Final Status Survey Report
Volume II – Former Operation Area

Survey Units Kaiser – FSSFOA – 001
Through Kaiser – FSSFOA - 009

Prepared For:

Kaiser Aluminum & Chemical Corporation
Thorium Remediation Project
Tulsa, Oklahoma Facility

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Executive Summary
Final Status Survey Report
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Penn Environmental & Remediation, Inc. (Penn E&R) has been retained by the Kaiser Aluminum & Chemical Corporation (Kaiser) to provide radiological final status survey technical support for the remediation of its Kaiser Aluminum Specialty Products facility (Tulsa, Oklahoma facility) located at 7311 East 41st Street in Tulsa, Oklahoma. The remediation of radiologically impacted portions of the Tulsa, Oklahoma facility has been authorized by the Nuclear Regulatory Commission (NRC) via approval of the site-specific Decommissioning Plan (DP) (June 2001, Rev. May 2003, September 2003, May 2005, and September 2005) and Decommissioning Plan Addendum (DPA) (May 2002, Rev. May 2003) for the facility. The DP and DPA were designed to address the remediation of thorium dross and contaminated soil known to be present at the Tulsa, Oklahoma facility (Thorium Remediation Project).

The DP addresses the remediation of the impacted portions of the 14-acre "Pond Parcel" at the Tulsa, Oklahoma facility and the DPA addresses the approximate 3.5-acre "Former Operational Area" (FOA). The remediation alternative chosen for the Pond Parcel requires excavating material with a net Th-232 activity concentration greater than the Derived Concentration Guideline Level ($DCGL_w$) of 3.0 pCi/g, based on a dose limit of 25 mrem/yr. Material with net Th-232 activity concentrations greater than the Derived Cutoff Concentration Level (DCCL) of 31.1 net pCi/g Th-232 is being segregated and disposed off site as exempt material at the U.S. Ecology Grand View, Idaho facility. Material with activity concentrations less than 31.1 net pCi/g Th-232 (Below Criteria Material or BCM) is being used as backfill in the Pond Parcel excavation. A layer of clean imported borrow material (minimum thickness of 10 feet) obtained from an off site source is being placed over the BCM and graded in a manner to direct drainage away from the site, after which the site will be revegetated. At the time of preparation of this report, approximately 93 percent of the impacted portion of the Pond Parcel has been remediated.

Remediation activities for the FOA were similar to those implemented for the Pond Parcel with the exception of the excavations being backfilled with clean imported borrow material. At the time of preparation of this **Final Status Survey Report**, the remediation of the impacted portions of the FOA had been completed.

Final status surveys for the Thorium Remediation Project consist of three distinct elements: (1) surveys of the "open land areas" of the site including the excavation bottom surface soils for the Pond Parcel and FOA; (2) surveys of BCM placed in the Pond Parcel excavations; and (3) surveys of structural surfaces. Final status surveys are completed

prior to the backfilling of any Pond Parcel or FOA remediation excavation and during/following the placement of BCM in the Pond Parcel. The survey unit acceptance criteria developed in the DP are applicable to the entire site. Thus, if each survey unit meets the acceptance criteria, the dose for the entire site will be less than the release criteria of 25 mrem/yr.

Pond Parcel Excavation Bottom and FOA Excavation Final Status Surveys

Final status surveys associated with the Pond Parcel and FOA excavation bottoms are conducted through a progression of Class 1 survey units. Survey units typically consist of excavation bottom surface soil and associated side walls, elevated soil areas (if left in-place), and embedded structures (if encountered and left in-place). The final status survey of excavation bottom survey units typically consists of a gross gamma scan of the exposed surface soil of the unit and systematic soil sampling. Additional scanning and soil sampling are included for each elevated measurement comparison (EMC) performed for elevated areas left in-place. Embedded structures (typically small pipes and concrete) are surveyed for total alpha contamination (when possible) and removable alpha contamination.

Compliance with survey unit acceptance criteria is demonstrated by comparison of the average residual contamination for each survey element (excavation bottom soil, elevated areas, and embedded structures) to the appropriate acceptance criteria value and a sum of fractions for each survey unit is also calculated. The sum of fractions is a very conservative assessment of the survey unit. Summing the fractions ensures the survey unit and the entire site will be a small fraction of 25 mrem/yr (the release criterion) when the actual as-left dose assessment is complete. Systematic final status survey data are also evaluated using the Wilcoxan Rank Sum Test procedure.

A total of 30 Pond Parcel excavation bottom survey units are anticipated for the Thorium Remediation Project. Final status surveying and reporting have been completed for 24 of the 30 Pond Parcel excavation bottom survey units. **Volume I** of this **Final Status Survey Report** documents the final status survey results for Survey Units Kaiser-FSS-001 through Kaiser-FSS-024. One of the 24 excavation bottom survey units (Kaiser-FSS-001) consisted of an embedded structure encountered (a buried concrete spillway) during the removal of radiologically impacted soil. A summary of the final status survey results by survey unit is provided below in **Table 1.**

Of the 6 remaining open land area survey units for the pond parcel (Survey Units Kaiser-FSS-025 through Kaiser-FSS-030) it should be noted that remediation and final status survey sampling have been completed for 4 of those units (Kaiser-FSS-027 through Kaiser-FSS-030). Soil screening values and/or analytical laboratory results for all systematic soil samples for each survey unit were below the $DCGL_W$. In addition, no elevated areas were left in-place, therefore, no elevated measurement comparisons will be required for these units. Kaiser anticipates that the remediation and final status survey sampling results for Survey Units Kaiser-FSS-025 and Kaiser-FSS-026 will also meet the DP acceptance criteria. The results of the final status surveys for the remaining 6 Pond

Parcel excavation bottom survey units will be documented in an addendum to this **Final Status Survey Report** to be submitted at the end of the remediation project.

Table 1 – Pond Parcel Excavation Final Status Survey Summary by Survey Unit

Survey Unit	Surface Area (m^2)	No. of Systematic Samples Collected	Systematic Sample Exceedance of DCGL Value	WRS Test Criterion Met	Elevated Area(s) Present	Embedded Structure(s) Present	Total Sum of Fractions	Survey Unit Meets DP Acceptance Criteria
Kaiser-FSS-001*	84.5	36	YES	YES	YES	N/A	0.99	YES
Kaiser-FSS-002	126.5	9	NO	YES	NO	NO	0.00	YES
Kaiser-FSS-003	80	9	NO	YES	NO	NO	0.00	YES
Kaiser-FSS-004	107	9	NO	YES	NO	NO	0.00	YES
Kaiser-FSS-005	35	9	NO	YES	NO	NO	0.00	YES
Kaiser-FSS-006	2,670	12	NO	YES	NO	NO	0.00	YES
Kaiser-FSS-007	1,182	16	NO	YES	NO	YES	0.04	YES
Kaiser-FSS-008	424	9	NO	YES	NO	NO	0.00	YES
Kaiser-FSS-009	1,000	9	NO	YES	NO	NO	0.00	YES
Kaiser-FSS-010	986	10	NO	YES	NO	YES	0.00	YES
Kaiser-FSS-011	2,400	12	NO	YES	NO	NO	0.00	YES
Kaiser-FSS-012	2,460	12	NO	YES	NO	NO	0.00	YES
Kaiser-FSS-013	1,320	10	NO	YES	YES	YES	0.38	YES
Kaiser-FSS-014	1,892	10	NO	YES	YES	YES	0.67	YES
Kaiser-FSS-015	1,997	10	NO	YES	NO	YES	0.18	YES
Kaiser-FSS-016	2,484	14	NO	YES	YES	NO	0.79	YES
Kaiser-FSS-017	2,230	17	NO	YES	NO	NO	0.00	YES
Kaiser-FSS-018	1,582	10	NO	YES	NO	NO	0.00	YES
Kaiser-FSS-019	1,582	10	NO	YES	NO	NO	0.00	YES
Kaiser-FSS-020	1,570	9	NO	YES	YES	NO	0.19	YES
Kaiser-FSS-021	1,985	9	NO	YES	NO	NO	0.00	YES
Kaiser-FSS-022	1,840	9	NO	YES	NO	NO	0.00	YES
Kaiser-FSS-023	1,750	10	NO	YES	NO	NO	0.00	YES
Kaiser-FSS-024	1,454	10	NO	YES	NO	NO	0.00	YES

* Survey Unit Kaiser- FSS-001 is the buried concrete spillway structure. The other pond parcel survey units are defined as open land areas.

Final status surveying and reporting have been completed for all 9 FOA excavation survey units. **Volume II** of this **Final Status Survey Report** documents the final status survey results for Survey Units Kaiser-FSSFOA-001 through Kaiser-FSSFOA-009. Three of the nine FOA excavation survey units consisted only of embedded structures (retaining walls) that were encountered during the removal of radiologically impacted

soil located adjacent to the structures. A summary of the final status survey results by survey unit is provided below in **Table 2**.

Table 2 – FOA Excavation Final Status Survey Summary by Survey Unit

Survey Unit	Surface Area (m^2)	No. of Systematic Samples Collected	Systematic Sample Exceedance of DCGL Value	WRS Test Criterion Met	Elevated Area(s) Present	Embedded Structure(s) Present	Total Sum of Fractions	Survey Unit Meets DP Acceptance Criteria
Kaiser-FSSFOA-001	228	9	NO	YES	NO	NO	0.00	YES
Kaiser-FSSFOA-002	49	9	NO	YES	NO	NO	0.00	YES
Kaiser-FSSFOA-003*	35	21	NO	YES	NO	N/A	0.16	YES
Kaiser-FSSFOA-004	84	10	NO	YES	NO	YES	0.15	YES
Kaiser-FSSFOA-005	1,320	9	NO	YES	NO	YES	0.03	YES
Kaiser-FSSFOA-006	2,550	13	NO	YES	YES	YES	0.59	YES
Kaiser-FSSFOA-007*	81.5	18	NO	YES	NO	N/A	0.07	YES
Kaiser-FSSFOA-008*	9.3	14	NO	YES	NO	N/A	0.09	YES
Kaiser-FSSFOA-009	19.5	10	NO	YES	NO	NO	0.00	YES

* Survey unit consists of a structure (cinderblock or concrete retaining wall) encountered during the removal of radiologically impacted soil.

Pond Parcel Excavation Backfill Units (BCM) Final Status Surveys

As with the Pond Parcel excavation bottoms, final status surveys associated with the Pond Parcel excavation backfill units (BCM) are conducted through a progression of Class 1 survey units. Typically a unit of BCM is placed in a portion(s) of a pond parcel excavation bottom(s) associated with a defined excavation bottom final status survey unit(s). Backfill units are completed through the placement of typically four to eight continuous layers (2-foot compacted lift depth) of BCM in a defined area. The final status survey of excavation backfill units consists of a gross gamma scan of each placed 2-foot lift of BCM and systematic soil core sampling upon completion of the BCM unit. Compliance with survey unit acceptance criteria is demonstrated by comparison of the average residual contamination for the survey unit to the appropriate acceptance criteria value. Systematic soil core sampling data are also evaluated using the Wilcoxan Rank Sum Test procedure.

A total of 15 Pond Parcel excavation backfill survey units are anticipated for the Thorium Remediation Project. Final status surveying and reporting have been completed for 9 of the 15 Pond Parcel excavation backfill survey units. **Volume III** of this **Final Status Survey Report** documents the final status survey results for Survey Units Kaiser-FSSB-001 through Kaiser-FSSB-009. A summary of the final status survey results by survey unit is provided below in **Table 3**.

Of the six remaining BCM survey units for the pond parcel (Survey Units Kaiser-FSSB-010 through Kaiser-FSSB-015), it should be noted that the placement of BCM and final status survey sampling have been completed for three of those units (Kaiser-FSSB-010 through Kaiser-FSS-012). Soil screening values and/or analytical laboratory results for all systematic core samples for each survey unit were below the DCCL. Kaiser anticipates that the final status survey sampling results for Survey Units Kaiser-FSSB-013 through Kaiser-FSSB-015 will also meet the DP acceptance criteria. The results of the final status surveys for the remaining six Pond Parcel backfill survey units will be documented in an addendum to this **Final Status Survey Report** to be submitted at the end of the remediation project.

Table 3 – Pond Parcel Excavation Backfill Final Status Survey Summary by Survey Unit

Survey Unit	Base Surface Area (m^2)	No. of Systematic Soil Cores	No. of Systematic Soil Core Composite Samples	Systematic Soil Core Sample Exceedance of DCCL Value	WRS Test Criterion Met	Elevated Area(s) Present	Survey Unit Meets DP Acceptance Criteria
Kaiser-FSSB-001	2,220	11	28	NO	YES	NO	YES
Kaiser-FSSB-002	2,405	12	17	NO	YES	NO	YES
Kaiser-FSSB-003	1,709	11	37	NO	YES	NO	YES
Kaiser-FSSB-004	1,647	9	33	NO	YES	NO	YES
Kaiser-FSSB-005	1,716	9	34	NO	YES	NO	YES
Kaiser-FSSB-006	2,177	12	44	NO	YES	NO	YES
Kaiser-FSSB-007	1,381	9	44	NO	YES	NO	YES
Kaiser-FSSB-008	1,431	9	45	NO	YES	NO	YES
Kaiser-FSSB-009	1,840	9	20	NO	YES	NO	YES

Bounding As-Left Condition Final Dose Assessment

A bounding as-left condition dose assessment based on the maximum activity concentration of the BCM and minimum clean soil cover requirement has been completed for the Thorium Remediation Project. The resulting maximum dose is 1.33 mrem/yr. At the conclusion of the Thorium Remediation Project, the actual activity concentrations and the actual dimensions of the cover could be used to reassess the final dose. Since the activity concentrations will be less than bounding values used and the dimensions of the cover will be at least what were used, the resulting dose would be less than 1.33 mrem/yr.

Final Status Survey Report
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

1.0 ROAD MAP – VOLUMES I THROUGH III

Penn Environmental & Remediation, Inc. (Penn E&R) has been retained by the Kaiser Aluminum & Chemical Corporation (Kaiser) to provide radiological final status survey technical support for the remediation of its Kaiser Aluminum Specialty Products facility (Tulsa, Oklahoma facility) located at 7311 East 41st Street in Tulsa, Oklahoma (**Figure 1**). The remediation of radiologically impacted portions of the Tulsa, Oklahoma facility has been authorized by the Nuclear Regulatory Commission (NRC) via approval of the site-specific Decommissioning Plan (DP) (June 2001, Rev. May 2003, September 2003, May 2005, and September 2005) and Decommissioning Plan Addendum (DPA) (May 2002, Rev. May 2003) for the facility. The DP and DPA were designed to address the remediation of thorium dross and contaminated soil known to be present at the Tulsa, Oklahoma facility (Thorium Remediation Project). The DP and DPA specify the procedures to safely decommission the Tulsa, Oklahoma facility and meet the NRC requirements for unrestricted use: residual radioactivity distinguishable from background will not result in a total effective dose equivalent (TEDE) to an average member of a critical group (resident farmer) that exceeds 25 millirem per year (mrem/yr). Additionally, implementation of the DP and the DPA will reduce residual radioactivity to levels that are as low as reasonably achievable (ALARA).

The final status survey technical approach authorized by the NRC (Chapter 14.0 of the DP and DPA) includes the protocols and guidance provided in NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (USEPA, December 1997) to demonstrate compliance with the DP and DPA release criteria. A copy of the most recent version (September 2005) of Chapter 14.0 is presented as an appendix to the Final Status Survey Report.

This Road Map was written to provide the reader with relevant background information related to the DP and DPA, a historical operations perspective for the site, as well as an overview of current site remediation and associated final status survey activities.

1.1 Decommissioning Plan and Decommissioning Plan Addendum

The DP addresses the remediation of the impacted portions of the 14-acre "Pond Parcel" at the Tulsa, Oklahoma facility and the DPA addresses the approximate 3.5-acre "Former Operational Area". The Pond Parcel has been divided into three parts: the non-impacted former Freshwater Pond area to the west (approximately 4 acres); the impacted

Retention Pond/Reserve Pond area to the east (approximately 9 acres); and the impacted area adjacent to the Flux Building and paved area (approximately 1 acre) **(Figure 2)**.

The Former Operational Area (FOA) is principally a triangular parcel of land north of 41st Street and south of the Union Pacific Railroad right-of-way, on which plant processes and operations occurred. None of the original buildings which housed magnesium-thorium alloy processing, existed on site at the onset of the Thorium Remediation Project. The Flux Building, located to the northeast of the triangular parcel, is part of the FOA **(Figure 2)**.

1.2 Historical Operations Perspective

The Standard Magnesium Corporation (SMC) built the Tulsa, Oklahoma facility in Tulsa, Oklahoma in the early to mid-1950s to manufacture magnesium products. SMC received a source materials license (C-4012) from the Atomic Energy Commission in March 1958 to receive possession and title to magnesium-thorium alloy (a thorium metal) with up to 4 percent thorium content for processing. Historical operations at the facility included the smelting of scrap magnesium alloy for the production of anodes. Scrap magnesium-thorium alloy was smelted, along with other magnesium materials, to recover the magnesium. Thorium alloy material comprised a small fraction of the total magnesium refined on site. Licensed operations involving the recovery of magnesium-thorium alloy began in 1958 and continued through 1968. Kaiser purchased the facility in 1964. Magnesium refining operations continued at the facility until approximately 1985. Aluminum then replaced magnesium in smelting and anode manufacture, and the plant continued operating until the 1997-1998 time frame.

License C-4012 was superseded by License STB-472 in November 1961. License STB-472 was amended in June 1968 to add uranium to the list of authorized materials, but there is no record that uranium-bearing materials were ever received on site. The license was terminated in 1971 by the AEC at Kaiser's request. At that time, Kaiser stated that it had not processed magnesium-thorium alloy in the past year.

The scrap magnesium alloy refining process consisted of placing the material into large melting pots, heating the material until molten, and then siphoning off the pure magnesium. Impurities from the mixture, including thorium, separated from the magnesium. This residue material was removed, allowed to cool, and crushed. The crushed material was returned to the heating pots for a second recovery process. Once refined, the metallic dross residue material was crushed and disposed on site.

The quantity of licensed material SMC and later Kaiser were authorized to possess at one time was periodically amended, but generally was limited to 30,000 pounds of magnesium-thorium alloy containing no more than 4 percent thorium. Records documenting the quantity of licensed material present at the site are not available.

1.3 Site Remediation

The site has been divided into two remediation areas: the Pond Parcel area where the dross residues were stored and the FOA where the site structures were located. These two areas and the planned/completed remedial activities are described in the following sections.

1.3.1 Pond Parcel Description and Remediation

Extensive site characterization activities were conducted within the 14-acre land area of the facility known as the Pond Parcel. These characterization activities indicated the presence of residual radioactive material within a 10-acre portion of the Pond Parcel. The radioactive material identified within this portion of land was a thorium-bearing dross containing the isotopes thorium-232 (Th-232), thorium-230 (Th-230), and thorium-228 (Th-228). No elevated uranium was detected. Th-228 and Th-232 were determined to be in secular equilibrium. In addition, a ratio of Th-230-to-((Th-232+Th-228)/2) of 3.5 was calculated based on characterization data.

As previously mentioned, the impacted portion of the parcel contains the Retention Pond and former Reserve Pond area. The non-impacted portion of the Pond Parcel contains the former Freshwater Pond area. The DP was written to address the remediation of the Pond Parcel land area. The impacted Pond Parcel land area is bounded by the south fence line, the former Freshwater Pond embankment on the west, Fulton Creek ditch on the north, and the east fence line. A central feature of this area is the Retention Pond and associated embankments.

Thorium-bearing dross was also present on land adjacent to current Kaiser Property along the east and south fence lines and represented the margins of the impacted material. Per an NRC-approved remediation plan, Kaiser remediated this "adjacent land" by excavation and storing impacted soil within the Pond Parcel. Kaiser conducted the adjacent land remediation project (ALRP) during the period of October 2000 through May 2001. Impacted soil generated during the ALRP was considered part of the on-site decommissioning. In a letter dated March 7, 2002, the NRC provided Kaiser with a determination that the remediated adjacent properties met the criteria for unrestricted release.

The remediation alternative chosen for the Pond Parcel requires excavating material with a net Th-232 activity concentration greater than the Derived Concentration Guideline Level ($DCGL_w$) of 3.0 pCi/g, based on a dose limit of 25 mrem/yr. Material with net Th-232 activity concentrations greater than the Derived Cutoff Concentration Level (DCCL) of 31.1 net pCi/g Th-232 is being segregated and disposed off site as exempt material at the U.S. Ecology Grand View Idaho facility. Material with activity concentrations less than 31.1 net pCi/g Th-232 (Below Criteria Material or BCM) is being used as backfill in the Pond Parcel excavation. A layer of clean imported borrow material (minimum thickness of 10 feet) obtained from an off-site source is being placed

over the BCM and graded in a manner to direct drainage away from the site, after which the site will be revegetated.

At the time of preparation of this report, approximately 93 percent of the impacted portion of the Pond Parcel has been remediated. The remediated portion of the Pond Parcel has been excavated to depths up to 15 to 20 feet and to an average depth estimated at 14 feet across most of the Retention and Reserve ponds. At the end of the Thorium Remediation Project, approximately 4,000,000 cubic feet (ft^3) of clean off-site soil will have been used to backfill the Pond Parcel excavations.

1.3.2 Former Operational Area (FOA) Description and Remediation

The DP identified the potential for radioactive material beneath several paved areas and building floor surfaces of the FOA. This determination was based upon an interpretation of historical data and/or observations made during the ALRP. As a result, a limited Additional Site Characterization Activities (ASCA) effort was conducted in the FOA during mid-2001. The objective of the ASCA was to determine if thorium-bearing dross/radioactive material was present beneath these areas of concern. Soil data obtained during the ASCA indicated the presence of residual radioactive material beneath several concrete-paved surfaces at relatively shallow depths. The presence of this material beneath the surfaces was most likely the result of historical grading activities.

A Historical Site Assessment (HSA) was then performed during late 2001 for the FOA. The HSA was conducted as the first step toward decommissioning the FOA at the Tulsa, Oklahoma facility. The objective of the HSA was to compile as much historical information as possible for the facility and, using the MARSSIM guidelines, categorize the land areas and structures of the FOA of the facility as either impacted or non-impacted. None of the original buildings which housed magnesium-thorium alloy processing existed on site at the time of the HSA. With the exception of the Flux Building, there were no buildings in the FOA of the facility classified as impacted in the HSA. The Flux Building was initially classified as an impacted structure due to past and current uses of the building to house and process soil core and surface samples. Land areas initially classified as impacted included the land areas beneath the Maintenance Building, the Crusher Building, the Crusher Addition Building, the North Extrusion Building, the Warehouse Building, and the former Smelter Building, as well as concrete paved areas completed post-1958 (**Figure 2**).

The results of the HSA (Appendix A of the DPA) were used to design radiological survey efforts for the structures and land areas of the FOA. The recommended radiological extended scoping (non-impacted structures) and characterization (impacted land areas) survey efforts were described in a work plan prepared by Earth Sciences Consultants, Inc. (December 2001). The primary objective of the extended scoping survey of the six existing site structures were to verify their initial classification as non-impacted in the HSA. The primary objectives of the characterization survey of the impacted land areas were to determine the nature and extent of residual radioactive materials within the FOA and collect sufficient data to support evaluation of remedial alternatives and technologies

for the impacted land areas of the FOA. The radiological survey efforts were completed during the months of January and February 2002. Results of the radiological surveys are presented in Chapter 4.0 of the DPA.

Based on the results of the survey effort, select land areas of the FOA were identified for remediation. These areas include the following:

- A portion of the land area beneath the former Warehouse Building (Survey Unit Kaiser-FSSFOA-005).
- A portion of the land area beneath the former Crusher Building (Survey Unit Kaiser-FSSFOA-006).
- The land area beneath a "built-up" dock area located immediately west of the former Crusher Building (Survey Unit Kaiser-FSSFOA-005).
- The land area beneath a built-up dock area located immediately west of the former Maintenance Building (Survey Unit Kaiser-FSSFOA-004).
- A portion of the land area beneath a paved concrete surface situated northwest of the former Maintenance Building, northeast of the former North Extrusion Building, and south of the Union Pacific Railroad right-of-way (Survey Unit Kaiser-FSSFOA-001).
- A portion of the land area along a concrete retaining wall situated at the southeastern corner of the former Maintenance Building (Survey Unit Kaiser-FSSFOA-002).
- A portion of the land area beneath a paved concrete surface situated to the north of the former Warehouse Building (Survey Unit Kaiser-FSSFOA-005).
- A portion of the land area beneath a paved concrete surface situated north of 41st Street and the former Crusher Building, south of the UPRR right-of-way, and west of the areas remediated during the ALRP (Survey Unit Kaiser-FSSFOA-006).

Kaiser completed select pre-decommissioning activities prior to undertaking the Thorium Remediation Project. The most significant pre-decommissioning activity was the demolition of several of the non-impacted FOA structures to facilitate the excavation of impacted material located beneath floor slabs. Non-impacted structures that were demolished included the Warehouse Building, the Crusher Building, and Crusher Addition Building. The Flux Building was demolished during the Thorium Remediation Project following the completion of a final status survey of the structure and NRC approval (August 1, 2005 NRC letter from John T. Buckley to Bill Vinzant). The demolished materials were disposed as construction debris off-site at a local permitted facility. The concrete floor slabs and paved surface concrete were removed in sections. The underside of each section of concrete was mechanically cleaned to remove loose soil and clearance surveyed based on the guidance of NRC FC 83-23. In addition, relative to the disposal of the cleared concrete slabs in a local permitted facility, the State of Oklahoma specified that contamination levels shall not be different than background.

At the time of preparation of this Final Status Survey report, the remediation of the impacted portions of the FOA had been completed. Remediation activities for the FOA consisted of the excavation of material with a net Th-232 activity concentration greater than the $DCGL_w$ of 3.0 pCi/g and the backfill of the excavations with clean imported borrow material. The excavated material was transported to the Pond Parcel where material with net Th-232 activity concentrations greater than the DCCL of 31.1 pCi/g was segregated on site and disposed off site as exempt material at the U.S. Ecology Grand View Idaho facility. BCM (material with net activity concentrations below 31.1 pCi/g Th-232) was placed in the Pond Parcel excavation as backfill. At the end of the decommissioning project, the backfilled excavations located within the FOA will be final graded and vegetated to minimize soil erosion and promote positive site drainage.

1.4 Final Status Surveys and Reporting

Final status surveys for the Thorium Remediation Project consists of three distinct elements: (1) surveys of the "open land areas" of the site including the excavation bottom surface soils for the Pond Parcel and FOA; (2) surveys of BCM placed in the Pond Parcel excavations; and (3) surveys of structural surfaces. Final status surveys are completed prior to the backfilling of any Pond Parcel or FOA remediation excavation and during/following the placement of BCM in the Pond Parcel. The survey unit acceptance criteria developed in the DP are applicable to the entire site. Thus, if each survey unit meets the acceptance criteria, the dose for the entire site will be less than the release criteria of 25 mrem/yr.

The Final Status Survey Report is being submitted to NRC to address the survey units completed to date for the Thorium Remediation Project. The layout of this submittal is as follows:

- Volume I – Pond Parcel Excavation Bottom Survey Units
- Volume II – Former Operational Area Excavation Survey Units
- Volume III – Pond Parcel Backfill (BCM) Survey Units

Each volume of the Final Status Survey Report contains individual sub-reports that provide final status survey results for a particular survey unit. Each volume also contains independent chapters describing the specific type and/or area of survey, applicable acceptance criteria and survey protocols, and a summary of survey results as well as supporting figures, tables, and attachments.

1.4.1 Pond Parcel and FOA Excavation Bottom Surveys and Reporting

Final status surveys associated with the Pond Parcel and FOA excavation bottoms are conducted through a progression of Class 1 survey units. Survey units typically consist of excavation bottom surface soil and associated side walls, elevated soil areas (if left in-place), and embedded structures (if encountered and left in-place). The final status survey of excavation bottom survey units typically consists of a gross gamma scan of the exposed surface soil of the unit and systematic soil sampling. Additional scanning and

soil sampling are included for each elevated measurement comparison (EMC) performed for elevated areas left in-place. Embedded structures (typically small pipes and concrete) are surveyed for total alpha contamination (when possible) and removable alpha contamination.

Compliance with survey unit acceptance criteria is demonstrated by comparison of the average residual contamination for each survey element (excavation bottom soil, elevated areas, and embedded structures) to the appropriate acceptance criteria value and a sum of fractions for each survey unit is also calculated. The sum of fractions is a very conservative assessment of the survey unit. Summing the fractions ensures the survey unit and the entire site will be a small fraction of 25 mrem/yr (the release criterion) when the actual as-left dose assessment is complete. Systematic final status survey data are also evaluated using the Wilcoxan Rank Sum Test procedure.

A total of 30 Pond Parcel excavation bottom survey units are anticipated for the Thorium Remediation Project. Final status surveying and reporting have been completed for 24 of the 30 Pond Parcel excavation bottom survey units. **Volume I** of this **Final Status Survey Report** documents the final status survey results for Survey Units Kaiser-FSS-001 through Kaiser-FSS-024. One of the 24 excavation bottom survey units (Kaiser-FSS-001) consisted of an embedded structure encountered (a buried concrete spillway) during the removal of radiologically impacted soil. A discussion of the appropriate survey unit acceptance criteria and surveying protocol for the Pond Parcel excavation bottom survey units is also presented in **Volume I** of this **Final Status Survey Report.** The results of the final status surveys for the remaining 6 Pond Parcel excavation bottom survey units will be documented in an addendum to this Final Status Survey Report to be submitted at the end of the remediation project.

Final status surveying and reporting have been completed for all 9 FOA excavation survey units. **Volume II** of this **Final Status Survey Report** documents the final status survey results for Survey Units Kaiser-FSSFOA-001 through Kaiser-FSSFOA-009. Three of the 9 FOA excavation survey units consisted only of embedded structures (retaining walls) that were encountered during the removal of radiologically impacted soil located adjacent to the structures. A discussion of the appropriate survey unit acceptance criteria and surveying protocol for the FOA excavation survey units is also presented in **Volume II** of this **Final Status Survey Report.**

1.4.2 Pond Parcel Excavation Backfill Units (BCM) Surveys and Reporting

As with the Pond Parcel excavation bottoms, final status surveys associated with the Pond Parcel excavation backfill units (BCM) are conducted through a progression of Class 1 survey units. Typically a unit of BCM is placed in a portion(s) of a pond parcel excavation bottom(s) associated with a defined excavation bottom final status survey unit(s). Backfill units are completed through the placement of typically four to eight continuous layers (2-foot compacted lift depth) of BCM in a defined area. The final status survey of excavation backfill units consists of a gross gamma scan of each placed 2-foot lift of BCM and systematic soil core sampling upon completion of the BCM unit.

Compliance with survey unit acceptance criteria is demonstrated by comparison of the average residual contamination for the survey unit to the appropriate acceptance criteria value. Systematic soil core sampling data are also evaluated using the Wilcoxan Rank Sum Test procedure.

A total of 15 Pond Parcel excavation backfill survey units are anticipated for the Thorium Remediation Project. Final status surveying and reporting have been completed for 9 of the 15 Pond Parcel excavation backfill survey units. **Volume III** of this **Final Status Survey Report** documents the final status survey results for Survey Units Kaiser-FSSB-001 through Kaiser-FSSB-009. A discussion of the appropriate survey unit acceptance criteria and surveying protocol for the Pond Parcel excavation backfill units is presented in **Volume III** of this **Final Status Survey Report.** The results of the final status surveys for the remaining 6 Pond Parcel excavation backfill survey units will be documented in an addendum to this **Final Status Survey Report** to be submitted at the end of the remediation project.

1.4.3 Final Status Survey QA Program

The final status survey QA program implemented for the Thorium Remediation Project includes QA functions that cover aspects of data collection, including both field radiation instrument surveys, and soil and smear sampling for laboratory analysis, through the preparation of the documentation of the results. Applicable field radiation instrument final status survey QA data for each survey unit is provided in **Appendix A to Volumes I through III of this Final Status Survey Report.** Analytical QA data for the final status surveys will be documented in an addendum to this Final Status Survey Report to be submitted at the end of the remediation project.

1.4.4 Documentation of As-Left Condition and the Completion of a Final Dose Assessment

A bounding dose assessment based on the maximum activity concentration and minimum soil cover requirement has been completed and is presented in **Appendix E** of **Volume III** of this **Final Status Survey Report.** The resulting maximum dose is 1.33 mrem/yr. At the conclusion of the Thorium Remediation Project, the actual activity concentrations and the actual dimensions of the cover could be used to reassess the final dose. Since the activity concentrations will be less than bounding values used and the dimensions of the cover will be at least what were used, the resulting dose would be less than 1.33 mrem/yr.

Final Status Survey Report
Volume II – Former Operational Area Excavations
Survey Units Kaiser-FSSFOA-001 through Kaiser-FSSFOA-009
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation
March 22, 2006

2.0 INTRODUCTION

This volume of the Final Status Survey Report presents the results of Former Operational Area (FOA) excavation final status survey activities completed as part of the Thorium Remediation Project at the Tulsa, Oklahoma facility (**Figure 1**). Final status surveys associated with the FOA excavations are being conducted through a progression of Class 1 survey units. Survey units typically consist of excavation bottom surface soil and associated side walls, elevated soil areas (if left in-place), and embedded structures (if encountered and left in-place). The final status survey of excavation bottom survey units typically consist of a gross gamma scan of the exposed surface soil of the unit and systematic soil sampling. Additional scanning and soil sampling are included for each elevated measurement comparison (EMC) performed for elevated areas left in-place. Embedded structures (if encountered and left in-place) are surveyed for total alpha contamination (when possible) and removable alpha contamination.

Final status surveying and reporting have been completed for all 9 FOA excavation survey units (Survey Units Kaiser-FSSFOA-001 through Kaiser-FSSFOA-009) (**Figure 3**). This volume of the Final Status Survey Report contains 9 individual sub-reports (EB-031 through EB-039), each documenting the final status survey results for a particular survey unit. Sub-Reports EB-033, EB-037, and EB-038 document the final status survey results for Survey Units Kaiser-FSSFOA-003, Kaiser-FSSFOA-007, and Kaiser-FSSFOA-008, structural retaining walls encountered during the removal of radiologically impacted soil located adjacent to these structures. The structural surface of each retaining wall constituted a survey unit and as such was systematically scanned and sampled per the final status protocols for structures. All additional embedded structures are included as part of the open land area survey unit sub-reports. Sub-Reports EB-031 (Survey Unit Kaiser-FSSFOA-001), EB-032 (Survey Unit Kaiser-FSSFOA-002), EB-034 (Survey Unit Kaiser-FSSFOA-004), EB-035 (Survey Unit Kaiser-FSSFOA-005), EB-036 (Survey Unit Kaiser-FSSFOA-006), and EB-039 (Survey Unit Kaiser-FSSFOA-009) document the final status survey results for open land areas (FOA excavation bottom surface soil) resulting from the removal of radiologically-impacted soil from impacted portions of the FOA. These open land area survey units are considered Class 1 survey units with surface areas generally less than 2,000 m^2.

The remaining chapters of this volume presents the site release criteria for the Tulsa, Oklahoma facility and the acceptance criteria to be used to clear survey units (**Chapter 3.0**), an overview of the surveying protocol for the Pond Parcel excavation bottom survey units (**Chapter 4.0**), and a summary of findings relative to the final status survey of FOA excavation Survey Units Kaiser-FSSFOA-001 through Kaiser-FSSFOA-009 (**Chapter 5.0**). Supporting appendices to this volume of the Final Status Survey Report include the following:

- **Appendix A** – Survey Instrument Quality Assurance/Quality Control (QA/QC) Documentation
- **Appendix B** – Chapter 14.0 of the Decommissioning Plan (September 2005 Revision)
- **Appendix C** – Evaluation of Survey Unit Analytical Results, Wilcoxon Rank Sum Test
- **Appendix D** – Onsite Cave Counter Calibration and Soil Sample Results

3.0 FINAL STATUS SURVEY ACCEPTANCE CRITERIA

3.1 Site Release Criteria and Survey Unit Acceptance Criteria

The site **release criteria** for the Kaiser Tulsa, Oklahoma facility, as presented in the DP are:

"The site will be remediated in accordance with decommissioning criteria of Subpart E, Radiological Criteria for License Termination of 10 CFR Part 20, Standards of Protection Against Radiation. Specifically, Subpart E, 10 CFR 20.1402, Radiological Criteria for Unrestricted Use, allows release of a site for unrestricted use if the residual radioactivity distinguishable from background results in a TEDE to an average member of the critical group that does not exceed 25 mrem/yr and the residual radioactivity has been reduced to levels that are ALARA."

In regards to **acceptance criteria** to be used to clear survey units the DP continues:

"Dose modeling is used to estimate the TEDE to the average member of the critical group (that group reasonably expected to receive the greatest exposure to residual radioactivity for any applicable circumstances). The concentration of residual radioactivity (per radionuclide) distinguishable from background that, if distributed uniformly throughout a survey unit, results in a TEDE of 25 mrem in 1 year to an average member of the critical group is the single-radionuclide $DCGL_W$."

Two factors complicate the application of $DCGL_W$ acceptance criteria at the Kaiser Tulsa, Oklahoma facility. The first is the presence of multiple radionuclides, specifically, Th-232, Th-228 and Ra-228 from the thorium decay series and Th-230, Ra-226 and Pb-210 from the uranium decay series. Each radionuclide has a $DCGL_W$ value corresponding to the 25 mrem TEDE criteria. When multiple radionuclides are present, compliance may be demonstrated by a sum of fractions calculation over the entire series of radionuclides or the use of a surrogate value to represent 25 mrem TEDE for the entire mix of radionuclides presents. The activity concentration of Th-232 in units of pCi/g has been established as the surrogate acceptance criteria for surveys of soil and soil-like material. Use of Th-232 as a surrogate for soil surveys is detailed in the DP. Likewise gross alpha activity has been established as the surrogate acceptance criteria for surveys of structural surfaces. The use of gross alpha as a surrogate for structure surveys is detailed in the Technical Addendum to the Decommissioning Plan and Addendum, Revised Structural Surface Acceptance Criteria (May 2005).

The second factor is the presence of three distinct survey elements onsite. In addition to the exposed surface soil of the excavated open land areas and surfaces of structures remaining onsite, a third survey element is present as a result of the remedy provided in the DP. In developing the remedial action plan, a derived cutoff concentration level (DCCL) of 31.1 net pCi/g Th-232 has been determined. This value represents the dividing line concentration between material which must be exported to an off-site disposal facility and material which can remain onsite under an unrestricted release scenario. The dose assessment presented in Chapter 5.0 of the DP demonstrates that unrestricted release dose levels can be achieved when material below the DCCL are returned to the excavation. The average concentration of BCM

remaining on site is termed in the DP as the Average Derived Concentration Level ($ADCL_W$). Dose-based criteria have been established for the Kaiser Tulsa, Oklahoma facility for three distinct survey elements: (1) surveys of the open land areas of the site including the FOA and the Pond Parcel excavation bottoms; (2) surveys of the Pond Parcel excavation backfill (BCM) units; and (3) surveys of structural surfaces.

Finally, for each survey element acceptance criteria there are additional criteria provided to address small areas of elevated activity calculated from area factors (AF) provided in the DP and the technical addendum to the DP. The elevated measurement comparison (EMC) criteria are referred to as $DCGL_{EMC}$ values.

The inputs and assumptions used to derive element specific acceptance criteria are not the same, but rather are conservative for the specific survey element. The stand-alone acceptance criteria and key inputs/assumptions are:

- **Excavation Bottom Surface Soil $DCGL_W$** – 3.0 net pCi/g of Th-232 over the entire survey unit. Inputs/assumptions include 6-inch contaminated zone thickness and no cover.
- **Excavation Bottom Surface Soil $DCGL_{EMC}$** – 37.5 net pCi/g of Th-232 over 1 m^2. Additional values are provided for increasing survey areas. Inputs/assumptions are the same as excavation bottom surface soil except for area.
- **Below Criteria Material (BCM) DCCL** – 31.1 net pCi/g of Th-232 over the entire survey unit. Inputs/assumptions include a 3.31-meter contaminated zone thickness and minimum 3.05-meter (10 feet) clean layer of import borrow (soil) material.
- **Below Criteria Material (BCM) $ADCL_{EMC}$** – 87.5 net pCi/g of Th-232 over 1 m^2. Additional values are provided for increasing survey areas. Inputs/assumptions are the same as BCM except for area.
- **Structure Surface Total Contamination GA-DCGL** – 944 net dpm/100cm^2 gross alpha over 100 m^2. Inputs/assumptions include 100 m^2 of surface area and a removable fraction of 0.1.
- **Structure Surface Removable Contamination GA-DCGL** – 94.4 net dpm/100cm^2 gross alpha over 100 m^2. Inputs/assumptions are the same as structure surface total contamination.
- **Structure Surface Total Contamination GA-$DCGL_{EMC}$** – 92,700 net dpm/100cm^2 gross alpha over 1 m^2. Inputs/assumptions are the same as structure surface total contamination except for area.
- **Structure Surface Removable Contamination GA-$DCGL_{EMC}$** – 9,270 net dpm/100cm^2 gross alpha over 1 m^2. Additional values are provided for increasing survey areas. Inputs/assumptions are the same as structure surface total contamination except for area.

3.2 Open Land Area Acceptance Criteria

For surveys of the open land surface (excavation bottom and side walls) remaining after excavation of radiologically impacted material from the Pond Parcel and FOA, a surrogate net Th-232 activity concentration of 3.0 pCi/g is the applicable $DCGL_W$ value. **Table 3-1** presents area factors (based upon MARSSIM guidance) to be used for elevated measurement comparisons

(EMC) and to determine sampling requirements in situations where the scan instrument's minimum detectable concentration (MDC) is greater than the $DCGL_W$. The $DCGL_{EMC}$ values applicable to the open land areas of the site area are calculated by multiplying the $DCGL_W$ by the area factors presented in **Table 3-1**. $DCGL_{EMC}$ values are presented in **Table 3-2.**

$$DCGL_{EMC} = \text{Area Factor} * DCGL_W$$

Table 3-1 – Open Land Areas Area Factors

Area Factors									
Radio-nuclide	1 m^2 (11 ft^2)	3 m^2 (32 ft^2)	10 m^2 (108 ft^2)	30 m^2 (323 ft^2)	100 m^2 (1,076 ft^2)	300 m^2 (3,229 ft^2)	1,000 m^2 (10,764 ft^2)	3,000 m^2 (32,292 ft^2)	10,000 m^2 (107,639 ft^2)
Th-232	12.5	6.2	3.2	2.3	1.8	1.5	1.1	1.0	1.0

Table 3-2 - $DCGL_{EMC}$ Values for Open Land Areas

$DCGL_{EMC}$ (pCi/g)									
Radio-nuclide	1 m^2 (11 ft^2)	3 m^2 (32 ft^2)	10 m^2 (108 ft^2)	30 m^2 (323 ft^2)	100 m^2 (1,076 ft^2)	300 m^2 (3,229 ft^2)	1,000 m^2 (10,764 ft^2)	3,000 m^2 (32,292 ft^2)	10,000 m^2 (107,639 ft^2)
Th-232	37.5	18.6	9.6	6.9	5.4	4.5	3.3	3.0	3.0

3.3 Below Criteria Material (BCM) Acceptance Criteria

For surveys of the BCM placed in Pond Parcel excavations, a surrogate net Th-232 activity concentration of 31.1 pCi/g is the DCCL value. **Table 3-1** presents area factors (based upon MARSSIM guidance) to be used for EMCs of open land areas and to determine sampling requirements in situations where the scan instrument's MDC is greater than the DCCL. (The use of the open land area areas factors is conservative for surveys of the BCM.) For the BCM used as Pond Parcel backfill, the ADCL value was multiplied by the area factors presented in **Table 3-1** and the results are presented in **Table 3-3.**

$$ADCL_{EMC} = \text{Area Factor} * ADCL$$

However, since the BCM can be as high as 31.1 net pCi/g Th-232, the EMC is only applicable to concentrations exceeding 31.1 pCi/g Th-232 above background. The ADCL value of 7 pCi/g of Th-232 was conservatively used to establish elevated measurement criteria for BCM greater than 31.1 pCi/g Th-232 above background, to maintain the average concentration of the backfill material ALARA.

