactivity at the site was conducted by ORAU in conjunction with their radiological survey of the site in 1984/1985 (ORAU 1985). ORAU reported that direct gamma-radiation background levels were 7 to 9 μR/h and background concentrations in soils and sediments ranged from 0.28 to 0.96 pCi/g for Th-232 and from 0.10 to 0.89 pCi/g from Th-228. Gross alpha background concentrations in water samples ranged from 0.21 to 8.02 pCi/L.

A second survey, focused expressly upon the detection and quantification of background concentrations of contaminants of potential concern (COPC), was completed in 1988 by ABB Environmental Services (ABB-ES) under contract to the MDNR (ABB 1998). Radiological data collected during the background study included direct gamma radiation levels, and the identification and quantification of radionuclide-specific concentrations in surface soil, subsurface soil, sediment, surface water, and groundwater. All samples were analyzed for thorium and uranium isotopes by alpha spectroscopy, for natural uranium and thorium-decay series nuclides by gamma spectroscopy (with daughter ingrowth for radium), and by gross alpha and beta counting. A summary of the results of the 1988 background assessment follows:

- 19 surface soil samples were taken. The range of Th-232 concentrations was 0.099 to 0.680 with an average of 0.252 pCi/g. The range of Th-230 concentrations was 0.094 to 0.830 with an average of 0.331 pCi/g.
- 5 subsurface soil samples were taken. The range of Th-232 concentrations was 0.151 to 0.369 with an average of 0.246 pCi/g. The range of Th-230 concentrations was 0.128 to 0.383 with an average of 0.240 pCi/g.
- 15 sediment samples were taken. The range of Th-232 concentrations was 0.072 to 1.19 with an average of 0.346 pCi/g. The range of Th-230 concentrations was 0.108 to 0.590 with an average of 0.368 pCi/g.
- 9 surface water samples were taken. The range of Th-232 concentrations was 0.012 to 0.065 with an average of 0.032 pCi/L. The range of Th-230 concentrations was 0.021 to 0.129 with an average of 0.054 pCi/L.
- 5 groundwater samples were taken. The range of Th-232 concentrations was 0.025 to 0.100 with an average of 0.053 pCi/L. The range of Th-230 concentrations was 0.084 to 0.190 with an average of 0.131 pCi/L.

These results are consistent with the background measurements reported in the ORAU survey (ORAU 1985) and compare well with values from the literature (ORNL 1980), which indicate a Th-232 concentration range for soils in the State of Michigan between 0.24 and 0.82 pCi/g with an average of 0.56.

4.4.3 Summary of the Radionuclide Composition of Residual Radioactivity at the Site

Figure 4-5 shows the progressive decay of Th-232 and its radioactive progeny. Figure 4-6 shows Th-230 in transient equilibrium with its radioactive progeny.

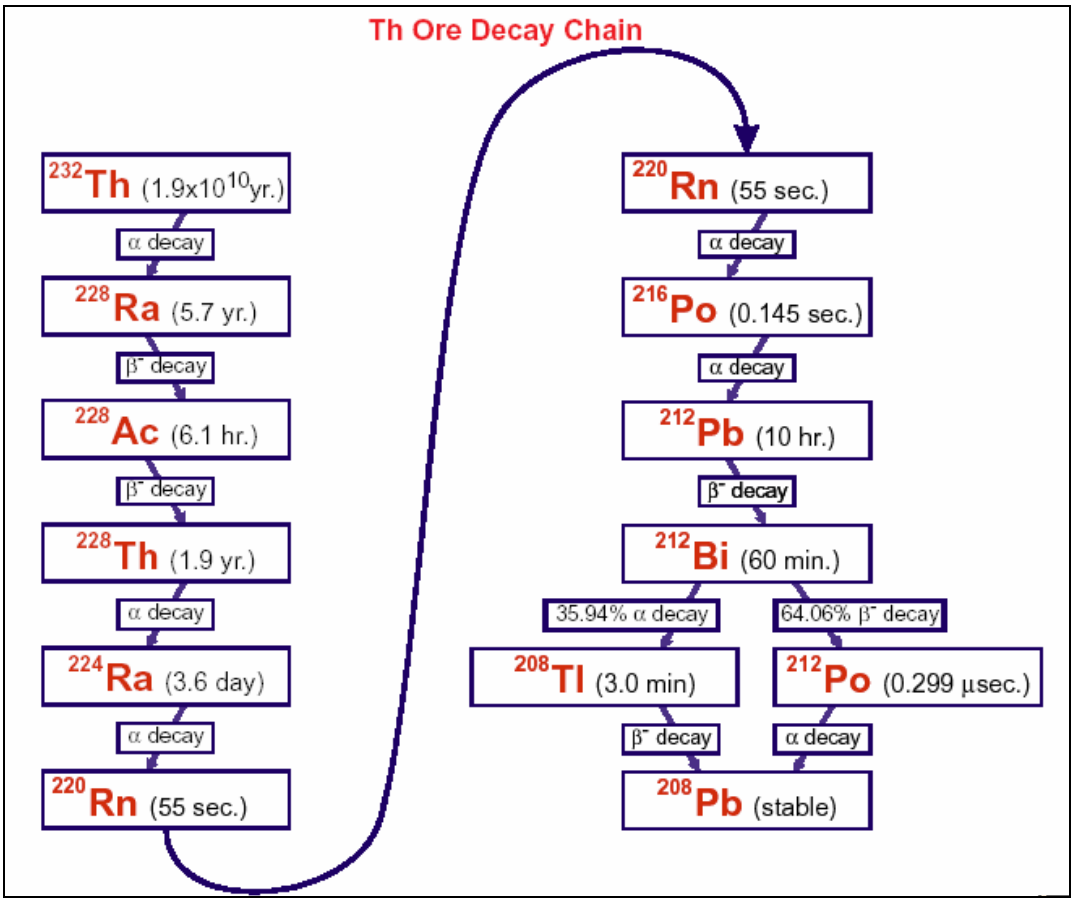

Figure 4-5 Th-232 Decay Series

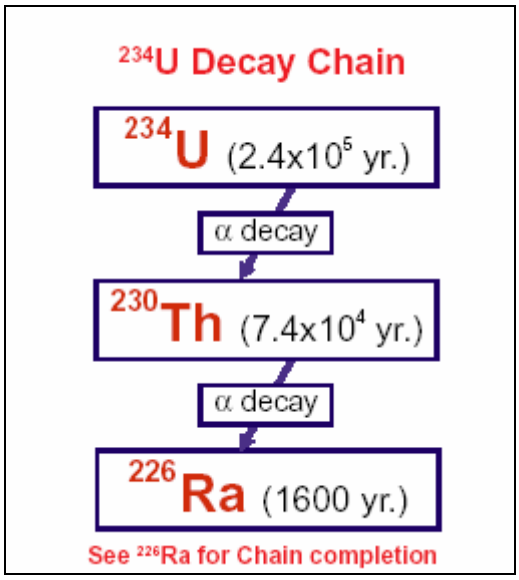

Figure 4-6 U-234 (Th-230) Decay Series

That Th-230 is elevated along with Th-232 in the slag is predictable considering the physio-chemical processes associated with the foundry operations that concentrated thorium and generated the slag.

The radiological characterization survey had as one of its objectives the identification of the radionuclide composition of the residual radioactivity at the site. From the ORAU survey (ORAU 1985), the scoping survey (HLA 1998b), and the characterization survey (Cabrera 2001), it is clearly and consistently reported that Th-232 is present in concentrations above background and in secular equilibrium with its radioactive progeny. However, the concentration relationship between Th-230 and Th-232, and the potential presence of elevated concentrations of Ra-226 and isotopes of uranium are also important to understanding the radionuclide composition of the source term.

A series of 52 subsurface soil samples were collected from across the site and analyzed by an independent offsite laboratory. Selection of the sample locations were guided by the knowledge gained through performance of both of the in-situ surveys described above and biased so as to collect subsurface soil samples from locations where the residual radioactivity concentration in soil was likely to be elevated. Each of these 52 samples was analyzed by gamma spectroscopy, and 34 samples were analyzed by alpha spectroscopy for both uranium and thorium-series radionuclides.

Soil sampling confirmed the presence of both Th-230 and Ra-226 in excess of background concentrations. Concentrations of Ra-226, ranging from background to a high of approximately 11 pCi/g, were co-located with elevated Th-230 concentrations, but were only approximately 3-percent of the corresponding Th-230 activity. Given the time elapsed since the slag might have been produced, it is reasonable to conclude that the slightly elevated Ra-226 concentrations present in the slag are the product of the radioactive decay of Th-230 and the resultant ingrowth of Ra-226.