Table 3-3 - $ADCL_{EMC}$ Values for Pond Parcel BCM Units

	$ADCL_{EMC}$ (pCi/g)								
Radio-nuclide	1 m^2 (11 ft^2)	3 m^2 (32 ft^2)	10 m^2 (108 ft^2)	30 m^2 (323 ft^2)	100 m^2 (1,076 ft^2)	300 m^2 (3,229 ft^2)	1,000 m^2 (10,764 ft^2)	3,000 m^2 (32,292 ft^2)	10,000 m^2 (107,639 ft^2)
Th-232	87.5	43.4	22.4	16.1	12.6	10.5	7.7	7.0	7.0

3.4 Structures Acceptance Criteria

For surveys of structures remaining onsite, 944 dpm/100cm^2 of total alpha contamination is the applicable GA-DCGL value. **Table 3-4** presents area factors (based on MARSSIM guidance) to be used for elevated measurement comparisons and to determine sampling requirements in situations where the scan instrument's MDC is greater than the GA-DCGL. The appropriate $GA\text{-}DCGL_{EMC}$ values are calculated by multiplying the GA-DCGL by the area factors presented in **Table 3-4** and the results are presented in **Table 3-5.**

$$GA\text{-}DCGL_{EMC} = \text{Area Factor} * GA\text{-}DCGL$$

Table 3-4 Structures Area Factors

	Area Factors								
GA-DCGL	1 m^2	2 m^2	3 m^2	4 m^2	5 m^2	10 m^2	20 m^2	30 m^2	100 m^2
	98.2	49.2	32.9	24.7	19.8	9.91	4.97	3.32	1.00

Table 3-5 $GA\text{-}DCGL_{EMC}$ Values Structures

	$DCGL_{EMC}$ (dpm/100cm^2)								
GA-DCGL	1 m^2	2 m^2	3 m^2	4 m^2	5 m^2	10 m^2	20 m^2	30 m^2	100 m^2
	9.27E+04	4.64e+04	3.10E+04	2.33E+04	1.87E+04	9.36E+03	4.69E+03	3.13E+03	9.44E+02

The criteria for total alpha contamination corresponds to 25 mrem/yr TEDE based on the assumption of less than 10% of the total contamination is removable. Compliance for structures is also demonstrated by taking smear samples of 100 cm^2 of surface area and comparison of the gross alpha count result to 10% of the applicable total contamination GA-DCGL.

3.5 Interim Sum of Fractions for Pond Parcel Excavation Bottom and FOA Excavation Surveys

The inputs and assumptions used to derive the DCCL value for BCM reflect the projected as-left condition of the site. This configuration is very conservative for all of the other survey elements since the DCGL derivation was based on no soil cover. When the layers of BCM and a minimum 10 foot clean cover are placed on top of the excavation surface soil and embedded structures, the dose from these survey elements are reduced to 0 mrem, since the great majority of exposure from these elements depends on direct contact or proximity to the element. Once the

final as-left configuration of the site has been determined through final status and land surveys, a final as-left dose assessment will be completed to demonstrate compliance with the DP release criteria of 25 mrem/yr TEDE.

Survey unit compliance is demonstrated by comparison of the average residual contamination for each survey element present to the appropriate acceptance criteria value and a sum of fractions for each survey unit is calculated. The sum of fractions is a very conservative assessment of the survey unit. Summing the fractions ensures the survey unit will be a small fraction of 25 mrem/yr (the release criteria) when the actual as-left dose assessment is complete. A bounding as-left condition dose assessment is included in **Volume III, Appendix E** of this Final Status Survey Report.

4.0 FINAL STATUS SURVEY PROTOCOL

4.1 Generic Survey Protocol

Survey units for the Thorium Remediation Project are evaluated to determine whether the average residual radioactivity concentration in a particular survey unit as a whole is below the applicable acceptance criterion concentration, i.e., the $DCGL_W$, GA-DCGL or DCCL. The final survey protocol uses both systematic grid sampling to determine this average radionuclide concentration in a survey unit in conjunction with scans to identify elevated areas of residual radioactivity. At least the minimum number of samples (N/2) is taken in each survey unit. Since the radionuclides of interest at the Tulsa, Oklahoma facility also occur naturally in background, survey unit final status survey data are compared to data from a reference area under what is known as a "two-sample test," or the Wilcoxon Rank Sum (WRS) Test. Application of the WRS Test procedure is described in **Appendix C** of this volume of the Final Status Survey Report.

When using the WRS Test, the minimum number of samples (N/2) is the number of samples required in the survey unit and in the reference background area. Hence "N" is the total number of samples required to complete the WRS Test. (Please note: N is often used to represent the number of samples in the survey unit or in the reference area also.) Paramount to determining the minimum number of samples is the determination of the relative shift, delta over sigma (Δ/σ). Delta is equal to the DCGL minus the lower-bound gray region (LBGR) value. The LBGR value is arbitrarily set at one-half the DCGL value to start the determination. Sigma is an estimate of the variability in a set of sample analysis results from a survey unit.

A random-start triangular pattern, or grid, is used in Class 1 and Class 2 survey units to locate the sample points. For Class 3 survey units, the samples are located randomly or at the discretion of the Data Manager. The distance between each sampling grid node, L, is determined by the following equation:

$$L = \sqrt{\frac{A}{0.866N}}$$

In the above equation, A is the survey unit area to be covered by the grid pattern and N (equal to N/2 for WRS testing) is the number of samples required for that survey unit. The random start point (X and Y coordinates) is selected using a random number generator ("RAND") function in the Microsoft computer application *Excel*©. Sample points are identified in the field by flags or other means using a global positioning system (or equivalent locating tool) to locate each grid node.

The routine method (of determining N) described above presumes that the actual scan MDC is less than or equal to the required scan MDC, i.e., there is sufficient scan sensitivity available to detect small areas of elevated activity. (The derivation of various scan MDCs is presented in **Section 4.2.**) For the infrequent situations where the actual scan MDC exceeds the required scan MDC (acceptance criteria for the survey unit), the alternate method for calculating the required number of samples N may be used. This alternate method is described in Section 5.5.2.4 of

MARSSIM and involves the calculation of an area factor corresponding to the actual scan MDC as follows:

$$AreaFactor = \frac{ScanMDC(actual)}{DCGL_W}$$

(Depending on the survey unit, *DCCL* or *GA-DCGL* is substituted for $DCGL_W$ in the above equation.) The size of an area of elevated radioactivity corresponding to this area factor is interpolated from the appropriate area factor tables contained in **Chapter 3.0** and divided into the survey unit area to determine the alternate number of sample locations N_1. If N_1 exceeds the value assigned to N, an alternate spacing L_1 for the systematic sampling grid is calculated using the equation:

$$L_1 = \sqrt{\frac{A}{0.866N_1}}$$

The corresponding height (h) of the equilateral triangle with side length equal to L (or L_1) is calculated using the following formula: $h = ((L^2 - (L/2)^2)^{1/2}$.

4.2 Final Status Survey Instrumentation

4.2.1 Soil Survey Instrumentation

The MARSSIM framework for determining the MDC for field instrument scanning activities is based on the premise that there are two stages of scanning. That is, surveyors do not make decisions on the basis of a single indication; rather, upon noting an increased number of counts, they pause briefly and then decide whether to move on or take further measurements. Thus, scanning consists of two components: continuous monitoring and stationary sampling. Accordingly, field instrument surveyor scan MDCs, $MDCR_S$, are calculated to control the occurrence of Type I (false negative) and Type II (false positive) errors using the following MARSSIM equation:

$$MDCR_S = \frac{MDCR}{\sqrt{p\varepsilon}}$$

where *MDCR* is the minimum detectable count rate (cpm), p is the surveyor efficiency (estimated in MARSSIM to be between 0.5 and 0.75; the value of 0.5 results in a more conservative $MDCR_S$ calculation and, therefore, will be used), and ε is the instrument efficiency (cpm per µR/hr; Table 6.4 of NUREG-1507). In addition:

$$MDCR = s_i\left(\frac{60}{i}\right)$$

$$s_i = d'\sqrt{b_i}$$

where s_i (counts) is the minimal number of net source counts required for a specified level of performance for the counting interval i (seconds); d' is the index of sensitivity; and b_i is the number of background counts in the interval. Index of sensitivity d' values are listed in MARSSIM Table 6.5 based on the proportions for required true positive and tolerable false positive occurrence rates. The index of sensitivity value selected for initial use at the Kaiser, Tulsa facility is 1.38, corresponding to a true positive proportion of 0.95 and a false positive proportion of 0.60.

Typical calculated Th-232 scan MDCs for a survey instrument equipped with 2-inch x 2-inch NaI (2x2) detector using this MARSSIM two-stage scanning framework are summarized below in **Table 4-1** for increasing background count rates.

Table 4-1 Typical Soil Scan MDCs for Th-232 Detection Using a 2 × 2 NaI Detector[a]

Bkg (cpm)	i (sec)	P -	ε (cpm per µR/hr)	D' -	s_i (counts)	$MDCR$ (ncpm)	$MDCR_S$ (ncpm)	CF[b]	*Scan MDC*[c] µR/hr	*Scan MDC*[c] pCi/g
5,000	1	0.5	830	1.38	13	756	1069	0.99	1.29	1.3
10,000					18	1069	1512		1.82	1.8

a. Th-232 in equilibrium with progeny uniformly distributed in a source thickness of 6 inches.

b. Conversion factor (pCi/g per µR/hr) taken from NUREG-1507, modeled using *MicroShield*. CF = Scan MDC (pCi/g) / Scan MDC (µR/hr)

c. *Scan MDC* (µR/hr) = $MDCR_S/\varepsilon$ and *Scan MDC* (pCi/g) = $(MDCR_S/\varepsilon)CF$

When scanning soil, the detector is held close to the ground (1 to 2 inches) and moved in a serpentine pattern. A scan rate of approximately 0.5 m per second is used reflecting the natural pace of the technician walking with the equipment swinging the detector a width of 1 meter in a serpentine pattern. Estimates of scan speed are provided for each soil survey unit for which the GPS/data logger system was used. The scan speed is estimated by dividing the total area surveyed by the number of 1 or 2 second interval gross gamma results recorded.

4.2.2 Structure Survey Instrumentation

Measurements of alpha activity are used to show compliance with the structural surface total and removable contamination acceptance criteria in units of dpm/100 cm^2. Scanning for gross alpha activity is used as part of final status surveys of structural surfaces to ensure elevated areas of activity are identified. In addition, static counts at predetermined sample points are used to assess total alpha contamination of structural surfaces. The following instrument is being used for the Thorium Remediation Project to survey structural surfaces:

Meter Manufacturer and Model	Detector Manufacturer and Model	Detector Type	Use
Ludlum 2221	Ludlum 43-68 Gas Proportional	Gas Proportional	Final status survey scans and static counts for total alpha contamination measurements

Structure survey instruments are evaluated and controlled to verify that MDCs of less than the $DCGL_w$ for direct measurements and/or scanning measurements are routinely achieved. Field instrument scan MDCs are calculated to control the occurrence of Type I (false negative) and Type II (false positive) as discussed in the following subsections.

4.2.2.1 Alpha Scan

For a typical alpha background level of less than 3 cpm, the probability of detecting a single count while passing over the contaminated area is:

$$P(n \geq 1) = 1 - e^{\frac{-GEd}{60v}}$$

where:

$P(n \geq 1)$ = probability of observing a single count,
G = activity (dpm),
E = 4π detector efficiency (cpd),
d = width of detector in direction of scan (cm), and
v = scan speed (cm/s).

The value of G is increased until the corresponding probability equaled the desired confidence level, e.g., 95 percent. **Table 4-2** summarizes the calculation of alpha scan MDCs for the 4π detector alpha efficiencies of the instruments used. The resulting values of G (dpm) are significantly below the GA-DCGL value of 944 dpm/100cm^2.

Table 4-2 Typical Structure Scan MDCs for Gross Alpha Detection

G (dpm)	d (cm)	E (cpm)	v (cm/s)	P (-)
380	11.7	0.1618	3.90	0.95
550	11.7	0.1618	5.9	0.95
720	11.7	0.1618	7.80	0.95
1080	11.7	0.1618	11.7	0.95

4.2.2.2 Alpha Static Counts

Minimum counting times for static counts of total and removable contamination will be chosen to provide an MDC that is a fraction (25 to 75 percent) of the survey unit-specific acceptance criteria. MARSSIM equations have been modified to convert to units of dpm/100 cm^2. Count times are determined using the following equation. Static counting MDCs at a 95 percent confidence level are calculated using the following equation which is an expansion of NUREG-1507, Equation 6-7 (Strom & Stansbury, 1992):

$$MDC_{static} = \frac{3 + 3.29\sqrt{B_r \cdot t_s \cdot (1 + \frac{t_s}{t_b})}}{t_s \cdot E_{tot} \cdot \frac{A}{100}}$$

where:

MDC_{static} = minimum detectable concentration level in dpm/100 cm^2,
B_R = background count rate in counts per minute,
t_B = background count time in minutes,
t_S = sample count time in minutes,
A = detector probe physical (active) area in cm^2, and
E_{tot} = total detector efficiency for radionuclide emission of
= $E_i \times E_s$,
where:
E_i = 2π instrument efficiency in counts per disintegration (cpd) and
E_s = source (or surface contamination) efficiency.

Note: E_s values can be determined or the default values provided in NUREG-1507 can be used as follows: 0.25 for all alpha energies and beta maximum energies between 0.15 and 0.4 MeV, 0.5 for all beta maximum energies greater than 0.4 MeV.

Table 4-3 contains example static alpha MDC calculation results for structural surfaces.

Table 4-3 Structural Surface Alpha Static MDC

Background Gross Alpha Count Rate (cpm)	Background Count Time (min)	Static Measurement Count Time (min)	Total Detector Efficiency	Detector Probe Area (cm^2)	Static MDC (dpm/100cm^2)
0.5	1	1	0.040	126	123
1.0	1	1	0.040	126	150
1.0	5	5	0.040	126	52.6
2.0	5	5	0.040	126	69.5

4.3 Laboratory Analysis

Final status survey analytical laboratory services for the Thorium Remediation Project are being provided by Outreach Laboratory (Outreach) of Broken Arrow, Oklahoma. Final status survey samples consist of soil media samples and smear samples of removable alpha contamination.

Final status survey soil samples are analyzed for Th-232 activity concentration in units of pCi/g via gamma spectroscopy. The samples are counted by the laboratory as received, i.e., they are not dried and/or ground. The MDC value required for each gamma spectroscopy analysis is 25 percent of the release criteria for Th-232. Characterization survey results confirm that Th-232 is in secular equilibrium with its short-lived progeny Ac-228 and Th-228. Outreach infers Th-232 activity from the high energy/high yield gamma emitted by progeny of the thorium decay series, e.g., Actinium-228 (secular equilibrium progeny) high energy gamma line (911 keV). The Th-228 activity is calculated by multiplying the Th-232 activity by 1. The Th-230 activity is calculated by multiplying the Th-232 activity by 3.5.

The laboratory's analytical results are reported to include the activity, the 95 percent confidence level uncertainty (2-sigma error), and the MDC all in the same units of the sample analyzed.

To exclude the bias introduced when grouping analytical results containing "less than" values, the laboratory has been instructed to report observed counting data when reporting results that are below the critical level L_C (and thus "not detected") established for each analysis.

4.4 Open Land Area Survey Protocol

4.4.1 Minimum Number of Samples Determination

The estimate of sigma used for the Thorium Remediation Project is based on the standard deviation of the Th-232 activity measured in survey units during the ALRP final status survey (0.42). Using the $DGCL_w$ value of 3.0 pCi/g of Th-232, Δ is equal to 3.0 - 1.5, or 1.5. Delta divided by the sigma of 0.42 results in a relative shift of 3.57 which is rounded to 3.5 for the purpose of determining the required number of samples. The corresponding minimum number of samples looked up in Table 5.3 of MARSSIM is 9.

4.4.2 Open Land Area Gross Gamma Scan Survey

Portable survey meters consisting of 2-inch by 2-inch sodium iodide (NaI) detectors (Ludlum Model 44-10) coupled with scaler instruments (Ludlum Model 2221) are used to perform gross gamma scans (to identify elevated areas). Typically, the portable survey meters are also coupled to a Global Positioning System (GPS) unit and a data logger to provide electronic downloads of coordinates and associated gross gamma count rates in units of counts per minute (cpm).

Per Section 5.3.3 of MARSSIM, scanning is used to identify locations within the survey unit that exceed the investigation level. For Class 1 survey units, the investigation level is the derived concentration guideline elevated measurement criteria ($DCGL_{EMC}$) value for the area scanned. The $DCGL_{EMC}$ values applicable to the open land areas of the site are calculated by multiplying

the $DCGL_W$ by the area factors presented in **Chapter 3.0.** $DCGL_{EMC}$ values are also presented in **Chapter 3.0.**

The scan MDC and the scanning thresholds in measurement units of net counts per minute (ncpm) are calculated in accordance with MARSSIM and NUREG-1507. These values are summarized below in **Table 4-5** for a maximum background of 50,000 cpm and increasing survey areas (A). The first line (A = 0.25 m^2) is the default area used to demonstrate the calculation of scan MDC and the derivation of the conversion factor (CF in units of pCi/g or μR/h) in NUREG-1507. However, surveys of an area this small are not applicable to final status, open land area surveys. The increasing areas presented in the table correspond to the approved area factors (DP) and result in scan thresholds for detection of both elevated areas (Fail $DCGL_{EMC}$) and complete survey units with activity concentration greater than the $DCGL_W$ (Fail $DCGL_W$). The CF's for increasing areas were derived using the identical inputs of the NUREG-1507 derivation changing only the area.

In addition to the derived scan thresholds, scan data are evaluated against empirical data gathered in the field. For example, soil samples are collected at biased locations (highest scan count rate) and screened on site for Th-232 activity concentration corresponding to the high count rate. All of these factors (derived thresholds, empirical thresholds, and biased samples) are used to identify elevated areas and to release the survey unit for final sampling. The threshold values provided are theoretical, depend on counting geometry and other factors that cannot be controlled in the field, and are used to aid identifying elevated areas that may require additional remediation or application of the elevated measurement comparison.

Table 4-5 – Open Land Areas Scan MDC and Threshold Values

A Area (m^2)	$DCGL_{EMC}$ (pCi/g)	B (cpm)	CF (pCi/g / μR/h)	Scan MDC (pCi/g)	Fail $DCGL_{EMC}$ (ncpm)	Fail $DCGL_W$ (ncpm)
0.25	N/A	50,000	0.99	4.0	N/A	2,515
1	37.5	50,000	0.62	2.5	50,578	4,046
3	18.6	50,000	0.51	2.1	30,212	4,873
10	9.6	50,000	0.46	1.9	17,227	5,383
30	6.9	50,000	0.45	1.8	12,851	5,588
100	5.4	50,000	0.44	1.8	10,250	5,695
300	4.5	50,000	0.43	1.8	8,624	5,749
1000	3.3	50,000	0.43	1.8	6,360	5,782
3000	3.0	50,000	0.43	1.7	5,799	5,799

4.4.3 Open Land Area Soil Sampling

4.4.3.1 Systematic Final Status Survey Soil Sampling

Systematic soil samples are collected at locations determined through the use of a random start point and an equal-distant triangular grid in accordance with MARSSIM and the DP. Soil sample locations are demarcated in the field (using a GPS unit) and soil samples are collected at

the surface (0-6-inch depth interval) level using a clean, decontaminated sampling auger or sharpshooter shovel.

4.4.3.2 Additional Biased and EMC Evaluation Soil Sampling

In addition to the systematic samples used to determine the average Th-232 activity concentration in the survey unit, other soil samples may be taken within a survey unit to help demonstrate compliance. At the discretion of the surveyor, biased samples are taken at high scan rate locations to help determine scan survey results. In addition, if small areas of elevated activity are identified, additional soil samples are taken at biased locations to aid in the elevated measurement comparison for the area.

4.4.3.3 Use of the On Site Cave Counter

Certain soil samples, e.g., biased and/or EMC samples collected as part of the final status survey process are screened for Th-232 activity concentration using an on site cave counter. The on site cave counter for the Thorium Remediation Project consists of a 2-inch by 2-inch NaI Ludlum Model 44-10 detector coupled with a Ludlum Model 2221 Scaler/Ratemeter instrument, mounted inside a shielded box with room for a standard soil sample container to be placed on the face (bottom, non-wire connecting end) of the detector. Two detectors (numbered NaI # 4 and NaI #8) have been used as part of the counter. The detectors were calibrated annually off-site by a qualified vendor to verify their response to high energy photons. The detectors, including their use as part of the counter, are utilized to obtain gross gamma readings from soil samples in units of counts per minute (cpm). The detector response is checked daily when in use to a Cs-137 source. Documentation of the on site cave counter calibration and the calculation of Th-232 activity concentration, 95% confidence level uncertainty, and the MDC, are presented in **Appendix D** of this volume of the Final Status Survey Report.

4.5 Structure Survey Protocol

Permanent structures (destined to remain on site) encountered during the implementation of the Thorium Remediation Project can be classified by type. The first type is termed "embedded structures" and consists of small pipes and remnants of previous structures uncovered during excavation activities. These structures consist of very small surface areas (< 1 or 2 m^2) and will be buried with BCM and/or clean fill based on the final site configuration. Measurements of total alpha contamination and smear samples of removable alpha contamination are taken on these structures and reported with the open land area survey unit for which they reside. The second type of structure is the large surface area (approaching 100 m^2) structure such as a concrete retaining wall. This type of structure constitutes a separate survey unit and is surveyed as such.

4.5.1 Minimum Number of Samples Determination

The estimate of sigma used for the Thorium Remediation Project is based on the standard deviation of a set of total alpha contamination results from the final status survey of the Flux Building (Survey Unit FB-001 Floor Surface: 45.9). Since the gross alpha activity concentration

of 944 dpm/100cm2 will be used as the DGCL-GA, Δ is equal to 944 - 472, or 472. Delta divided by the sigma of 45.9 results in a relative shift of 10.3. The minimum number of samples (looked up in Table 5.3 of MARSSIM) corresponding to alpha and beta error rates of 0.05 and a relative shift of 10.3 is 9.

4.5.2 Structure Surfaces Gross Alpha Scan Survey

Portable survey meters consisting of gas proportional detectors (Ludlum Model 43-68) coupled to alpha/beta scaler instruments (Ludlum Model 2360) are used wherever possible to perform scans (to identify elevated areas of alpha activity). Whenever the structure is too small or inaccessible for a gas proportional detector, surveys of gross gamma activity are performed using a 2-inch by 2-inch sodium iodide (NaI) detector (Ludlum Model 44-10) coupled with a scaler instrument (Ludlum Model 2221)

4.5.3 Systematic Measurements of Total and Removable Alpha Contamination

Systematic sample points are marked at locations determined through the use of a random start point and an equal-distant triangular grid in accordance with MARSSIM and the DP. Static measurements are taken at each sample point location to determine the total alpha contamination (in units of dpm/100cm^2). Smear samples representing 100cm^2 areas are also collected at the same sample point location to assess removable alpha contamination (in units of dpm/100cm^2). The smear samples are sent to Outreach for laboratory analysis.

For small embedded structures, static counts are taken to determine total alpha contamination (in units of dpm/100cm^2) at biased locations (highest scan result) when possible. Smear samples representing 100 cm^2 areas are also collected at the same sample locations and counted for removable alpha contamination by Outreach. In areas such as the interiors of small diameter piping, the gas proportional detectors typically can not be used for static measurements; therefore, only smear samples are taken to assess the removable alpha contamination.

4.6 BCM Unit Survey Protocol

4.6.1 Minimum Number of Samples Determination

The estimate of sigma used for the Thorium Remediation Project is based on an estimate of the variance of Th-232 activity concentrations of core composite samples of 4.4. Using the DCCL value of 31.1 pCi/g of Th-232, and a LBGR of 31.1/2, Δ is equal to 31.1 - 15.55, or 15.55. Delta divided by the sigma of 4.4 results in a relative shift of 3.5. The corresponding minimum number of samples looked up in Table 5.3 of MARSSIM is 9.

4.6.2 BCM Unit Gross Gamma Scan Survey

Portable survey meters consisting of 2-inch by 2-inch sodium iodide (NaI) detectors (Ludlum Model 44-10) coupled with scaler instruments (Ludlum Model 2221) are used to perform gross gamma scans (to identify elevated areas) for each 2-foot lift of placed BCM. Typically, the portable survey meters are also coupled to a GPS unit and a data logger to provide electronic

downloads of coordinates and associated gross gamma count rates in units of counts per minute (cpm).

Per Section 5.3.3 of MARSSIM, scanning is used to identify locations within the survey unit that exceed the investigation level. For Class 1 survey units, the investigation level is the derived concentration guideline elevated measurement criteria ($DCGL_{EMC}$) value for the area scanned. The $DCGL_{EMC}$ values applicable to the BCM survey units are calculated by multiplying the ADCL by the area factors presented in **Chapter 3.0.** $ADCL_{EMC}$ values are also presented in **Chapter 3.0.**

The scan MDC and the scanning thresholds in measurement units of net counts per minute (ncpm) are calculated in accordance with MARSSIM and NUREG-1507. These values are summarized below in **Table 4-6** for a maximum background of 50,000 cpm and increasing survey areas (A). The first line (A = 0.25 m^2) is the default area used to demonstrate the calculation of scan MDC and the derivation of the conversion factor (CF in units of pCi/g or μR/h) in NUREG-1507. However, surveys of an area this small are not applicable to final status, open land area surveys. The increasing areas presented in the table correspond to the approved area factors (DP) and result in scan thresholds for detection of both elevated areas (Fail $DCGL_{EMC}$) and complete surveys units with activity concentration greater than the $DCGL_W$ (Fail $DCGL_W$). The CFs for increasing areas were derived using the identical inputs of the NUREG-1507 derivation changing only the area.

In addition to the derived scan thresholds, scan data are evaluated against empirical data gathered in the field. For example, soil samples are collected at biased locations (highest scan count rate) and screened on site for Th-232 activity concentration corresponding to the high count rate. All of these factors (derived thresholds, empirical thresholds, and biased samples) are used to identify elevated areas and to release the survey unit for final sampling. The threshold values provided are theoretical, depend on counting geometry and other factors that cannot be controlled in the field, and are used to aid identifying elevated areas that may require additional remediation or application of the elevated measurement comparison.

Table 4-6 – BCM Scan MDC and Threshold Values

A Area (m^2)	$ADCL_{EMC}$ (pCi/g)	B (cpm)	CF (pCi/g / mR/h)	Scan MDC (pCi/g)	Fail $ADCL_{EMC}$ (ncpm)	Fail DCCL (ncpm)
0.25	N/A	150,000	0.99	7.0	N/A	26,074
1	87.5	150,000	0.62	4.3	118,016	41,946
3	43.4	150,000	0.51	3.6	70,495	50,516
10	31.1	150,000	0.46	3.3	55,808	55,808
30	31.1	150,000	0.45	3.1	57,924	57,924
100	31.1	150,000	0.44	3.1	59,034	59,034
300	31.1	150,000	0.43	3.1	59,602	59,602
1000	31.1	150,000	0.43	3.0	59,938	59,938
3000	31.1	150,000	0.43	3.0	60,118	60,118

4.6.3 BCM Unit Systematic Soil Core Sampling

Upon completion of the placement of a BCM unit, systematic soil core samples are collected at locations determined through the use of a random start point and an equal-distant triangular grid in accordance with MARSSIM and the DP. Soil core sample locations are demarcated in the field using a GPS unit. Soil core samples are collected through the entire layer of placed BCM. It should be noted that the entire length of each soil core from a BCM survey unit may not equal the total depth of the placed BCM due to the following:

- The bottom surface (grade) of each excavation bottom unit may not be level when a BCM unit is placed.
- The top surface of BCM in a unit may not be level based upon the site's final grade plan relative to maintaining the minimum 10 feet of clean cover soil.
- BCM units are placed in 2 foot lifts with sloping side walls. As a result, succeeding lifts become smaller in surface area (a core sample point may fall on the unit's sloped side walls).

Core segments of BCM (typically 3 feet in length) are scanned in the field in 1-foot increments. Each one foot increment is also characterized by a 1-minute static count of gross gamma activity. A composite sample representing each core segment is then prepared by combining each set of three 1-foot increments in a bucket and breaking up the cores. The final segment of core may be less than or greater than 3 feet depending on the point at which virgin material is encountered. A sample (usually between 500 and 800 grams) is taken from each composite and forwarded to Outreach for analysis of Th-232 activity concentration.

5.0 SUMMARY OF FINDINGS

This chapter of Volume II of the Final Status Survey Report presents a summary of the final status survey findings and an overall summation of fractions for each FOA excavation survey unit.

5.1 Structural Surfaces - Survey Units Kaiser-FSSFOA-003, Kaiser-FSSFOA-007, and Kaiser-FSSFOA-008

Final status survey activities for Survey Units Kaiser-FSSFOA-003, Kaiser-FSSFOA-007, and Kaiser-FSSFOA-008, structural retaining walls, consisted of a gross gamma scan of the exposed concrete/cinderblock surface of each survey unit and systematic measurements of total and removable alpha contamination. The results of the final status survey activities were as follows:

- The 100 percent coverage gross alpha scan of the structural surface for each survey unit did not indicate the presence of small areas of elevated activity (above the DCGL-GA for the site).
- The systematic measurements of total alpha contamination for each survey unit were below the DCGL-GA of 944 dpm/100cm^2.
- The smear sample results for each survey unit were below the DCGL-GA of 94.4 dpm/100cm^2 for removable alpha contamination.
- The total alpha contamination results for each survey unit met the DP statistical criterion based on the first statistical evaluation of the data (WRS Test procedure).
- No elevated areas were left in-place; therefore, no elevated measurements were required for these units.

A summary of the final status survey results by survey unit is provided below in **Table 1.**

5.2 Open Land Areas - Survey Units Kaiser-FSSFOA-001, Kaiser-FSSFOA-002, Kaiser-FSSFOA-004 through Kaiser-FSSFOA-006, and Kaiser-FSSFOA-009

Final status survey activities for open land areas Survey Units Kaiser-FSSFOA-001, Kaiser-FSSFOA-002, Kaiser-FSSFOA-004 through Kaiser-FSSFOA-006, and Kaiser-FSSFOA-009 consisted of a gross gamma scan of the exposed surface soil of each survey unit (excavation bottom and side walls, if present) and systematic soil sampling. The results of the final status survey activities were as follows:

- The 100 percent coverage gamma scan (final as-left condition) of Survey Units Kaiser-FSSFOA-001, Kaiser-FSSFOA-002, Kaiser-FSSFOA-004, Kaiser-FSSFOA-005, and Kaiser-FSSFOA-009 did not indicate the presence of small areas of elevated activity (above the $DCGL_W$ for the site).
- The systematic soil sample analytical results (net) for each survey unit were below the open land area surrogate value of 3.0 pCi/g net Th-232 activity concentration ($DCGL_W$).
- The systematic soil sample analytical results for each survey met the DP statistical criterion based on the first statistical evaluation of the data (WRS Test procedure).
- An elevated area was left in-place for Survey Unit Kaiser-FSSFOA-006; therefore, an elevated measurement comparison was required for this unit.

- Embedded structures were encountered and left in-place for Survey Units Kaiser-FSSFOA-004, Kaiser-FSSFOA-005, and Kaiser-FSSFOA-006.

A summary of the final status survey results by survey unit is provided below in **Table 1.**

5.3 Sum of Fractions

To evaluate the status of each survey unit prior to backfill with clean import borrow material, as a whole (excavation bottom/side wall surface soil, elevated areas, and embedded structures), the fraction of each survey element's average net activity divided by the applicable acceptance criteria is calculated for inclusion in the Sum of Fractions for the each survey unit. The Total Sum of Fractions for surface soil, elevated areas, and embedded structures respectively is presented below in **Table 1** by survey unit. The sum of fractions is a very conservative assessment of the survey unit. Summing the fractions ensures the survey unit will be a small fraction of 25 mrem/yr (the release criteria) when the actual as-left dose assessment is complete. The results of the Sum of Fractions assessment show that Survey Units Kaiser-FSSFOA-001 through Kaiser-FSSFOA-009 meet the DP acceptance criteria.

Table 1 – FOA Excavation Final Status Survey Summary by Survey Unit

Survey Unit	Surface Area (m^2)	No. of Systematic Samples Collected	Systematic Sample Exceedance of DCGL Value	WRS Test Criterion Met	Elevated Area(s) Present	Embedded Structure(s) Present	Total Sum of Fractions	Survey Unit Meets DP Acceptance Criteria
Kaiser-FSSFOA-001	228	9	NO	YES	NO	NO	0.00	YES
Kaiser-FSSFOA-002	49	9	NO	YES	NO	NO	0.00	YES
Kaiser-FSSFOA-003*	35	21	NO	YES	NO	N/A	0.16	YES
Kaiser-FSSFOA-004	84	10	NO	YES	NO	YES	0.15	YES
Kaiser-FSSFOA-005	1,320	9	NO	YES	NO	YES	0.03	YES
Kaiser-FSSFOA-006	2,550	13	NO	YES	YES	YES	0.59	YES
Kaiser-FSSFOA-007*	81.5	18	NO	YES	NO	N/A	0.07	YES
Kaiser-FSSFOA-008*	9.3	14	NO	YES	NO	N/A	0.09	YES
Kaiser-FSSFOA-009	19.5	10	NO	YES	NO	NO	0.00	YES

* Survey unit consists of a structure (cinderblock or concrete retaining wall) encountered during the removal of radiologically impacted soil.

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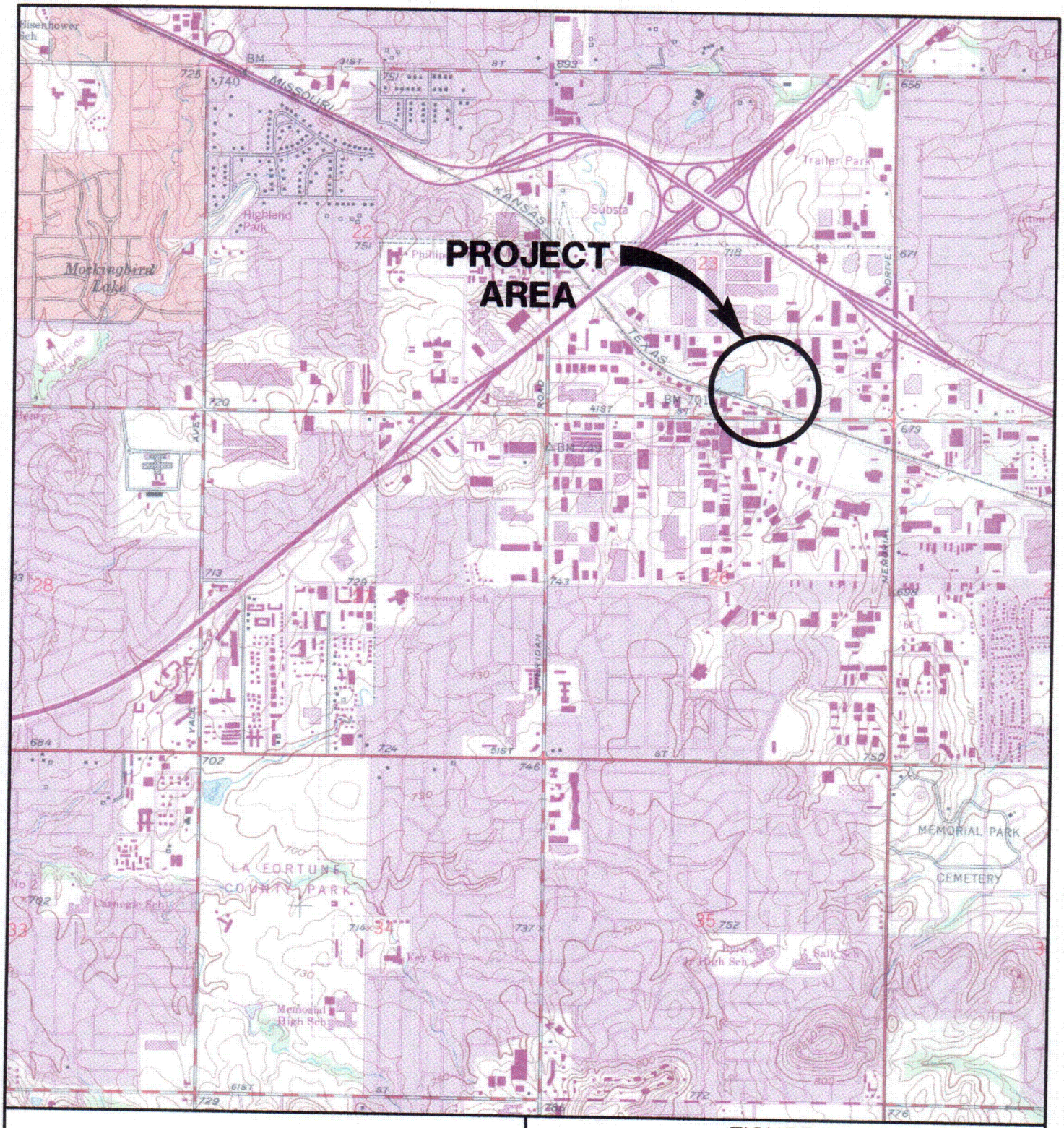
(9) NRC, 1997, Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions, NUREG/CR-1507, Final, NRC, Washington, DC.



REFERENCE
USGS 7.5-MIN TOPOGRAPHIC QUADRANGLE
JENKS, OK
DATED 1952, PHOTOREVISED 1982
SCALE 1:24000.

FIGURE 1
SITE LOCATION MAP

THORIUM REMEDIATION PROJECT
TULSA, OKLAHOMA FACILITY

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

APPROVED	RFD 3-3-06
CHECKED	RFD 3-3-06
DRAWN	DEB 08/17/05
DRAWING NUMBER	PA4072021

Penn E&R
Environmental & Remediation, Inc.

C01

LEGEND

- APPROXIMATE PROPERTY LINE
- APPROXIMATE RIGHT–OF–WAY
- FENCE
- RAILROAD
- ASPHALT PAVEMENT
- CURB
- PAVED ROAD
- DIRT/GRAVEL ROAD
- SIDEWALK
- CONCRETE/SLAB
- WALL
- TREE LINE
- MISC. STRUCTURE
- GUARD RAIL
- STREET SIGN
- POST
- FIRE HYDRANT
- TREE
- MISC. TANK
- LIGHT POLE
- TRAFFIC SIGNAL POLE
- MANHOLE
- POWER POLE
- CULVERT OUTFALL

FIGURE 2
SITE PLAN

THORIUM REMEDIATION PROJECT
TULSA, OKLAHOMA FACILITY

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

APPROVED	RFD 3-3-06
CHECKED	RFD 3-3-06
DRAWN	DEB 02/23/06
DRAWING NUMBER	PA4072202

Penn E&R
Environmental & Remediation, Inc.

C02

FSS-006
FSSB-002
FSS-022
FSS-021
FSSB-009
FSS-017
FSSB-006
FSS-015
FSSB-004
FSSB-003
FSS-014
FSS-024
FSSB-011
FSS-023
FSSB-010
FSS-018
FSSB-007
FSS-016
FSS-013
FSS-010
FSS-011
FSSB-001
FSS-025
FSS-026
FSS-028
FSS-027
FSSB-012
FSS-019
FSSB-008
FSSB-005
FSS-009
FSS-012
FSS-008
FSS-005
FSS-001
FSS-002
FSS-004
FSS-003
FSS-007
FSS-030
FSS-029
FSS-020
KAISER-FSSFOA-001
KAISER-FSSFOA-004
KAISER-FSSFOA-003
KAISER-FSSFOA-002
KAISER-FSSFOA-007
KAISER-FSSFOA-008
KAISER-FSSFOA-006
KAISER-FSSFOA-005
KAISER-FSSFOA-009
N
SCALE – FEET
0
100
COMPLETED EXCAVATION BOTTOM FINAL STATUS SURVEY UNIT (FSS AND FSSFOA)
COMPLETED BCM FINAL STATUS SURVEY UNIT (FSSB)
PLANNED EXCAVATION/FINAL STATUS SURVEY UNIT (FSS)

FIGURE 3
FINAL STATUS SURVEY UNIT LAYOUT

THORIUM REMEDIATION PROJECT
TULSA, OKLAHOMA FACILITY

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

APPROVED	RFD 3-17-06
CHECKED	RFD 3-17-06
DRAWN	DEB 02/21/06
DRAWING NUMBER	PA4072201

Penn E&R
Environmental & Remediation, Inc.

C03

SUB-REPORT

SURVEY UNIT KAISER-FSSFOA-001

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ATTACHMENTS

ATTACHMENT A: Figure A-1 Gross Gamma Background and Scanning Survey Results
Figure A-2 Biased Soil Sampling Locations
Figure A-3 Systematic Soil Sampling Locations

ATTACHMENT B: Soil Survey Unit Worksheet No. 1
Soil Survey Unit Worksheet No. 2

ATTACHMENT C: Laboratory Analytical Results

Final Status Survey Report
Volume II – Former Operational Area
Sub-Report No. EB-031
Survey Unit Kaiser-FSSFOA-001
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation
March 22, 2006

1.0 BACKGROUND

This sub-report documents the results of Former Operational Area (FOA) excavation final status survey activities completed as part of the Thorium Remediation Project at the Tulsa, Oklahoma facility **(Figure 1)**. Specifically, this technical report addresses the final status survey of Survey Unit Kaiser-FSSFOA-001, an open land area (FOA excavation surface soil) resulting from the removal of radiologically-affected soil from the northwestern portion of the FOA. The survey unit is situated northwest of the Maintenance Building, northeast of the North Extrusion Building, and south of the Union Pacific Railroad right-of-way **(Figure 3)**. Survey Unit Kaiser-FSSFOA-001 is considered a Class 1 survey unit with an approximate surface area of 228 m^2.