The relationship between Th-230 and Th-232 concentrations in the slag is likely derived from their relative concentrations in the ores from which they were derived. Isotopic thorium analyses indicate that the Th-230 to Th-232 activity ratios are located in clusters, associated with what appears to be two different waste streams. Activity ratios were consistently measured at approximately 1:1 over the majority of the site. However, in two small clusters (one at the north end of the site, the other on the south end) the ratio is approximately 10:1 (See Figure 4-7). The estimated volume of radioactively contaminated material in these two small clusters is diminutive relative to the total volume of material with concentrations in excess of background.

Because the sampling method from which the isotopic ratios were obtained was not collected using a random sample method, and because there are evidently two discrete populations with respect to the Th-230:Th-232 ratio, it is appropriate to apply a weighting process to arrive at the best estimate of representative isotopic ratio to be used in dose modeling. The use of volume weighting is particularly appropriate in this case. The volume-weighted Th-230:Th-232 ratio is calculated to be approximately 3.1:1 and is proposed for use in the abstract description of the source term for modeling. It is informative to note that there is little implication to the projected annual dose to a receptor exposed at the site arising from the value of the Th-230:Th-232 ratio used in describing the source term for the buried waste layer within the cell. In fact, sensitivity analysis performed using the RESRAD dose model indicates an unremarkable change (increase) in the projected dose from the encapsulated waste layer when the Th-230:Th-232 ratio is set to the maximum ratio measured at the site (11:1).

It had been suggested earlier that concentrations of uranium isotopes might also be considered as a component of the elevated radioactivity in slag materials buried on the site. To assess this possibility, alpha spectroscopy for uranium isotopes was performed on 34 samples collected from among locations where the highest in-situ gamma measurements were recorded. The laboratory analytical analyses indicated the presence of U-234, U-235, and U-238 in concentrations comparable to those found in background soils in the vicinity of the site and in U.S. soils in general (Cabrera 2001). Correlation between uranium isotopes and elevated concentrations of thorium isotopes was not observed.

Having considered the analytical evidence for establishing the radionuclide composition of residual radioactivity at the site, the following source-term isotopic composition is defined:

- Pb-210 0.5%
- Ra-226 1.1%
- Ra-228 16.1%
- Th-228 16.1%
- Th-230 50.0%
- Th-232 16.1%