Survey Unit Kaiser-FSSFOA-001 consists of an excavation bottom surface soil with three side walls (north wall, east wall, and west wall). No elevated areas were left in-place, therefore, no elevated measurement comparisons were required for this unit. During the removal of the radiologically-affected soil, one embedded "structure", a 24-inch diameter storm drain line, was encountered. The storm drain line piping was removed (and disposed as a radiological waste) to facilitate the excavation of radiologically-affected soil located beneath it. The drain line was ultimately replaced with new piping.

2.0 SURVEY ACTIVITIES AND RESULTS

This section of the sub-report presents the final status survey data for the excavation bottom, northern side wall, eastern side wall, and western side wall surface soil of Survey Unit Kaiser-FSSFOA-001. The final status survey consisted of a gross gamma scan of the exposed surface soil of the survey unit and systematic soil sampling.

2.1 Gross Gamma Scan

The exposed surface soil of the Class 1 survey unit (excavation bottom, northern side wall, eastern side wall, and western side wall) was surveyed through a 100 percent coverage gamma scan to confirm acceptable radiological conditions and identify any elevated areas. During the scanning of the soil, the detector was held close to the ground surface (1 to 2 inches) and moved in a serpentine pattern. Background measurements were obtained at 1-meter above the ground surface at 25 approximately equal-distant locations in the survey unit. The statistics for the 25 background measurements are provided below in **Table 1**. Background measurements ranged from 6,887 counts per minute (cpm) to 14,092 cpm moving south to north across the survey unit. The scan results increase as the surveyor moves closer to impacted material located to the north of the survey unit (pond parcel).

Similar results were obtained for the gross gamma scan of the survey unit's surface area. A total of 2,351 measurements of gross count rate were made at one second intervals across the survey unit's 228 m^2 surface area. The results ranged from 6,837 cpm to 18,945 cpm. A statistical summary of the 100 percent coverage gamma scan of the survey unit is provided below in **Table 1**.

Table 1 – Gross Gamma Scan Results Summary

Survey Area:	228 m^2	
Number of Scan Measurements (1-Second Intervals)	2,351	
Scan Rate: (Swinging the detector a width of 1-meter side to side)	0.10 m/s (MARSSIM recommends 0.5m/s)	
Results Summary:	**Background (Gross cpm)**	**Scan (Gross cpm)**
Minimum	6,887	6,837
Maximum	14,092	18,945
Average	9,457	11,087
Standard Deviation	1,618	1,724
Median	9,316	10,782

Contour maps of the gross gamma background and final (as-left condition) scanning survey results are presented on **Figure A-1** contained in **Attachment A**. The 100 percent coverage gross gamma scan did not indicate the presence of small areas of elevated activity (above the $DCGL_W$ for the site). As part of the gross gamma survey, two biased soil samples (K-471 and

K-503) were collected at locations exhibiting high scan rates on the western side wall **(Figure A-2, Attachment A)**. In addition, four biased soil samples (K-466 through K-469) were collected at equal-distant locations along the excavation bottom relative to the position of the removed drain line **(Figure A-2, Attachment A)**. The biased soil samples were screened on-site in a lead cave. Results of the sample screening are presented below in **Table 2.** The sample screening levels were below the $DCGL_W$ for the site.

Table 2 – Biased Soil Sample Screening Results

Soil Sample ID	Gross Th-232 (pCi/g)	Std. Error (pCi/g)	MDC (pCi/g)
$DCGL_W$	*3.0*		
Site Background	*1.1*	*0.3*	
K-466	1.35	0.950	1.52
K-467	0.524	0.978	1.52
K-468	1.49	0.875	1.52
K-469	1.55	0.882	1.52
K-471	1.09	0.859	1.56
K-503*	2.32	0.161	0.550

*Analyzed by Outreach.

2.2 Systematic Soil Sampling – Excavation Bottom/Side Wall Surface Soil

The final status survey also consisted of systematic soil sampling based on a random start point and an equal-distant triangular grid. The Minimum Number of Samples Required (N) based on the scan MDC was determined to be 9 as documented on Soil Survey Unit Worksheet No. 1 **(Attachment B)**. Once N was determined, the Survey Unit Area (A) of 228 m^2 along with the N of 9 were used to calculate the Triangular Grid Node Length (L) of 5.4 meters and the Height of the Equilateral Triangle (h) of 4.7 meters. A random start point was generated using the random number feature of Excel and documented on Soil Survey Unit Worksheet No. 2 **(Attachment B)**.

A layout of the soil sampling locations is provided on **Figure A-3** contained in **Attachment A.** The soil sampling locations were demarcated in the field using a GPS unit. A total of 9 soil samples (identified as K-435 through K-443) were collected at the excavation bottom/side wall surface (0-6-inch depth interval) level using a clean, decontaminated sampling auger or sharpshooter shovel. The samples were forwarded to Outreach for analysis of Th-232 activity concentration. Analytical results are provided below in **Table 3.** Analytical data reports are contained in **Attachment C.**

Table 3 – Systematic Soil Sample Results

Soil Sample ID	Gross Th-232 (pCi/g)	Std. Error (pCi/g)	MDC (pCi/g)	Net Th-232 (pCi/g)	Net DCGL (pCi/g)
K-435	0.826	0.100	0.420	0	3.0
K-436	1.04	0.113	0.251	0	3.0
K-437	1.54	0.162	0.574	0.44	3.0
K-438	0.716	0.080	0.352	0	3.0
K-439	1.08	0.114	0.396	0	3.0
K-440	1.09	0.096	0.238	0	3.0
K-441	0.911	0.130	0.475	0	3.0
K-442	0.679	0.099	0.403	0	3.0
K-443	0.649	0.084	0.318	0	3.0
Average	***0.948***				
Standard Dev.	***0.280***				
Minimum	***0.649***				
Maximum	***1.54***				
Median	***0.911***				

All 9 systematic soil sample results (gross and net) were below the open land area surrogate value of 3.0 pCi/g net Th-232 activity concentration ($DCGL_W$). The maximum gross Th-232 activity concentration was 1.54 pCi/g, which fell slightly above the background Th-232 activity of 1.1 pCi/g for the site. The average gross Th-232 activity concentration was 0.948 pCi/g. The standard deviation of the 9 equal-distant samples was 0.280, which fell below the estimated standard deviation of 0.42 (based on the adjacent land final status survey results) used to calculate the minimum number of samples required.

2.3 Wilcoxon Rank Sum (WRS) Testing

The analytical results for the systematic soil samples were evaluated using the procedure contained in **Appendix C, Volume I** of this Final Status Survey Report (Wilcoxon Rank Sum Test). The evaluation showed that the survey unit soil sample results meet the DP statistical criterion based on the first statistical test as described below.

If the difference (0.70 pCi/g) between the maximum survey unit soil sample activity concentration (1.54 pCi/g) and the minimum reference background area soil sample activity concentration (0.84 pCi/g) is less than $DCGL_W$ (3.0 pCi/g), then the survey unit meets the release criterion. **Table 4** presents a summary of the data used to complete the statistical evaluation of the survey unit.

Table 4 – Reference Group and Survey Unit Sample Results

Reference Group	Sample ID	Th-232 (pCi/g)	Survey Unit Group	Sample ID	Th-232 (pCi/g)
R1	235	1.18	S1	K-435	0.826
R2	268	2.32	S2	K-436	1.04
R3	66	0.84	S3	K-437	1.54
R4	319	1.31	S4	K-438	0.716
R5	173	0.86	S5	K-439	1.08
R6	227	2.25	S6	K-440	1.09
R7	298	1.38	S7	K-441	0.911
R8	150	1.50	S8	K-442	0.679
R9	255	1.42	S9	K-443	0.649
	Average	***1.45***		***Average***	***0.948***
	Std. Dev.	***0.53***		***Std. Dev.***	***0.280***
	Minimum	***0.84***		***Minimum***	***0.649***
	Maximum	***2.32***		***Maximum***	***1.54***
	Median	***1.38***		***Median***	***0.911***

3.0 SUMMARY OF FINDINGS

The removal of radiologically-affected soil from the northwestern portion of the FOA resulted in an open land area consisting of an excavation approximately 228 m^2 in area. This open land area, identified as Survey Unit Kaiser-FSSFOA-001, is considered a Class 1 survey unit. The survey unit is situated northwest of the Maintenance Building, northeast of the North Extrusion Building, and south of the Union Pacific Railroad right-of-way **(Figure 3)**. This section of the sub-report presents a summary of the final status survey findings and an overall summation of fractions for the survey unit.

3.1 Excavation Bottom/Side Wall Surface Soil

The acceptance criterion for open land areas (FOA excavation surface soil) at the Tulsa facility is the $DCGL_W$ of 3.0 pCi/g net Th-232 activity concentration. Final status survey activities for Survey Unit Kaiser-FSSFOA-001 consisted of a gross gamma scan of the exposed surface soil of the survey unit (excavation bottom, northern side wall, eastern side wall, and western side wall) and systematic soil sampling. The results of the final status survey activities were as follows:

- The 100 percent coverage gamma scan (final as-left condition) did not indicate the presence of small areas of elevated activity (above the $DCGL_W$ for the site).
- All 9 systematic soil sample results (gross and net) were below the open land area surrogate value of 3.0 pCi/g net Th-232 activity concentration ($DCGL_W$).
- The analytical results meet the DP statistical criterion based on the first statistical evaluation of the data (WRS Test procedure).
- No elevated areas were left in-place, therefore, no elevated measurement comparisons were required for this unit.

3.2 Sum of Fractions for Entire Survey Unit

To evaluate the status of Survey Unit Kaiser-FSSFOA-001 prior to backfill with clean import borrow material, as a whole (excavation bottom/side wall surface soil, elevated areas, and embedded structures), the fraction of each survey element's average net activity divided by the applicable acceptance criteria is calculated for inclusion in the Sum of Fractions for the entire survey unit. The Total Sum of Fractions for surface soil, elevated areas, and embedded structures respectively is presented below in **Table 5.** As previously mentioned, no embedded structures or elevated areas were left in-place for the survey unit.

Table 5 – Fraction of Applicable Acceptance Criteria per Survey Unit Element

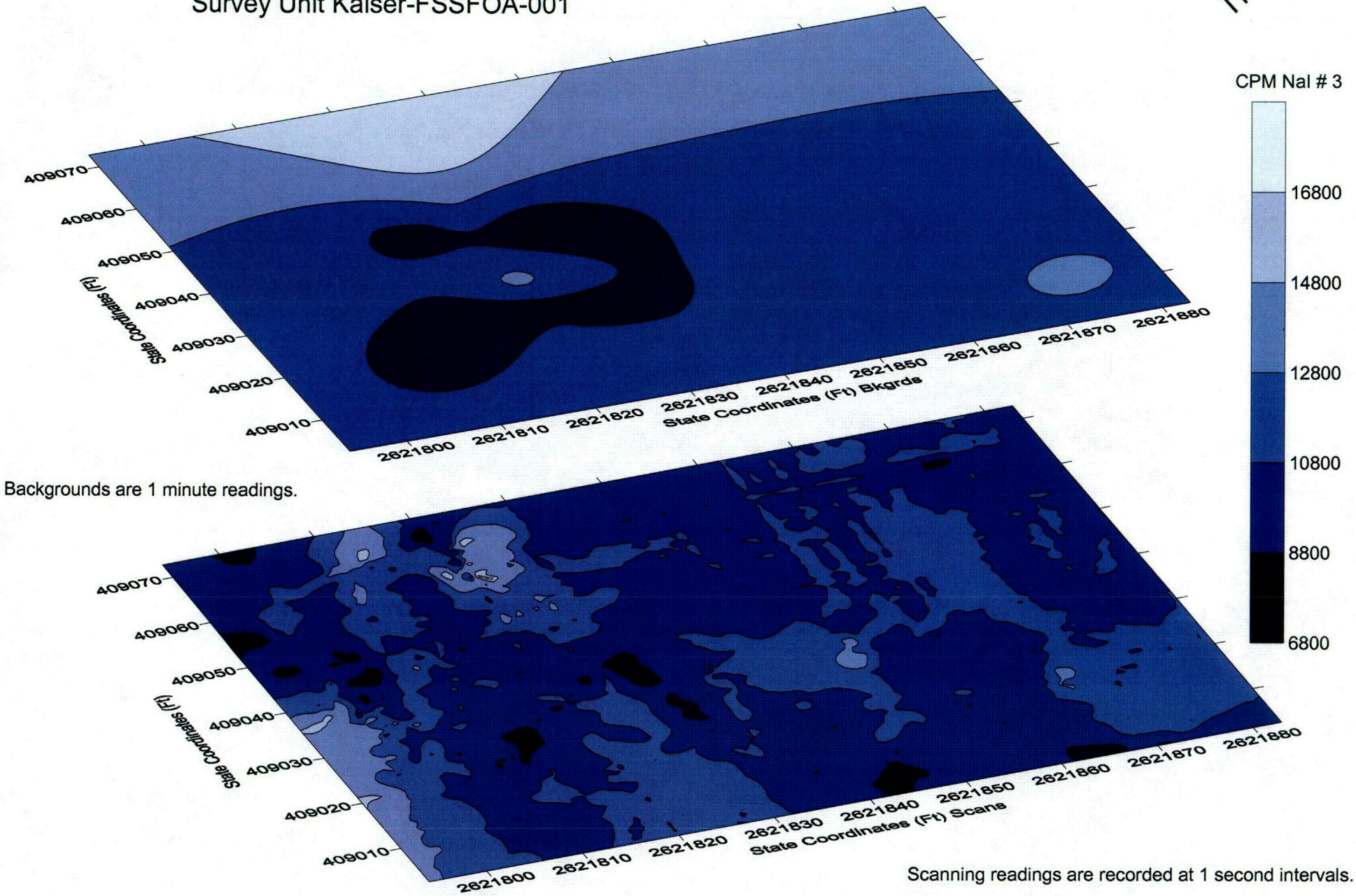
Survey Unit Element	Units	Average Net Activity	Acceptance Criteria	Fraction
-FSSFOA-001 Excavation Surface Soil	pCi/g	0	3.0	0.00
-Elevated Areas (None Left In-Place)	pCi/g	0		0.00
-Embedded Structures (None Left In-Place)	dpm/100cm^2	0		0.00
TOTAL SUM OF FRACTIONS				***0.00***

The Sum of Fractions provides a conservative assessment of the survey unit without backfill. The results of the Sum of Fractions assessment show that Survey Unit Kaiser-FSSFOA-001 meets the DP acceptance criteria.

ATTACHMENT A
TABLE OF CONTENTS

- **FIGURE A-1 Gross Gamma Background and Scanning Survey Results**
- **FIGURE A-2 Biased Soil Sampling Locations**
- **FIGURE A-3 Systematic Soil Sampling Locations**

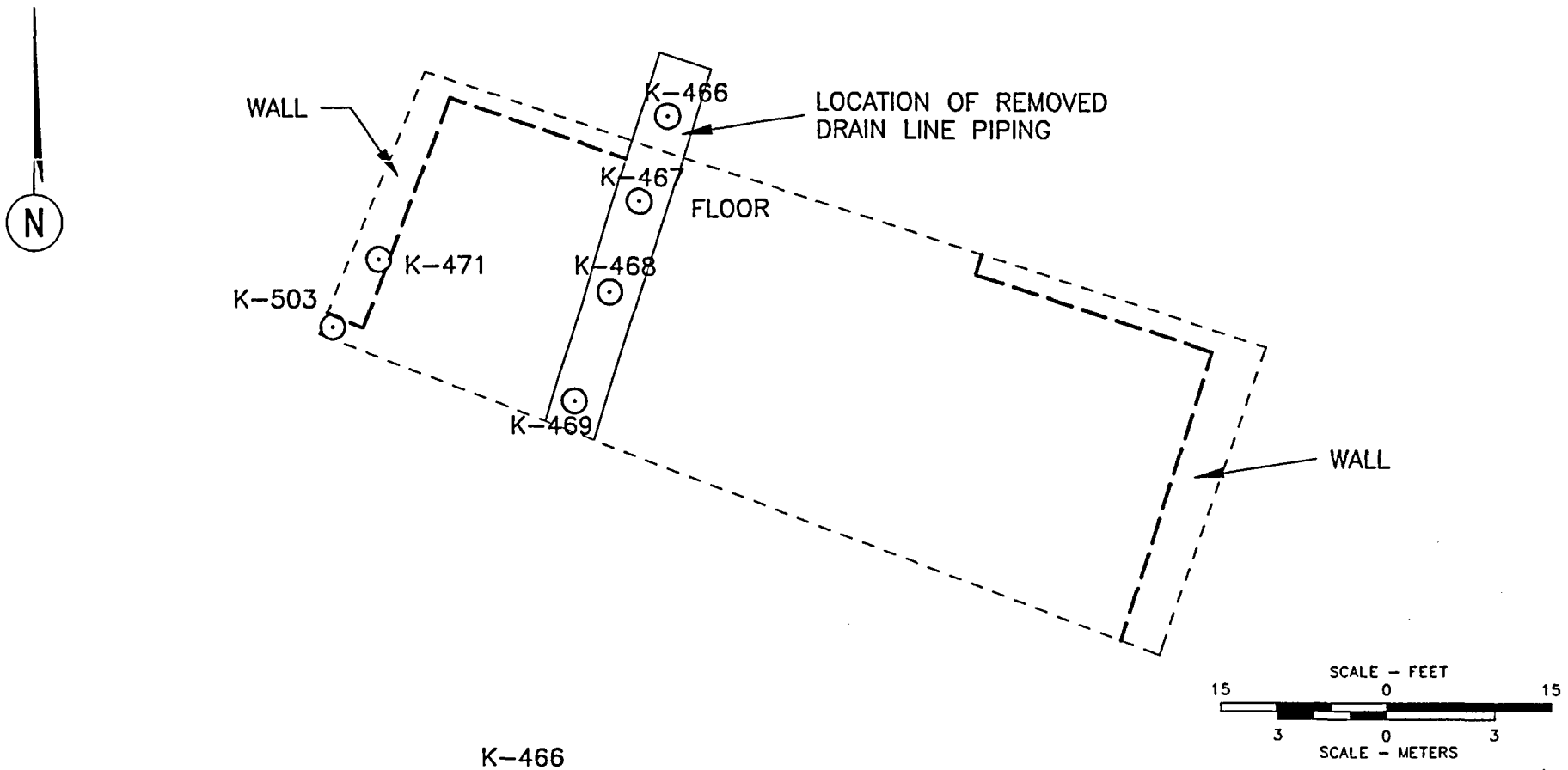
Attachment A, Figure A-1
Gross Gamma Background and Scanning Survey Results
Survey Unit Kaiser-FSSFOA-001



Backgrounds are 1 minute readings.

Scanning readings are recorded at 1 second intervals.

C04



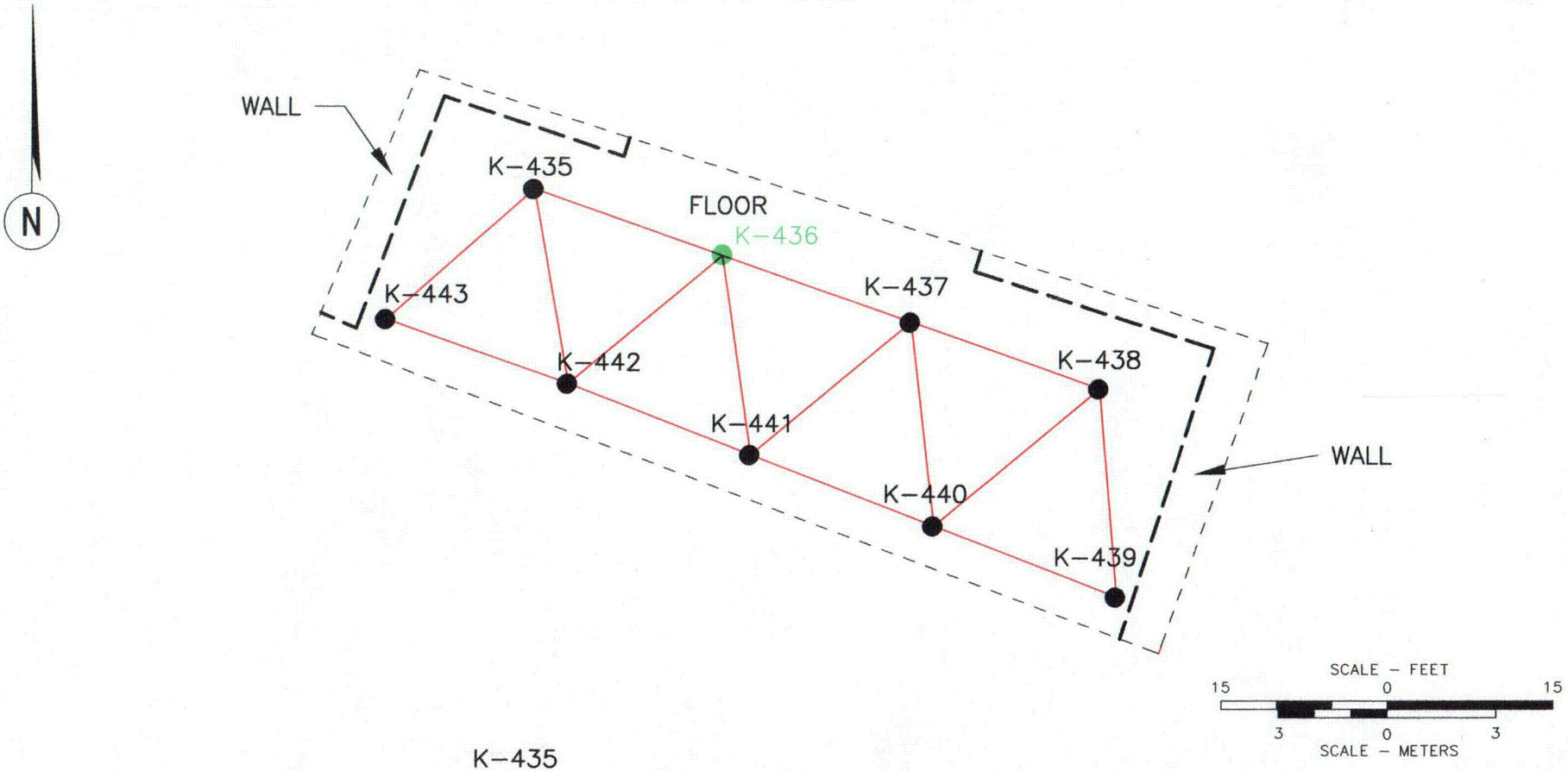
K-466
⊙ BIASED SOIL SAMPLING LOCATION

FIGURE A-2
BIASED SOIL SAMPLING LOCATIONS
SURVEY UNIT KAISER – FSSFOA-001
FINAL STATUS SURVEY
THORIUM REMEDIATION PROJECT
TULSA, OKLAHOMA FACILITY

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
TULSA, OKLAHOMA

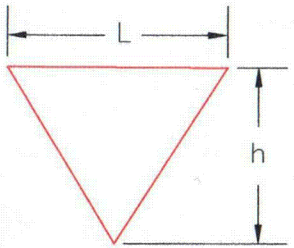
APPROVED	3.3.06
CHECKED	3.3.06
DRAWN	DEB 01/17/06
DRAWING NUMBER	PA4072071A

Penn E&R
Environmental & Remediation, Inc.



K-435
● SYSTEMATIC SOIL SAMPLING LOCATION BASED ON RANDOM START POINT AND AN EQUAL DISTANT TRIANGULAR GRID

K-436
● RANDOM START POINT



N = 9
L = 5.4m
h = 4.7m
AREA = 228m^2

FIGURE A–3
SYSTEMATIC SOIL SAMPLING LOCATIONS SURVEY UNIT KAISER – FSSFOA–001 FINAL STATUS SURVEY THORIUM REMEDIATION PROJECT TULSA, OKLAHOMA FACILITY

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
TULSA, OKLAHOMA

APPROVED	RFD 3-3-06
CHECKED	RFD 3-3-06
DRAWN	DEB 01/17/06
DRAWING NUMBER	PA4072071

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Environmental & Remediation, Inc.

C05

ATTACHMENT B
TABLE OF CONTENTS

- **Soil Survey Unit Worksheet No. 1**
- **Soil Survey Unit Worksheet No. 2**

Soil Survey Unit Work Sheet No. 1
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

1. Soil Survey Unit: KAISER-FSSFOA-001

2. Description: Former Operational Area, North of Survey Unit Kaiser-FSSFOA-004

3. Net Th-232 Acceptance Criteria (pCi/g): 3.0

4. Dimensions (m): Excavation Bottom – Approx. 25 meters x 9 meters; Area, A (m^2): 228

5. Estimate of Gross Gamma Scan Background Readings (cpm)
Average: 20,000 Minimum: 10,000 Maximum: 50,000

6. Based on the maximum background gross gamma scan reading, the scan MDC (Minimum Detectable Concentration of Th-232), the corresponding N (Minimum Number of Required Samples) and L (Triangular Grid Node Length) for a standard 2,000 m^2 Class 1 survey unit are:

- Gross Gamma Scan MDC (pCi/g): 4.0
- Minimum Number of Samples (N): 9 Triangular Grid Node Length (L): 16.0 m

7. If the area of the Survey Unit is less than 2,000 m^2, recalculate the corresponding Triangular Grid Node Length (L_1) for the Survey Unit Area (A), using the following formula: $L_1 = (A/(0.866 \times 9))^{1/2}$: 5.4 m

8. If N is greater than 9 and the A is other than 2,000 m^2, recalculate the corresponding Triangular Grid Node Length (L_1) using the following formula $L_1 = (A/(0.866 \times N))^{1/2}$: N/A

9. If A is greater than 2,000 m^2 and N is equal to 9, recalculate the minimum number of samples (N_1) corresponding to a Triangular Grid Node Length (L) of 16 m using the following formula $N_1 = A / (0.866 \times 16^2)$, N_1: N/A

10. Calculate the height (h) of the equilateral triangle with side length equal to L (or (L_1) using the following formula: $h = ((L^2 - (L/2)^2)^{1/2}$: 4.7 m.

1

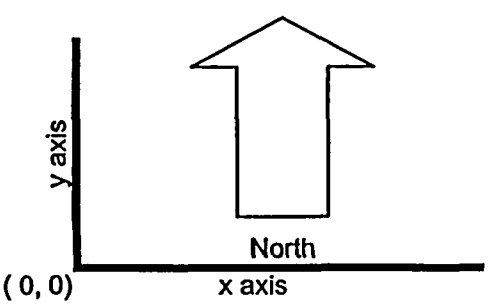
Soil Survey Unit Worksheet No. 2
Random Number Generator for Start Point
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

SURVEY UNIT: KAISER-FSSFOA-001

RANDOM START POINT

x axis (Meters)	y axis (Meters)
9	6

	x axis	y axis
lower bound	0	0
upper bound	25	9



ATTACHMENT C

LABORATORY ANALYTICAL RESULTS

Outreach Laboratory
11 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0003

January 25, 2005

Invoice # 10692
Rec'd 1/26/2005

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20050056

Dear Mr. Weyant:

Please find enclosed the analytical report for your samples received in our laboratory on January 18, 2004 for the above captioned project. Nine soil samples were received in good condition and analyzed for Th-232 by Gamma Spectroscopy without drying and grinding and Percent Moisture with an expedited 5 work day turn. Results were faxed 1/25/05.

All Quality Control for the requested analyses is reported on the analytical report. The laboratory control standard and duplicates for all analyses were within method control limits.

Your samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions, please call us at 918-251-2515.

Laboratory Director

U-435

ODEQ ID #9517
DEQ LIC. #27522-01

ACCREDITED IN ACCORDANCE WITH nelac
CERT. ID #OK001

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050056
Date Reported:	1/25/2005
Date Received:	1/18/05
Page Number:	1 of 3

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050056-01**						
Client ID:	**K-435**						
Date Sampled:	**1/17/2005 10:40:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Ac-228	HASL 300	0.826 +/- 0.100	pCi/g	0.420		1/18/2005	RE
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	11.7	%		1/19/2005	1/20/2005	RT
Lab ID:	**20050056-02**						
Client ID:	**K-436**						
Date Sampled:	**1/17/2005 10:55:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Ac-228	HASL 300	1.04 +/- 0.113	pCi/g	0.251		1/18/2005	RE
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	11.4	%		1/19/2005	1/20/2005	RT
Lab ID:	**20050056-03**						
Client ID:	**K-437**						
Date Sampled:	**1/17/2005 11:10:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Ac-228	HASL 300	1.54 +/- 0.162	pCi/g	0.574		1/18/2005	RE
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	15.7	%		1/19/2005	1/20/2005	RT
Lab ID:	**20050056-04**						
Client ID:	**K-438**						
Date Sampled:	**1/17/2005 11:25:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Ac-228	HASL 300	0.716 +/- 0.080	pCi/g	0.352		1/18/2005	RE
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	24.5	%		1/19/2005	1/20/2005	RT

BDL = Below Detection Limit

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050056
Date Reported:	1/25/2005
Date Received:	1/18/05
Page Number:	2 of 3

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050056-05**						
Client ID:	**K-439**						
Date Sampled:	**1/17/2005 11:40:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Ac-228	HASL 300	1.08 +/- 0.114	pCi/g	0.396		1/18/2005	RE
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	12.6	%		1/19/2005	1/20/2005	RT
Lab ID:	**20050056-06**						
Client ID:	**K-440**						
Date Sampled:	**1/17/2005 11:55:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Ac-228	HASL 300	1.09 +/- 0.096	pCi/g	0.238		1/18/2005	RE
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	14.2	%		1/19/2005	1/20/2005	RT
Lab ID:	**20050056-07**						
Client ID:	**K-441**						
Date Sampled:	**1/17/2005 12:10:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Ac-228	HASL 300	0.911 +/- 0.130	pCi/g	0.475		1/18/2005	RE
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	9.7	%		1/19/2005	1/20/2005	RT
Lab ID:	**20050056-08**						
Client ID:	**K-442**						
Date Sampled:	**1/17/2005 12:25:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Ac-228	HASL 300	0.679 +/- 0.099	pCi/g	0.403		1/18/2005	RE
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	14.5	%		1/19/2005	1/20/2005	RT

BDL = Below Detection Limit

Outreach Laboratory
311 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050056
Date Reported:	1/25/2005
Date Received:	1/18/05
Page Number:	3 of 3

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050056-09**						
Client ID:	**K-443**						
Date Sampled:	**1/17/2005 12:40:00 PM**						
Matrix:	**Soil**						
	Radiochemical Analyses						
Ac-228	HASL 300	0.649 +/- 0.084	pCi/g	0.318		1/18/2005	RE
	Inorganics Analyses						
Percent Moisture	ASTM D2216-92	9.8	%		1/19/2005	1/20/2005	RT

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Ac-228					0.9				1/17/2005
Am-241		99.0	112.0	11.8					1/17/2005
Co-60		93.0	95.0	1.9					1/17/2005
Cs-137		96.0	96.0	0.3					1/17/2005
Percent Moisture					3.7				1/20/2005

Lab Approval: _____

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
Company KAISER Alum & Chem. Inc.
Name Attn: David Weyant
Address 7311 E. 41st Street
City Tulsa State OK Zip 74145
Phone 724-934-3539 Fax # 918-384-3171
LOCAL: 918-384-0566
CELL: 724-799-0071

Bill To:
Company PEAK E&C / KAISER
Name David Weyant
Address 7311 E. 41st Street
City Tulsa State OK Zip 74145

ANALYSIS REQUESTED

PO # KAISER-4072
PROJECT # PA-4000-4072
PROJECT NAME KAISER-Alum & Chem.
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY) 5 T.A.T. DW
SAMPLER David R. Wright
Signature
David R. Wright Dan Banks

LOC SAMPLE ID	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	Gamma Spec 41-232	MDC <0.5 pCi/g	Return to Client for Archive monthly Contract Ashtad 22.16.92	REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
2005005601	K-435	1-17-05	1015	Soil	1	Plastic 500ml		X	X	X	GRAB
02	K-436		1035	Soil	1			X	X	X	
03	K-437		1110	Soil	1			X	X	X	
04	K-438		1125	Soil	1			X	X	X	
05	K-439		1140	Soil	1			X	X	X	
06	K-440		1155	Soil	1			X	X	X	
07	K-441		1210	Soil	1			X	X	X	
08	K-442		1225	Soil	1			X	X	X	
09	K-443		1240	Soil	1			X	X	X	
10											
11											
12											
13											
14											

RELINQUISHED BY: David R. Wright DATE 1/18/05 TIME 0805 RECEIVED BY: DATE 1/18/05 TIME 805

RELINQUISHED BY: DATE TIME RECEIVED BY: DATE TIME

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

FOR LABORATORY USE ONLY

SAMPLE LOGIN

Date Received: *1/18/2005 9:46:55* **Lab Number:** 20050056 **Due:**

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20050056-01 a	K-435	Soil	01/17/05	Plastic	16 oz	None	Yes	Yes
Gamma Spec (NORM)								
Percent Moisture (LOD)								
20050056-02 a	K-436	Soil	01/17/05	Plastic	16 oz	None	Yes	Yes
Gamma Spec (NORM)								
Percent Moisture (LOD)								
20050056-03 a	K-437	Soil	01/17/05	Plastic	16 oz	None	Yes	Yes
Gamma Spec (NORM)								
Percent Moisture (LOD)								
20050056-04 a	K-438	Soil	01/17/05	Plastic	16 oz	None	Yes	Yes
Gamma Spec (NORM)								
Percent Moisture (LOD)								
20050056-05 a	K-439	Soil	01/17/05	Plastic	16 oz	None	Yes	Yes
Gamma Spec (NORM)								
Percent Moisture (LOD)								
20050056-06 a	K-440	Soil	01/17/05	Plastic	16 oz	None	Yes	Yes
Gamma Spec (NORM)								
Percent Moisture (LOD)								
20050056-07 a	K-441	Soil	01/17/05	Plastic	16 oz	None	Yes	Yes
Gamma Spec (NORM)								
Percent Moisture (LOD)								
20050056-08 a	K-442	Soil	01/17/05	Plastic	16 oz	None	Yes	Yes

	Gamma Spec (NORM) Percent Moisture (LOD)								
20050056-09 a	K-443	Soil	01/17/05	Plastic	16 oz	None		Yes	Yes
	Gamma Spec (NORM) Percent Moisture (LOD)								

CONTAINER INSPECTION

 # Coolers 10 **Custody Seals Broken - Y/N** **Temperature** _____ **Blue Ice / Wet Ice** **Radiation Survey** _____**fixed**_____**removable**

SAMPLE INSPECTION

Custody Seals Broken - Y/N 2 **Chain of Custody Record Y/N** 2 **Labels in Tact Y/N** 2 **Radiation Survey Complete Y/N** 2

Anomalies: _____

_____

_____

Inspected By: _____ **DATE** 1/17/05

QA or Designee Review: _____**DATE**_____

Sample Custodian Review:_____**DATE**_____

Project Notes:

Outreach Laboratory
11 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Lucie # 10703
D1. 1/31/05

January 31, 2005

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20050081

Dear Mr. Weyant:

Please find enclosed the analytical report for your samples received in our laboratory on January 25, 2004 for the above captioned project. One soil sample was received in good condition and analyzed for Th-232 by Gamma Spectroscopy without drying and grinding and Percent Moisture with an expedited 5 work day turn. Results were faxed 1/31/05.

All Quality Control for the requested analyses is reported on the analytical report. The laboratory control standard and duplicates for all analyses were within method control limits.

Your samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions, please call us at 918-251-2515.

Laboratory Director

ODEQ ID #9517
DEQ LIC. #27522-01

ACCREDITED IN ACCORDANCE WITH nelac
CERT. ID #OK001

Outreach Laboratory
11 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050081
Date Reported:	1/31/2005
Date Received:	1/25/05
Page Number:	1 of 1

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050081-01**						
Client ID:	**K-503**						
Date Sampled:	**1/24/2005 9:30:00 AM**						
Matrix:	**Soil**						
	Radiochemical Analyses						
Th-232	HASL 300	2.32 +/- 0.161	pCi/g	0.550		1/26/2005	SD
	Inorganics Analyses						
Percent Moisture	ASTM D2216-92	16.7	%		1/24/2005	1/25/2005	RT

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Ac-228					10.7				1/26/2005
Am-241		99.0	89.0	10.6					1/26/2005
Co-60		90.0	93.0	3.3					1/26/2005
Cs-137		96.0	92.0	4.7					1/26/2005
Percent Moisture					12.1				1/25/2005

Lab Approval: _____

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
LOCAL: 918-384-0566
CELL: 724-799-0071
Company KAISER - Alum & Chem Inc.
Name DAVID B. WEYAND
Address 7311 E. 41ST STREET
City TULSA State OK Zip 74145
Phone 724-934-[illegible] Fax # 918-384-3171

Bill To:
Company KAISER / PEER ENG
Name DAVID B. WEYAND / PAUL HAAN
Address 7311 E. 41ST STREET
City TULSA State OK Zip 74145

ANALYSIS REQUESTED

PO # KAISER-4072
PROJECT # PA-4000-4072
PROJECT NAME KAISER-TAR RIVER PEER,
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY) 5 DAY
SAMPLER [signature] Signature
DAVID B. WEYAND

LAB SAMPLE #	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	GAMMA SPEC (Z-232)	RETURN to CLIENT for Analysis	MDC <0.5 pCi/g	ASTM D2216 Moisture Content Test	REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
	K-503	1-24-07	0930	SOIL	1	500ml Plastic	NONE	X	X	X	X	

RELINQUISHED BY: [signature] DATE 1-25 TIME 935 RECEIVED BY: [signature] DATE 1/25/07 TIME 935
DAVID B. WEYAND

RELINQUISHED BY: _____ DATE _____ TIME _____ RECEIVED BY: _____ DATE _____ TIME _____

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

SAMPLE RETURN/DISPOSAL: All non-hazardous samples shall be disposed of 30 days after issue of final report. All others will be returned at client's expense.

FOR LABORATORY USE ONLY

SAMPLE LOGIN

Date Received: *1/25/2005 12:30:4* **Lab Number:** 20050081 **Due:** 2/1/2005

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20050081-01 A	K-503	Soil	01/24/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								

CONTAINER INSPECTION

Coolers 0 Custody Seals Broken - Y/N Temperature _____ Blue Ice / Wet Ice Radiation Survey _____fixed_____removable

SAMPLE INSPECTION

Custody Seals Broken - Y/N 0 Chain of Custody Record Y/N Labels in Tact Y/N Radiation Survey Complete Y/N

Anomalies: _____

Inspected By: _____ DATE 1/25/05

QA or Designee Review: Raymond Thomas DATE 01/25/05

Sample Custodian Review: Michelle Sutton DATE 1-25-05

Project Notes:

SUB-REPORT

SURVEY UNIT KAISER-FSSFOA-002

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2.0 SURVEY ACTIVITIES AND RESULTS	2
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2.2 Systematic Soil Sampling – Excavation Bottom/Side Wall Surface Soil	3
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3.1 Excavation Bottom/Side Wall Surface Soil	6
3.2 Sum of Fractions for Entire Survey Unit	6

ATTACHMENTS

ATTACHMENT A: Figure A-1 Gross Gamma Background and Scanning Survey Results
Figure A-2 Systematic Soil Sampling Locations

ATTACHMENT B: Soil Survey Unit Worksheet No. 1
Soil Survey Unit Worksheet No. 2

ATTACHMENT C: Laboratory Analytical Results

Final Status Survey Report
Volume II – Former Operational Area
Sub-Report No. EB-032
Survey Unit Kaiser-FSSFOA-002
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation
March 22, 2006

1.0 BACKGROUND

This sub-report documents the results of Former Operational Area (FOA) excavation final status survey activities completed as part of the Thorium Remediation Project at the Tulsa, Oklahoma facility (**Figure 1**). Specifically, this technical report addresses the final status survey of Survey Unit Kaiser-FSSFOA-002, an open land area (excavation surface soil) resulting from the removal of radiologically-affected soil located adjacent to a concrete retaining wall. The survey unit is situated at the southeastern corner of the Maintenance Building (**Figure 3**). Survey Unit Kaiser-FSSFOA-002 is considered a Class 1 survey unit with an approximate surface area of 49 m^2.

Survey Unit Kaiser-FSSFOA-002 consists of an excavation bottom surface soil with two side walls (west wall and south wall). No elevated areas were left in-place, therefore, no elevated measurement comparisons were required for this unit. The final status survey of the concrete retaining wall and an embedded sub-footer encountered during the removal of radiologically-affected soil are addressed in a separate sub-report (EB-033).

2.0 SURVEY ACTIVITIES AND RESULTS

This section of the sub-report presents the final status survey data for the excavation bottom, western side wall, and southern side wall surface soil of Survey Unit Kaiser-FSSFOA-002. The final status survey consisted of a gross gamma scan of the exposed surface soil of the survey unit and systematic soil sampling.

2.1 Gross Gamma Scan

The exposed surface soil of the Class 1 survey unit (excavation bottom, western side wall, and southern side wall) was surveyed through a 100 percent coverage gamma scan to confirm acceptable radiological conditions and identify any elevated areas. During the scanning of the soil, the detector was held close to the ground surface (1 to 2 inches) and moved in a serpentine pattern. Background measurements were obtained at 1-meter above the ground surface at 16 approximately equal-distant locations in the survey unit. The statistics for the 16 background measurements are provided below in **Table 1**. Background measurements ranged from 8,152 counts per minute (cpm) to 10,015 cpm moving east to west across the survey unit.

Similar results were obtained for the gross gamma scan of the survey unit's surface area. A total of 350 measurements of gross count rate were made at one second intervals across the survey unit's 49 m^2 surface area. The results ranged from 7,571 cpm to 15,175 cpm. A statistical summary of the 100 percent coverage gamma scan of the survey unit is provided below in **Table 1.**

Table 1 – Gross Gamma Scan Results Summary

Survey Area:	49 m^2	
Number of Scan Measurements (1-Second Intervals)	350	
Scan Rate: (Swinging the detector a width of 1-meter side to side)	0.14 m/s (MARSSIM recommends 0.5m/s)	
Results Summary:	**Background (Gross cpm)**	**Scan (Gross cpm)**
Minimum	8,152	7,571
Maximum	10,015	15,175
Average	9,070	12,307
Standard Deviation	568	1,275
Median	9,061	12,393

Contour maps of the gross gamma background and final (as-left condition) scanning survey results are presented on **Figure A-1** contained in **Attachment A.** The 100 percent coverage gross gamma scan did not indicate the presence of small areas of elevated activity (above the $DCGL_W$ for the site). As part of the gross gamma survey, one biased soil sample (K-470) was collected at a location exhibiting a high scan rate on the excavation floor along the base of the

concrete wall (**Figure A-2, Attachment A**). The sample was forwarded to Outreach for analysis of Th-232 activity concentration. The analytical result is provided below in **Table 2.**

Table 2 – Biased Soil Sample Result

Soil Sample ID	Gross Th-232 (pCi/g)	Std. Error (pCi/g)	MDC (pCi/g)
$DCGL_W$	*3.0*		
Site Background	*1.1*	*0.3*	
K-470	2.12	0.097	0.251

2.2 Systematic Soil Sampling – Excavation Bottom/Side Wall Surface Soil

The final status survey also consisted of systematic soil sampling based on a random start point and an equal-distant triangular grid. The Minimum Number of Samples Required (N) based on the scan MDC was determined to be 9 as documented on Soil Survey Unit Worksheet No. 1 (**Attachment B**). Once N was determined, the Survey Unit Area (A) of 49 m^2 along with the N of 9 were used to calculate the Triangular Grid Node Length (L) of 2.5 meters and the Height of the Equilateral Triangle (h) of 2.2 meters. A random start point was generated using the random number feature of Excel and documented on Soil Survey Unit Worksheet No. 2 (**Attachment B**).