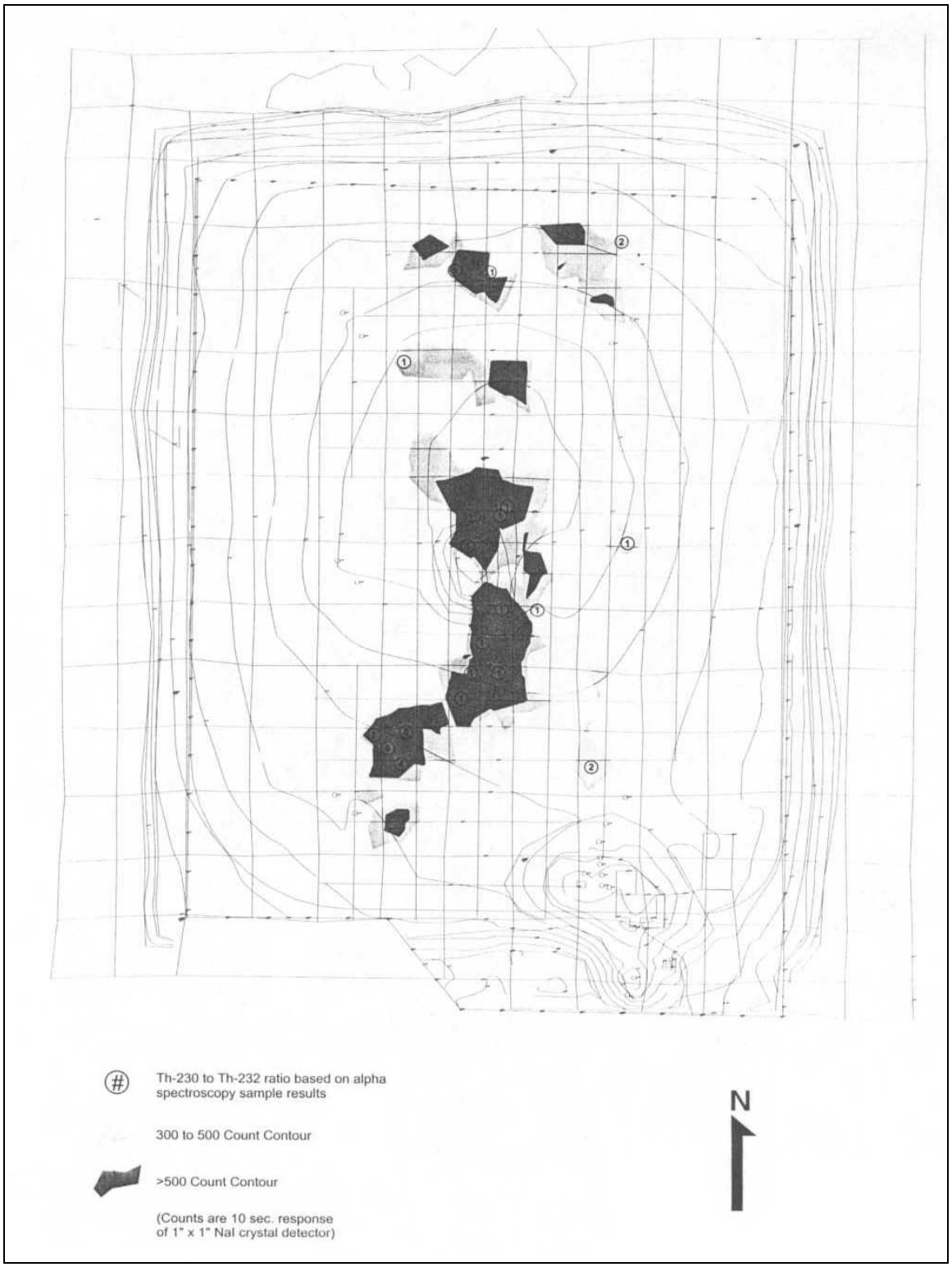

Figure 4-7 Lateral Distribution of Thorium 230:232 Activity Ratios

The proposed isotopic composition is based upon the volume-weighted isotopic ratio between Th-230 and Th-232 as measured on the site (Cabrera 2001). It is assumed that

the Th-232 series radionuclides are present in secular equilibrium. The Th-230 was decayed for a period of 50 years to calculate the amount of Ra-226 and Pb-210 progeny ingrowth. The Ra-226 ingrowth activity calculated by decaying Th-230 for 50 years results in a Ra-226:Th-230 ratio that agrees well with that measured (2 to 3-percent). The isotopic ratios used in calculating the projected annual dose to potentially exposed persons is presented in Figure 4-8. The short-lived progeny (those with half-lives less than 180 days) are assumed to be in equilibrium with the parent nuclide and are accounted for in the dose modeling through the RESRAD code's use of "parent +D" dose conversion factors.