A layout of the soil sampling locations is provided on **Figure A-2** contained in **Attachment A.** The soil sampling locations were demarcated in the field using a GPS unit. A total of 9 soil samples (identified as K-444 through K-452) were collected at the excavation bottom/side wall surface (0-6-inch depth interval) level using a clean, decontaminated sampling auger or sharpshooter shovel. The samples were forwarded to Outreach for analysis of Th-232 activity concentration. Analytical results are provided below in **Table 3.** Analytical data reports are contained in **Attachment C.**

Table 3 – Systematic Soil Sample Results

Soil Sample ID	Gross Th-232 (pCi/g)	Std. Error (pCi/g)	MDC (pCi/g)	Net Th-232 (pCi/g)	Net DCGL (pCi/g)
K-444	1.01	0.098	0.289	0	3.0
K-445	0.756	0.094	0.338	0	3.0
K-446	1.15	1.11	0.250	0.05	3.0
K-447	0.881	0.089	0.272	0	3.0
K-448	0.947	0.044	0.329	0	3.0
K-449	1.33	0.118	0.326	0.23	3.0
K-450	0.912	0.107	0.281	0	3.0
K-451	0.868	0.085	0.347	0	3.0
K-452	0.733	0.072	0.249	0	3.0
Average	***0.954***				
Standard Dev.	***0.189***				
Minimum	***0.733***				
Maximum	***1.33***				
Median	***0.912***				

All 9 systematic soil sample results (gross and net) were below the open land area surrogate value of 3.0 pCi/g net Th-232 activity concentration ($DCGL_W$). The maximum gross Th-232 activity concentration was 1.33 pCi/g, which fell slightly above the background Th-232 activity of 1.1 pCi/g for the site. The average gross Th-232 activity concentration was 0.954 pCi/g. The standard deviation of the 9 equal-distant samples was 0.189, which fell below the estimated standard deviation of 0.42 (based on the adjacent land final status survey results) used to calculate the minimum number of samples required.

2.3 Wilcoxon Rank Sum (WRS) Testing

The analytical results for the systematic soil samples were evaluated using the procedure contained in **Appendix C, Volume I** of this Final Status Survey Report (Wilcoxon Rank Sum Test). The evaluation showed that the survey unit soil sample results meet the DP statistical criterion based on the first statistical test as described below.

If the difference (0.52 pCi/g) between the maximum survey unit soil sample activity concentration (1.33 pCi/g) and the minimum reference background area soil sample activity concentration (0.81 pCi/g) is less than $DCGL_W$ (3.0 pCi/g), then the survey unit meets the release criterion. **Table 4** presents a summary of the data used to complete the statistical evaluation of the survey unit.

Table 4 – Reference Group and Survey Unit Sample Results

Reference Group	Sample ID	Th-232 (pCi/g)	Survey Unit Group	Sample ID	Th-232 (pCi/g)
R1	34	1.11	S1	K-444	1.01
R2	235	1.18	S2	K-445	0.756
R3	153	0.85	S3	K-446	1.15
R4	109	1.27	S4	K-447	0.881
R5	302	1.16	S5	K-448	0.947
R6	183	0.81	S6	K-449	1.33
R7	180	0.96	S7	K-450	0.912
R8	315	0.84	S8	K-451	0.868
R9	236	1.14	S9	K-452	0.733
	Average	***1.04***		***Average***	***0.954***
	Std. Dev.	***0.17***		***Std. Dev.***	***0.189***
	Minimum	***0.81***		***Minimum***	***0.733***
	Maximum	***1.27***		***Maximum***	***1.33***
	Median	***1.11***		***Median***	***0.912***

3.0 SUMMARY OF FINDINGS

The removal of radiologically-affected soil located adjacent to an FOA concrete retaining wall resulted in an open land area consisting of an excavation approximately 49 m^2 in area. This open land area, identified as Survey Unit Kaiser-FSSFOA-002, is considered a Class 1 survey unit. The survey unit is situated at the southeastern corner of the Maintenance Building **(Figure 3)**. The final status survey of the concrete retaining wall and sub-footer (Survey Unit Kaiser-FSSFOA-003) is addressed in a separate sub-report (EB-033). This section of the sub-report presents a summary of the final status survey findings and an overall summation of fractions for the survey unit.

3.1 Excavation Bottom/Side Wall Surface Soil

The acceptance criterion for open land areas (FOA excavation surface soil) at the Tulsa facility is the $DCGL_W$ of 3.0 pCi/g net Th-232 activity concentration. Final status survey activities for Survey Unit Kaiser-FSSFOA-002 consisted of a gross gamma scan of the exposed surface soil of the survey unit (excavation bottom, western side wall, and southern side wall) and systematic soil sampling. The results of the final status survey activities were as follows:

- The 100 percent coverage gamma scan (final as-left condition) did not indicate the presence of small areas of elevated activity (above the $DCGL_W$ for the site).
- All 9 systematic soil sample results (gross and net) were below the open land area surrogate value of 3.0 pCi/g net Th-232 activity concentration ($DCGL_W$).
- The analytical results meet the DP statistical criterion based on the first statistical evaluation of the data (WRS Test procedure).
- No elevated areas were left in-place, therefore, no elevated measurement comparisons were required for this unit.

3.2 Sum of Fractions for Entire Survey Unit

To evaluate the status of Survey Unit Kaiser-FSSFOA-002 prior to backfill with clean import borrow material, as a whole (excavation bottom/side wall surface soil, elevated areas, and embedded structures), the fraction of each survey element's average net activity divided by the applicable acceptance criteria is calculated for inclusion in the Sum of Fractions for the entire survey unit. The Total Sum of Fractions for surface soil and elevated areas is presented below in **Table 5.** As previously mentioned, no elevated areas were left in-place for the survey unit.

Table 5 – Fraction of Applicable Acceptance Criteria per Survey Unit Element

Survey Unit Element	Units	Average Net Activity	Acceptance Criteria	Fraction
-FSSFOA-002 Excavation Surface Soil	pCi/g	0	3.0	0.00
-Elevated Areas (None Left In-Place)	pCi/g	0		0.00
TOTAL SUM OF FRACTIONS				***0.00***

The Sum of Fractions provides a conservative assessment of the survey unit without backfill. The results of the Sum of Fractions assessment show that Survey Unit Kaiser-FSSFOA-002 meets the DP acceptance criteria.

ATTACHMENT A
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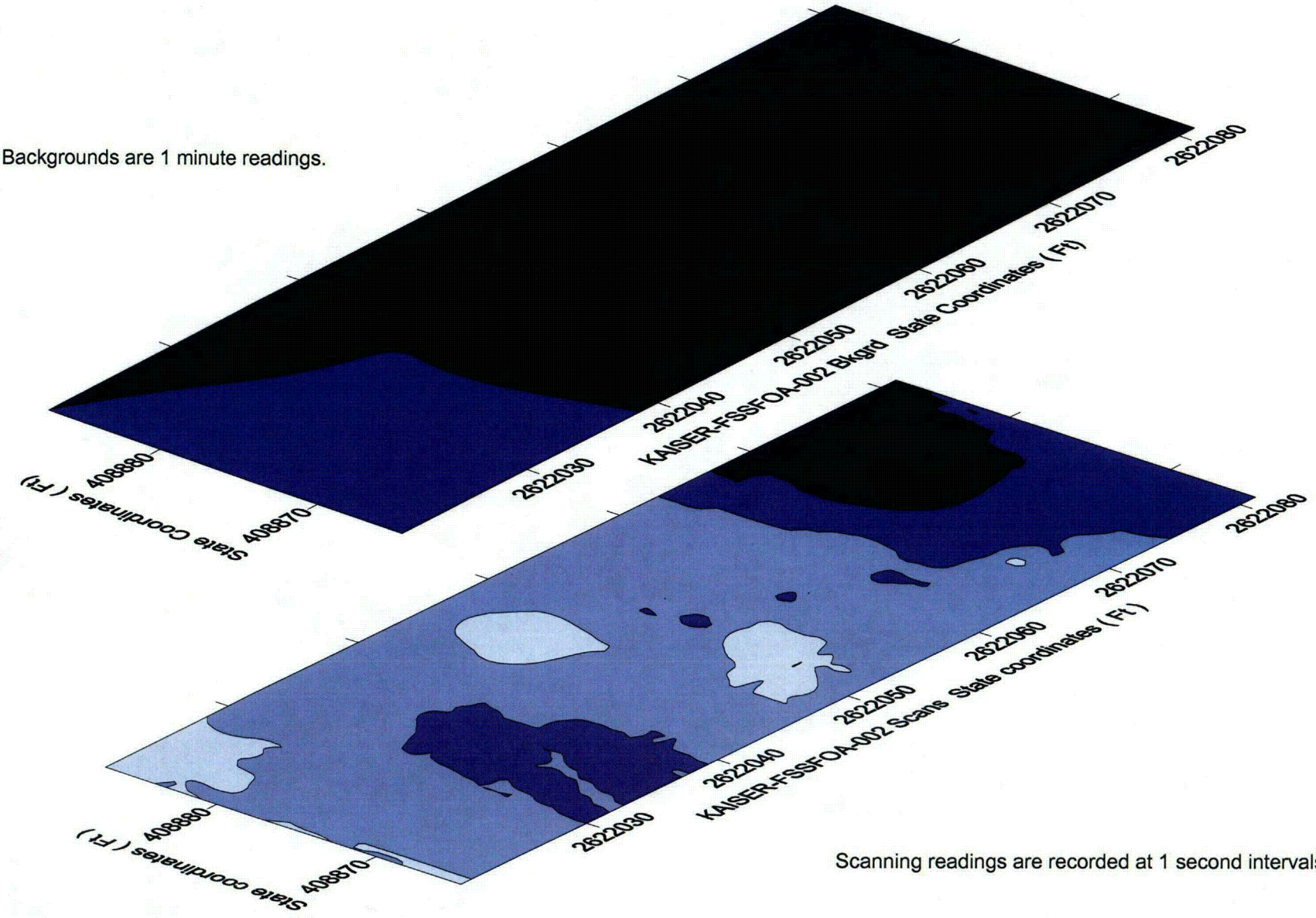
- **FIGURE A-1 Gross Gamma Background and Scanning Survey Results**

- **FIGURE A-2 Systematic Soil Sampling Locations**

Attachment A, Figure A-1
Gross Gamma Background and Scanning Survey Results
Survey Unit Kaiser-FSSFOA-002

Backgrounds are 1 minute readings.

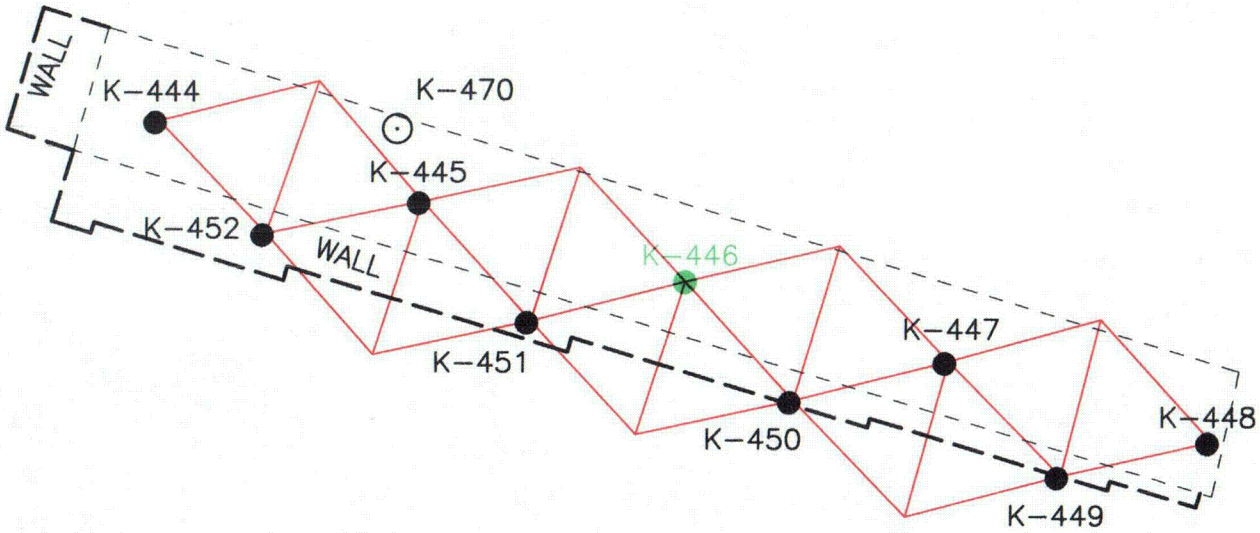


CPM NaI # 3

15500
13500
11500
9500
7500

Scanning readings are recorded at 1 second intervals

C06



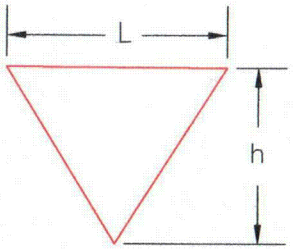
N

SCALE – FEET
10 0 10
3 0 3
SCALE – METERS

K-444
● SYSTEMATIC SOIL SAMPLING LOCATION BASED ON RANDOM START POINT AND AN EQUAL DISTANT TRIANGULAR GRID

K-446
● RANDOM START POINT

K-470
⊙ BIASED SOIL SAMPLING LOCATION BASED ON GROSS GAMMA SCAN RESULTS



N = 9
L = 2.5m
h = 2.2m
AREA = 49m^2

FIGURE A–2
SYSTEMATIC SOIL SAMPLING LOCATIONS
SURVEY UNIT KAISER – FSSFOA–002
FINAL STATUS SURVEY
THORIUM REMEDIATION PROJECT
TULSA, OKLAHOMA FACILITY

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
TULSA, OKLAHOMA

APPROVED	RD 3-3-06
CHECKED	RD 3-3-06
DRAWN	DEB 01/17/06
DRAWING NUMBER	PA4072070

Penn E&R
Environmental & Remediation, Inc.

C07

ATTACHMENT B
TABLE OF CONTENTS

- **Soil Survey Unit Worksheet No. 1**
- **Soil Survey Unit Worksheet No. 2**

Soil Survey Unit Work Sheet No. 1
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

1. Soil Survey Unit: KAISER-FSSFOA-002

2. Description: Former Operational Area, Adjacent to Survey Unit Kaiser-FSSFOA-003

3. Net Th-232 Acceptance Criteria (pCi/g): 3.0

4. Dimensions (m): Excavation Bottom – Approx. 19 meters x 2.6 meters; Area, A (m^2): 49

5. Estimate of Gross Gamma Scan Background Readings (cpm)
Average: 20,000 Minimum: 10,000 Maximum: 50,000

6. Based on the maximum background gross gamma scan reading, the scan MDC (Minimum Detectable Concentration of Th-232), the corresponding N (Minimum Number of Required Samples) and L (Triangular Grid Node Length) for a standard 2,000 m^2 Class 1 survey unit are:

- Gross Gamma Scan MDC (pCi/g): 4.0
- Minimum Number of Samples (N): 9 Triangular Grid Node Length (L): 16.0 m

7. If the area of the Survey Unit is less than 2,000 m^2, recalculate the corresponding Triangular Grid Node Length (L_1) for the Survey Unit Area (A), using the following formula: $L_1 = (A/(0.866 \times 9))^{1/2}$: 2.5 m

8. If N is greater than 9 and the A is other than 2,000 m^2, recalculate the corresponding Triangular Grid Node Length (L_1) using the following formula $L_1 = (A/(0.866 \times N))^{1/2}$: N/A

9. If A is greater than 2,000 m^2 and N is equal to 9, recalculate the minimum number of samples (N_1) corresponding to a Triangular Grid Node Length (L) of 16 m using the following formula $N_1 = A / (0.866 \times 16^2)$, N_1: N/A

10. Calculate the height (h) of the equilateral triangle with side length equal to L (or (L_1) using the following formula: $h = ((L^2 - (L/2)^2)^{1/2}$: 2.2 m.

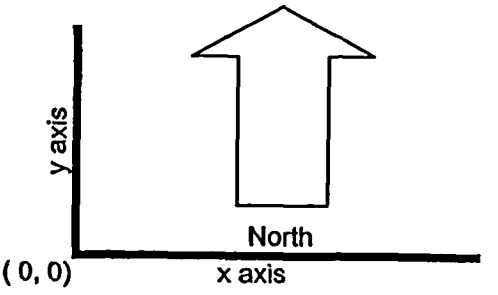
Soil Survey Unit Worksheet No. 2
Random Number Generator for Start Point
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

SURVEY UNIT: KAISER-FSSFOA-002

RANDOM START POINT

x axis (Meters)	y axis (Meters)
11	2

	x axis	y axis
lower bound	0	0
upper bound	19	2.6



ATTACHMENT C

LABORATORY ANALYTICAL RESULTS

Outreach
aboratory
. 1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Invoice # 10607
pd. 12/30/04

December 30, 2004

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20040912

Dear Mr. Weyant:

Please find enclosed the analytical report for your samples received in our laboratory on December 17, 2004 for the above captioned project. Nine soil samples were received in good condition and analyzed for Th-232 by Gamma Spectroscopy without drying and grinding and Percent Moisture with an expedited 5 work day turn. Results were faxed early on 12/22/04.

All Quality Control for the requested analyses is reported on the analytical report. The laboratory control standard and duplicates for all analyses were within method control limits.

Your samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions, please call us at 918-251-2515.

K-nnn

Laboratory Director

ACCREDITED IN ACCORDANCE WITH nelac
CERT. ID #OK001

ODEQ ID #9517
DEQ LIC. #27522-01

Outreach Laboratory
11 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20040912
Date Reported:	12/30/2004
Date Received:	12/17/04
Page Number:	1 of 3

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20040912-01**						
Client ID:	**K-444**						
Date Sampled:	**12/15/2004 12:40:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	1.01 +/- 0.098	pCi/g	0.289		12/17/2004	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	15.6	%		12/17/2004	12/20/2004	RT
Lab ID:	**20040912-02**						
Client ID:	**K-445**						
Date Sampled:	**12/15/2004 12:50:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.756 +/- 0.094	pCi/g	0.338		12/17/2004	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	18.0	%		12/17/2004	12/20/2004	RT
Lab ID:	**20040912-03**						
Client ID:	**K-446**						
Date Sampled:	**12/15/2004 1:00:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	1.15 +/- 1.11	pCi/g	0.250		12/17/2004	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	17.0	%		12/17/2004	12/20/2004	RT
Lab ID:	**20040912-04**						
Client ID:	**K-447**						
Date Sampled:	**12/15/2004 1:10:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.881 +/- 0.089	pCi/g	0.272		12/17/2004	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	18.6	%		12/17/2004	12/20/2004	RT

BDL = Below Detection Limit

Outreach Laboratory
:1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0003

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20040912
Date Reported:	12/30/2004
Date Received:	12/17/04
Page Number:	2 of 3

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20040912-05**						
Client ID:	**K-448**						
Date Sampled:	**12/15/2004 1:20:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.947 +/- 0.044	pCi/g	0.329		12/17/2004	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	18.6	%		12/17/2004	12/20/2004	RT
Lab ID:	**20040912-06**						
Client ID:	**K-449**						
Date Sampled:	**12/15/2004 1:30:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	1.33 +/- 0.118	pCi/g	0.326		12/17/2004	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	17.8	%		12/17/2004	12/20/2004	RT
Lab ID:	**20040912-07**						
Client ID:	**K-450**						
Date Sampled:	**12/15/2004 1:40:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.912 +/- 0.107	pCi/g	0.281		12/17/2004	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	17.1	%		12/17/2004	12/20/2004	RT
Lab ID:	**20040912-08**						
Client ID:	**K-451**						
Date Sampled:	**12/15/2004 1:50:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.868 +/- 0.085	pCi/g	0.347		12/17/2004	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	18.1	%		12/17/2004	12/20/2004	RT

BDL = Below Detection Limit

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0083

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20040912
Date Reported:	12/30/2004
Date Received:	12/17/04
Page Number:	3 of 3

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20040912-09**						
Client ID:	**K-452**						
Date Sampled:	**12/15/2004 2:00:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.733 +/- 0.072	pCi/g	0.249		12/17/2004	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	20.3	%		12/17/2004	12/20/2004	RT

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Ac-228					NC				12/17/2004
Am-241		93.0	87.0	6.5					12/17/2004
Co-60		94.0	93.0	1.3					12/17/2004
Cs-137		94.0	98.0	3.9					12/17/2004
Percent Moisture					1.0				12/20/2004

Lab Approval:

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
LOCAL: 918-384-0566
Cell: 724-799-6071

Company: KAISER - Alum & Chem INC.
Name: ATT'N: DAVID R. WEVADT
Address: 7311 E. 41ST STREET
City: TULSA State: OK Zip: 74145
Phone: 724-934-3330 Fax #: 918-384-3171

Bill To:
Company: BECHTEL E&R / KAISER
Name: DAVID R. WEVADT / PAUL HAMM
Address: 7311 E. 41ST STREET
City: TULSA State: OK Zip: 74145

ANALYSIS REQUESTED

PO #: KAISER-4072
PROJECT #: PA-4000-4072
PROJECT NAME: KAISER - Alum & Chem.
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY): mixed see AR.
SAMPLER: Signature — Daniel Baker

LOC SAMPLE ID	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE (PLASTIC OR GLASS)	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	GAMMA spec 1A-232	MDC, LOD's per Ops	Return to client for disposal	5 day turn *	20 day turn	Master Contract			REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
001	K-444	12/15/04	1240	Soil	1	500ml Plastic	None	X	X	X	X		X			* Results of 5 day
002	K-445	"	1250	Soil	1	"	"	X	X	X	X		X			turn requested to be
003	K-446	"	1300	Soil	1	"	"	X	X	X	X		X			reported seperate of
004	K-447	"	1310	Soil	1	"	"	X	X	X	X		X			20 day turn samples.
005	K-448	"	1320	Soil	1	"	"	X	X	X	X		X			Please do not hold
006	K-449	"	1330	Soil	1	"	"	X	X	X	X		X			report.
007	K-450	"	1340	Soil	1	"	"	X	X	X	X		X			
008	K-451	"	1350	Soil	1	"	"	X	X	X	X		X			
009	K-452	"	1400	Soil	1	"	"	X	X	X	X		X			
010	K-453			Soil	1			X	X	X	X	12-13-04	X			
011	K-454	12/15/04	1515	Soil	1	500ml	None	X	X	X		X	X			
012	K-455	"	1500	"	1	"	"	X	X	X		X	X			
013	K-456	"	1430	"	1	"	"	X	X	X	X		X			
014	Trip Blank	N/A	N/A	N/A	N/A	N/A	N/A									

RELINQUISHED BY: [signature] DATE 12/16/04 TIME 0835 RECEIVED BY: [signature] DATE 12/17/04 TIME 835

RELINQUISHED BY: _____ DATE _____ TIME _____ RECEIVED BY: _____ DATE _____ TIME _____

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

SAMPLE RETURN/DISPOSAL: All non-hazardous samples shall be disposed of 30 days after issue of final report. All others will be returned at client's expense.

FOR LABORATORY USE ONLY

SAMPLE LOGIN

Date Received: *12/17/2004 10:01:* **Lab Number:** 20040912 **Due:** 12/23/2004

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20040912-01 A	K-444	Water	12/15/04	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20040912-02 A	K-445	Water	12/15/04	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20040912-03 A	K-446	Water	12/15/04	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20040912-04 A	K-447	Water	12/15/04	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20040912-05 A	K-448	Water	12/15/04	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20040912-06 A	K-449	Water	12/15/04	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20040912-07 A	K-450	Water	12/15/04	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20040912-08 A	K-451	Water	12/15/04	Plastic	16 oz	None	Yes	Yes

	Percent Moisture (LOD) Th-232 by Gamma Spec								
20040912-09 A	K-452	Water	12/15/04	Plastic	16 oz	None		Yes	Yes
	Percent Moisture (LOD) Th-232 by Gamma Spec								

CONTAINER INSPECTION

 # Coolers 1 . Custody Seals Broken - Y/N Temperature _____ Blue Ice / Wet Ice Radiation Survey _____fixed_____removable

SAMPLE INSPECTION

Custody Seals Broken - Y/N N Chain of Custody Record Y/N Labels in Tact Y/N Radiation Survey Complete Y/N

Anomalies: _____

_____

_____

Inspected By: _____ **DATE** 12/17/04

QA or Designee Review: _____ **DATE** _____

Sample Custodian Review: _____ **DATE** _____

Project Notes:

Outreach Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Invoice # 10694
DL- 1/26/05

January 25, 2005

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20050055

Dear Mr. Weyant:

Please find enclosed the analytical report for your samples received in our laboratory on January 17, 2004 for the above captioned project. One soil sample was received in good condition and analyzed for Th-232 by Gamma Spectroscopy without drying and grinding and Percent Moisture with an expedited 5 work day turn. Results were faxed 1/25/05.

All Quality Control for the requested analyses is reported on the analytical report. The laboratory control standard and duplicates for all analyses were within method control limits.

Your samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions, please call us at 918-251-2515.

Laboratory Director

ODEQ ID #9517
DEQ LIC. #27522-01

K-470

ACCREDITED IN ACCORDANCE WITH nelac
CERT. ID #OK001

Outreach Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050055
Date Reported:	1/25/2005
Date Received:	1/17/05
Page Number:	1 of 1

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050055-01**						
Client ID:	**K-470**						
Date Sampled:	**1/14/2005 11:50:00 AM**						
Matrix:	**Soil**						
	Radiochemical Analyses						
Ac-228	HASL 300	2.12 +/- 0.097	pCi/g	0.251		1/17/2005	E/D
	Inorganics Analyses						
Percent Moisture	ASTM D2216-92	13.1	%		1/17/2005	1/18/2005	RT

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Ac-228					0.9				1/17/2005
Am-241		99.0	112.0	11.8					1/17/2005
Co-60		93.0	95.0	1.9					1/17/2005
Cs-137		96.0	96.0	0.3					1/17/2005
Percent Moisture					8.4				1/18/2005

Lab Approval: _____

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
Company KAISER-Alum & Chem Corp
Name DAVID G. WEYANT
Address 7311 E. 41ST STREET
City TULSA State OK Zip 74145
Phone 724 934-3530 Fax # 918-384-3171

LOCAL 918-384-0566
CELL: 724-799-0071

Bill To:
Company KAISER-/PSS E&C
Name DAVID G. WEYANT / PAUL HARRIS
Address 7311 E. 41ST ST.
City TULSA State OK Zip 74145

ANALYSIS REQUESTED

PO # KAISER 4072
PROJECT # PA-4000-4072
PROJECT NAME KAISER-Thorium REMED.
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY) 5 DAY T.A.T.
SAMPLER David G. Weyant
Signature
DAVID G. WEYANT

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	GAMMA SPEC (Th-232)	RADIUM 226 + DAUGHTERS (Ra-226 & Ra-228)	MDC < 0.5 pCi/g	ASTM D2216-92 MOISTURE (Soil Only)				REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
	K-470	1-14-05	11:50	Drum Cuttings	1	500 ml PLASTIC	NONE	X	X	X	X				GRAB

RELINQUISHED BY: David G. Weyant DATE 1-17-05 TIME 0930 RECEIVED BY: _____ DATE 1/19/05 TIME 830

RELINQUISHED BY: _____ DATE _____ TIME _____ RECEIVED BY: _____ DATE _____ TIME _____

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

FOR LABORATORY USE ONLY

SAMPLE LOGIN

Date Received: *1/17/2005 9:25:53* Lab Number: 20050055 Due: 1/21/2005

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20050055-01 a	K-470	Soil	01/14/05	Plastic	16 oz	None	Yes	Yes
Gamma Spec (NORM)								
Percent Moisture (LOD)								

CONTAINER INSPECTION

Coolers NA Custody Seals Broken - Y/N (N) Temperature N/A Blue Ice / Wet Ice Radiation Survey 4305 fixed NA removable

SAMPLE INSPECTION

Custody Seals Broken - Y/(N) Chain of Custody Record (Y)/N Labels in Tact (Y)/N Radiation Survey Complete (Y)/N

Anomalies: _____

Inspected By: _____ DATE 1/17/05

QA or Designee Review: Raymond Otoms DATE 01/17/05

Sample Custodian Review: Michelle Sattow DATE 1/17/05

Project Notes:

SUB-REPORT

SURVEY UNIT KAISER-FSSFOA-003

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3.0 SUMMARY OF FINDINGS	9
3.1 Structural Surface – Total and Removable Alpha Contamination	9
3.2 Sum of Fractions for Entire Survey Unit	9

ATTACHMENTS

ATTACHMENT A: Figure A-1 Gross Alpha Scan Grid Layout
Figure A-2 Systematic Sampling Locations
Alpha Scan MDC Calculation Form
Total Alpha Contamination Survey Data Conversion Forms
Table A-1 Gross Alpha Scan Results Summary

ATTACHMENT B: Survey Unit Worksheet No. 1
Survey Unit Worksheet No. 2

ATTACHMENT C: Laboratory Analytical Results

Final Status Survey Report
Volume II – Former Operational Area
Sub-Report No. EB-033
Survey Unit Kaiser-FSSFOA-003
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation
March 22, 2006

1.0 BACKGROUND

This sub-report documents the results of Former Operational Area (FOA) excavation final status survey activities completed as part of the Thorium Remediation Project at the Tulsa, Oklahoma facility (**Figure 1**). Specifically, this technical report addresses the final status survey of Survey Unit Kaiser-FSSFOA-003, a structure (cinderblock wall) encountered during the removal of radiologically-affected soil from the Survey Unit Kaiser-FSSFOA-002 (**Figure 3**). Survey Unit Kaiser-FSSFOA-003 consists of the cinderblock wall's structural surface. It is considered a Class 1 survey unit with an approximate surface area of 30 m^2. An additional embedded structure was encountered during the removal of radiologically-affected soil from the Survey Unit Kaiser-FSSFOA-002. A small concrete sub-footer of approximately 5 m^2 (located directly across the excavation from the cinderblock wall) was also surveyed and the results presented in this sub-report. No elevated areas were left in-place, therefore, no elevated measurement comparisons were required for this unit.

2.0 SURVEY ACTIVITIES AND RESULTS

This section of the sub-report presents the final status survey data for the structural surface of the cinderblock wall and concrete sub-footer defined as Survey Unit Kaiser-FSSFOA-003. The final status survey consisted of a gross alpha scan of the cinderblock and concrete surfaces and systematic measurements of total and removable alpha contamination. The supporting documentation for the final status survey of the cinderblock wall and concrete sub-footer's structural surface is contained in **Attachment A** and includes the following:

- **Figure A-1,** Gross Alpha Scan Grid Layout
- **Figure A-2,** Systematic Sampling Locations
- Alpha Scan MDC Calculation
- Total Alpha Contamination Survey Data Conversion Forms
- **Table A-1,** Gross Alpha Scan Results Summary

2.1 Gross Alpha Scan of Structural Surface

The structural surface of the Class 1 survey unit was surveyed through a 100 percent coverage gross alpha scan, to confirm acceptable radiological conditions and identify any elevated areas. The structural surface was divided into 1-meter by 1-meter grids for recording the results of the 100 percent coverage gross alpha scan (**Figure A-1, Attachment A**). Minimum, maximum, and average scan rates for alpha activity in gross counts per minute (cpm) were recorded for each grid. The results of the scanning activities are summarized in **Table A-1** contained in **Attachment A.** The 100 percent coverage gross alpha scan of the structural surface did not indicate the presence of small areas of elevated activity (above the DCGL-GA for the site).

2.2 Systematic Measurements of Total and Removable Alpha Contamination

The final status survey of the cinderblock wall also consisted of systematic measurements of total and removable alpha contamination based on a random start point and an equal-distant triangular grid. Three equal-distant measurements of total and removable contamination were also taken on the concrete sub-footer. Since the DCGL values for total and removable contamination contained in the DPA have been revised (and approved by the NRC), the minimum number of sample points for the measurement of total and removable alpha contamination has been recalculated. Since scanning measures total alpha contamination, the minimum number of sample points required (N) is re-determined if the alpha scan minimum detectable concentration (MDC) is greater than the total contamination DCGL.

2.2.1 Determination of the Minimum Number of Sample Points (N)

Paramount to determining the minimum number of sample points is the determination of the relative shift, delta over sigma (Δ/σ). Delta is equal to the difference between the DCGL and the lower-bound gray region (LBGR) value. The LBGR value is arbitrarily set at one-half the

DCGL value to start the determination. Sigma is an estimate of the variability in a set of sample analysis results from a survey unit. The estimate of sigma used in the determination is based on the standard deviation of a set of total alpha contamination results from the final status survey of the Flux Building (Survey Unit FB-001 Floor Surface: 45.9). Since the gross alpha activity of 944 dpm/100cm^2 is the revised DGCL-GA, Δ is equal to 944 - 472, or 472. Delta divided by the sigma of 45.9 results in a relative shift of 10.3. The minimum number of samples (looked up in Table 5.3 of MARSSIM) corresponding to alpha and beta error rates of 0.05 and a relative shift of 10.3 is 9.

2.2.2 Adjusting N Based on Scan Minimum Detectable Contamination (MDC)

The scan of structural surfaces is used to detect elevated areas. The total contamination DCGL value applicable to final status surveys of structures for the Tulsa site is the DCGL-GA (DCGL gross alpha) and the value is 944 dpm/100cm^2 of total alpha contamination. Since the background count rate for gross alpha is usually very low, e.g., 1 count per minute (cpm), MARSSIM provides guidance for determining the scanning MDC for gross alpha based on the probability of detecting very small increments in gross alpha count rate, i.e., one of two counts. For a typical alpha background level of less than 3 cpm, the probability of detecting a single count while passing over the contaminated area is:

$$P(n \geq 1) = 1 - e^{\frac{-GEd}{60v}}$$

where:

P(n ≥ 1) = probability of observing a single count,
G = activity (dpm),
E = 4π detector efficiency (cpd),
d = width of detector in direction of scan (cm), and
v = scan speed (cm/s).

Increase the value of G until the corresponding probability equals the desired confidence level, e.g., 95 percent, and the resulting dpm is the MDC. (The dpm value may be divided by the active area of the detector, e.g., 100 cm^2 to yield an MDC result in dpm/100cm^2.) This method of determining the alpha scan MDC is not background dependent (assuming the background alpha count rate is low). However, the calculated MDC is dependent on the scan speed. Using this formula and typical alpha efficiencies for gas proportional detectors, the calculated scan MDC range from 330 to 1,000 dpm/100cm^2 based on scan speeds of a third of a detector width to one detector width per second. *This range of MDC values is the same magnitude as the DCGL-GA and does not result in an increase in the minimum number of samples required.*

The Minimum Number of Samples Required (N) was determined to be 9 as documented on Survey Unit Worksheet No. 1 (**Attachment B**). However, the number of sample points used was 18 for the cinderblock wall. The Survey Unit Area (A) of 30 m^2 along with the N of 18 were used to calculate the Triangular Grid Node Length (L) of 1.4 meters and the Height of the Equilateral Triangle (h) of 1.2 meters. A random start point was generated using the random number feature of Excel and documented on Survey Unit Worksheet No. 2 (**Attachment B**).

2.2.3 Total and Removable Alpha Contamination Measurement Results

A layout of the total and removable alpha contamination measurement locations is provided on **Figure A-2** contained in **Attachment A.** At each of the 18 locations on the cinderblock wall, a measurement (static count with a gas proportional detector) of total alpha contamination (identified as MARSSIM-001 through MARSSIM-018) and a smear sample for determination of removable alpha contamination (identified as K-SS-048 through K-SS-065) were collected on the cinderblock wall surface. Three of the locations (K-SS-053, K-SS-061, and K-SS-062) were subsequently re-sampled (Smear Samples K-SS-066, K-SS-067, and K-SS-068) after remediation. The smear samples were forwarded to Outreach for analysis of alpha activity (per the 100 cm^2 surface area sampled).

Three additional systematic measurements of total and removable contamination were taken on the concrete sub-footer surface. The total alpha contamination measurements were identified as A1 subfooter through C1 subfooter and the smear samples for determination of removable alpha contamination were identified as K-SS-071 through K-SS-073.

Total alpha contamination measurement results are provided below in **Table 1.**

Table 1 – Systematic Total Alpha Contamination Measurement Results

Sample ID	DCGL-GA (dpm/100cm^2)	Total Alpha Contamination (dpm/100cm^2)	Std. Error (dpm/100cm^2)	MDC (dpm/100cm^2)
MARSSIM-001	944	127	84.9	117
MARSSIM-002	944	225	103	117
MARSSIM-003	944	323	118	117
MARSSIM-004	944	314	117	117
MARSSIM-005	944	-16.1	48.1	117
MARSSIM-006	944	37.5	64.4	117
MARSSIM-007	944	-25.0	44.8	117
MARSSIM-008	944	19.6	59.5	117
MARSSIM-009	944	46.4	66.8	117
MARSSIM-010	944	-33.9	41.3	117
MARSSIM-011	944	55.4	69.0	117
MARSSIM-012	944	180	95.1	117
MARSSIM-013	944	359	123	117
MARSSIM-014	944	-51.8	33.0	117
MARSSIM-015	944	261	109	117
MARSSIM-016	944	55.4	69.0	117
MARSSIM-017	944	19.6	59.5	117
MARSSIM-018	944	162	91.9	117
A1 subfooter	944	44.6	63.1	110
B1 subfooter	944	545	145	110
C1 subfooter	944	339	119	110
Average		***142***		
Standard Dev.		***163***		
Minimum		***-51.8***		
Maximum		***545***		
Median		***55.4***		

All 21 systematic total alpha contamination measurements were below the DCGL-GA of 944 dpm/100cm^2. The maximum total alpha contamination result was 545 dpm/100cm^2. The average total alpha contamination result was 142 dpm/100cm^2.

The standard deviation of the 21 equal-distant samples was 163, greater than the estimated standard deviation of 45.9 (based on the Flux Building Survey Unit FB-001 final status survey results) used to calculate the minimum number of samples (N) required. Using the observed standard deviation of 163 and the same methodology to determine N as presented in **Section 2.2.1** above, a relative shift of 2.9 results. The N from Table 5.3 (MARSSIM) corresponding to a relative shift of 2.9 is 10 for a 100 m^2 survey unit.

Analytical results of the smear samples are provided below in **Table 2.** The analytical data reports are contained in **Attachment C.**

Table 2 – Systematic Removable Alpha Contamination Smear Sample Results

Sample ID	DCGL-GA (dpm/100cm^2)	Removable Alpha Contamination (dpm/100cm^2)	Std. Error (dpm/100cm^2)	MDC (dpm/100cm^2)
MARSSIM-001 (K-SS-048)	94.4	0.689	0.507	0.350
MARSSIM-002 (K-SS-049)	94.4	0.624	0.496	0.355
MARSSIM-003 (K-SS-050)	94.4	0.631	0.495	0.350
MARSSIM-004 (K-SS-051)	94.4	0.258	0.636	0.287
MARSSIM-005 (K-SS-052)	94.4	0	0.327	0.162
MARSSIM-006 (K-SS-066)	94.4	7.48	1.78	0.673
MARSSIM-007 (K-SS-054)	94.4	0.862	0.544	0.158
MARSSIM-008 (K-SS-055)	94.4	0.397	0.469	0.177
MARSSIM-009 (K-SS-056)	94.4	0.573	0.482	0.158
MARSSIM-010 (K-SS-057)	94.4	0.277	0.411	0.160
MARSSIM-011 (K-SS-058)	94.4	0.400	0.440	0.158
MARSSIM-012 (K-SS-059)	94.4	1.12	0.772	0.287
MARSSIM-013 (K-SS-060)	94.4	0.617	0.498	0.162
MARSSIM-014 (K-SS-067)	94.4	0.637	0.788	0.673
MARSSIM-015 (K-SS-068)	94.4	0.155	0.666	0.673
MARSSIM-016 (K-SS-063)	94.4	0.628	0.521	0.177
MARSSIM-017 (K-SS-064)	94.4	0.226	0.394	0.158
MARSSIM-018 (K-SS-065)	94.4	0.508	0.470	0.160
A1 subfooter (K-SS-071)	94.4	0.241	0.466	0.425
B1 subfooter (K-SS-072)	94.4	4.36	1.16	0.509
C1 subfooter (K-SS-073)	94.4	2.34	0.849	0.369
Average		***1.10***		
Standard Dev.		***1.74***		
Minimum		***0***		
Maximum		***7.48***		
Median		***0.617***		

All 21 smear sample results were below the removable alpha contamination DCGL-GA of 94.4 dpm/100cm^2 (10% of the total contamination DCGL-GA value). The maximum removable alpha contamination result was 7.48 dpm/100cm^2. The average removable alpha contamination result was 1.10 dpm/100cm^2, less than 1% of the average total alpha contamination result.

2.3 Wilcoxon Rank Sum (WRS) Testing

The total alpha contamination results were evaluated using the procedure contained in **Appendix C, Volume I** of this Final Status Survey Report (Wilcoxon Rank Sum Test). The evaluation showed that the survey unit total alpha contamination results meet the DP statistical criterion based on the first statistical test described below.

If the difference (545 dpm/100cm^2) between the maximum survey unit total alpha contamination result (545 dpm/100cm^2) and the minimum reference background area total alpha contamination result (0 dpm/100cm^2) is less than DCGL-GA (944 dpm/100cm^2), then the survey unit meets the release criterion. **Table 3** presents a summary of the data used to complete the statistical evaluation of the survey unit. Since the survey unit consisted of 18 cinderblock surface sample points and 3 concrete surface sample points, the reference group selected consisted of 18 cinderblock surface background values and 3 concrete surface values.

Table 3 – Reference Area and Survey Unit Total Alpha Contamination Results

Reference Group	Sample ID	Total Alpha Contamination (dpm/100cm^2)	Survey Unit Group	Sample ID	Total Alpha Contamination (dpm/100cm^2)
R1	12	30.2	S1	MARSSIM-001	127
R2	42	40.3	S2	MARSSIM-002	225
R3	52	29.5	S3	MARSSIM-003	323
R4	3	13.8	S4	MARSSIM-004	314
R5	5	30.2	S5	MARSSIM-005	-16.1
R6	45	3.93	S6	MARSSIM-006	37.5
R7	6	111	S7	MARSSIM-007	-25.0
R8	1	10.1	S8	MARSSIM-008	19.6
R9	66	26.2	S9	MARSSIM-009	46.4
R10	29	10.1	S10	MARSSIM-010	-33.9
R11	16	80.5	S11	MARSSIM-011	55.4
R12	55	12.1	S12	MARSSIM-012	180
R13	26	30.2	S13	MARSSIM-013	359
R14	69	26.2	S14	MARSSIM-014	-51.8
R15	48	43.2	S15	MARSSIM-015	261
R16	11	0	S16	MARSSIM-016	55.4
R17	40	20.1	S17	MARSSIM-017	19.6
R18	60	2.01	S18	MARSSIM-018	162
R19	75	62.9	S19	MARSSIM-019	44.6
R20	53	66.4	S20	MARSSIM-020	545
R21	50	33.4	S21	MARSSIM-021	339
	Average:	***32.5***		***Average:***	***142***
	Standard Dev.	***27.8***		***Standard Dev.***	***163***
	Minimum:	***0***		***Minimum:***	***-51.8***
	Maximum:	***111***		***Maximum:***	***545***
	Median:	***29.5***		***Median:***	***55.4***

3.0 SUMMARY OF FINDINGS

Two structures (a cinderblock wall and a concrete sub-footer) were encountered during the removal of radiologically-affected soil from FOA Survey Unit Kaiser-FSSFOA-002 **(Figure 3)**. These structures, identified as Survey Unit Kaiser-FSSFOA-003 are considered a Class 1 survey unit with an approximate surface area of 35 m^2. This section of the sub-report presents a summary of the final status survey findings and an overall summation of fractions for the survey unit.

3.1 Structural Surface - Total and Removable Alpha Contamination

The acceptance criterion for structures remaining at the Tulsa facility is the DCGL-GA of 944 dpm/100cm^2 for total alpha contamination and 94.4 dpm/100cm^2 for removable alpha contamination. Final status survey activities for Survey Unit Kaiser-FSSFOA-003 consisted of a gross alpha scan of the exposed structural surface of the survey unit and systematic measurements of total and removable alpha contamination. The results of the final status survey activities were as follows:

- The 100 percent coverage gross alpha scan of the structural surface did not indicate the presence of small areas of elevated activity (above the DCGL-GA for the site).
- All 21 systematic measurements of total alpha contamination were below the DCGL-GA of 944 dpm/100cm^2.
- All 21 smear sample results were below the DCGL-GA of 94.4 dpm/100cm^2 for removable alpha contamination.
- The total alpha contamination results meet the DP statistical criterion based on the first statistical evaluation of the data (WRS Test procedure).
- No elevated areas were left in-place, therefore, no elevated measurement comparisons were required for this unit.

3.2 Sum of Fractions for Entire Survey Unit

To evaluate the status of Survey Unit Kaiser-FSSFOA-003 as a whole, the fraction of each survey element's average activity divided by the applicable acceptance criteria is calculated for inclusion in the Sum of Fractions for the entire survey unit. The Total Sum of Fractions for total alpha contamination, removable alpha contamination, and elevated areas is presented below in **Table 4.** As previously mentioned, no elevated areas were left in-place for the survey unit.

Table 4 – Fraction of Applicable Acceptance Criteria per Survey Unit Element

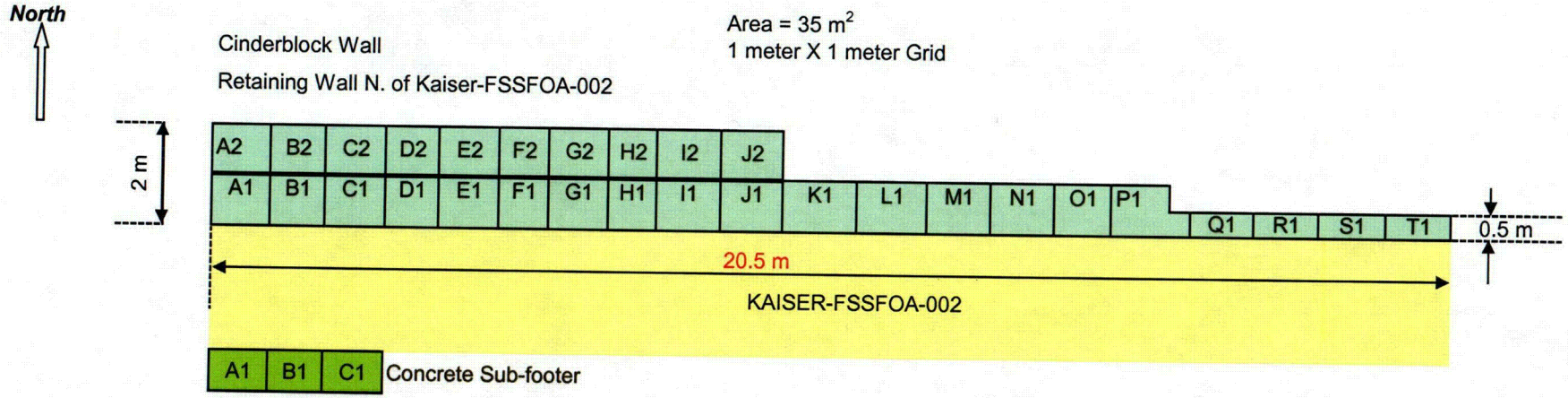
Survey Unit Element	Units	Average Activity	Acceptance Criteria	Fraction
FSSFOA-003 Total Alpha Contamination	dpm/100cm^2	142	944	0.15
FSSFOA-003 Removable Alpha Contamination	dpm/100cm^2	1.10	94.4	0.01
Elevated Areas (None Left In-Place)	dpm/100cm^2			0.00
TOTAL SUM OF FRACTIONS				***0.16***

The Sum of Fractions provides a conservative assessment of the survey unit without backfill. The results of the Sum of Fractions assessment show that Survey Unit Kaiser-FSSFOA-003 meets the DP acceptance criteria.

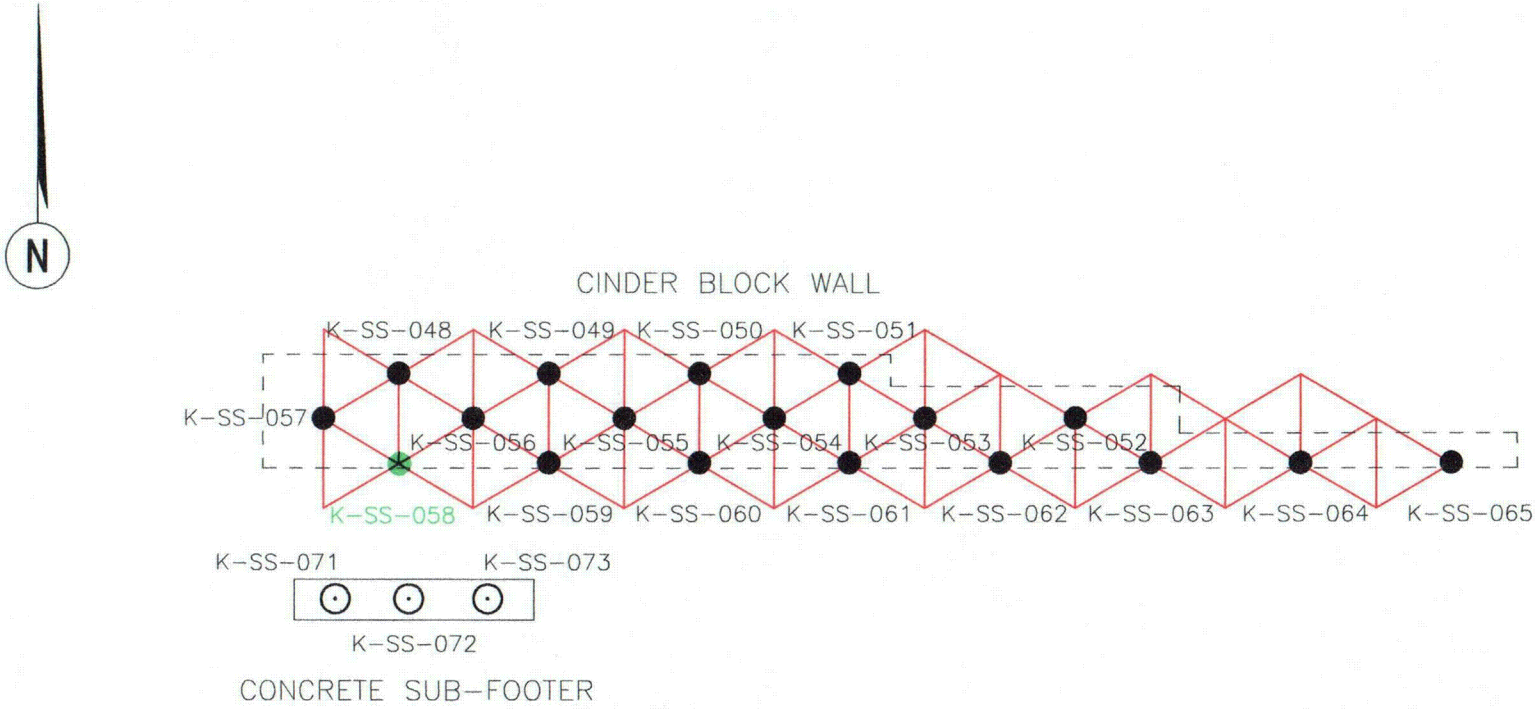
ATTACHMENT A
TABLE OF CONTENTS

- **FIGURE A-1** Gross Alpha Scan Grid Layout
- **FIGURE A-2** Systematic Sampling Locations
- Alpha Scan MDC Calculation Form
- Total Alpha Contamination Survey Data Conversion Forms
- **TABLE A-1** Gross Alpha Scan Results Summary

Attachment A, Figure A-1
Gross Alpha Scan Grid Layout
Survey Unit Kaiser-FSSFOA-003
Final Status Survey
Throium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation



C08

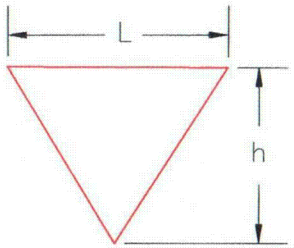


SCALE – FEET
10 0 10
3 0 3
SCALE – METERS

K-SS-048
● SYSTEMATIC SAMPLING LOCATION BASED ON RANDOM START POINT AND AN EQUAL DISTANT TRIANGULAR GRID

K-SS-058
● RANDOM START POINT

K-SS-071
⊙ EQUAL DISTANCE SAMPLING LOCATION ON CONCRETE SUB-FLOOR



N = 18
L = 1.4m
h = 1.2m
AREA = 30m^2

FIGURE A-2
SYSTEMATIC SAMPLING LOCATIONS
SURVEY UNIT KAISER – FSSFOA-003
FINAL STATUS SURVEY
THORIUM REMEDIATION PROJECT
TULSA, OKLAHOMA FACILITY

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
TULSA, OKLAHOMA

APPROVED	RFD 3-3-06
CHECKED	RFD 3-3-06
DRAWN	DEB 01/16/06
DRAWING NUMBER	PA4072069

Penn E&R
Environmental & Remediation, Inc.

C09

Form HPM/M-2-2-3
Alpha Scan MDC Calculation

Instrument Serial Number:	193686	Cal. Due:	5/4/2005
Detector Serial Number:	PR190485	Cal. Due:	5/4/2005
Radiation Detected:	Alpha		For < 3 count background

Probability of observing 2 or more counts:

$$P(n \geq 2) = 1 - \left(1 + \frac{(GE+B)d}{60v}\right)\left(e^{-\frac{(GE+B)d}{60v}}\right)$$

Probability of observing a single count:

$$P(n \geq 1) = 1 - e^{\frac{-GEd}{60v}}$$

	D Date	G Activity (dpm)	d Detector Width (cm)	E Instrument Efficiency (cpm)	v Scan Speed (cm/s)	B Background Countrate (cpm)	P Probability (-)
1	1/20/2005	330	11.7	0.1778	3.90	N/A	0.95
2	1/20/2005	1000	11.7	0.1778	11.7	N/A	0.95
3	1/26/2005	330	11.7	0.1778	3.90	N/A	0.95
4	1/26/2005	1000	11.7	0.1778	11.7	N/A	0.95
5	2/1/2005	330	11.7	0.1778	3.90	N/A	0.95
6	2/1/2005	1000	11.7	0.1778	11.7	N/A	0.95
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							

Comments:

Prepared By:	David B. Weyant	Date:	2/1/05
Reviewed By:	Andrew J. Lombardo	Date:	2/1/05

Notes:
1.) Instrument Efficiency is the 4π instrument efficiency.

Total Alpha Contamination
Survey Unit Kaiser-FSSFOA-003
Survey Data Conversion Form
Form ESC/HPM/M-3-2-2

Date of Survey:	1/26/2005	Type of Radiation:	Alpha
Instrument Serial #: 193686		Calibration Due Date:	5/4/2005
Detector Serial #: PR190485		Calibration Due Date:	5/4/2005
E_s (Surface Efficiency):	0.25	E_i (Insturment Efficiency):	0.1778
BKG Counts:	39	BKG Count Time (min):	10
Active Area of Detector Probe (cm^2):	126	MDC ($dpm/100cm^2$):	117

FSS Swipe Number	Survey Location	Survey Point Count Time (min)	Gross Counts (cts)	Gross Count Rate (cpm)	Net Count Rate (cpm)	Total Contamination ($dpm/100cm^2$)	95% CL Uncertainty ($dpm/100cm^2$)
K-SS-048	MARSSIM-001	2	22	11.0	7.10	127	84.9
K-SS-049	MARSSIM-002	2	33	16.5	12.6	225	103
K-SS-050	MARSSIM-003	2	44	22.0	18.1	323	118
K-SS-051	MARSSIM-004	2	43	21.5	17.6	314	117
K-SS-052	MARSSIM-005	2	6	3.00	-0.90	-16.1	48.1
K-SS-066	MARSSIM-006	2	12	6.00	2.10	37.5	64.4
K-SS-054	MARSSIM-007	2	5	2.50	-1.40	-25.0	44.8
K-SS-055	MARSSIM-008	2	10	5.00	1.10	19.6	59.5
K-SS-056	MARSSIM-009	2	13	6.50	2.60	46.4	66.8
K-SS-057	MARSSIM-010	2	4	2.00	-1.90	-33.9	41.3
K-SS-058	MARSSIM-011	2	14	7.00	3.10	55.4	69.0
K-SS-059	MARSSIM-012	2	28	14.0	10.1	180	95.1
K-SS-060	MARSSIM-013	2	48	24.0	20.1	359	123
K-SS-067	MARSSIM-014	2	2	1.00	-2.90	-51.8	33.0
K-SS-068	MARSSIM-015	2	37	18.5	14.6	261	109
K-SS-063	MARSSIM-016	2	14	7.00	3.10	55.4	69.0
K-SS-064	MARSSIM-017	2	10	5.00	1.10	19.6	59.5
K-SS-065	MARSSIM-018	2	26	13.0	9.1	162	91.9

Comments

Cinder Block Wall Survey

Prepared By: David B. Weyant	Date: 2/1/2005
Reviewed By: Andrew J. Lombardo	Date: 2/2/2005

Total Alpha Contamination
Survey Unit Kaiser-FSSFOA-003
Survey Data Conversion Form
Form ESC/HPM/M-3-2-2

Date of Survey:	1/20/2005	Type of Radiation:	Alpha
Instrument Serial #:	193686	Calibration Due Date:	5/4/2005
Detector Serial #:	PR190485	Calibration Due Date:	5/4/2005
E_s (Surface Efficiency):	0.25	E_i (Insturment Efficiency):	0.1778
BKG Counts:	4	BKG Count Time (min):	2
Active Area of Detector Probe (cm^2):	126	MDC ($dpm/100cm^2$):	110

FSS Swipe Number	Survey Location	Survey Point Count Time (min)	Gross Counts (cts)	Gross Count Rate (cpm)	Net Count Rate (cpm)	Total Contamination ($dpm/100cm^2$)	95% CL Uncertainty ($dpm/100cm^2$)
K-SS-071	A1 subfooter	2	9	5	3	44.6	63.1
K-SS-072	B1 subfooter	2	65	33	31	545	145
K-SS-073	C1 subfooter	2	42	21	19	339	119

Comments: Concrete Sub-Footer Survey

Prepared By: David B. Weyant	Date: 1/20/2005
Reviewed By: Andrew J. Lombardo	Date: 1/20/2005

Attachment A, Table A-1
Gross Alpha Scan Results Summary
Survey Unit Kaiser-FSSFOA-003
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Survey Number **KAISER-FSSFOA-003** s/n: 193686/PR190485 Cal Due: 5/4/2005
Cinderblock Wall Alpha Eff: 17.78%
Tech: DBW

		Scan				weighted	weighted	Bgrd	
Location	Grid	cpm min	dpm/100cm^2 min	cpm max	dpm/100cm^2 max	cpm ave	dpm/100cm^2 ave	cpm (1 min)	Date
Cinderblock Wall	A1	0	-75	20	282	3	-21	4.2	1/26/2005
Cinderblock Wall	A2	0	-75	10	104	2	-39	4.2	1/26/2005
Cinderblock Wall	B1	0	-75	10	104	1	-57	4.2	1/26/2005
Cinderblock Wall	B2	0	-75	0	-75	0	-75	4.2	1/26/2005
Cinderblock Wall	C1	0	-75	10	104	1	-57	4.2	1/26/2005
Cinderblock Wall	C2	0	-75	10	104	2	-39	4.2	1/26/2005
Cinderblock Wall	D1	0	-75	10	104	1	-57	4.2	1/26/2005
Cinderblock Wall	D2	0	-75	0	-75	0	-75	4.2	1/26/2005
Cinderblock Wall	E1	0	-75	10	104	2	-39	4.2	1/26/2005
Cinderblock Wall	E2	0	-75	0	-75	0	-75	4.2	1/26/2005
Cinderblock Wall	F1	0	-75	0	-75	0	-75	4.2	1/26/2005
Cinderblock Wall	F2	0	-75	10	104	1	-57	4.2	1/26/2005
Cinderblock Wall	G1	0	-75	0	-75	0	-75	4.2	1/26/2005
Cinderblock Wall	G2	0	-75	10	104	3	-21	4.2	1/26/2005
Cinderblock Wall	H1	0	-75	10	104	1	-57	4.2	1/26/2005
Cinderblock Wall	H2	0	-75	0	-75	0	-75	4.2	1/26/2005
Cinderblock Wall	I1	0	-18	10	161	2	18	1.0	2/1/2005
Cinderblock Wall	I2	0	-18	10	161	1	0	1.0	2/1/2005
Cinderblock Wall	J1	0	-18	10	161	1	0	1.0	2/1/2005
Cinderblock Wall	J2	0	-18	15	250	1	0	1.0	2/1/2005
Cinderblock Wall	K1	0	-18	20	339	2	18	1.0	2/1/2005

Attachment A, Table A-1
Gross Alpha Scan Results Summary
Survey Unit Kaiser-FSSFOA-003
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Survey Number **KAISER-FSSFOA-003** s/n: 193686/PR190485 Cal Due: 5/4/2005
Cinderblock Wall Alpha Eff: 17.78%
Tech: DBW

Location	Grid	Scan cpm min	Scan dpm/100cm² min	Scan cpm max	Scan dpm/100cm² max	weighted cpm ave	weighted dpm/100cm² ave	Bgrd cpm (1 min)	Date
Cinderblock Wall	L1	0	-75	0	-75	0	-75	4.2	1/26/2005
Cinderblock Wall	M1	0	-75	40	639	2	-39	4.2	1/26/2005
Cinderblock Wall	N1	0	-75	10	104	2	-39	4.2	1/26/2005
Cinderblock Wall	O1	0	-75	20	282	2	-39	4.2	1/26/2005
Cinderblock Wall	P1	0	-75	10	104	1	-57	4.2	1/26/2005
Cinderblock Wall	Q1	0	-75	0	-75	0	-75	4.2	1/26/2005
Cinderblock Wall	R1	0	-75	0	-75	0	-75	4.2	1/26/2005
Cinderblock Wall	S1	0	-75	10	104	0	-75	4.2	1/26/2005
Cinderblock Wall	T1	0	-75	10	104	0	-75	4.2	1/26/2005
Concrete Sub-Footer	concrete	0	0	10	179	1	18	0.0	2/1/2005

Notes:

1. The weighted cpm is determined by the surveyor. Since alpha counts (clicks on audible) are infrequent, and 1 count may equal 10 cpm, the surveyor determines the "weighted average".
2. The acceptance criteria for Total Contamination is 944 dpm/100cm^2. 10 cpm is approximately 150 dpm/100cm2.
3. Scans are used to identify elevated area above the acceptance criteria.
4. Compliance is demonstrated by static counts and smear (sample) results.

ATTACHMENT B
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- **Survey Unit Worksheet No. 1**
- **Survey Unit Worksheet No. 2**

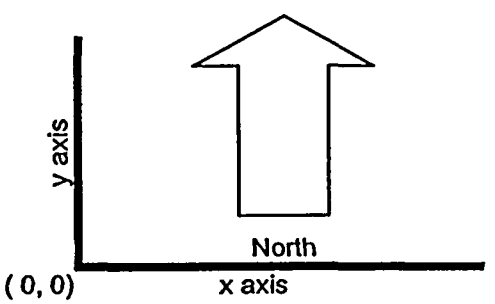
Survey Unit Worksheet No. 2
Random Number Generator for Start Point
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

SURVEY UNIT: KAISER-FSSFOA-003

RANDOM START POINT

x axis (Meters)	y axis (Meters)
2	0

	x axis	y axis
lower bound	0	0
upper bound	20.5	2



ATTACHMENT C

LABORATORY ANALYTICAL RESULTS

Outreach
Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Invoice # 10705
D/- 1/31/05

January 28, 2005

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20050072

Dear Mr. Weyant,

Please find enclosed the analytical report for your samples received in our laboratory on January 21, 2005 for the above captioned project. Three filters were received in good condition and analyzed for Gross Alpha/Beta with an expedited 5-work day turnaround. Results were faxed 1/28/05.

All QC is within limits. The samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions feel free to call.

Laboratory Director

ODEQ ID #9517
CERT. ID# OK001
NRC ODEQ LIC. #27522-01

ACCREDITED IN ACCORDANCE WITH nelac

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050072
Date Reported:	1/28/2005
Date Received:	1/21/05
Page Number:	1 of 2

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050072-01**						
Client ID:	**K-SS-071**						
Date Sampled:	**1/20/2005 3:40:00 PM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.241 +/- 0.466	dpm/100cm 2	0.425	1/21/2005	1/21/2005	RE
Gross Beta	EPA 900/9310	0.881 +/- 1.42	dpm/100cm 2	1.47	1/21/2005	1/21/2005	RE
Lab ID:	**20050072-02**						
Client ID:	**K-SS-072**						
Date Sampled:	**1/20/2005 3:45:00 PM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	4.36 +/- 1.16	dpm/100cm 2	0.509	1/21/2005	1/21/2005	RE
Gross Beta	EPA 900/9310	2.38 +/- 1.49	dpm/100cm 2	1.44	1/21/2005	1/21/2005	RE
Lab ID:	**20050072-03**						
Client ID:	**K-SS-073**						
Date Sampled:	**1/20/2005 3:50:00 PM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	2.34 +/- 0.849	dpm/100cm 2	0.369	1/21/2005	1/21/2005	RE
Gross Beta	EPA 900/9310	2.18 +/- 1.44	dpm/100cm 2	1.39	1/21/2005	1/21/2005	RE

BDL = Below Detection Limit

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050072
Date Reported:	1/28/2005
Date Received:	1/21/05
Page Number:	2 of 2

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Gross Alpha	0+/-0.4	114.0			NC				1/21/2005
Gross Beta	1.2+/-1.4	106.0			NC				1/21/2005

Lab Approval: _____

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
Company KAISER Alum & Chem TX.
LOCAL: 918-364-0566
Name DAVID G. WRIGHT
Address 7311 E. 41ST STREET
CELL: 724-799-6071
City TULSA State OK Zip 74145
Phone 724-934-3330 Fax # 918-384-3171

Bill To:
Company KAISER / PEM ENG
Name DAVID G. WRIGHT / PAM HANNA
Address 7311 E. 41ST STREET
City TULSA State OK Zip 74145

ANALYSIS REQUESTED

PO # KAISER-4072
PROJECT # PA-4000-4072
PROJECT NAME KAISER-THORIUM REMED.
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY) 5 DAY
SAMPLER David Wright (Signature)
DAVID G. WRIGHT

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	Gross α/β	α-RAD <1 DPM/100CM²	β-RAD <7 DPM/100CM²	Radium 226 + Client Specific Analysis	Radium 228 DPM/100CM²				REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
	K-SS-071	1-20-05	15:40 15:50	SWIPE	1	CLOTH	NONE	X	X	X	X	X			A	GRAB
	K-SS-072	"	15:45	"	1	"	"	X	X	X	X	X				"
	K-SS-073	"	15:50	"	1	"	"	X	X	X	X	X				"

RELINQUISHED BY: David Wright DATE 1-21-05 TIME 821 RECEIVED BY: _____ DATE 1/21/05 TIME 0821

RELINQUISHED BY: _____ DATE _____ TIME _____ RECEIVED BY: _____ DATE _____ TIME _____

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

SAMPLE RETURN/DISPOSAL: All non-hazardous samples shall be disposed of 30 days after issue of final report. All others will be returned at client's expense.

FOR LABORATORY USE ONLY

SAMPLE LOGIN

Date Received: *1/21/2005 9:27:06* **Lab Number:** 20050072 **Due:** 1/28/2005

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20050072-01 A Gross Alpha/Beta	K-SS-071	Filter	01/20/05	Other	N/A	None	No	No
20050072-02 A Gross Alpha/Beta	K-SS-072	Filter	01/20/05	Other	N/A	None	No	No
20050072-03 A Gross Alpha/Beta	K-SS-073	Filter	01/20/05	Other	N/A	None	No	No

CONTAINER INSPECTION Ron Picked up N/A 1-21-05

Coolers 0 Custody Seals Broken - Y/N Temperature amb · ~~Blue Ice / Wet Ice~~ N/A Radiation Survey <300 fixed _____ removable

SAMPLE INSPECTION N/A

Custody Seals Broken - ~~Y/N~~ Chain of Custody Record Y/N Labels in Tact Y/N Radiation Survey Complete Y/N

Anomalies: _____

_____

_____

Inspected By: _____ DATE _____

QA or Designee Review: Raymond Thomas DATE 01/21/05

Sample Custodian Review: Michelle Dutton DATE 1/24/05

Project Notes:

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Lwmit # 10644
D/. 1/12/2005

January 12, 2005

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20050020

Dear Mr. Weyant,

Please find enclosed the analytical report for your samples received in our laboratory on January 07, 2005 for the above captioned project. Three filters were received in good condition and analyzed for Gross Alpha/Beta with an expedited 1-work day turnaround. Results were faxed 1/10/05.

All QC is within limits. The samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions feel free to call.

Laboratory Director

ODEQ ID #9517
CERT. ID# OK001
NRC ODEQ LIC. #27522-01

ACCREDITED IN ACCORDANCE WITH nelac

Outreach Laboratory
11 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050020
Date Reported:	1/10/2005
Date Received:	1/7/05
Page Number:	1 of 2

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050020-01**						
Client ID:	**K-SS-066**						
Date Sampled:	**1/6/2005 12:45:00 PM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	7.48 +/- 1.78	DPM/F	0.673		1/10/2005	SD
Gross Beta	EPA 900/9310	7.50 +/- 3.15	DPM/F	2.84		1/10/2005	SD
Lab ID:	**20050020-02**						
Client ID:	**K-SS-067**						
Date Sampled:	**1/6/2005 12:55:00 PM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.637 +/- 0.788	DPM/F	0.673		1/10/2005	SD
Gross Beta	EPA 900/9310	0.917 +/- 2.69	DPM/F	2.84		1/10/2005	SD
Lab ID:	**20050020-03**						
Client ID:	**K-SS-068**						
Date Sampled:	**1/6/2005 1:00:00 PM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.155 +/- 0.666	DPM/F	0.673		1/10/2005	SD
Gross Beta	EPA 900/9310	1.57 +/- 2.73	DPM/F	2.84		1/10/2005	SD

BDL = Below Detection Limit

Outreach Laboratory
11 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050020
Date Reported:	1/10/2005
Date Received:	1/7/05
Page Number:	2 of 2

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Gross Alpha	0+/-0.58	76.1							1/10/2005
Gross Beta	2.1+/-2.8	72.6							1/10/2005

Lab Approval: _____

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
Local: 918-364-0566
Cell: 724-799-0071

Company: KAISER - Alum & Chem Tech.
Name: DAVID G. WEYAND
Address: 7311 E. 41st Street
City: TULSA State: OK Zip: 74145
Phone: 724-3530 Fax #: 918-384-3171

Bill To:
Company: KAISER / CAR & GR
Name: DAVID G. WEYAND / PAUL HANNA
Address: 7311 E. 41st Street
City: TULSA State: OK Zip: 74145

ANALYSIS REQUESTED

PO #: KAISER-4072
PROJECT #: PA-4000-4072
PROJECT NAME: KAISER - Uranium Remediation
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY): 2 days
SAMPLER: Signature — Daniel Baker

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	Gross α/β	α RAD > 1 MDC / 100 cm²	β-γ RAD > 1 MDC / 100 cm²	Rn-222	REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
	K-SS-066	1-6-05	1245	Swipe	1	cloth	NONE	X	X	X	X	GRAB
	K-SS-067	↓	1255	Swipe	1	cloth	NONE	X	X	X	X	↓
	K-SS-068	↓	1300	Swipe	1	cloth	NONE	X	X	X	X	

* Report Units: In Dpm / 100 cm²

RELINQUISHED BY: _____ DATE 1-6-05 TIME 1630 RECEIVED BY: _____ DATE 1/6/05 TIME 1630

RELINQUISHED BY: _____ DATE _____ TIME _____ RECEIVED BY: _____ DATE _____ TIME _____

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

FOR LABORATORY USE ONLY: 050106-20

Outreach P/U

CONTAINER INSPECTION

Coolers 0 Custody Seals Broken - Y/N Temperature _____ Blue Ice / Wet Ice Radiation Survey _____fixed_____removable

SAMPLE INSPECTION

Custody Seals Broken - Y/N Chain of Custody Record Y/N Labels in Tact Y/N Radiation Survey Complete Y/N

Anomalies:_____

_____

_____

Inspected By: _____ DATE 1/7/05

QA or Designee Review: _____DATE_____

Sample Custodian Review:_____DATE_____

Project Notes:

Outreach
Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Invoice # 10573.
Rd. 12/19/04

December 17, 2004

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20040904

Dear Mr. Weyant,

Please find enclosed the analytical report for your samples received in our laboratory on December 15, 2004 for the above captioned project. Eighteen filters were received in good condition and analyzed for Gross Alpha/Beta with an expedited 2-day turnaround. Results were faxed 12/17/04.

All QC is within limits. The samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions feel free to call.

Laboratory Director

ACCREDITED IN ACCORDANCE WITH nelac

ODEQ ID #9517
NRC ODEQ LIC. #27522-01

CERT. ID# OK001

Outreach Laboratory
11 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20040904
Date Reported:	12/17/2004
Date Received:	12/15/04
Page Number:	1 of 5

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20040904-01**						
Client ID:	**K-SS-048**						
Date Sampled:	**12/15/2004 8:02:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.689 +/- 0.507	DPM/F	0.350	12/15/2004	12/15/2004	RE
Gross Beta	EPA 900/9310	1.58 +/- 1.62	DPM/F	1.66	12/15/2004	12/15/2004	RE
Lab ID:	**20040904-02**						
Client ID:	**K-SS-049**						
Date Sampled:	**12/15/2004 8:04:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.624 +/- 0.496	DPM/F	0.355	12/15/2004	12/15/2004	RE
Gross Beta	EPA 900/9310	2.08 +/- 1.23	DPM/F	1.17	12/15/2004	12/15/2004	RE
Lab ID:	**20040904-03**						
Client ID:	**K-SS-050**						
Date Sampled:	**12/15/2004 8:06:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.631 +/- 0.495	DPM/F	0.350	12/15/2004	12/15/2004	RE
Gross Beta	EPA 900/9310	1.03 +/- 1.36	DPM/F	1.40	12/15/2004	12/15/2004	RE
Lab ID:	**20040904-04**						
Client ID:	**K-SS-051**						
Date Sampled:	**12/15/2004 8:08:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.258 +/- 0.636	DPM/F	0.287	12/15/2004	12/15/2004	RE
Gross Beta	EPA 900/9310	0.502 +/- 1.38	DPM/F	0.659	12/15/2004	12/15/2004	RE
Lab ID:	**20040904-05**						
Client ID:	**K-SS-052**						
Date Sampled:	**12/15/2004 8:10:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					

BDL = Below Detection Limit

Outreach Laboratory
11 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20040904
Date Reported:	12/17/2004
Date Received:	12/15/04
Page Number:	2 of 5

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Gross Alpha	EPA 900/9310	0 +/- 0.327	DPM/F	0.162	12/15/2004	12/15/2004	RE
Gross Beta	EPA 900/9310	1.37 +/- 1.19	DPM/F	0.529	12/15/2004	12/15/2004	RE
Lab ID:	**20040904-06**						
Client ID:	**K-SS-053**						
Date Sampled:	**12/15/2004 8:12:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.733 +/- 0.523	DPM/F	0.162	12/15/2004	12/15/2004	RE
Gross Beta	EPA 900/9310	1.29 +/- 1.21	DPM/F	0.545	12/15/2004	12/15/2004	RE
Lab ID:	**20040904-07**						
Client ID:	**K-SS-054**						
Date Sampled:	**12/15/2004 8:14:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.862 +/- 0.544	DPM/F	0.158	12/15/2004	12/15/2004	RE
Gross Beta	EPA 900/9310	1.93 +/- 1.28	DPM/F	0.556	12/15/2004	12/15/2004	RE
Lab ID:	**20040904-08**						
Client ID:	**K-SS-055**						
Date Sampled:	**12/15/2004 8:16:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.397 +/- 0.469	DPM/F	0.177	12/15/2004	12/15/2004	RE
Gross Beta	EPA 900/9310	2.08 +/- 1.27	DPM/F	0.548	12/15/2004	12/15/2004	RE
Lab ID:	**20040904-09**						
Client ID:	**K-SS-056**						
Date Sampled:	**12/15/2004 8:18:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.573 +/- 0.482	DPM/F	0.158	12/15/2004	12/15/2004	RE
Gross Beta	EPA 900/9310	2.11 +/- 1.65	DPM/F	0.749	12/15/2004	12/15/2004	RE

BDL = Below Detection Limit

Outreach Laboratory
11 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20040904
Date Reported:	12/17/2004
Date Received:	12/15/04
Page Number:	3 of 5

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20040904-10**						
Client ID:	**K-SS-057**						
Date Sampled:	**12/15/2004 8:20:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.277 +/- 0.411	DPM/F	0.160	12/15/2004	12/15/2004	RE
Gross Beta	EPA 900/9310	2.48 +/- 1.26	DPM/F	0.525	12/15/2004	12/15/2004	RE
Lab ID:	**20040904-11**						
Client ID:	**K-SS-058**						
Date Sampled:	**12/15/2004 8:22:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.400 +/- 0.440	DPM/F	0.158	12/15/2004	12/15/2004	RE
Gross Beta	EPA 900/9310	1.25 +/- 1.37	DPM/F	0.629	12/15/2004	12/15/2004	RE
Lab ID:	**20040904-12**						
Client ID:	**K-SS-059**						
Date Sampled:	**12/15/2004 8:24:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	1.12 +/- 0.772	DPM/F	0.287	12/15/2004	12/15/2004	RE
Gross Beta	EPA 900/9310	1.82 +/- 1.46	DPM/F	0.659	12/15/2004	12/15/2004	RE
Lab ID:	**20040904-13**						
Client ID:	**K-SS-060**						
Date Sampled:	**12/15/2004 8:26:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.617 +/- 0.498	DPM/F	0.162	12/15/2004	12/15/2004	RE
Gross Beta	EPA 900/9310	2.43 +/- 1.26	DPM/F	0.529	12/15/2004	12/15/2004	RE
Lab ID:	**20040904-14**						
Client ID:	**K-SS-061**						
Date Sampled:	**12/15/2004 8:28:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					

BDL = Below Detection Limit

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20040904
Date Reported:	12/17/2004
Date Received:	12/15/04
Page Number:	4 of 5

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Gross Alpha	EPA 900/9310	25.4 +/- 2.40	DPM/F	0.162	12/15/2004	12/15/2004	RE
Gross Beta	EPA 900/9310	15.4 +/- 1.97	DPM/F	0.545	12/15/2004	12/15/2004	RE
Lab ID:	**20040904-15**						
Client ID:	**K-SS-062**						
Date Sampled:	**12/15/2004 8:30:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	2.48 +/- 0.809	DPM/F	0.158	12/15/2004	12/15/2004	RE
Gross Beta	EPA 900/9310	2.54 +/- 1.32	DPM/F	0.556	12/15/2004	12/15/2004	RE
Lab ID:	**20040904-16**						
Client ID:	**K-SS-063**						
Date Sampled:	**12/15/2004 8:32:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.628 +/- 0.521	DPM/F	0.177	12/15/2004	12/15/2004	RE
Gross Beta	EPA 900/9310	2.39 +/- 1.29	DPM/F	0.548	12/15/2004	12/15/2004	RE
Lab ID:	**20040904-17**						
Client ID:	**K-SS-064**						
Date Sampled:	**12/15/2004 8:34:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.226 +/- 0.394	DPM/F	0.158	12/15/2004	12/15/2004	RE
Gross Beta	EPA 900/9310	0.261 +/- 1.55	DPM/F	0.749	12/15/2004	12/15/2004	RE
Lab ID:	**20040904-18**						
Client ID:	**K-SS-065**						
Date Sampled:	**12/15/2004 8:36:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.508 +/- 0.470	DPM/F	0.160	12/15/2004	12/15/2004	RE
Gross Beta	EPA 900/9310	1.95 +/- 1.22	DPM/F	0.525	12/15/2004	12/15/2004	RE

BDL = Below Detection Limit

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20040904
Date Reported:	12/17/2004
Date Received:	12/15/04
Page Number:	5 of 5

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Gross Alpha	0+/-0.3	103.0			NC				12/15/2004
Gross Beta	2.2+/-1.6	105.0			NC				12/15/2004

Lab Approval: _____

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
LOCAL
918-384-0566
Cell: 724-799-0071
Company KAISER-FRANCIS OIL CO.
Name DAVID G. WRIGHT
Address 7311 E. 41ST STREET
City TULSA State OK Zip 74145
Phone 724 934-3330 Fax # 918-384-3171

Bill To:
Company KAISER/FRANCIS OIL CO
Name DAVID G. WRIGHT AND HARRY
Address 7311 E. 41ST STREET
City TULSA State OK Zip 74145

ANALYSIS REQUESTED

PO # KAISER-4072
PROJECT # PA-4000-4072
PROJECT NAME KAISER-THORIUM REMED.
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY) 2 DAY
SAMPLER DAVID G. WRIGHT
Signature

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	Gross α/β	α RAD, ≤ 1 pCi/100 cm²	β-γ RAD, ≤ 3 pCi/100 cm²	Removable α, clear to Reg Agency	REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
	K-SS-048	12-15-04	0802	SWIPE	1	Cloth	NONE	X	X	X	X	GRAB Report in Dpm/100cm²
	K-SS-049		0804					X	X	X	X	
	K-SS-050		0806					X	X	X	X	
	K-SS-051		0808					X	X	X	X	
	K-SS-052		0810					X	X	X	X	
	K-SS-053		0812					X	X	X	X	
	K-SS-054		0814					X	X	X	X	
	K-SS-055		0816					X	X	X	X	
	K-SS-056		0818					X	X	X	X	
	K-SS-057		0820					X	X	X	X	
	K-SS-058		0822					X	X	X	X	
	K-SS-059		0824					X	X	X	X	
	K-SS-060		0826					X	X	X	X	
	K-SS-061		0828					X	X	X	X	

RELINQUISHED BY: DAVID G. WRIGHT DATE 12-15-04 TIME 815 RECEIVED BY: DATE 12/15/04 TIME 915

RELINQUISHED BY: DATE TIME RECEIVED BY: DATE TIME

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

SAMPLE RETURN/DISPOSAL: All non-hazardous samples shall be disposed of 30 days after issue of final report. All others will be returned at client's expense.