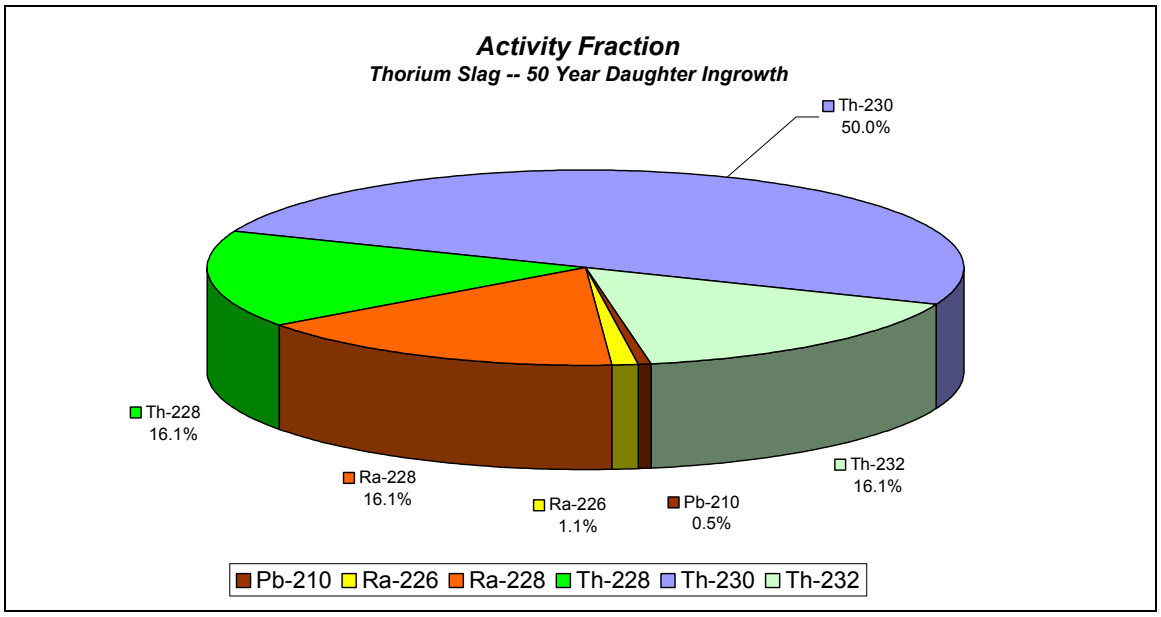

Figure 4-8 Radionuclide Composition of Residual Radioactivity

4.4.4 Depth of Residual Radioactivity in Subsurface Soils

A principle design objective for the radiological characterization survey was to develop a three-dimensional view of the site's residual radioactivity deposition. This was accomplished through the collection of almost 6,000 gross gamma radiation measurements within the GeoProbe® casings emplaced across the site. The lateral placement locations were determined by a systematic grid established with a global positioning satellite (GPS) system. Additional locations were placed in areas where elevated radiation levels were encountered to further resolve the three-dimensional profile. Vertically, measurements were made at 1-foot intervals beginning from a depth of 1 foot bgs and proceeding down until the casing terminated at the bottom of the sample core. Figure 4-9 through Figure 4-12 present plots of gross gamma logging data displayed in vertical cross section. For reference, the ground surface (the top of the clay cover) is approximately 592 feet above mean sea level. Cross section C–C' is drawn approximately down the path of the former access road through the site, along which

radiological surveys have consistently located the elevated-radioactivity deposits. This cross section provides the best overall (most representative) vertical profile.