FOR LABORATORY USE ONLY

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
LOCAL 918-384-0366
CELL: 724-799-0071
Company KAISER-ALUM & CHEM JAC.
Name DAVID B. WEYANT
Address 7311 E. 41ST STREET
City TULSA State OK Zip 74145
Phone 724-934-3530 Fax # 918-384-3171

Bill To:
Company KAISER / PAN E&C
Name DAVID B. WEYANT / PAUL HARDO
Address 7311 E. 41ST STREET
City TULSA State OK Zip

ANALYSIS REQUESTED

PO # KAISER-4072
PROJECT # PA-4000-4072
PROJECT NAME KAISER-THORIUM REMED.
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY) 2 DAY
SAMPLER David B. Weyant
Signature

LAB USE ONLY	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	Gross α/β	Th-232 + Decay Products	Ra-226 + Decay Products	Ra-228 + Decay Products	REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
	K-SS-062	12-15-04	0830	Soil	1	Cloth	None	X	X	X	X	GRAB Report In DPM/100cm²
	K-SS-063		0832					X	X	X	X	
	K-SS-064		0834					X	X	X	X	
	K-SS-065		0836					X	X	X	X	

RELINQUISHED BY: David B. Weyant DATE 12-15-04 TIME 815 RECEIVED BY: R. Liebson DATE 12/15/04 TIME

RELINQUISHED BY: DATE TIME RECEIVED BY: DATE TIME

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

FOR LABORATORY USE ONLY

SAMPLE LOGIN

Date Received: *12/15/2004 8:39:2* **Lab Number:** 20040904 **Due:** 12/17/2004

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20040904-01 A Gross Alpha/Beta	K-SS-048	Filter	12/15/04	Plastic	N/A	None	No	No
20040904-02 A Gross Alpha/Beta	K-SS-049	Filter	12/15/04	Plastic	N/A	None	No	No
20040904-03 A Gross Alpha/Beta	K-SS-050	Filter	12/15/04	Plastic	N/A	None	No	No
20040904-04 A Gross Alpha/Beta	K-SS-051	Filter	12/15/04	Plastic	N/A	None	No	No
20040904-05 A Gross Alpha/Beta	K-SS-052	Filter	12/15/04	Plastic	N/A	None	No	No
20040904-06 A Gross Alpha/Beta	K-SS-053	Filter	12/15/04	Plastic	N/A	None	No	No
20040904-07 A Gross Alpha/Beta	K-SS-054	Filter	12/15/04	Plastic	N/A	None	No	No
20040904-08 A Gross Alpha/Beta	K-SS-055	Filter	12/15/04	Plastic	N/A	None	No	No
20040904-09 A Gross Alpha/Beta	K-SS-056	Filter	12/15/04	Plastic	N/A	None	No	No
20040904-10 A	K-SS-057	Filter	12/15/04	Plastic	N/A	None	No	No

Gross Alpha/Beta								
20040904-11 A Gross Alpha/Beta	K-SS-058	Filter	12/15/04	Plastic	N/A	None	No	No
20040904-12 A Gross Alpha/Beta	K-SS-059	Filter	12/15/04	Plastic	N/A	None	No	No
20040904-13 A Gross Alpha/Beta	K-SS-060	Filter	12/15/04	Plastic	N/A	None	No	No
20040904-14 A Gross Alpha/Beta	K-SS-061	Filter	12/15/04	Plastic	N/A	None	No	No
20040904-15 A Gross Alpha/Beta	K-SS-062	Filter	12/15/04	Plastic	N/A	None	No	No
20040904-16 A Gross Alpha/Beta	K-SS-063	Filter	12/15/04	Plastic	N/A	None	No	No
20040904-17 A Gross Alpha/Beta	K-SS-064	Filter	12/15/04	Plastic	N/A	None	No	No
20040904-18 A Gross Alpha/Beta	K-SS-065	Filter	12/15/04	Plastic	N/A	None	No	No

CONTAINER INSPECTION

Coolers 2 Custody Seals Broken - Y/N Temperature _____ Blue Ice / Wet Ice Radiation Survey _____fixed_____removable

SAMPLE INSPECTION

Custody Seals Broken - Y/N 2 Chain of Custody Record Y/N 2 Labels in Tact Y/N 2 Radiation Survey Complete Y/N 2

Anomalies:_____

_____

_____

Inspected By: _____ DATE 12/15/04

QA or Designee Review: _____DATE_____

Sample Custodian Review:_____DATE_____

Project Notes:

SUB-REPORT

SURVEY UNIT KAISER-FSSFOA-004

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ATTACHMENTS

ATTACHMENT A: Figure A-1 Gross Gamma Background and Scanning Survey Results
Figure A-2 Systematic Soil Sampling Locations

ATTACHMENT B: Soil Survey Unit Worksheet No. 1
Soil Survey Unit Worksheet No. 2

ATTACHMENT C: Laboratory Analytical Results

ATTACHMENT D: Figure D-1 Embedded Structure Location Map
Alpha Scan MDC Calculation Form
Total Alpha Contamination Survey Data Conversion Form
Table D-1 Embedded Structure Gross Alpha Scan Results

Final Status Survey Report
Volume II – Former Operational Area
Sub-Report No. EB-034
Survey Unit Kaiser-FSSFOA-004
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation
March 22, 2006

1.0 BACKGROUND

This sub-report documents the results of Former Operational Area (FOA) excavation final status survey activities completed as part of the Thorium Remediation Project at the Tulsa, Oklahoma facility **(Figure 1)**. Specifically, this technical report addresses the final status survey of Survey Unit Kaiser-FSSFOA-004, an open land area (FOA excavation surface soil) resulting from the removal of radiologically-affected soil from beneath a "built-up" dock area associated with the Maintenance Building. The survey unit is located immediately west of the Maintenance Building **(Figure 3)**. Survey Unit Kaiser-FSSFOA-004 is considered a Class 1 survey unit with an approximate surface area of 84 m^2.

Survey Unit Kaiser-FSSFOA-004 consists of an excavation bottom surface soil with no side walls. No elevated areas were left in-place, therefore, no elevated measurement comparisons were required for this unit. During the removal of the radiologically-affected soil, one embedded "structure" (a cinderblock wall and associated concrete footer) was encountered and left in-place along the eastern boundary of the excavation.

2.0 SURVEY ACTIVITIES AND RESULTS

This section of the sub-report presents the final status survey data for the following physical features or elements of Survey Unit Kaiser-FSSFOA-004:

- Excavation bottom surface soil.
- Embedded structure (a cinderblock wall and associated concrete footer) remaining on the eastern boundary of the survey unit.

2.1 Excavation Bottom Surface Soil

The final status survey of the excavation bottom surface soil consisted of a gross gamma scan of the exposed surface soil and systematic soil sampling.

2.1.1 Gross Gamma Scan

The exposed surface soil of the Class 1 survey unit (excavation bottom) was surveyed through a 100 percent coverage gamma scan to confirm acceptable radiological conditions and identify any elevated areas. During the scanning of the soil, the detector was held close to the ground surface (1 to 2 inches) and moved in a serpentine pattern. Background measurements were obtained at 1-meter above the ground surface at 14 approximately equal-distant locations in the survey unit. The statistics for the 14 background measurements are provided below in **Table 1.** Background measurements ranged from 10,359 counts per minute (cpm) to 12,462 cpm.

Similar results were obtained for the gross gamma scan of the survey unit's surface area. A total of 20 area-averaged measurements of gross count rate were made across the survey unit's 84 m^2 surface area. The results ranged from 10,200 cpm to 14,500 cpm. A statistical summary of the 100 percent coverage gamma scan of the survey unit is provided below in **Table 1.**

Table 1 – Gross Gamma Scan Results Summary

Survey Area:	84 m^2	
Number of Scan Measurements (Recorded Average per 2 m^2 grid area)	20	
Scan Rate: (Swinging the detector a width of 1-meter side to side)	0.5 m/s (MARSSIM recommends 0.5m/s)	
Results Summary:	**Background (Gross cpm)**	**Scan (Gross cpm)**
Minimum	10,359	10,200
Maximum	12,462	14,500
Average	11,121	12,300
Standard Deviation	545	970
Median	11,070	12,200

Contour maps of the gross gamma background and final (as-left condition) scanning survey results are presented on **Figure A-1** contained in **Attachment A.** The 100 percent coverage gross gamma scan did not indicate the presence of small areas of elevated activity (above the $DCGL_W$ for the site). As part of the gross gamma survey, 1 biased soil sample (K-484) was collected at a location exhibiting a high scan rate under the concrete footer **(Figure A-2, Attachment A).** The biased soil sample was forwarded to Outreach for analysis of Th-232 activity concentration. The analytical result is presented below in **Table 2.** The biased soil sample result was below the $DCGL_W$ for the site.

Table 2 – Biased Soil Sample Result

Soil Sample ID	Gross Th-232 (pCi/g)	Std. Error (pCi/g)	MDC (pCi/g)
$DCGL_W$	*3.0*		
Site Background	*1.1*	*0.3*	
K-484	2.01	0.355	0.757

2.1.2 Systematic Soil Sampling – Excavation Bottom Surface Soil

The final status survey also consisted of systematic soil sampling based on a random start point and an equal-distant triangular grid. The Minimum Number of Samples Required (N) based on the scan MDC was determined to be 9 as documented on Soil Survey Unit Worksheet No. 1 **(Attachment B).** Once N was determined, the Survey Unit Area (A) of 84 m^2 along with the N of 9 were used to calculate the Triangular Grid Node Length (L) of 3.3 meters and the Height of the Equilateral Triangle (h) of 2.8 meters. A random start point was generated using the random number feature of Excel and documented on Soil Survey Unit Worksheet No. 2 **(Attachment B).**

A layout of the soil sampling locations is provided on **Figure A-2** contained in **Attachment A.** The soil sampling locations were demarcated in the field using a GPS unit. A total of 10 soil samples (identified as K-493 through K-502) were collected at the excavation bottom surface (0-6-inch depth interval) level using a clean, decontaminated sampling auger or sharpshooter shovel. The samples were forwarded to Outreach for analysis of Th-232 activity concentration. Analytical results are provided below in **Table 3.** Analytical data reports are contained in **Attachment C.**

Table 3 – Systematic Soil Sample Results

Soil Sample ID	Gross Th-232 (pCi/g)	Std. Error (pCi/g)	MDC (pCi/g)	Net Th-232 (pCi/g)	Net DCGL (pCi/g)
K-493	0.844	0.103	0.365	0	3.0
K-494	0.786	0.069	0.318	0	3.0
K-495	0.883	0.148	0.595	0	3.0
K-496	0.547	0.064	0.281	0	3.0
K-497	0.978	0.062	0.302	0	3.0
K-498	1.00	0.104	0.288	0	3.0
K-499	1.13	0.235	0.506	0.03	3.0
K-500	1.29	0.115	0.462	0.19	3.0
K-501	0.905	0.100	0.427	0	3.0
K-502	1.14	0.074	0.286	0.04	3.0
Average	***0.950***				
Standard Dev.	***0.209***				
Minimum	***0.547***				
Maximum	***1.29***				
Median	***0.942***				

All 10 systematic soil sample results (gross and net) were below the open land area surrogate value of 3.0 pCi/g net Th-232 activity concentration ($DCGL_W$). The maximum gross Th-232 activity concentration was 1.29 pCi/g, which fell slightly above the background Th-232 activity of 1.1 pCi/g for the site. The average gross Th-232 activity concentration was 0.950 pCi/g. The standard deviation of the 10 equal-distant samples was 0.209, which fell below the estimated standard deviation of 0.42 (based on the adjacent land final status survey results) used to calculate the minimum number of samples required.

2.1.3 Wilcoxon Rank Sum (WRS) Testing

The analytical results for the systematic soil samples were evaluated using the procedure contained in **Appendix C, Volume I** of this Final Status Survey Report (Wilcoxon Rank Sum Test). The evaluation showed that the survey unit soil sample results meet the DP statistical criterion based on the first statistical test as described below.

If the difference (0.48 pCi/g) between the maximum survey unit soil sample activity concentration (1.29 pCi/g) and the minimum reference background area soil sample activity concentration (0.81 pCi/g) is less than $DCGL_W$ (3.0 pCi/g), then the survey unit meets the release criterion. **Table 4** presents a summary of the data used to complete the statistical evaluation of the survey unit.

Table 4 – Reference Group and Survey Unit Sample Results

Reference Group	Sample ID	Th-232 (pCi/g)	Survey Unit Group	Sample ID	Th-232 (pCi/g)
R1	74	0.87	S1	K-493	0.844
R2	90	1.37	S2	K-494	0.786
R3	257	1.31	S3	K-495	0.883
R4	272	1.43	S4	K-496	0.547
R5	258	0.81	S5	K-497	0.978
R6	262	1.63	S6	K-498	1.00
R7	171	1.16	S7	K-499	1.13
R8	207	1.56	S8	K-500	1.29
R9	362	1.18	S9	K-501	0.905
R10	26	1.47	S10	K-502	1.14
	Average	***1.28***		***Average***	***0.950***
	Standard Dev.	***0.28***		***Standard Dev.***	***0.209***
	Minimum	***0.81***		***Minimum***	***0.547***
	Maximum	***1.63***		***Maximum***	***1.29***
	Median	***1.34***		***Median***	***0.942***

2.2 Embedded Structures

As previously noted, one embedded "structure" (a cinderblock wall and associated concrete footer) was encountered along the eastern boundary of the excavation (**Attachment D, Figure D-1**). The structure was surveyed and sampled in-place. A description of the survey and sample activities used to evaluate any potential exposure from the structure is presented in this section.

The supporting documentation for the surveying and sampling of the Survey Unit Kaiser-FSSFOA-004 embedded structure is contained in **Attachment D** and includes the following:

- **Figure D-1**, Embedded Structure Location Map
- Alpha Scan MDC Calculation Form
- Total Alpha Contamination Survey Data Conversion Form
- **Table D-1**, Embedded Structure Gross Alpha Scan Results

The cinderblock wall was approximately 2 m^2 in total surface area and the concrete footer another 5 m^2. The cinderblock wall and concrete footer were scanned for gross alpha contamination. No elevated areas were detected. The results of the gross alpha scan are presented in **Table D-1** contained in **Attachment D.** Four static counts to determine total alpha contamination were taken on the wall and footer (A, B and C on the wall and 1 biased location on the footer). Two smear samples of removable contamination were also taken on the exposed structural surface (K-SS-070 and K-SS-079). Smear Sample K-SS-070 was taken at Location B on the cinderblock wall and Smear Sample K-SS-079 was taken on the concrete footer. The results of the total and removable alpha contamination measurements are presented below in **Table 5.**

Table 5 - Cinderblock Wall and Associated Concrete Footer Total and Removable Alpha Contamination Results

Sample ID	DCGL-GA (dpm/100cm^2)	Alpha (dpm/100cm^2)	Std. Error (dpm/100cm^2)	MDC (dpm/100cm^2)
Total Contamination				
Concrete Footer	944	80.3	52.5	26.8
Wall (A)	944	98.2	72.1	98.7
Wall (C)	944	8.93	46.3	98.7
Wall (B)	944	393	124	98.7
Removable Contamination				
K-SS-070	94.4	0	0.368	0.441
K-SS-079	94.4	0.361	0.887	0.811

3.0 SUMMARY OF FINDINGS

The removal of radiologically-affected soil from beneath a built-up dock area associated with the Maintenance Building resulted in an open land area consisting of an excavation approximately 84 m^2 in area. This open land area, identified as Survey Unit Kaiser-FSSFOA-004 is considered a Class 1 survey unit. The survey unit is located immediately west of the Maintenance Building within the FOA **(Figure 3)**. This section of the sub-report presents a summary of the final status survey findings and an overall summation of fractions for the survey unit including the identified embedded structure (cinderblock wall and associated concrete footer).

3.1 Excavation Bottom Surface Soil

The acceptance criterion for open land areas (FOA excavation surface soil) at the Tulsa facility is the DCGLw of 3.0 pCi/g net Th-232 activity concentration. Final status survey activities for Survey Unit Kaiser-FSSFOA-004 consisted of a gross gamma scan of the exposed surface soil of the survey unit (excavation bottom) and systematic soil sampling. The results of the final status survey activities were as follows:

- The 100 percent coverage gamma scan (final as-left condition) did not indicate the presence of small areas of elevated activity (above the $DCGL_W$ for the site).
- All 10 systematic soil sample results (gross and net) were below the open land area surrogate value of 3.0 pCi/g net Th-232 activity concentration ($DCGL_W$).
- The analytical results meet the DP statistical criterion based on the first statistical evaluation of the data (WRS Test procedure).
- No elevated areas were left in-place, therefore, no elevated measurement comparisons were required for this unit.

3.2 Sum of Fractions for Entire Survey Unit

To evaluate the status of Survey Unit Kaiser-FSSFOA-004 prior to backfill with clean import borrow material, as a whole (excavation bottom/side wall surface soil, elevated areas, and embedded structures), the fraction of each survey element's average net activity divided by the applicable acceptance criteria is calculated for inclusion in the Sum of Fractions for the entire survey unit. The Total Sum of Fractions for surface soil, elevated areas, and embedded structures respectively is presented below in **Table 6.** As previously mentioned, no elevated areas were left in-place for the survey unit.

Table 6 – Fraction of Applicable Acceptance Criteria per Survey Unit Element

Survey Unit Element	Units	Average Net Activity	Acceptance Criteria	Fraction
-FSSFOA-004 Excavation Surface Soil	pCi/g	0	3.0	0.00
-Elevated Areas (None Left In-Place)	pCi/g	0		0.00
-Embedded Structure (Total Contamination)	dpm/100cm^2	145	944	0.15
-Embedded Structure (Removable Contamination)	dpm/100cm^2	0.181	94.4	0.00
TOTAL SUM OF FRACTIONS				***0.15***

The Sum of Fractions provides a conservative assessment of the survey unit without backfill. The results of the Sum of Fractions assessment show that Survey Unit Kaiser-FSSFOA-004 meets the DP acceptance criteria.

ATTACHMENT A
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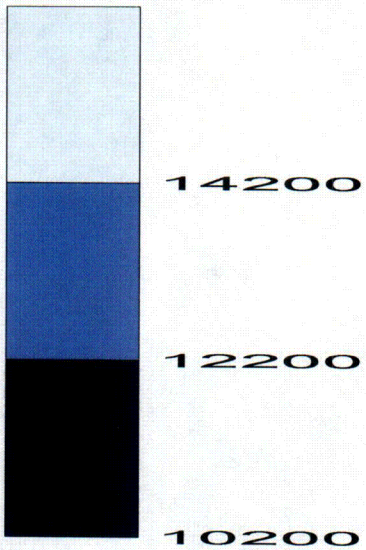
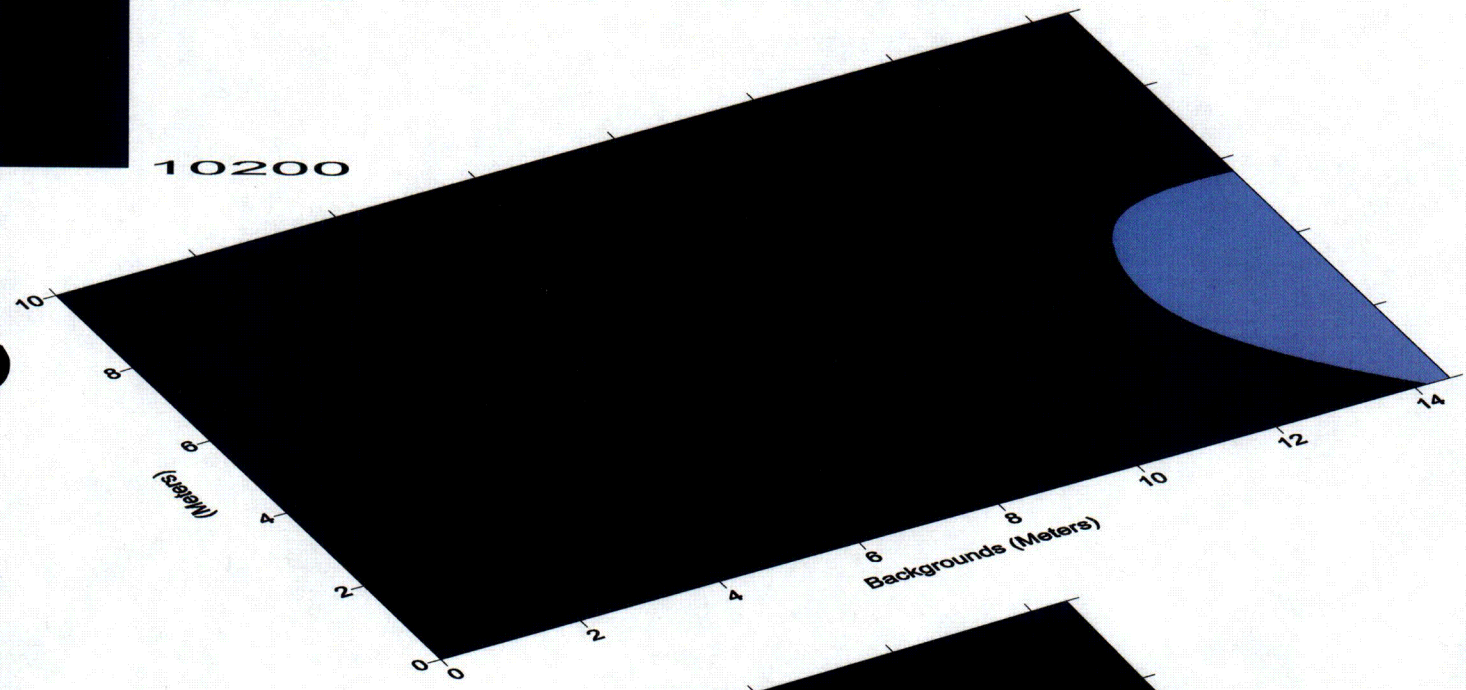
- **FIGURE A-1 Gross Gamma Background and Scanning Survey Results**
- **FIGURE A-2 Systematic Soil Sampling Locations**

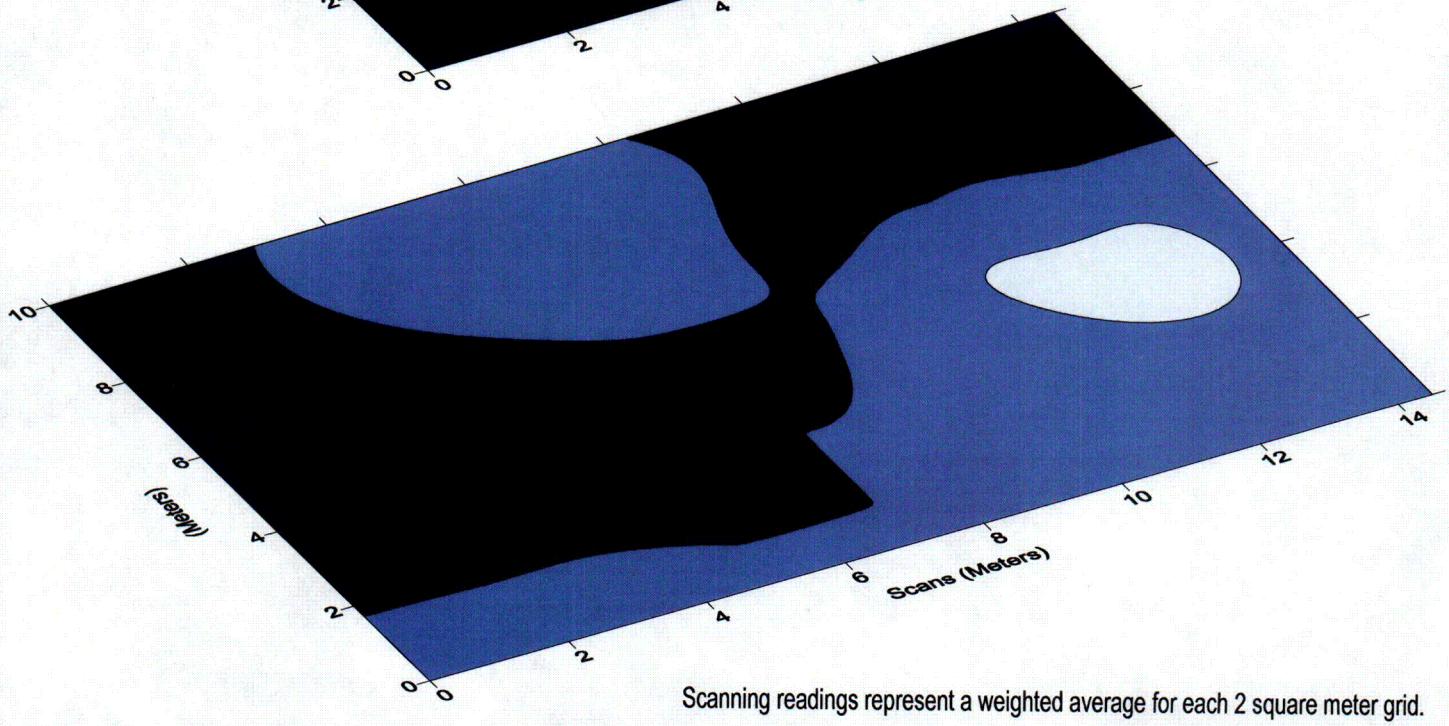
Attachment A, Figure A-1
Gross Gamma Background and Scanning Survey Results
Survey Unit Kaiser-FSSFOA-004

CPM NaI # 4

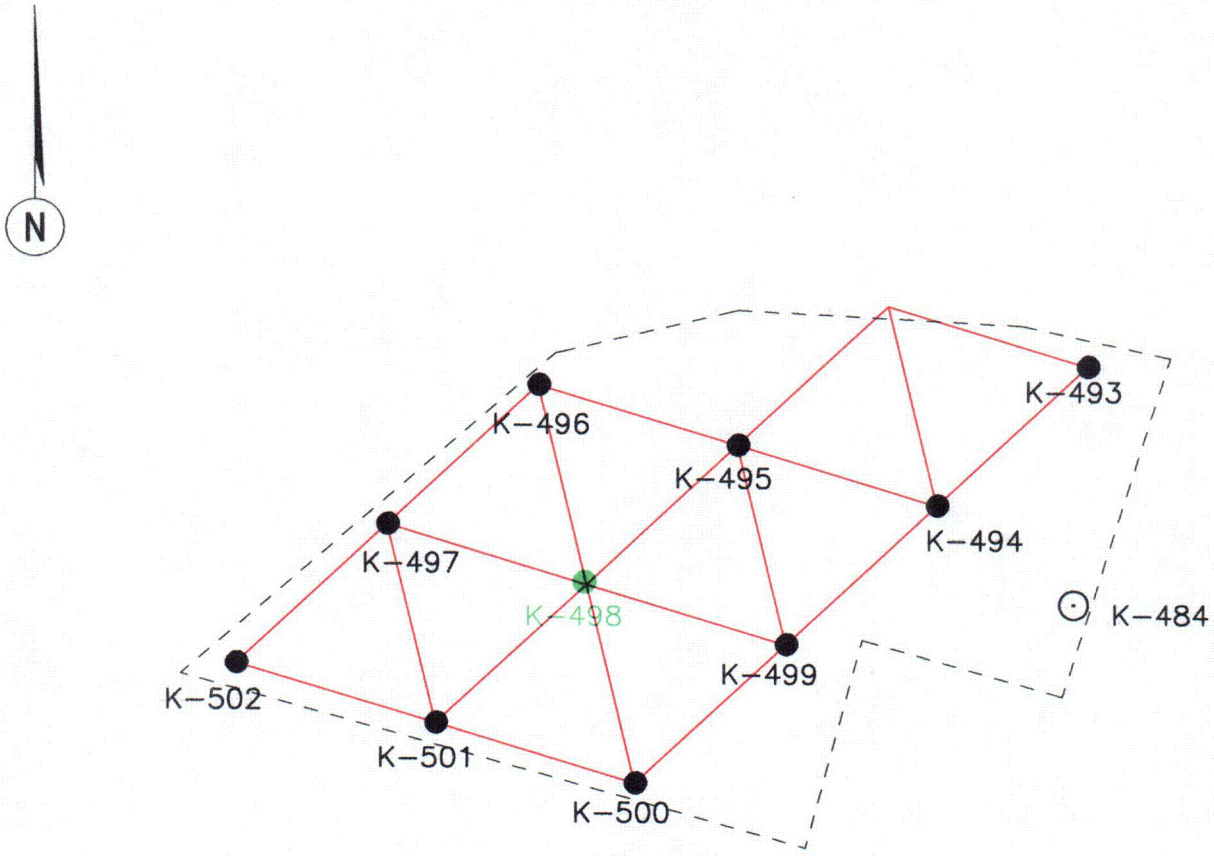


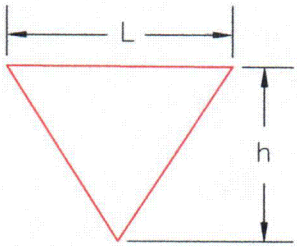
Backgrounds are 1 minute readings.



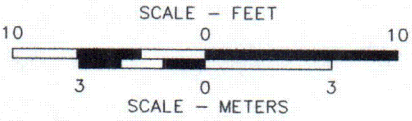


Scanning readings represent a weighted average for each 2 square meter grid.





N = 10 (COLLECTED)
L = 3.3m
h = 2.8m
AREA = 84m^2



K-493
● SYSTEMATIC SOIL SAMPLING LOCATION BASED ON RANDOM START POINT AND AN EQUAL DISTANT TRIANGULAR GRID

K-498
● RANDOM START POINT

K-484
⊙ BIASED SOIL SAMPLING LOCATION BASED ON GROSS GAMMA SCAN RESULTS

FIGURE A-2
SYSTEMATIC SOIL SAMPLING LOCATIONS
SURVEY UNIT KAISER – FSSFOA-004
FINAL STATUS SURVEY
THORIUM REMEDIATION PROJECT
TULSA, OKLAHOMA FACILITY

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
TULSA, OKLAHOMA

APPROVED	RFD 3/3/06
CHECKED	RFD 3/3/06
DRAWN	DEB 01/16/06
DRAWING NUMBER	PA4072068

Penn E&R
Environmental & Remediation, Inc.

C11

ATTACHMENT B
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- **Soil Survey Unit Worksheet No. 1**
- **Soil Survey Unit Worksheet No. 2**

Soil Survey Unit Work Sheet No. 1
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

1. Soil Survey Unit: KAISER-FSSFOA-004

2. Description: Former Operational Area, West of Maintenance Building

3. Net Th-232 Acceptance Criteria (pCi/g): 3.0

4. Dimensions (m): Excavation Bottom – Approx. 9.2 meters x 9.2 meters; Area, A (m^2): 84

5. Estimate of Gross Gamma Scan Background Readings (cpm)
Average: 20,000 Minimum: 10,000 Maximum: 50,000

6. Based on the maximum background gross gamma scan reading, the scan MDC (Minimum Detectable Concentration of Th-232), the corresponding N (Minimum Number of Required Samples) and L (Triangular Grid Node Length) for a standard 2,000 m^2 Class 1 survey unit are:

- Gross Gamma Scan MDC (pCi/g): 4.0
- Minimum Number of Samples (N): 9 Triangular Grid Node Length (L): 16.0 m

7. If the area of the Survey Unit is less than 2,000 m^2, recalculate the corresponding Triangular Grid Node Length (L_1) for the Survey Unit Area (A), using the following formula: $L_1 = (A/(0.866 \times 9))^{1/2}$: 3.3 m

8. If N is greater than 9 and the A is other than 2,000 m^2, recalculate the corresponding Triangular Grid Node Length (L_1) using the following formula $L_1 = (A/(0.866 \times N))^{1/2}$: N/A

9. If A is greater than 2,000 m^2 and N is equal to 9, recalculate the minimum number of samples (N_1) corresponding to a Triangular Grid Node Length (L) of 16 m using the following formula $N_1 = A / (0.866 \times 16^2)$, N_1: N/A

10. Calculate the height (h) of the equilateral triangle with side length equal to L (or (L_1) using the following formula: $h = ((L^2 - (L/2)^2)^{1/2}$: 2.8 m.

1

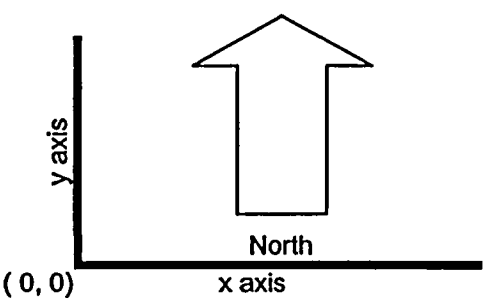
Soil Survey Unit Worksheet No. 2
Random Number Generator for Start Point
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

SURVEY UNIT: KAISER-FSSFOA-004

RANDOM START POINT

x axis (Meters)	y axis (Meters)
7	3

	x axis	y axis
lower bound	0	0
upper bound	9.2	9.2



ATTACHMENT C

LABORATORY ANALYTICAL RESULTS

Outreach Laboratory
11 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Limit # 10702
M - 1/31/05

January 31, 2005

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20050087

Dear Mr. Weyant:

Please find enclosed the analytical report for your samples received in our laboratory on January 26, 2004 for the above captioned project. Nine soil samples were received in good condition and analyzed for Th-232 by Gamma Spectroscopy without drying and grinding and Percent Moisture with an expedited 5-work day turn. Results were faxed 1/31/05.

All Quality Control for the requested analyses is reported on the analytical report. The laboratory control standard and duplicates for all analyses were within method control limits.

Your samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions, please call us at 918-251-2515.

Laboratory Director

K-493

ODEQ ID #9517
DEQ LIC. #27522-01

ACCREDITED IN ACCORDANCE WITH nelac
CERT. ID #OK001

Outreach Laboratory
311 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050087
Date Reported:	1/31/2005
Date Received:	1/26/05
Page Number:	1 of 3

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050087-01**						
Client ID:	**K-493**						
Date Sampled:	**1/25/2005 1:45:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.844 +/- 0.103	pCi/g	0.365		1/26/2005	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	12.4	%		1/26/2005	1/27/2005	RT
Lab ID:	**20050087-02**						
Client ID:	**K-494**						
Date Sampled:	**1/25/2005 1:50:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.786 +/- 0.069	pCi/g	0.318		1/26/2005	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	14.2	%		1/26/2005	1/27/2005	RT
Lab ID:	**20050087-03**						
Client ID:	**K-495**						
Date Sampled:	**1/25/2005 1:55:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.883 +/- 0.148	pCi/g	0.595		1/26/2005	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	14.6	%		1/26/2005	1/27/2005	RT
Lab ID:	**20050087-04**						
Client ID:	**K-496**						
Date Sampled:	**1/25/2005 2:00:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.547 +/- 0.064	pCi/g	0.281		1/26/2005	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	12.3	%		1/26/2005	1/27/2005	RT

BDL = Below Detection Limit

Outreach Laboratory
311 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050087
Date Reported:	1/31/2005
Date Received:	1/26/05
Page Number:	2 of 3

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050087-05**						
Client ID:	**K-497**						
Date Sampled:	**1/25/2005 2:05:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.978 +/- 0.062	pCi/g	0.302		1/26/2005	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	14.5	%		1/26/2005	1/27/2005	RT
Lab ID:	**20050087-06**						
Client ID:	**K-498**						
Date Sampled:	**1/25/2005 2:10:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	1.00 +/- 0.104	pCi/g	0.288		1/26/2005	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	11.4	%		1/26/2005	1/27/2005	RT
Lab ID:	**20050087-07**						
Client ID:	**K-500**						
Date Sampled:	**1/25/2005 2:20:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	1.29 +/- 0.115	pCi/g	0.462		1/26/2005	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	13.3	%		1/26/2005	1/27/2005	RT
Lab ID:	**20050087-08**						
Client ID:	**K-501**						
Date Sampled:	**1/25/2005 2:25:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.905 +/- 0.100	pCi/g	0.427		1/26/2005	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	5.8	%		1/26/2005	1/27/2005	RT

BDL = Below Detection Limit

Outreach Laboratory
211 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050087
Date Reported:	1/31/2005
Date Received:	1/26/05
Page Number:	3 of 3

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050087-09**						
Client ID:	**K-502**						
Date Sampled:	**1/25/2005 2:30:00 PM**						
Matrix:	**Soil**						
	Radiochemical Analyses						
Th-232	HASL 300	1.14 +/- 0.074	pCi/g	0.286		1/26/2005	SD
	Inorganics Analyses						
Percent Moisture	ASTM D2216-92	12.0	%		1/26/2005	1/27/2005	RT

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Ac-228					10.7				1/26/2005
Am-241		99.0	89.0	10.6					1/26/2005
Co-60		90.0	93.0	3.3					1/26/2005
Cs-137		96.0	92.0	4.7					1/26/2005
Percent Moisture					13.2				1/27/2005

Lab Approval:

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
LOCAL 918-384-0566
Cell: 724-799-0071

Company: KAISER - ALUM & CHEM LLC.
Name: DAVID R. WEYAND
Address: 7311 E. 41ST STREET
City: TULSA State: OK Zip: 74145
Phone: 724-934-3330 Fax #: 918-384-3171

Bill To:
Company: KAISER - / PENN E&R
Name: DAVID R. WEYAND / PAUL HANNA
Address: 7311 E. 41ST STREET
City: TULSA State: OK Zip: 74145

ANALYSIS REQUESTED

PO #: KAISER. 40 72
PROJECT #: PA - Penn - 4072
PROJECT NAME: KAISER - Thorium Proj.
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY): 24 A
SAMPLER: [signature] DAVID R. WEYAND
Signature

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	Gamma Spec (Th-232)	Pb/Tl-212 to Th-232 for Archive	MDC 20.5 pCi/g	Ra-226 & Th-232 Activity (with Th-232 in equilibrium)	5 DAY T.A.T.	20 DAY T.A.T.			REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
20071-1	K-493	1-25-05	13:45	SOIL	1	SOIL PLASTIC	NONE	X	X	X	X	X		J		GRAB
-2	K-494	1-25-05	13:50		1			X	X	X	X	X				
-3	K-495	1-25-05	13:55		1			X	X	X	X	X			A	
-4	K-496	1-25-05	14:00		1			X	X	X	X	X				
-5	K-497	1-25-05	14:05		1			X	X	X	X	X				
-6	K-498	1-25-05	14:10		1			X	X	X	X	X				
-7	K-500	1-25-05	14:20		1			X	X	X	X	X				
-8	K-501	1-25-05	14:25		1			X	X	X	X	X				
-9	K-502	1-25-05	14:30		1			X	X	X	X	X				
-10	K-504	1-26-05	07:44		1			X	X	X	X	X	X			
-11	K-505	1-26-05	07:59		1			X	X	X	X	X	X			
-12		N						N	A			D/C				N
-13			A													A

RELINQUISHED BY: DAVID R. WEYAND DATE 1-26 TIME 830 RECEIVED BY: [signature] DATE 1/26/05 TIME 850

RELINQUISHED BY: _____ DATE _____ TIME _____ RECEIVED BY: _____ DATE _____ TIME _____

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

SAMPLE RETURN/DISPOSAL: All non-hazardous samples shall be disposed of 30 days after issue of final report. All others will be returned at client's expense.

FOR LABORATORY USE ONLY

SAMPLE LOGIN

Date Received: *1/26/2005 9:22:11* **Lab Number:** 20050087 **Due:** 2/2/2005

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20050087-01 A	K-493	Soil	01/25/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050087-02 A	K-494	Soil	01/25/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050087-03 A	K-495	Soil	01/25/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050087-04 A	K-496	Soil	01/25/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050087-05 A	K-497	Soil	01/25/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050087-06 A	K-498	Soil	01/25/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050087-07 A	K-500	Soil	01/25/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050087-08 A	K-501	Soil	01/25/05	Plastic	16 oz	None	Yes	Yes

	Percent Moisture (LOD) Th-232 by Gamma Spec								
20050087-09 A	K-502	Soil	01/25/05	Plastic	16 oz	None	Yes	Yes	
	Percent Moisture (LOD) Th-232 by Gamma Spec								

CONTAINER INSPECTION

 # Coolers 1 **Custody Seals Broken - Y/N** (N) **Temperature** NA **Blue Ice / Wet Ice** **Radiation Survey** C300 **fixed** _____ **removable**

SAMPLE INSPECTION

Custody Seals Broken - Y/N (N) **Chain of Custody Record** (Y)/N **Labels in Tact** (Y)/N **Radiation Survey Complete** (Y)/N

Anomalies: _____

Inspected By: _____ **DATE** 1/26/05

QA or Designee Review: _____ **DATE** _____

Sample Custodian Review: Michelle Dutton **DATE** 1-26-05

Project Notes:

Outreach
Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Invoice # 11681
D/- 1/20/06

January 19, 2006

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20060018

Dear Mr. Weyant:

Please find enclosed the analytical report for your samples received in our laboratory on January 10, 2005 for the above captioned project. Four soil samples were received in good condition and analyzed by Gamma Spectroscopy without drying and grinding and Percent Moisture with an expedited 5-work day turn.

All Quality Control for the requested analyses is reported on the analytical report. The laboratory control standard and duplicates for all analyses were within method control limits.

Your samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions, please call us at 918-251-2515.

Laboratory Director

ODEQ ID #9517
DEQ LIC. #27522-01

ACCREDITED IN ACCORDANCE WITH nelac
CERT. ID #OK001

Outreach Laboratory
311 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20060018
Date Reported:	1/19/06
Date Received:	1/10/06
Page Number:	1 of 2

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	20060018-01						
Client ID:	K-484						
Date Sampled:	1/19/05 2:25:00 PM						
Matrix:	Soil						
		Radiochemical Analyses					
Thorium 232	HASL 300	2.01 +/- 0.355	pCi/g	0.757		1/10/06	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	18.2	%		1/11/06	1/12/06	RT
Lab ID:	20060018-02						
Client ID:	K-499						
Date Sampled:	1/25/05 2:15:00 PM						
Matrix:	Soil						
		Radiochemical Analyses					
Thorium 232	HASL 300	1.13 +/- 0.235	pCi/g	0.506		1/10/06	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	7.4	%		1/11/06	1/12/06	RT
Lab ID:	20060018-03						
Client ID:	K-810						
Date Sampled:	7/20/05 2:20:00 PM						
Matrix:	Soil						
		Radiochemical Analyses					
Thorium 232	HASL 300	0.819 +/- 0.184	pCi/g	0.258		1/10/06	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	21.8	%		1/11/06	1/12/06	RT
Lab ID:	20060018-04						
Client ID:	K-896						
Date Sampled:	8/3/05 8:45:00 AM						
Matrix:	Soil						
		Radiochemical Analyses					
Thorium 232	HASL 300	1.13 +/- 0.249	pCi/g	0.453		1/10/06	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	6.6	%		1/11/06	1/12/06	RT

BDL = Below Detection Limit

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20060018
Date Reported:	1/19/06
Date Received:	1/10/06
Page Number:	2 of 2

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Ac228					NC				1/10/06
Am-241		82.0	81.0	1.0					1/10/06
Co-60		95.0	94.0	1.3					1/10/06
Cs-137		94.0	94.0	0.7					1/10/06
Percent Moisture					7.0				1/12/06

Lab Approval: _____

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
Company Kaiser-Alum & Chem, Inc.
Name David E. Wright
Address 7311 E. 41st St.
City Tulsa State OK Zip 74145
Phone 918-384-0566 Fax # 918-384-3171

Bill To:
Company Kaiser / Paul Ada
Name Paul Ada / David E. Wright
Address 7311 E. 41st St.
City Tulsa State OK Zip 74145

PO # Kaiser-4072
PROJECT # PA-4000-4072
PROJECT NAME Kaiser-Hanlon Pond.
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY) 5 DAY T.A.T.
SAMPLER David E. Wright
Signature David E. Wright

ANALYSIS REQUESTED

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	Gamma (EPA 901.1)	Gamma (EPA 901.1) client list for Methyl	Mod. Ra-226	Ra-226 & 228 (EPA 903.1 Modified)	REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
	K-484	1-19-05	1425	Soil	1	Plastic	None	X	X	X	X	Grab
	K-489	1-25-05	1415		1			X	X	X	X	
	K-810	7-20-05	1420		1			X	X	X	X	
	K-896	8-3-05	0845		1			X	X	X	X	

RELINQUISHED BY: David E. Wright DATE 11/8/06 TIME 1200 RECEIVED BY: Donna Eidson DATE 11/10/06 TIME 1200
David E. Wright

RELINQUISHED BY: _____ DATE _____ TIME _____ RECEIVED BY: _____ DATE _____ TIME _____

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

FOR LABORATORY USE ONLY: 2006C018
Sample Condition Upon Receipt: Good
Custody Seals Intact: Yes
Cooler Temperature:

SAMPLE LOG-IN

Date Received: *1/10/06 12:52:08* Lab Number: 20060018 Due: 1/17/06

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20060018-01 A	K-484	Soil	01/19/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20060018-02 A	K-499	Soil	01/25/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20060018-03 A	K-810	Soil	07/20/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20060018-04 A	K-896	Soil	08/03/05	Plastic	16 oz	None	Yes	Yes
Gamma Spec - Thorium 232								
Percent Moisture (LOD)								

CONTAINER INSPECTION

Coolers 0 Custody Seals Broken ☐ Temperature Ice Radiation Survey: <300 cpm

SAMPLE INSPECTION

Sample Seal Broken NA Chain of Custody Record ☑ Labels in Tact ☑ Radiation Survey Complete ☑

Anomalies

Inspected By: _____ DATE 01/10/06

QA or Designee Review: _____ DATE 01/10/06

Sample Custodian Review: _____ DATE 1-10-06

Project Notes:

Outreach Laboratory
11 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Invoice # 10704.
DI - 1/31/05

January 28, 2005

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20050065

Dear Mr. Weyant,

Please find enclosed the analytical report for your samples received in our laboratory on January 20, 2005 for the above captioned project. One filter was received in good condition and analyzed for Gross Alpha/Beta with an expedited 5-work day turnaround. Results were faxed 1/28/05.

All QC is within limits. The samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions feel free to call.

Laboratory Director

ODEQ ID #9517
CERT. ID# OK001
NRC ODEQ LIC. #27522-01

ACCREDITED IN ACCORDANCE WITH nelac

Outreach Laboratory
411 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050065
Date Reported:	1/28/2005
Date Received:	1/20/05
Page Number:	1 of 1

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050065-01**						
Client ID:	**K-SS-070**						
Date Sampled:	**1/19/2005 2:30:00 PM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0 +/- 0.368	dpm/100cm 2	0.441	1/21/2005	1/21/2005	RE
Gross Beta	EPA 900/9310	0 +/- 1.19	dpm/100cm 2	1.31	1/21/2005	1/21/2005	RE

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Gross Alpha	0+/-0.4	114.0			NC				1/21/2005
Gross Beta	1.2+/-1.4	106.0			NC				1/21/2005

Lab Approval: _____

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
Company KAISER - Alum & Chem JV
Name DAVID R. WEIANT
Address 7311 E. 41ST STREET
City TULSA State OK Zip 74145
Phone 724-934-3530 Fax # 918-384-3171
LOCAL: 918-384-0516
CELL: 724-799-6071

Bill To:
Company KAISER / PEAK ERE
Name DAVID R WEIANT / PAUL HANN
Address 7311 E. 41ST STREET
City TULSA State OK Zip 74145

ANALYSIS REQUESTED

PO # KAISER-4072
PROJECT # PA-4000-4072
PROJECT NAME KAISER-HORIZON REMED.
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY) 5 DAY T.A.T
SAMPLER David R. Weiant
Signature
DAVID R WEIANT

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE (1. HNO_3 pH<2, 2. Ice <4°C, 3. HCl pH<2, 4. H_2SO_4 pH<2, 5. NaOH pH>11)	Gross α/β	α mac <1 dpm/100cm²	R-mac <3 dpm/100cm²	Rad with 1 dpm/100cm²	Return to Client for Archive				REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
	K-SS-070	1-19-05	14:30	Swipe	1	Cloth	NONE	X	X	X	X	X				GRAB

RELINQUISHED BY: David R. Weiant DATE 1-20-05 TIME 1000 RECEIVED BY: Raymond Thomas DATE 1-20-05 TIME 1000

RELINQUISHED BY: _____ DATE _____ TIME _____ RECEIVED BY: Michelle Hatton DATE 1-20-05 TIME 10:20

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

SAMPLE RETURN/DISPOSAL: All non-hazardous samples shall be disposed of 30 days after issue of final report. All others will be returned at client's expense.

FOR LABORATORY USE ONLY: 0005066
Received on Ice: Yes
Temperature: 4°C

SAMPLE LOGIN

Date Received: *1/20/2005 10:16:4* **Lab Number:** 20050065 **Due:** 1/27/2005

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20050065-01 A Gross Alpha/Beta	K-SS-070	Filter	01/19/05	Other	N/A	None	Yes	Yes

CONTAINER INSPECTION

 # Coolers 0 box **Custody Seals Broken - Y(N)** **Temperature** amb. ~~**Blue Ice / Wet Ice**~~ N/A **Radiation Survey** 300 **fixed** _____ **removable**

SAMPLE INSPECTION

Custody Seals Broken - Y(N) **Chain of Custody Record (Y)N** **Labels in Tact (Y)N** **Radiation Survey Complete (Y)N**

Anomalies: _____

Inspected By: Raymonda Thomas **DATE** 01/20/05

QA or Designee Review: [illegible] **DATE** 1/20/05

Sample Custodian Review: Michelle Hatton **DATE** 1/20/05

Project Notes:

Outreach
Laboratory
11 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Lynne # 10727 01 - 2/7/05

February 7, 2005

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20050108

Dear Mr. Weyant,

Please find enclosed the analytical report for your samples received in our laboratory on February 2, 2005 for the above captioned project. Two filters were received in good condition and analyzed for Gross Alpha/Beta with an expedited turn time. Results were faxed 2/07/05.

All QC is within limits. The samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions feel free to call.

Laboratory Director

ACCREDITED IN ACCORDANCE WITH nelac

CERT. ID# OK001

ODEQ ID #9517
NRC ODEQ LIC. #27522-01

Outreach Laboratory
211 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050108
Date Reported:	2/7/2005
Date Received:	2/2/05
Page Number:	1 of 1

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050108-01**						
Client ID:	**K-SS-078**						
Date Sampled:	**2/1/2005 11:28:00 AM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0 +/- 0.618	dpm/100cm 2	0.811		2/3/2005	RE
Gross Beta	EPA 900/9310	0.298 +/- 3.39	dpm/100cm 2	3.63		2/3/2005	RE
Lab ID:	**20050108-02**						
Client ID:	**K-SS-079**						
Date Sampled:	**2/1/2005 2:33:00 PM**						
Matrix:	**Filter**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.361 +/- 0.887	dpm/100cm 2	0.811		2/3/2005	RE
Gross Beta	EPA 900/9310	1.47 +/- 3.52	dpm/100cm 2	3.63		2/3/2005	RE

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Gross Alpha	0.4+/-0.9	111.0			NC				2/3/2005
Gross Beta	1.3+/-3.5	89.0			NC				2/3/2005

Lab Approval: _____

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
LOCAL 918-384-0566
CELL: 724-799-0071

Company KAISER-ALCAN & CHEM JV.
Name DAVID R. WEYANT
Address 7311 E. 41ST STREET
City TULSA State OK Zip 74145
Phone 724-934-3539 Fax # 918-384-3171

Bill To:
Company KAISER/PAW E&C
Name DAVID R. WEYANT/PAW HANDL
Address 7311 E. 41ST STREET
City TULSA State OK Zip 74145

ANALYSIS REQUESTED

PO # KAISER-4572
PROJECT # PA-4-00-4572
PROJECT NAME KAISER-thorium Rema
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY) 5 DAY
SAMPLER David R. Weyant
Signature
DAVID R. WEYANT

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	Gross α/β	α EMC 1 dpm/100cm²	α EMC 1 dpm/100cm² Uranium & Thorium Isotopic For Anchlus	REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
	K-SS-078	2-1-05	11:28	SWIPE	1	Cloth	NONE	X	X	X	GRAB
	K-SS-079	2-1-05	14:33	SWIPE	1	Cloth	NONE	X	X	X	GRAB

* Report units in DPM/100cm²

RELINQUISHED BY: David R. Weyant DATE 2-2-05 TIME 847 RECEIVED BY: ROB REDSON DATE 2/2/05 TIME 847
RELINQUISHED BY: DAVID R. WEYANT DATE _____ TIME _____ RECEIVED BY: _____ DATE _____ TIME _____

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

FOR LABORATORY USE ONLY

SAMPLE LOGIN

Date Received: *2/2/2005 10:42:45* **Lab Number:** 20050108 **Due:** 2/7/2005

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20050108-01 A Gross Alpha/Beta	K-SS-078	Filter	02/01/05	Plastic	Encore	None	Yes	Yes
20050108-02 A Gross Alpha/Beta	K-SS-079	Filter	02/01/05	Plastic	Encore	None	Yes	Yes

CONTAINER INSPECTION

 # Coolers 0 **Custody Seals Broken - Y/N** **Temperature** _____ **Blue Ice / Wet Ice** **Radiation Survey** _____**fixed** _____**removable**

SAMPLE INSPECTION

Custody Seals Broken - Y/N **Chain of Custody Record Y/N** **Labels in Tact Y/N** **Radiation Survey Complete Y/N**

Anomalies: _____

Inspected By: _____ **DATE** 2/2/05

QA or Designee Review: Raymond Thomas **DATE** 02/02/05

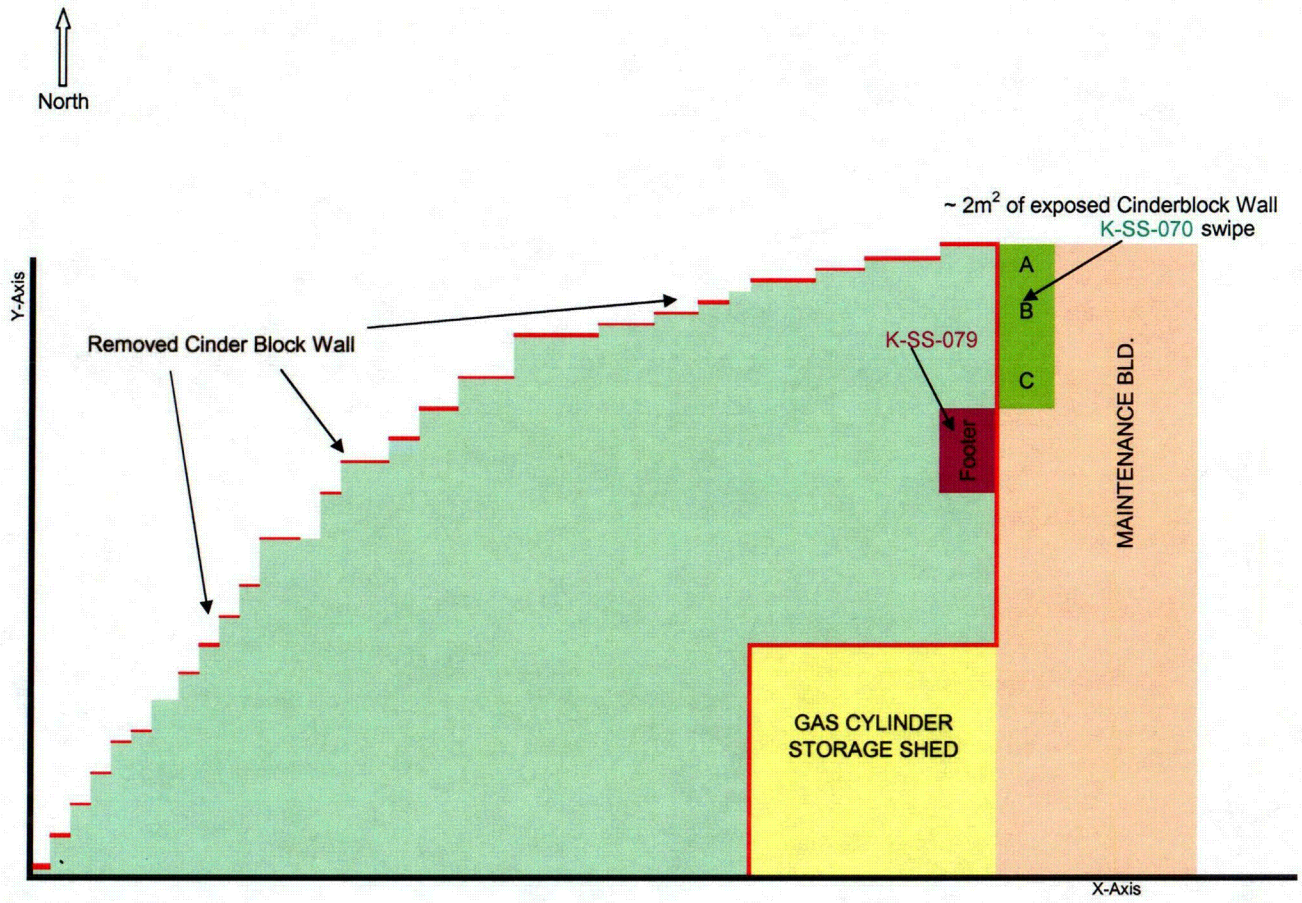
Sample Custodian Review: Michelle Lewallen **DATE** 2/2/05

Project Notes:

ATTACHMENT D
TABLE OF CONTENTS

- **FIGURE D-1 Embedded Structure Location Map**
- **Alpha Scan MDC Calculation Form**
- **Total Alpha Contamination Survey Data Conversion Form**
- **TABLE D-1 Embedded Structure Gross Alpha Scan Results**

Attachment D, Figure D-1
Embedded Structure Map
Survey Unit Kaiser-FSSFOA-004
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation



Q:\P4000\PA4072\FSS Reports\Volume II\Survey Unit FSSFOA-004\Attachment D\Figure D-1

C12

Alpha Scan MDC Calculation

Instrument Serial Number:	193686	Cal. Due:	5/4/2005
Detector Serial Number:	PR190485	Cal. Due:	5/4/2005
Radiation Detected:	Alpha	For < 3 count background	

Probability of observing 2 or more counts:

$$P(n \geq 2) = 1 - \left(1 + \frac{(GE+B)d}{60v}\right)\left(e^{\frac{(GE+B)d}{60v}}\right)$$

Probability of observing a single count:

$$P(n \geq 1) = 1 - e^{\frac{-GEd}{60v}}$$

	D Date	G Activity (dpm)	d Detector Width (cm)	E Instrument Efficiency (cpm)	v Scan Speed (cm/s)	B Background Countrate (cpm)	P Probability (-)
1	1/27/2005	520	11.7	0.1778	5.85	N/A	0.95
2	2/1/2005	520	11.7	0.1778	5.85	N/A	0.95
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

Comments:

Prepared By:	David B. Weyant	Date:	2/1/05
Reviewed By:	Andrew J Lombardo	Date:	2/1/05

Notes:

1.) Instrument Efficiency is the 4π instrument efficiency.

Total Alpha Contamination
Survey Unit Kaiser-FSSFOA-004
Survey Data Conversion Form
Form ESC/HPM/M-3-2-2

Date of Survey:	2/2/2005	Type of Radiation:	Alpha
Instrument Serial #:	193686	Calibration Due Date:	5/4/2005
Detector Serial #:	PR190485	Calibration Due Date:	5/4/2005
E_s (Surface Efficiency):	0.25	E_i (Insturment Efficiency):	0.1778
BKG Counts:	2/2/2005 3	BKG Count Time (min):	2
Active Area of Detector Probe (cm^2):	126	MDC ($dpm/100cm^2$):	98.7

FSS Swipe Number	Survey Location	Survey Point Count Time (min)	Gross Counts (cts)	Gross Count Rate (cpm)	Net Count Rate (cpm)	Total Contamination ($dpm/100cm^2$)	95% CL Uncertainty ($dpm/100cm^2$)
	Wall A	2	14	7.00	5.50	98.2	72.1
	Wall C	2	4	2.00	0.50	8.93	46.3

Comments

Prepared By: David B. Weyant	Date: 2/2/2005
Reviewed By: Andrew J. Lombardo	Date: 2/2/2005

Total Alpha Contamination
Survey Unit Kaiser-FSSFOA-004
Survey Data Conversion Form
Form ESC/HPM/M-3-2-2

Date of Survey:	2/1/2005	Type of Radiation:	Alpha
Instrument Serial #: 193686		Calibration Due Date:	5/4/2005
Detector Serial #: PR190485		Calibration Due Date:	5/4/2005
E_s (Surface Efficiency):	0.25	E_i (Insturment Efficiency):	0.1778
BKG Counts:	0	BKG Count Time (min):	2
Active Area of Detector Probe (cm^2):	126	MDC ($dpm/100cm^2$):	26.8

FSS Swipe Number	Survey Location	Survey Point Count Time (min)	Gross Counts (cts)	Gross Count Rate (cpm)	Net Count Rate (cpm)	Total Contamination ($dpm/100cm^2$)	95% CL Uncertainty ($dpm/100cm^2$)
K-SS-079	Concrete Footer	2	9	4.50	4.50	80.3	52.5

Comments

Prepared By: David B. Weyant	Date: 2/1/2005
Reviewed By: Andrew J. Lombardo	Date: 2/1/2005

Total Alpha Contamination
Survey Unit Kaiser-FSSFOA-004
Survey Data Conversion Form
Form ESC/HPM/M-3-2-2

Date of Survey:	1/27/2005	Type of Radiation:	Alpha
Instrument Serial #: 193686		Calibration Due Date:	5/4/2005
Detector Serial #: PR190485		Calibration Due Date:	5/4/2005
E_s (Surface Efficiency):	0.25	E_i (Insturment Efficiency):	0.1778
BKG Counts: 1/27/2005	3	BKG Count Time (min):	2
Active Area of Detector Probe (cm^2):	126	MDC ($dpm/100cm^2$):	98.7

Smear Sample Number	Survey Location	Survey Point Count Time (min)	Gross Counts (cts)	Gross Count Rate (cpm)	Net Count Rate (cpm)	Total Contamination ($dpm/100cm^2$)	95% CL Uncertainty ($dpm/100cm^2$)
K-SS-070 (Wall "B")	Wall B	2	47	23.5	22.0	393	124

Comments

Prepared By: David B. Weyant	Date: 1/27/2005
Reviewed By: Andrew J. Lombardo	Date: 1/27/2005

Attachment D, Table D-1
Embedded Structure Gross Alpha Scan Summary
Survey Unit Kaiser-FSSFOA-004
Cinderblock Wall and Associated Concrete Footer
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Survey Number: KAISER-FSSFOA-004		Instrument Serial Number: 193686			Cal. Due: 5/4/2005		
Tech:DBW	Alpha Eff: 17.78%	Detector Serial Number: PR190485			Cal. Due: 5/4/2005		
Structure/Location	***Area***	***Date***	***Scan***		***weighted***	***Bgrd***	***Average***
			cpm min	***cpm*** max	***cpm*** ave	***cpm*** (2 min)	***(dpm/100cm^2)*** net
Cinderblock Wall	~ 2 m^2	1/27/2005	0	40	5	1.5	62
Concrete Footer	~ 5 m^2	2/1/2005	0	10	1	0.0	18

Notes:

1. The weighted cpm is determined by the surveyor. Since alpha counts (clicks on audible) are infrequent, and 1 count may equal 10 cpm, the surveyor determines the "weighted average".

2. The acceptance criteria for Total Contamination is 944 dpm/100cm^2. 10 cpm is approximately 150 dpm/100cm^2.

3. Scans are used to identify elevated area above the acceptance criteria.

4. Compliance is demonstrated by static counts and smear (sample) results.

SUB-REPORT

SURVEY UNIT KAISER-FSSFOA-005

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2.1.1 Gross Gamma Scan	2
2.1.2 Systematic Soil Sampling – Excavation Bottom/Side Wall Surface Soil	3
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3.0 SUMMARY OF FINDINGS	7
3.1 Excavation Bottom/Side Wall Surface Soil	7
3.2 Sum of Fractions for Entire Survey Unit	7

ATTACHMENTS

ATTACHMENT A: Figure A-1 Gross Gamma Background and Scanning Survey Results
Figure A-2 Biased Soil Sampling Locations-
Figure A-3 Systematic Soil Sampling Locations

ATTACHMENT B: Soil Survey Unit Worksheet No. 1
Soil Survey Unit Worksheet No. 2

ATTACHMENT C: Laboratory Analytical Results

ATTACHMENT D: Figure D-1 Embedded Structures Location Map

Final Status Survey Report
Volume II – Former Operational Area
Sub-Report No. EB-035
Survey Unit Kaiser-FSSFOA-005
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation
March 22, 2006

1.0 BACKGROUND

This sub-report documents the results of Former Operational Area (FOA) excavation final status survey activities completed as part of the Thorium Remediation Project at the Tulsa, Oklahoma facility (**Figure 1**). Specifically, this technical report addresses the final status survey of Survey Unit Kaiser-FSSFOA-005, an open land area (FOA excavation surface) resulting from the removal of radiologically-affected soil from beneath the former Warehouse Building, a "built-up" dock area located immediately west of the former Crusher Building, and a paved concrete surface situated immediately north of the former Warehouse Building (**Figure 3**). Survey Unit Kaiser-FSSFOA-005 is considered a Class 1 survey unit with an approximate surface area of 1,320 m^2.

Survey Unit Kaiser-FSSFOA-005 consists of an excavation bottom surface soil with side walls. No elevated areas were left in-place, therefore, no elevated measurement comparisons were required for this unit. During the removal of the radiologically-affected soil, several embedded "structures" were encountered throughout the survey unit in the form of small diameter pipes including the following:

- Pipe 1 - 6-inch diameter metal,
- Pipe 2 – 12-inch diameter ceramic,
- Pipe 3 - 8-inch diameter ceramic,
- Pipe 4 – 6-inch diameter metal,
- Pipe 5 – 12-inch diameter ceramic,
- Pipe 6 – 8-inch diameter PVC,
- Pipe 7 - 6-inch diameter PVC,
- Pipe 8 – 10-inch diameter PVC,
- Pipe 9 - 4-inch diameter metal, and
- Pipe 10 – 3-inch diameter metal.

2.0 SURVEY ACTIVITIES AND RESULTS

This section of the sub-report presents the final status survey data for the following physical features or elements of Survey Unit Kaiser-FSSFOA-005:

- Excavation bottom surface soil, including side walls, and
- Embedded structures (10 small diameter pipes).

2.1 Excavation Bottom/Side Wall Surface Soil

The final status survey of the excavation bottom/side wall surface soil consisted of a gross gamma scan of the exposed surface soil and systematic soil sampling.

2.1.1 Gross Gamma Scan

The exposed surface soil of the Class 1 survey unit (excavation bottom and side walls) were surveyed through a 100 percent coverage gamma scan to confirm acceptable radiological conditions and identify any elevated areas. During the scanning of the soil, the detector was held close to the ground surface (1 to 2 inches) and moved in a serpentine pattern. Background measurements were obtained at 1-meter above the ground surface at 10 approximately equal-distant locations within the survey unit. The statistics for the 10 background measurements are provided below in **Table 1.** Background measurements ranged from 12,126 counts per minute (cpm) to 14,239 cpm.

Similar results were obtained for the gross gamma scan of the survey unit's surface area. A total of 7,486 measurements of gross count rate were made at one second intervals across the survey unit's 1,320 m^2 surface area. The results ranged from 7,774 cpm to 18,035 cpm. A statistical summary of the 100 percent coverage gamma scan of the survey unit is provided below in **Table 1.**

Table 1 – Gross Gamma Scan Results Summary

Survey Area:	1,320 m^2	
Number of Scan Measurements (1-Second Intervals)	7,486	
Scan Rate: (Swinging the detector a width of 1-meter side to side)	0.18 m/s (MARSSIM recommends 0.5m/s)	
Results Summary:	**Background (Gross cpm)**	**Scan (Gross cpm)**
Minimum	12,126	7,774
Maximum	14,239	18,035
Average	13,217	13,805
Standard Deviation	861	1,305
Median	13,335	13,786

Contour maps of the gross gamma background and final (as-left condition) scanning survey results are presented on **Figure A-1** contained in **Attachment A.** The 100 percent coverage gross gamma scan did not indicate the presence of small areas of elevated activity (above the $DCGL_W$ for the site). As part of the gross gamma survey, 7 biased soil samples were collected at locations exhibiting the highest scan rates on the excavation bottom **(Figure A-2, Attachment A).** The biased soil samples were screened on-site in a lead cave. Results of the sample screening are presented below in **Table 2.** The sample screening levels were below the $DCGL_W$ for the site.

Table 2 – Biased Soil Sample Screening Results

Soil Sample ID	Gross Th-232 (pCi/g)	Std. Error (pCi/g)	MDC (pCi/g)
$DCGL_W$	*3.0*		
Site Background	*1.1*	*0.3*	
K-658	-0.986	1.22	1.56
K-659	-0.754	1.21	1.56
K-660	0.907	1.08	1.56
K-661	0.750	1.05	1.56
K-710	2.89	1.04	1.57
K-711	1.93	1.03	1.56
K-712	1.73	1.13	1.56

2.1.2 Systematic Soil Sampling – Excavation Bottom/Side Wall Surface Soil

The final status survey also consisted of systematic soil sampling based on a random start point and an equal-distant triangular grid. The Minimum Number of Samples Required (N) based on the scan MDC was determined to be 9 as documented on Soil Survey Unit Worksheet No. 1 **(Attachment B).** Once N was determined, the Survey Unit Area (A) of 1,320 m^2 along with the N of 9 were used to calculate the Triangular Grid Node Length (L) of 13.0 meters and the Height of the Equilateral Triangle (h) of 11.3 meters. A random start point was generated using the random number feature of Excel and documented on Soil Survey Unit Worksheet No. 2 **(Attachment B).**

A layout of the soil sampling locations is provided on **Figure A-3** contained in **Attachment A.** The soil sample locations were demarcated in the field using a GPS unit. A total of 9 soil samples (identified as K-648 through K-656) were collected at the excavation bottom/side wall surface (0-6-inch depth interval) level using a clean, decontaminated sampling auger or sharpshooter shovel. The samples were forwarded to Outreach for analysis of Th-232 activity concentration. Analytical results are provided below in **Table 3.** Analytical data reports are contained in **Attachment C.**

Table 3 – Systematic Soil Sample Results

Soil Sample ID	Gross Th-232 (pCi/g)	Std. Error (pCi/g)	MDC (pCi/g)	Net Th-232 (pCi/g)	Net DCGL (pCi/g)
K-648	0.680	0.111	0.393	0	3.0
K-649	1.12	0.109	0.358	0.02	3.0
K-650	0.601	0.062	0.393	0	3.0
K-651	0.894	0.119	0.338	0	3.0
K-652	0.806	0.106	0.397	0	3.0
K-653	0.706	0.078	0.325	0	3.0
K-654	0.737	0.074	0.309	0	3.0
K-655	0.961	0.130	0.374	0	3.0
K-656	0.776	0.127	0.456	0	3.0
Average	***0.809***				
Standard Dev.	***0.160***				
Minimum	***0.601***				
Maximum	***1.12***				
Median	***0.776***				

All 9 systematic soil sample results (gross and net) were below the open land area surrogate value of 3.0 pCi/g net Th-232 activity concentration ($DCGL_W$). The maximum gross Th-232 activity concentration was 1.12 pCi/g, which fell slightly above the background Th-232 activity of 1.1 pCi/g for the site. The average gross Th-232 activity concentration was 0.809 pCi/g. The standard deviation of the 9 equal-distant samples was 0.160, which fell below the estimated standard deviation of 0.42 (based on the adjacent land final status survey results) used to calculate the minimum number of samples required.

2.1.3 Wilcoxon Rank Sum (WRS) Testing

The analytical results for the systematic soil samples were evaluated using the procedure contained in **Appendix C, Volume I** of this Final Status Survey Report (Wilcoxon Rank Sum Test). The evaluation showed that the survey unit soil sample results meet the DP statistical criterion based on the first statistical test as described below.

If the difference (0.48 pCi/g) between the maximum survey unit soil sample activity concentration (1.12 pCi/g) and the minimum reference background area soil sample activity concentration (0.64 pCi/g) is less than $DCGL_W$ (3.0 pCi/g), then the survey unit meets the release criterion. **Table 4** presents a summary of the data used to complete the statistical evaluation of the survey unit.

Table 4 – Reference Group and Survey Unit Sample Results

Reference Group	Sample ID	Th-232 (pCi/g)	Survey Unit Group	Sample ID	Th-232 (pCi/g)
R1	376	0.96	S1	K-648	0.680
R2	273	0.84	S2	K-649	1.12
R3	330	1.22	S3	K-650	0.601
R4	177	0.64	S4	K-651	0.894
R5	158	1.22	S5	K-652	0.806
R6	95	0.89	S6	K-653	0.706
R7	352	1.09	S7	K-654	0.737
R8	348	0.87	S8	K-655	0.961
R9	90	1.37	S9	K-656	0.776
	Average	***1.01***		***Average***	***0.809***
	Standard Dev.	***0.23***		***Standard Dev.***	***0.160***
	Minimum	***0.64***		***Minimum***	***0.601***
	Maximum	***1.37***		***Maximum***	***1.12***
	Median	***0.96***		***Median***	***0.776***

2.2 Embedded Structures

As previously noted, several embedded "structures" were encountered within the excavation. These structures included the following 10 small diameter pipes:

- Pipe 1 - 6-inch diameter metal,
- Pipe 2 – 12-inch diameter ceramic,
- Pipe 3 - 8-inch diameter ceramic,
- Pipe 4 – 6-inch diameter metal,
- Pipe 5 – 12-inch diameter ceramic,
- Pipe 6 – 8-inch diameter PVC,
- Pipe 7 - 6-inch diameter PVC,
- Pipe 8 – 10-inch diameter PVC,
- Pipe 9 - 4-inch diameter metal, and
- Pipe 10 – 3-inch diameter metal.

The approximate locations of the 10 embedded pipes soil sampling locations are provided on **Figure D-1** contained in **Attachment D.** These structures were surveyed and sampled in-place. A description of the survey and sample activities used to evaluate any potential exposure from the structures is presented in this section.

The embedded structures were surveyed for gross gamma activity since none of the pipes had enough flat structural surface to allow the appropriate gas proportional detector counting geometry to determine total alpha contamination. The results of the gross gamma survey are presented below in **Table 5.**

Table 5 – Embedded Pipe Gross Gamma Survey Results

Pipe	Inside (cpm)	Outside (cpm)	Background @ 1 meter (cpm)
Pipe 1 – 6-inch diameter metal	End crimped	11,584	13,058
Pipe 2 – 12-inch diameter ceramic	14,942	13,268	11,541
Pipe 3 – 8-inch diameter ceramic	13,018	13,849	14,089
Pipe 4 – 6-inch diameter metal	End crimped	Not Surveyed	Not Surveyed
Pipe 5 – 12-inch diameter ceramic	16,859	14,884	13,285
Pipe 6 – 8-inch diameter PVC	10,206	10,491	11,177
Pipe 7 – 6-inch diameter PVC	10,647	11,229	11,444
Pipe 8 – 10-inch diameter PVC	9,247	9,906	12,105
Pipe 9 – 4-inch diameter metal	End crimped	10,069	11,687
Pipe 10 – 3-inch diameter metal	Not Surveyed	10,043	10,946

Smear samples (K-SS-116 through K-SS-125 for Pipes 1 through 10 respectively) of removable contamination were taken inside each assessable pipe and on the outside of closed (crimped) pipes. The results of the removable contamination measurements are presented below in **Table 6.**

Table 6 – Embedded Pipe Removable Alpha Contamination Results

Sample ID	DCGL-GA (dpm/100cm^2)	Alpha (dpm/100cm^2)	Std. Error (dpm/100cm^2)	MDC (dpm/100cm^2)
K-SS-116	94.4	0	0.481	0.543
K-SS-117	94.4	7.02	1.72	1.16
K-SS-118	94.4	1.97	0.824	0.444
K-SS-119	94.4	2.54	0.939	0.513
K-SS-120	94.4	5.71	1.28	0.424
K-SS-121	94.4	0.607	0.687	0.607
K-SS-122	94.4	0.189	0.548	0.543
K-SS-123	94.4	3.04	1.39	1.16
K-SS-124	94.4	0.351	0.509	0.444
K-SS-125	94.4	2.27	0.901	0.513

3.0 SUMMARY OF FINDINGS

The removal of radiologically-affected soil from beneath the former Warehouse Building, a "built-up" dock area located immediately west of the former Crusher Building, and a paved concrete surface situated immediately north of the former Warehouse Building resulted in an open land area consisting of an excavation approximately 1,320 m^2 in area (**Figure 3**). This open land area, identified as Survey Unit Kaiser-FSSFOA-005 is considered a Class 1 survey unit. This section of the sub-report presents a summary of the final status survey findings and an overall summation of fractions for the survey unit including the identified embedded structures (pipes).

3.1 Excavation Bottom/Side Wall Surface Soil

The acceptance criterion for open land areas (FOA excavation surface soil) at the Tulsa facility is the DCGLw of 3.0 pCi/g net Th-232 activity concentration. Final status survey activities for Survey Unit Kaiser-FSSFOA-005 consisted of a gross gamma scan of the exposed surface soil of the survey unit (excavation bottom and side walls) and systematic soil sampling. The results of the final status survey activities were as follows:

- The 100 percent coverage gamma scan (final as-left condition) did not indicate the presence of small areas of elevated activity (above the $DCGL_W$ for the site).
- All 9 systematic soil sample results (gross and net) were below the open land area surrogate value of 3.0 pCi/g net Th-232 activity concentration ($DCGL_W$).
- The analytical results meet the DP statistical criterion based on the first statistical evaluation of the data (WRS Test procedure).
- No elevated areas were left in-place, therefore, no elevated measurement comparisons were required for this unit.

3.2 Sum of Fractions for Entire Survey Unit

To evaluate the status of Survey Unit Kaiser-FSSFOA-005 prior to backfill with clean import borrow material, as a whole (excavation bottom/side wall surface soil, elevated areas, and embedded structures), the fraction of each survey element's average net activity divided by the applicable acceptance criteria is calculated for inclusion in the Sum of Fractions for the entire survey unit. The Total Sum of Fractions for surface soil, elevated areas, and embedded structures respectively is presented below in **Table 7.** As previously mentioned, no elevated areas were left in-place for the survey unit.

Table 7 – Fraction of Applicable Acceptance Criteria per Survey Unit Element

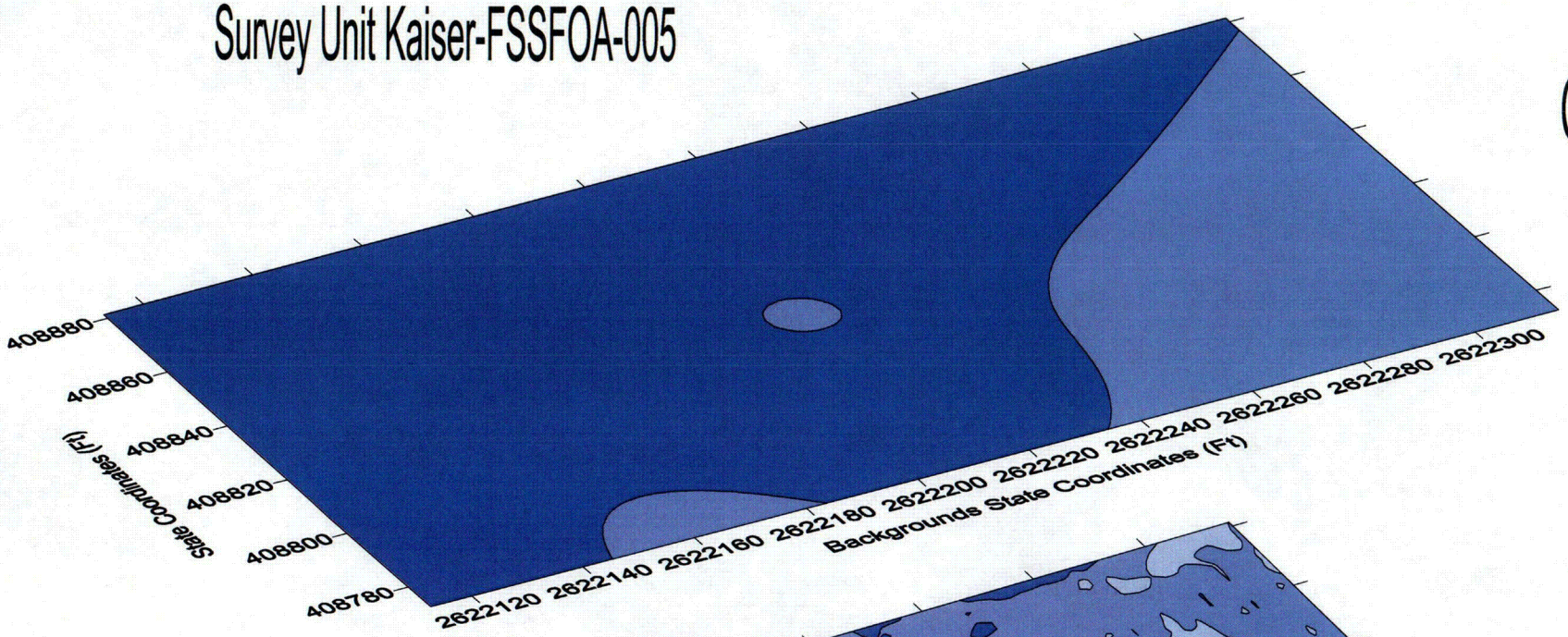
Survey Unit Element	Units	Average Net Activity	Acceptance Criteria	Fraction
-FSSFOA-005 Excavation Surface Soil	pCi/g	0	3.0	0.00
-Elevated Areas (None Left-In Place)	pCi/g	0		0.00
-Embedded Pipes (Removable Contamination.)	dpm/100cm^2	2.37	94.4	0.03
TOTAL SUM OF FRACTIONS				***0.03***

The Sum of Fractions provides a conservative assessment of the survey unit without backfill. The results of the Sum of Fractions assessment show that Survey Unit Kaiser-FSSFOA-005 meets the DP acceptance criteria.

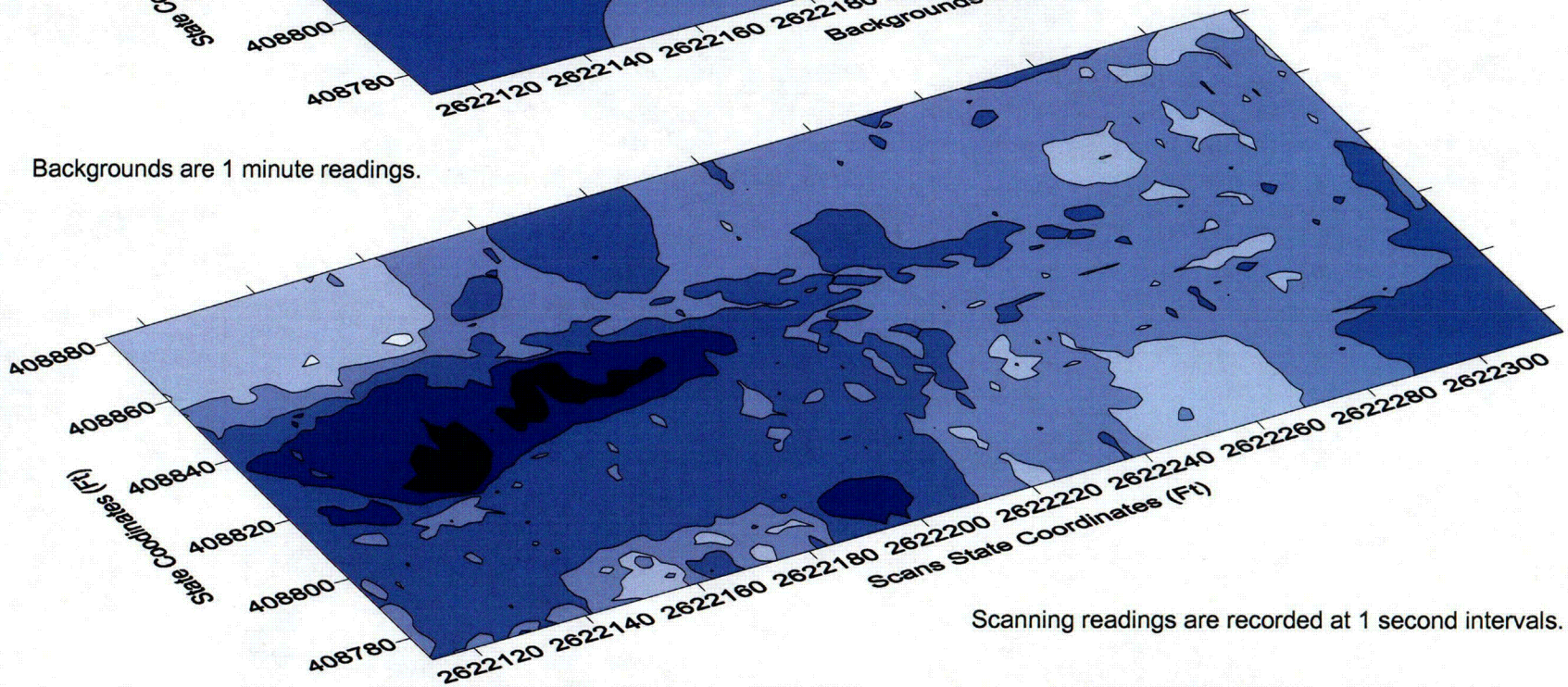
ATTACHMENT A
TABLE OF CONTENTS

- **FIGURE A-1 Gross Gamma Background and Scanning Survey Results**
- **FIGURE A-2 Biased Soil Sampling Locations**
- **FIGURE A-3 Systematic Soil Sampling Locations**

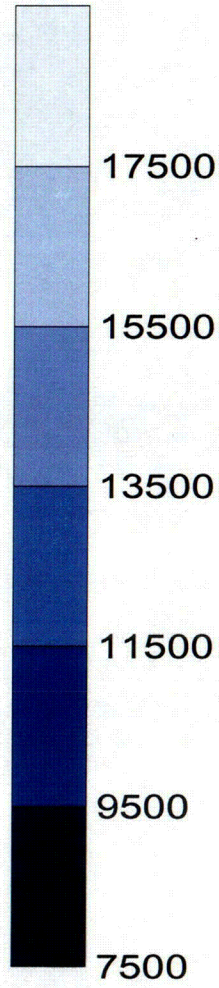
Attachment A, Figure A-1
Gross Gamma Background and Scanning Survey Results
Survey Unit Kaiser-FSSFOA-005



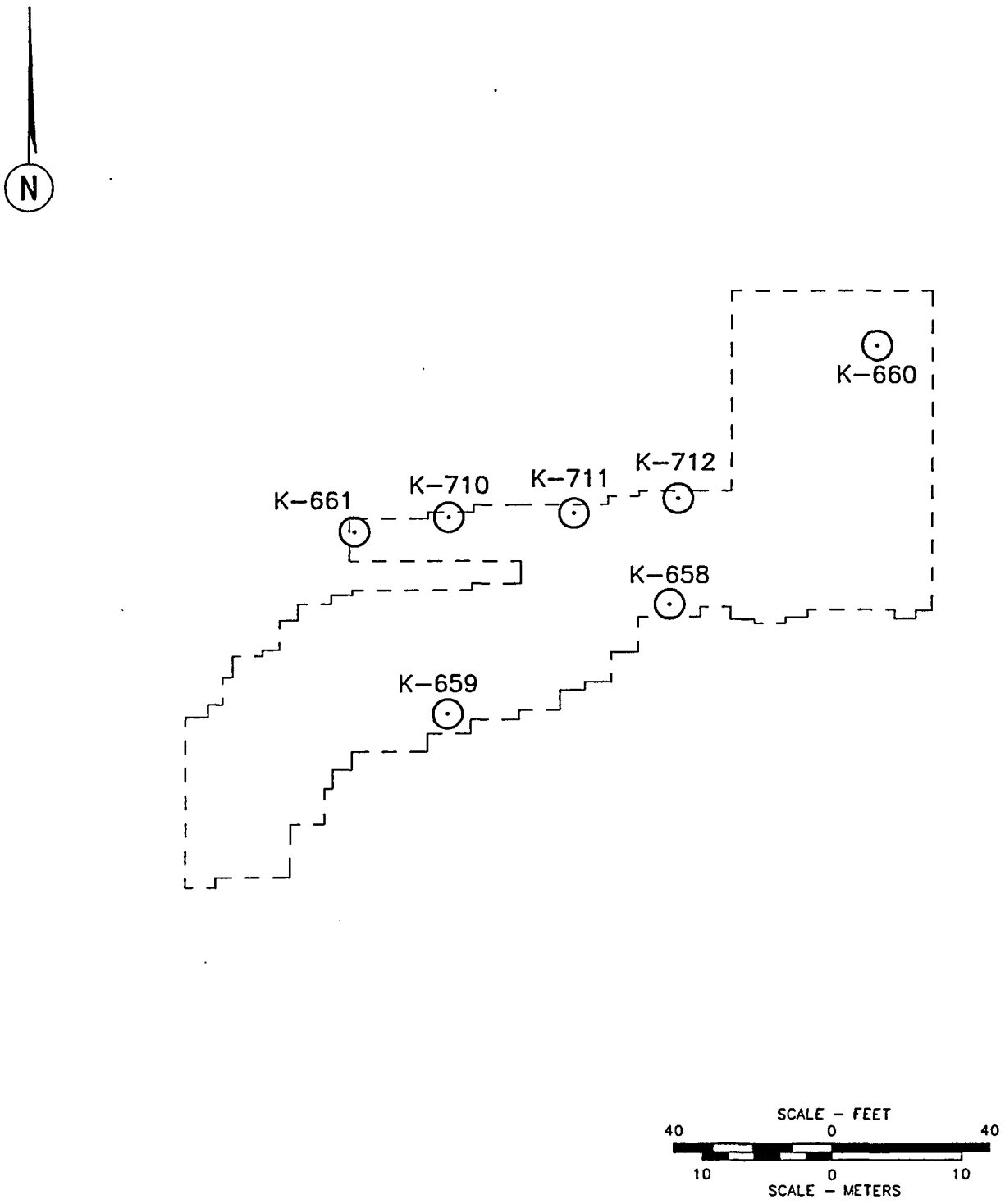
Backgrounds are 1 minute readings.