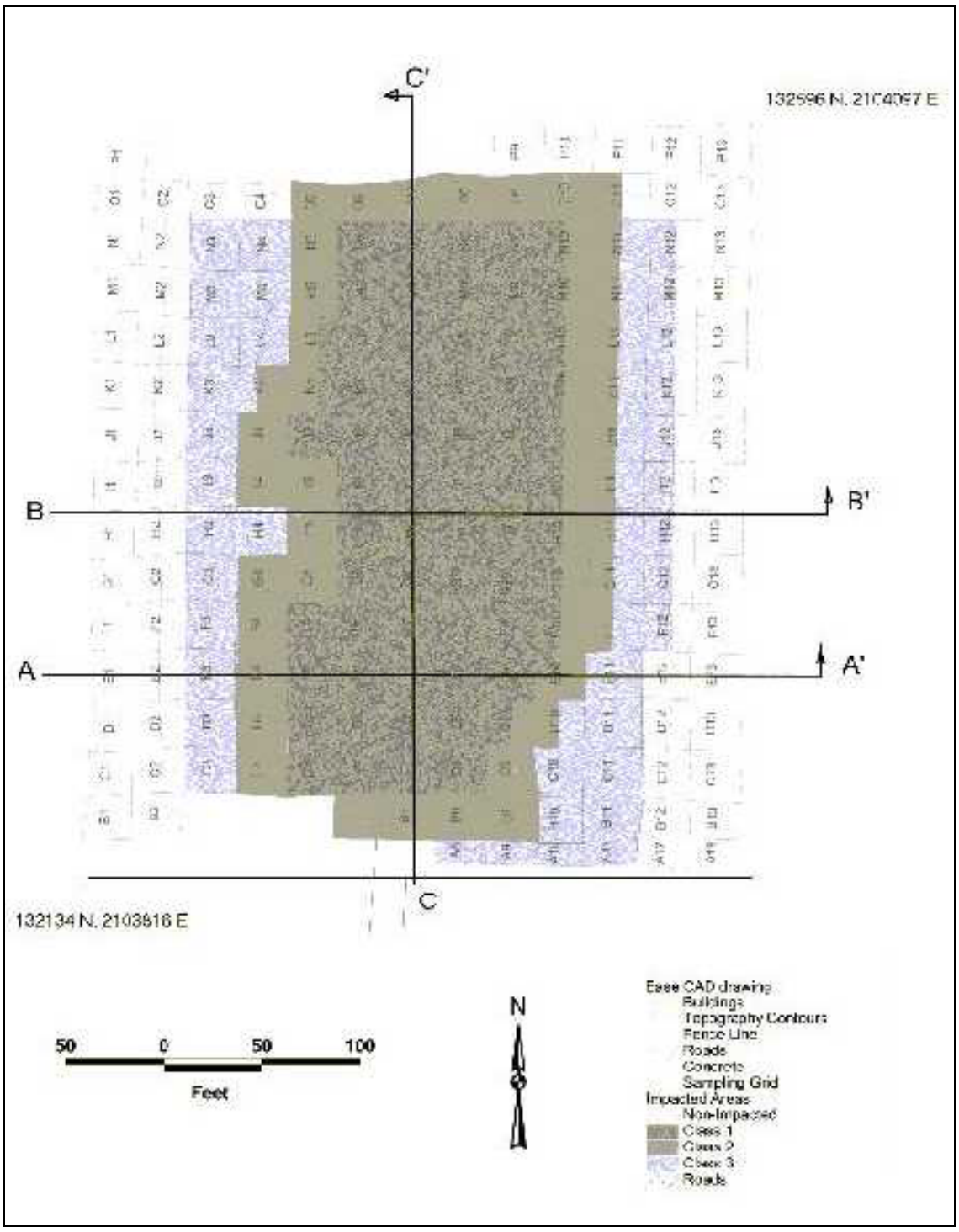

Figure 4-9 Cross Section Locations

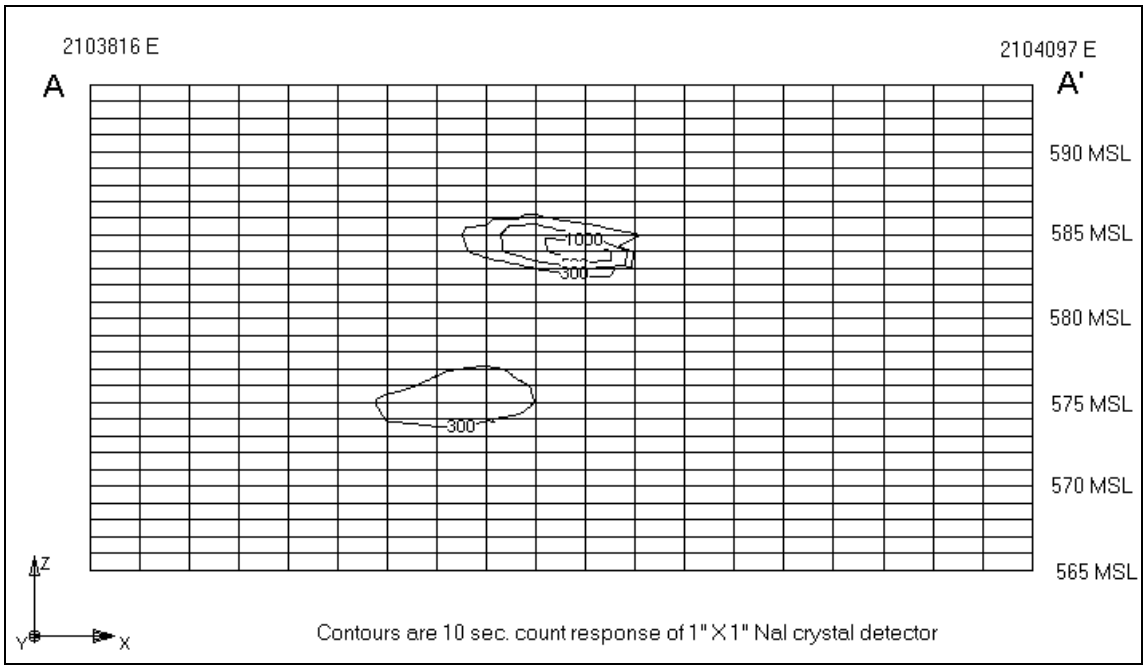

Figure 4-10 Cross Section A-A'

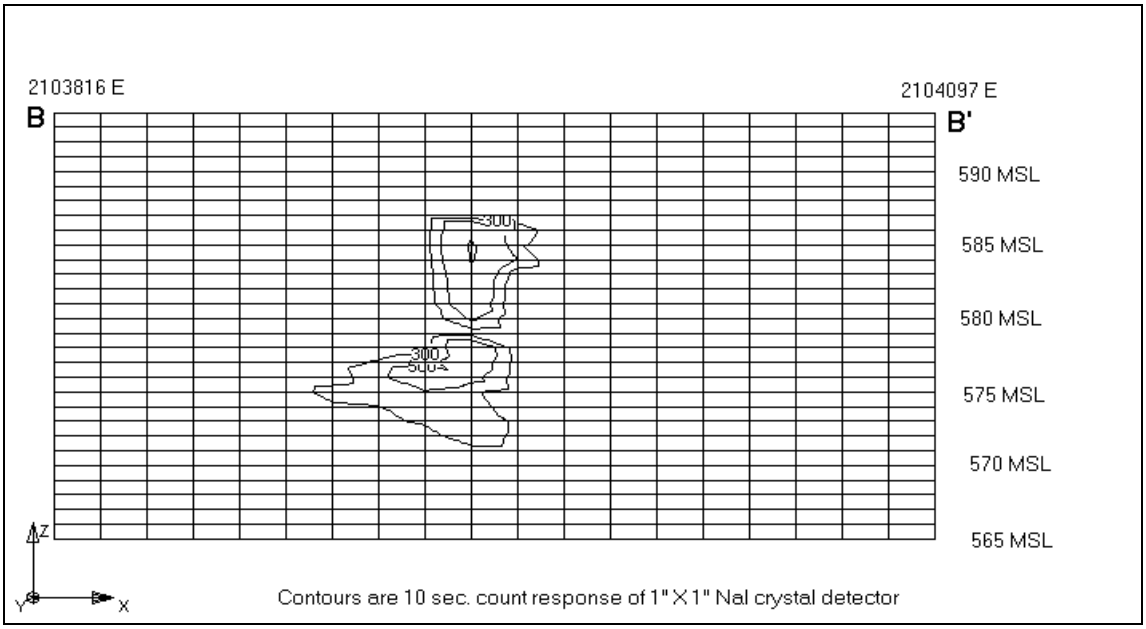

Figure 4-11 Cross Section B-B'

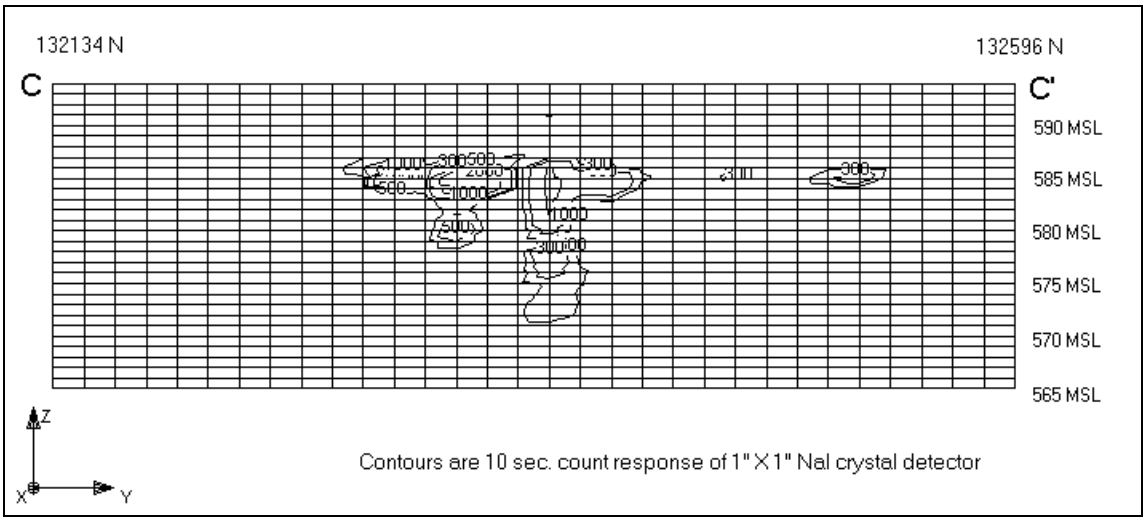

Figure 4-12 Cross Section C-C'

From these figures, it is evident that there are two discrete locations where radioactive slag has been deposited in pockets deeper than a few feet, but elevated radioactivity was confined to depths well above the interface of the clay-bearing till layer underlying the site. It is also evident that the majority of radioactivity is located just slightly beneath the bottom of the clay cover and within an interval of approximately 4 feet (1.22 meters) in thickness.

4.5 SURFACE WATER

Surface water samples collected over the years have been analyzed for radioactivity by gross alpha and beta counting. There is no indication that surface water contains residual radioactive material in excess of site background levels (HLA 1998 and MDNR 1991).

4.6 GROUNDWATER

Near-surface groundwater at the site exists in the region above and vertically confined by the native clay-bearing till layer that underlies the site. This groundwater has been designated by the State of Michigan (MDEQ) to be "groundwater, not in an aquifer." Much of the site and surrounding land is covered with ponds and wetlands. The saturated zone is limited to the shallow sandy loam and is perched on the basal clay unit. The thickness of the saturated zone varies seasonally, but is generally one to a few feet thick. Several investigations into the clay unit (60 feet bgs) indicated that saturated formations were not present below the surficial loam water-bearing zone. Based on the above data and using reasonable and relevant assumptions, the saturated zone at the site is not in, nor connected to, an aquifer pursuant to the general provisions provided in Rule 299.5101. (MDEQ 2002). As such, it is not considered a viable or adequate drinking water source for residential use or irrigation purposes. Sampling of the groundwater at the site has shown that residual radioactivity from the slag deposits (contaminants of concern for the site) are not present in concentrations in excess of site background levels.

4.6.1 Leachate Sampling

In addition to groundwater sampling (outside of the slurry walls), a sampling program was undertaken to assess the radioactivity of leachate that is confined within the slurry walls. There are six dewatering wells and three monitoring wells within the site's slurry walls. In 1996 and 1997, ABB Environmental Services performed three rounds of leachate sampling to determine its radiological composition in comparison to background (ABB 1997). All nine wells were sampled during Round I and Round II using the low-flow technique. High-turbidity samples were obtained from three of the nine wells. A well located approximately thirty yards north of the Site (MW-6) was sampled to provide an estimate of natural background radionuclide concentrations. Round III was a repeat of the Round II sampling and added a high-turbidity sample from the background well.

Round I, II, and III samples were analyzed for thorium and uranium by alpha spectroscopy, total-uranium by fluoroscopy, Ra-226 by Rn-222 emanation, Ra-228 by β/γ coincidence counting, gamma spectroscopy, gross alpha counting, and gross beta counting. All sample analyses in Rounds II and III were performed on both the soluble and insoluble fractions of the samples.

This leachate sampling program identified elevated levels of Potassium-40 (K-40), a constituent not found at elevated concentrations within the slag. It is possible that some other non-licensed constituent within the disposal area (e.g., potassium-based pesticides) is contributing to the detection of K-40. It is noted that in each instance where gross beta activity was measured in concentrations higher than those expected in background, the K-40 concentration was correspondingly elevated as well. K-40 is not associated with the known and well-defined source term (thoriated slag), is naturally occurring, and not specifically licensable as a radioactive material; therefore, it is not considered further in this DP.

Analytical results for both soluble and insoluble radioactive alpha emitters indicated that some of the samples had detectable concentrations of alpha emitters consistent with background concentrations in groundwater and well below the surface water discharge limits specified by the NRC in 10 CFR 20 (NRC 1997a).

An additional leachate sampling program was undertaken in the summer of 2002. Two rounds of sampling were collected and submitted for analysis by alpha spectroscopy (for uranium and thorium) and gamma spectroscopy. Sample results confirm that concentrations of uranium, thorium, and radium in leachate within the slurry walls are very low and within the range encountered in background (MACTEC 2002). These results affirm that the radiological contaminants in the slag are highly insoluble and thus highly immobile. They are unlikely to impact the environment or the surrounding ecosystems.