Scanning readings are recorded at 1 second intervals.



C13



K–658

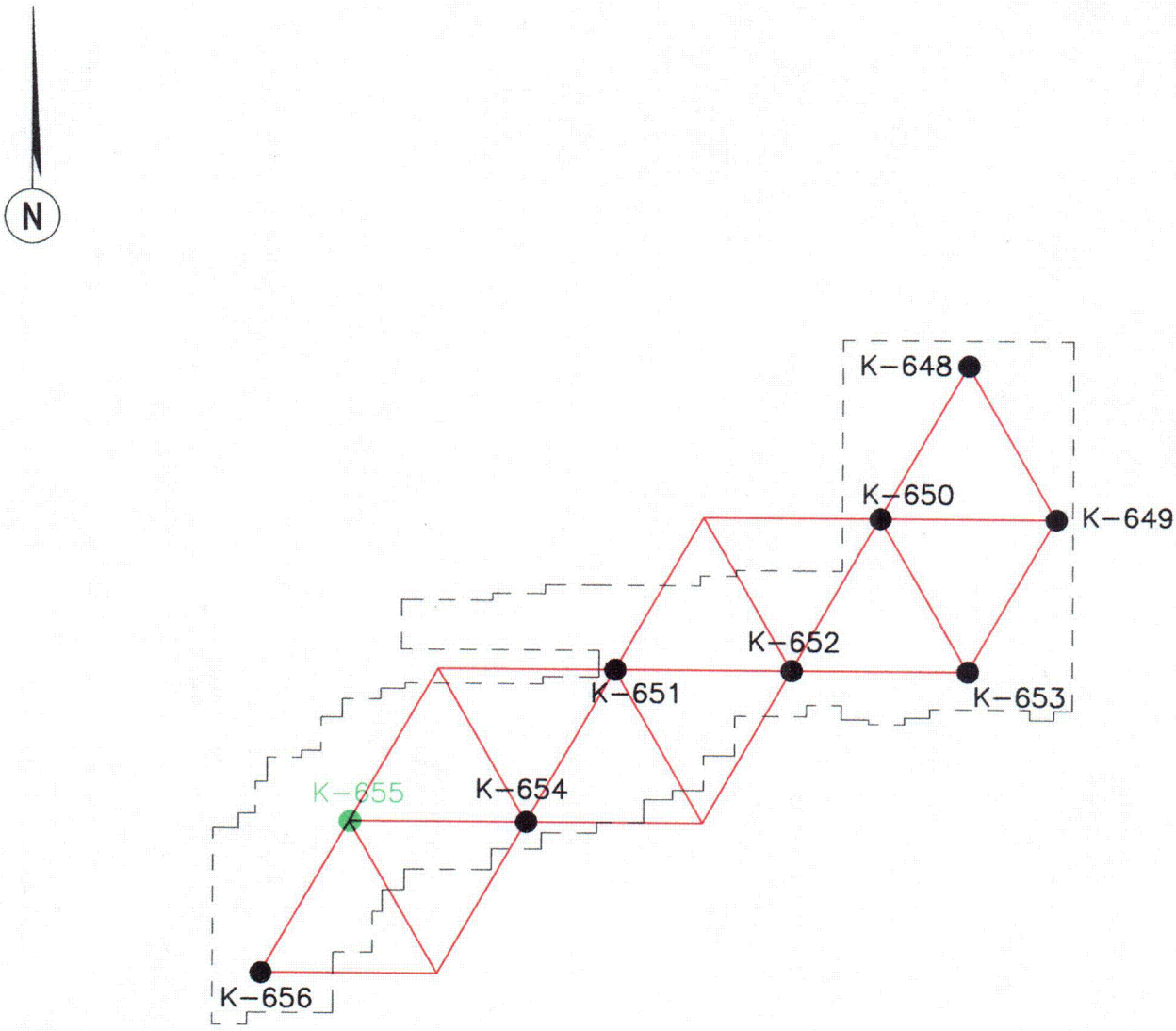
⊙ BIASED SOIL SAMPLING LOCATION

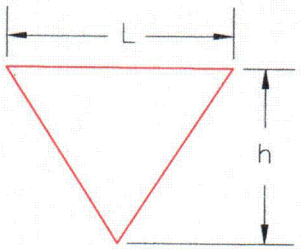
FIGURE A–2
BIASED SOIL SAMPLING LOCATIONS
SURVEY UNIT KAISER – FSSFOA–005
FINAL STATUS SURVEY
THORIUM REMEDIATION PROJECT
TULSA, OKLAHOMA FACILITY

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
TULSA, OKLAHOMA

APPROVED	RD 5-3-06
CHECKED	RD 5-3-06
DRAWN	DEB 01/19/06
DRAWING NUMBER	PA4072067A

Penn E&R
Environmental & Remediation, Inc.





N = 9
L = 13m
h = 11.3m
AREA = 1,320m^2

SCALE – FEET
40 0 40
10 0 10
SCALE – METERS

K–656
- SYSTEMATIC SOIL SAMPLING LOCATION BASED ON RANDOM START POINT AND AN EQUAL DISTANT TRIANGULAR GRID

K–655
- RANDOM START POINT

FIGURE A–3
SYSTEMATIC SOIL SAMPLING LOCATIONS SURVEY UNIT KAISER – FSSFOA–005 FINAL STATUS SURVEY THORIUM REMEDIATION PROJECT TULSA, OKLAHOMA FACILITY

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
TULSA, OKLAHOMA

APPROVED	RPD 3.3.06
CHECKED	RPD 3.3.06
DRAWN	DEB 12/27/05
DRAWING NUMBER	PA4072067

Penn E&R
Environmental & Remediation, Inc.

ATTACHMENT B
TABLE OF CONTENTS

- **Soil Survey Unit Worksheet No. 1**
- **Soil Survey Unit Worksheet No. 2**

Soil Survey Unit Work Sheet No. 1
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

1. Soil Survey Unit: KAISER-FSSFOA-005

2. Description: Former Operational Area, Former Warehouse Building Area

3. Net Th-232 Acceptance Criteria (pCi/g): 3.0

4. Dimensions (m): Excavation Bottom – Irregular; Area, A (m^2): 1,320

5. Estimate of Gross Gamma Scan Background Readings (cpm)
Average: 20,000 Minimum: 10,000 Maximum: 50,000

6. Based on the maximum background gross gamma scan reading, the scan MDC (Minimum Detectable Concentration of Th-232), the corresponding N (Minimum Number of Required Samples) and L (Triangular Grid Node Length) for a standard 2,000 m^2 Class 1 survey unit are:

- Gross Gamma Scan MDC (pCi/g): 4.0
- Minimum Number of Samples (N): 9 Triangular Grid Node Length (L): 16.0 m

7. If the area of the Survey Unit is less than 2,000 m^2, recalculate the corresponding Triangular Grid Node Length (L_1) for the Survey Unit Area (A), using the following formula: $L_1 = (A/(0.866 \times 9))^{1/2}$: 13 m

8. If N is greater than 9 and the A is other than 2,000 m^2, recalculate the corresponding Triangular Grid Node Length (L_1) using the following formula $L_1 = (A/(0.866 \times N))^{1/2}$: N/A

9. If A is greater than 2,000 m^2 and N is equal to 9, recalculate the minimum number of samples (N_1) corresponding to a Triangular Grid Node Length (L) of 16 m using the following formula $N_1 = A / (0.866 \times 16^2)$, N_1: N/A

10. Calculate the height (h) of the equilateral triangle with side length equal to L (or (L_1) using the following formula: $h = ((L^2 - (L/2)^2)^{1/2}$: 11.3 m.

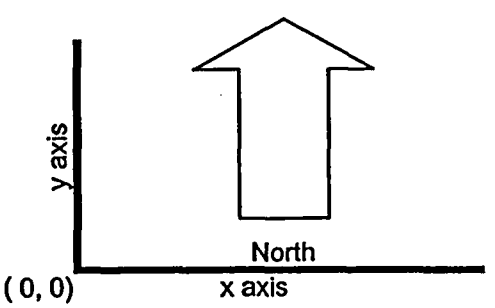
Soil Survey Unit Worksheet No. 2
Random Number Generator for Start Point
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

SURVEY UNIT: KAISER-FSSFOA-005

RANDOM START POINT

x axis (Meters)	y axis (Meters)
9	16

	x axis	y axis
lower bound	0	0
upper bound	60	50



ATTACHMENT C

LABORATORY ANALYTICAL RESULTS

Outreach Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Invoice # 11022
D/- 6/7/2005

June 7, 2005

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20050370

Dear Mr. Weyant:

Please find enclosed the analytical report for your samples received in our laboratory on May 18, 2005. Nine soil samples were received in good condition and analyzed for Thorium-232 by Gamma Spectroscopy without drying and grinding and Percent Moisture. Preliminary results were faxed May 27, 2005.

All Quality Control for the requested analyses is reported on the analytical report. The laboratory control standard and duplicates for all analyses were within method control limits.

Your samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions, please call us at 918-251-2515.

Laboratory Director

ODEQ ID #9517
DEQ LIC. #27522-01

ACCREDITED IN ACCORDANCE WITH nelac
CERT. ID #OK001

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050370
Date Reported:	6/6/05
Date Received:	5/18/05
Page Number:	1 of 3

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050370-01**						
Client ID:	**K-648**						
Date Sampled:	**5/17/05 2:35:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.680 +/- 0.111	pCi/g	0.393		5/19/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	11.7	%		5/18/05	5/19/05	RT
Lab ID:	**20050370-02**						
Client ID:	**K-649**						
Date Sampled:	**5/17/05 2:45:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	1.12 +/- 0.109	pCi/g	0.358		5/19/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	12.6	%		5/18/05	5/19/05	RT
Lab ID:	**20050370-03**						
Client ID:	**K-650**						
Date Sampled:	**5/17/05 2:50:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.601 +/- 0.062	pCi/g	0.393		5/19/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	11.0	%		5/18/05	5/19/05	RT
Lab ID:	**20050370-04**						
Client ID:	**K-651**						
Date Sampled:	**5/17/05 3:05:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.894 +/- 0.119	pCi/g	0.338		5/19/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	14.1	%		5/18/05	5/19/05	RT

BDL = Below Detection Limit

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0003

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050370
Date Reported:	6/6/05
Date Received:	5/18/05
Page Number:	2 of 3

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050370-05**						
Client ID:	**K-652**						
Date Sampled:	**5/17/05 3:00:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.806 +/- 0.106	pCi/g	0.397		5/19/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	9.7	%		5/18/05	5/19/05	RT
Lab ID:	**20050370-06**						
Client ID:	**K-653**						
Date Sampled:	**5/17/05 2:55:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.706 +/- 0.078	pCi/g	0.325		5/19/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	10.1	%		5/18/05	5/19/05	RT
Lab ID:	**20050370-07**						
Client ID:	**K-654**						
Date Sampled:	**5/17/05 3:10:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.737 +/- 0.074	pCi/g	0.309		5/19/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	14.2	%		5/18/05	5/19/05	RT
Lab ID:	**20050370-08**						
Client ID:	**K-655**						
Date Sampled:	**5/17/05 3:15:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.961 +/- 0.130	pCi/g	0.374		5/19/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	15.3	%		5/18/05	5/19/05	RT

BDL = Below Detection Limit

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050370
Date Reported:	6/6/05
Date Received:	5/18/05
Page Number:	3 of 3

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050370-09**						
Client ID:	**K-656**						
Date Sampled:	**5/17/05 3:20:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.776 +/- 0.127	pCi/g	0.456		5/19/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	16.3	%		5/18/05	5/19/05	RT

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Ac-228					NC				5/16/05
Am-241		93.0	93.0	0.0					5/16/05
Co-60		94.0	94.0	0.0					5/16/05
Cs-137		95.0	95.0	0.7					5/16/05
Percent Moisture					7.9				5/19/05

Lab Approval: _____

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:		Bill To:	
LOCAL: 918-384-0561	Company KAISER-Alum & Chem. Inc.	Company	KAISER/PENN E&R
TOLL: 724-794-0071	Name DAVID B. WEHAT	Name	DAVID B. WEHAT/PAUL HANSON
	Address 7311 E. 41ST STREET	Address	7311 E. 41ST STREET
	City TULSA State OK Zip 74145	City	TULSA State OK Zip 74145
	Phone 724-934-3530 Fax # 918-284-3171		

ANALYSIS REQUESTED

PO # KAISER 4072
PROJECT # PA-4500-4072
PROJECT NAME KAISER-Thornton Pemco.
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY) 5 DAY
SAMPLER 5 DAY T.AT
Signature DAVID B. WEHAT

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	GAMMA SPEC (Th-232)	TOTAL URANIUM Ion Analysis	RaEx 226	Ra-226 (Rn-222)				REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
	K-648	5-17-05	1435	SOIL	1	PLASTIC	NONE	X	X	X	X				GRAB
	K-649	"	1445	"	1	"	"	X	X	X	X				"
	K-650	"	1450	"	1	"	"	X	X	X	X				"
	K-651	"	1505	"	1	"	"	X	X	X	X				"
	K-652	"	1500	"	1	"	"	X	X	X	X				"
	K-653	"	1455	"	1	"	"	X	X	X	X				"
	K-654	↓	1510	"	1	"	"	X	X	X	X				"
	K-655	5-17-05	1515	"	1	"	"	X	X	X	X				"
	K-656	↓	1520	↓	1	↓	↓	X	X	X	X				"

SAMPLE [illegible]IN

Date Received: *5/18/05 10:18:15* Lab Number: 20050370 Due: 5/20/05

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20050370-01 A	K-648	Soil	05/17/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050370-02 A	K-649	Soil	05/17/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050370-03 A	K-650	Soil	05/17/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050370-04 A	K-651	Soil	05/17/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050370-05 A	K-652	Soil	05/17/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050370-06 A	K-653	Soil	05/17/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050370-07 A	K-654	Soil	05/17/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050370-08 A	K-655	Soil	05/17/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050370-09 A	K-656	Soil	05/17/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								

CONTAIN NSPECTION

Coolers 1 Custody Seals Broken - Y/N Temperature NA Blue Ice / Wet Ice Radiation Survey <300 fixed _____ removable

SAMPLE INSPECTION

Custody Seals Broken - Y/N Chain of Custody Record Y/N Labels in Tact Y/N Radiation Survey Complete Y/N

Anomalies: _____

Inspected By: Raymond Thomas DATE 05/18/05

QA or Designee Review: RCL DATE 5/18/05

Sample Custodian Review: Michelle Potter DATE 5-18-05

Project Notes:

Outreach
Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Invoice # 11020
A/- 6/7/05

June 7, 2005

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20050386

Dear Mr. Weyant,

Please find enclosed the analytical report for your samples received in our laboratory on May 23, 2005 for the above captioned project. Ten filters were received in good condition and analyzed for Gross Alpha/Beta with an expedited 5 work-day turn time. Preliminary results were faxed on 5/24/05.

All Quality Control for the requested analyses is reported on the analytical report. The method blank, laboratory control standard and matrix spikes and spike duplicates for all analyses were within method control limits.

Your samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions feel free to call.

Laboratory Director

ODEQ ID #9517
NRC ODEQ LIC. #27522-01

ACCREDITED IN ACCORDANCE WITH nelac
C
CERT. ID# OK001

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050386
Date Reported:	6/6/05
Date Received:	5/23/05
Page Number:	1 of 4

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050386-01**						
Client ID:	**K-SS-116**						
Date Sampled:	**5/20/05 8:30:00 AM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0 +/- 0.481	dpm/100cm 2	0.543		5/23/05	RE
Gross Beta	EPA 900/9310	0.514 +/- 1.43	dpm/100cm 2	1.51		5/23/05	RE
Lab ID:	**20050386-02**						
Client ID:	**K-SS-117**						
Date Sampled:	**5/20/05 8:32:00 AM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	7.02 +/- 1.72	dpm/100cm 2	1.16		5/23/05	RE
Gross Beta	EPA 900/9310	15.9 +/- 2.70	dpm/100cm 2	2.20		5/23/05	RE
Lab ID:	**20050386-03**						
Client ID:	**K-SS-118**						
Date Sampled:	**5/20/05 8:34:00 AM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	1.97 +/- 0.824	dpm/100cm 2	0.444		5/23/05	RE
Gross Beta	EPA 900/9310	8.97 +/- 1.89	dpm/100cm 2	1.44		5/23/05	OL
Lab ID:	**20050386-04**						
Client ID:	**K-SS-119**						
Date Sampled:	**5/20/05 8:36:00 AM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	2.54 +/- 0.939	dpm/100cm 2	0.513		5/23/05	RE

BDL = Below Detection Limit

Outreach Laboratory
11 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client: Kaiser Aluminum
Client Project: Thorium Remediation
Lab Number: 20050386
Date Reported: 6/6/05
Date Received: 5/23/05

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Gross Beta	EPA 900/9310	957 +/- 13.8	dpm/100cm 2	1.28		5/23/05	RE
Lab ID:	**20050386-05**						
Client ID:	**K-SS-120**						
Date Sampled:	**5/20/05 8:38:00 AM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	5.71 +/- 1.28	dpm/100cm 2	0.424		5/23/05	RE
Gross Beta	EPA 900/9310	7.27 +/- 1.81	dpm/100cm 2	1.47		5/23/05	RE
Lab ID:	**20050386-06**						
Client ID:	**K-SS-121**						
Date Sampled:	**5/20/05 8:40:00 AM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.607 +/- 0.687	dpm/100cm 2	0.607		5/23/05	RE
Gross Beta	EPA 900/9310	1.12 +/- 1.38	dpm/100cm 2	1.40		5/23/05	RE
Lab ID:	**20050386-07**						
Client ID:	**K-SS-122**						
Date Sampled:	**5/20/05 8:42:00 AM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.189 +/- 0.548	dpm/100cm 2	0.543		5/23/05	RE
Gross Beta	EPA 900/9310	0.720 +/- 1.45	dpm/100cm 2	1.51		5/23/05	RE
Lab ID:	**20050386-08**						
Client ID:	**K-SS-123**						
Date Sampled:	**5/20/05 8:44:00 AM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					

BDL = Below Detection Limit

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050386
Date Reported:	6/6/05
Date Received:	5/23/05
Page Number:	3 of 4

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Gross Alpha	EPA 900/9310	3.04 +/- 1.39	dpm/100cm 2	1.16		5/23/05	RE
Gross Beta	EPA 900/9310	8.44 +/- 2.41	dpm/100cm 2	2.20		5/23/05	RE

Lab ID: 20050386-09
Client ID: K-SS-124
Date Sampled: 5/20/05 8:46:00 AM
Matrix: Swipe

Radiochemical Analyses

Gross Alpha	EPA 900/9310	0.351 +/- 0.509	dpm/100cm 2	0.444		5/23/05	RE
Gross Beta	EPA 900/9310	0.895 +/- 1.40	dpm/100cm 2	1.44		5/23/05	RE

Lab ID: 20050386-10
Client ID: K-SS-125
Date Sampled: 5/20/05 8:48:00 AM
Matrix: Swipe

Radiochemical Analyses

Gross Alpha	EPA 900/9310	2.27 +/- 0.901	dpm/100cm 2	0.513		5/23/05	RE
Gross Beta	EPA 900/9310	29.9 +/- 2.71	dpm/100cm 2	1.28		5/23/05	RE

BDL = Below Detection Limit

Outreach Laboratory
311 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050386
Date Reported:	6/6/05
Date Received:	5/23/05
Page Number:	4 of 4

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Gross Alpha	0+/-0.3	90.0	90.0	1.2	NC				5/23/05
Gross Beta	3.7+/-2.1	76.0	87.0	12.8	NC				5/23/05

Lab Approval: _____

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
Company: Kaiser Alum & Chem Jnl.
Name: David S. Weyant
Address: 7311 E. 41st Street
City: Tulsa State: OK Zip: 74145
Phone: 724-934-3536 Fax #: 918-384-3171
Local: 918-384-0566
Cell: 724-749-0071

Bill To:
Company: Kaiser/Ceam EHC
Name: David S. Weyant/Paul Hanna
Address: 7311 E. 41st St.
City: Tulsa State: OK Zip: 74145

ANALYSIS REQUESTED

PO #: Kaiser-4072
PROJECT #: PA-4000-4072
PROJECT NAME: Kaiser-Thorium Bomb Pit #1
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY): 5 DAY
SAMPLER: David W. Offutt
Signature:

LOCATION SAMPLED	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	Gross α/β	α-RAC w/ Ba-133 Tracer	α-RAC w/ Ba-133 Tracer	Ra-226 + Th-232 Client Specific Analysis	Ra-226 + Th-232 Client Specific Analysis	REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
	K-SS-116	5-20-05	08:30	Solid	1	Cloth	None	X	X	X	X	X	GRAB
	K-SS-117		08:32					X	X	X	X	X	
	K-SS-118		08:34					X	X	X	X	X	
	K-SS-119		08:36					X	X	X	X	X	
	K-SS-120		08:38					X	X	X	X	X	
	K-SS-121		08:40					X	X	X	X	X	
	K-SS-122		08:42					X	X	X	X	X	
	K-SS-123		08:44					X	X	X	X	X	
	K-SS-124		08:46					X	X	X	X	X	
	K-SS-125		08:48					X	X	X	X	X	

RELINQUISHED BY: David S. Weyant DATE 5/23/05 TIME 916 RECEIVED BY: Donna Eidson DATE 5/23/05 TIME 916

RELINQUISHED BY: _____ DATE _____ TIME _____ RECEIVED BY: _____ DATE _____ TIME _____

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

FOR LABORATORY USE ONLY: Received 5/23/05 @ 916
SAMPLE CONDITION RECEIVED: Good

SAMPLE GIN

Date Received: *5/23/05 10:36:40* Lab Number: 20050386 Due: 5/27/05

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20050386-01 A Gross Alpha/Beta	K-SS-116	Swipe	05/20/05	Plastic	Sm Zip Bag	None	No	No
20050386-02 A Gross Alpha/Beta	K-SS-117	Swipe	05/20/05	Plastic	Sm Zip Bag	None	No	No
20050386-03 A Gross Alpha/Beta	K-SS-118	Swipe	05/20/05	Plastic	Sm Zip Bag	None	No	No
20050386-04 A Gross Alpha/Beta	K-SS-119	Swipe	05/20/05	Plastic	Sm Zip Bag	None	No	No
20050386-05 A Gross Alpha/Beta	K-SS-120	Swipe	05/20/05	Plastic	Sm Zip Bag	None	No	No
20050386-06 A Gross Alpha/Beta	K-SS-121	Swipe	05/20/05	Plastic	Sm Zip Bag	None	No	No
20050386-07 A Gross Alpha/Beta	K-SS-122	Swipe	05/20/05	Plastic	Sm Zip Bag	None	No	No
20050386-08 A Gross Alpha/Beta	K-SS-123	Swipe	05/20/05	Plastic	Sm Zip Bag	None	No	No
20050386-09 A Gross Alpha/Beta	K-SS-124	Swipe	05/20/05	Plastic	Sm Zip Bag	None	No	No
20050386-10 A Gross Alpha/Beta	K-SS-125	Swipe	05/20/05	Plastic	Sm Zip Bag	None	No	No

CONTAL . INSPECTION

Coolers N/A Custody Seals Broken - Y/N N/A Temperature N/A Blue Ice / Wet Ice Radiation Survey _____fixed_____removable

SAMPLE INSPECTION

Custody Seals Broken - Y/N N/A Chain of Custody Record Y/N Labels in Tact Y/N Radiation Survey Complete Y/N 1300 cpm

Anomalies: _____

Inspected By: _____ DATE 5/23/05

QA or Designee Review: _____ DATE _____

Sample Custodian Review: Desiree Gregory DATE 5-23-05

Project Notes:

ATTACHMENT D
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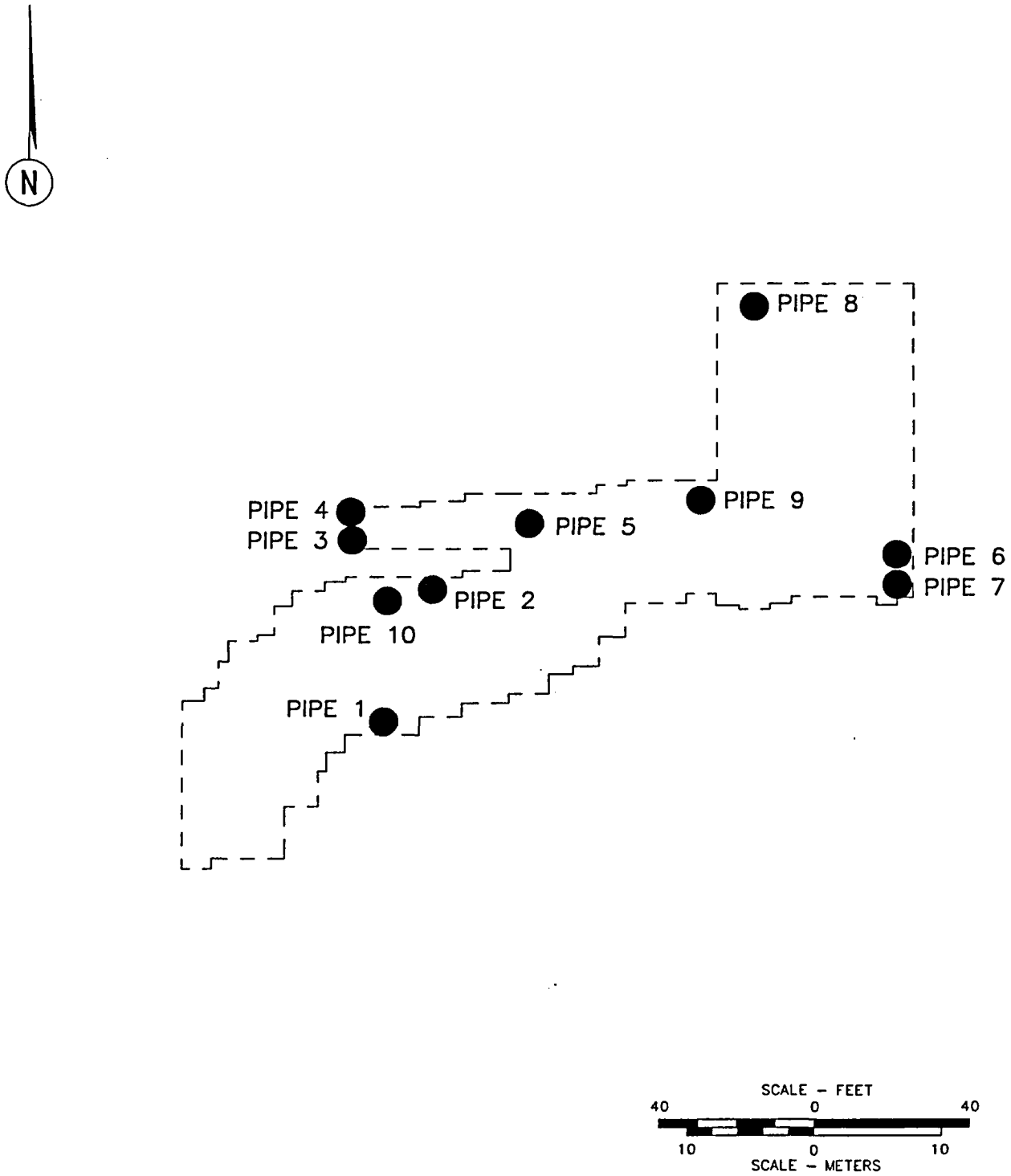
- **FIGURE D-1 Embedded Structures Location Map**



PIPE 1

PIPE LOCATION

FIGURE D-1
EMBEDDED STRUCTURES LOCATION MAP
SURVEY UNIT KAISER - FSSFOA-005
FINAL STATUS SURVEY
THORIUM REMEDIATION PROJECT
TULSA, OKLAHOMA FACILITY

PREPARED FOR

KAISER ALUMINUM & CHEMICAL CORPORATION
TULSA, OKLAHOMA

APPROVED	RD 3-3-06
CHECKED	RD 3-3-06
DRAWN	DEB 01/19/06
DRAWING NUMBER	PA4072067B

Penn E&R
Environmental & Remediation, Inc.

SUB-REPORT

SURVEY UNIT KAISER-FSSFOA-006

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ATTACHMENTS

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Figure A-2 Biased Soil Sampling Locations
Figure A-3 Systematic Soil Sampling Locations

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Final Status Survey Report
Volume II – Former Operational Area
Sub-Report No. FSS-036
Survey Unit Kaiser-FSSFOA-006
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation
March 22, 2006

1.0 BACKGROUND

This sub-report documents the results of Former Operational Area (FOA) excavation final status survey activities completed as part of the Thorium Remediation Project at the Tulsa, Oklahoma facility **(Figure 1)**. Specifically, this technical report addresses the final status survey of Survey Unit Kaiser-FSSFOA-006, an open land area (FOA excavation surface) resulting from the removal of radiologically-affected soil from beneath the former Crusher Building and a paved concrete surface situated north of 41st Street and the former Crusher Building, south of the Union Pacific Railroad right-of-way, and west of the areas remediated during the Adjacent Land Remediation Project **(Figure 3)**. Survey Unit Kaiser-FSSFOA-006 is considered a Class 1 survey unit with an approximate surface area of 2,550 m^2.

Survey Unit Kaiser-FSSFOA-006 consists of an excavation bottom surface soil with side walls. During the removal of the radiologically-affected soil, the following embedded "structures" were encountered and left in-place along the north and south walls of the excavation. These structures included the following:

- A concrete wall with both vertical and horizontal surfaces (south wall of the excavation)
- 4 PVC pipes (south wall of the excavation)
- 2 steel pipes (north wall of the excavation)

In addition, an elevated area was identified by surface scans within the north wall of the excavation adjacent to the Union Pacific Railroad. The elevated area was left in-place and was evaluated using the elevated measurement comparison (EMC).

2.0 SURVEY ACTIVITIES AND RESULTS

This section of the sub-report presents the final status survey data for the following physical features or elements of Survey Unit Kaiser-FSSFOA-006:

- Excavation bottom surface soil, including side wall surface soil.
- Elevated soil area located along the north wall of the survey unit.
- Embedded structures remaining in the north and south walls of the survey unit.

2.1 Excavation Bottom/Side Wall Surface Soil

The final status survey of the excavation bottom/side wall surface soil consisted of a gross gamma scan of the exposed surface soil and systematic soil sampling.

2.1.1 Gross Gamma Scan

The exposed surface soil of the Class 1 survey unit (excavation bottom and side walls) was surveyed through a 100 percent coverage gamma scan to confirm acceptable radiological conditions and identify any elevated areas. During the scanning of the soil, the detector was held close to the ground surface (1 – 2 inches) and moved in a serpentine pattern. Background measurements were obtained at 1-meter above the ground surface at 18 approximately equal-distant locations within the survey unit. The statistics for the 18 background measurements are provided below in **Table 1.** Background measurements ranged from 12,236 counts per minute (cpm) to 16,903 cpm.

Similar results were obtained for the gross gamma scan of the survey unit's surface area. A total of 10,151 measurements of gross count rate were made at one second intervals across the survey unit's 2,550 m^2 surface area. The results ranged from 10,373 cpm to 41,637 cpm. A statistical summary of the 100 percent coverage gamma scan of the survey unit is provided below in **Table 1.**

Table 1 – Gross Gamma Scan Results Summary

Survey Area:	2,550 m^2	
Number of Scan Measurements (1-Second Intervals)	10,151	
Scan Rate: (Swinging the detector a width of 1-meter side to side)	0.25 m/s (MARSSIM recommends 0.5m/s)	
Results Summary:	**Background (Gross cpm)**	**Scan (Gross cpm)**
Minimum	12,236	10,373
Maximum	16,903	41,637
Average	14,601	15,495
Standard Deviation	1,255	2,121
Median	14,495	15,188

Contour maps of the gross gamma background and final (as-left condition) scanning survey results are presented on **Figure A-1** contained in **Attachment A.** The 100 percent coverage gross gamma scan did not indicate the presence of small areas of elevated activity (above the $DCGL_W$ for the site) with the exception of one area of elevated activity identified along the excavation's north wall (addressed in **Section 2.2** of this sub-report).

As part of the gross gamma survey, 6 biased soil samples were collected at locations exhibiting relatively high scan rates around 2 metal pipes embedded in the north wall of the excavation **(Figure A-2, Attachment A).** The biased soil samples were forwarded to Outreach for analysis of Th-232 activity concentration. The analytical results are presented below in **Table 2.**

Table 2 – Biased Soil Sample Results

Soil Sample ID	Gross Th-232 (pCi/g)	Std. Error (pCi/g)	MDC (pCi/g)
$DCGL_W$	*3.0*		
Site Background	*1.1*	*0.3*	
K-1426	2.52	0.119	0.156
K-1427	2.68	0.261	0.175
K-1428	1.13	0.246	0.319
K-1429	0.664	0.181	0.443
K-1430	0.744	0.100	0.189
K-1431	0.977	0.188	0.391

2.1.2 Systematic Soil Sampling – Excavation Bottom/Side Wall Surface Soil

The final status survey also consisted of systematic soil sampling based on a random start point and an equal-distant triangular grid. The Minimum Number of Samples Required (N) in a standard 2,000 m^2 Class 1 survey unit, based on the scan MDC was determined to be 9 as documented on Soil Survey Unit Worksheet No. 1 **(Attachment B).** The Survey Unit Area (A) of 2,550 m^2 and the standard Triangular Grid Node Length (L) of 16 meters (corresponding to a 2,000 m^2 survey unit) were used to recalculate N (13). The corresponding Height of the Equilateral Triangle (h) is 11.3 meters. A random start point was generated using the random number feature of Excel and documented on Soil Survey Unit Worksheet No. 2 **(Attachment B).**

A layout of the soil sampling locations is provided on **Figure A-3** contained in **Attachment A.** The soil sample locations were demarcated in the field using a GPS unit. A total of 13 soil samples (identified as K-809 through K-821) were collected at the excavation bottom/side wall surface (0-6-inch depth interval) level using a clean, decontaminated sampling auger or sharpshooter shovel. The samples were forwarded to Outreach for analysis of Th-232 activity concentration. Analytical results are provided below in **Table 3.** Analytical data reports are contained in **Attachment C.**

Table 3 – Systematic Soil Sample Results

Soil Sample ID	Gross Th-232 (pCi/g)	Std. Error (pCi/g)	MDC (pCi/g)	Net Th-232 (pCi/g)	Net DCGL (pCi/g)
K-809	0.706	0.052	0.223	0	3.0
K-810	0.528	0.042	0.271	0	3.0
K-811	0.786	0.072	0.247	0	3.0
K-812	0.576	0.086	0.388	0	3.0
K-813	0.662	0.026	0.248	0	3.0
K-814	0.563	0.082	0.382	0	3.0
K-815	0.719	0.068	0.391	0	3.0
K-816	0.657	0.099	0.426	0	3.0
K-817	0.822	0.047	0.251	0	3.0
K-818	0.703	0.087	0.415	0	3.0
K-819	0.945	0.028	0.236	0	3.0
K-820	0.925	0.110	0.402	0	3.0
K-821	1.14	0.085	0.413	0.04	3.0
Average	***0.749***				
Standard Dev.	***0.174***				
Minimum	***0.528***				
Maximum	***1.14***				
Median	***0.706***				

All 13 systematic soil sample results (gross and net) were below the open land area surrogate value of 3.0 pCi/g net Th-232 activity concentration ($DCGL_W$). The maximum gross Th-232 activity concentration was 1.14 pCi/g, which fell slightly above the background Th-232 activity of 1.1 pCi/g for the site. The average gross Th-232 activity concentration was 0.749 pCi/g. The standard deviation of the 13 equal-distant samples was 0.174, which fell below the estimated standard deviation of 0.42 (based on the adjacent land final status survey results) used to calculate the minimum number of samples required.

2.1.3 Wilcoxon Rank Sum (WRS) Testing

The analytical results for the systematic soil samples were evaluated using the procedure contained in **Appendix C, Volume I** of this Final Status Survey Report (Wilcoxon Rank Sum Test). The evaluation showed that the survey unit soil sample results meet the DP statistical criterion based on the first statistical test as described below.

If the difference (0.51 pCi/g) between the maximum survey unit soil sample activity concentration (1.14 pCi/g) and the minimum reference background area soil sample activity concentration (0.63 pCi/g) is less than $DCGL_W$ (3.0 pCi/g), then the survey unit meets the release criterion. **Table 4** presents a summary of the data used to complete the statistical evaluation of the survey unit.

Table 4 – Reference Group and Survey Unit Sample Results

Reference Group	Sample ID	Th-232 (pCi/g)	Survey Unit Group	Sample ID	Th-232 (pCi/g)
R1	243	0.77	S1	K-809	0.706
R2	126	1.29	S2	K-810	0.528
R3	298	1.38	S3	K-811	0.786
R4	98	1.39	S4	K-812	0.576
R5	208	0.79	S5	K-813	0.662
R6	285	0.64	S6	K-814	0.563
R7	47	0.63	S7	K-815	0.719
R8	360	1.08	S8	K-816	0.657
R9	196	0.91	S9	K-817	0.822
R10	242	1.01	S10	K-818	0.703
R11	55	1.31	S11	K-819	0.945
R12	223	1.02	S12	K-820	0.925
R13	378	0.77	S13	K-821	1.14
	Average	***1.00***		***Average***	***0.749***
	Standard Dev.	***0.28***		***Standard Dev.***	***0.174***
	Minimum	***0.63***		***Minimum***	***0.528***
	Maximum	***1.39***		***Maximum***	***1.14***
	Median	***1.01***		***Median***	***0.706***

2.2 Elevated Area

An elevated area was identified by surface scans on the north wall of the excavation adjacent to the Union Pacific Railroad **(Attachment D, Figure D-1)**. The area of elevated activity was remediated to the fullest extent possible without undermining the railroad. The total area of the elevated area was conservatively estimated as 3.5 m^2 (3.5 meters x 1 meter). The area of elevated activity was defined using 12 soil samples. Eight of the samples were forwarded to Outreach for analysis of Th-232 activity concentration with 4 soil samples only being counted on-site in a lead cave. **Figure D-1** shows the soil sampling locations for this elevated area **(Attachment D)**. The soil sample analytical results are presented below in **Table 5**.

Table 5 - EMC Soil Sample Analytical Results

Soil Sample ID	Gross Th-232 (pCi/g)	Std. Error (pCi/g)	MDC (pCi/g)	Net Th-232 (pCi/g)	EMC-1 Net DCGL (pCi/g)	EMC-2 Net DCGL (pCi/g)
K-755*	-0.908	0.880	1.54	0	3.0	3.0
K-756	13.5	0.412	0.574	12.4	17.7	37.7
K-757	10.1	0.276	0.417	9.00	17.7	37.7
K-758	1.91	0.121	0.488	0.81	17.7	3.0
K-759*	2.04	0.916	1.54	0.94	3.0	3.0
K-760	0.546	0.096	0.300	0	17.7	3.0
K-768	6.74	0.231	0.361	5.64	17.7	37.7
K-769	0.737	0.064	0.250	0	17.7	3.0
K-770	3.18	0.154	0.250	2.08	17.7	3.0
K-771	3.88	0.206	0.542	2.78	17.7	3.0
K-772*	0.920	1.11	1.54	0	3.0	3.0
K-773*	2.00	1.13	1.56	0.90	3.0	3.0

*Analyzed only in the on-site cave counter.

An elevated measurement comparison (EMC-1) was performed for the entire 3.5 m^2 area (Samples K-770, K-760, K-756, K-769, K-768, K-757, K-771 and K-758) and for a smaller 1 m^2 area (EMC-2) within the entire 3.5 m^2 area encompassing the 3 samples exceeding the gross activity DCGL value of 4.1 pCi/g Th-232 (K-756, K-757 and K-768). Samples K-755, K-759, and K-773 were used define the extent of the elevated area for EMC-1. The elevated measurement comparisons are presented in **Section 3.2** of this sub-report and the Elevated Measurement Worksheet is contained in **Attachment D.**

2.3 Embedded Structures

As previously noted, several embedded "structures" were encountered within the excavation. These structures included the following:

- A concrete wall with both vertical and horizontal surfaces (south wall of the excavation)
- 4 small diameter PVC pipes (south wall of the excavation)
- 2 small diameter steel pipes (north wall of the excavation)

These structures were surveyed and sampled in-place. A description of the survey and sample activities used to evaluate any potential exposure from the structures is presented in this section.

The supporting documentation for surveys of the Survey Unit-Kaiser-FSSFOA-006 embedded structures are contained in **Attachment E** and include the following:

- **Figure E-1,** Embedded Structures Location Map
- **Figure E-2,** Concrete Wall Survey Map

- Alpha Scan MDC Calculation Form
- Total Alpha Contamination Survey Data Conversion Forms
- **Table E-1,** Gross Alpha Scan Summary, Concrete Wall
- **Table E-2,** Gross Alpha Scan Summary, Metal Pipes

A concrete wall was encountered along the south wall of the excavation. The wall was approximately 3 meters in length and 0.5 meter in height with a top horizontal surface of approximately 0.5 meter across and an additional upper vertical surface on the east side of the wall, also 0.5 meter in height **(Figure E-2, Attachment E).** The wall surface was scanned for gross alpha contamination. No elevated areas were identified. Scan results are provided in **Table E-1, Attachment E.** Nine static counts to determine total alpha contamination were taken at locations exhibiting the highest scan results. Six smear samples of removable contamination were also taken on the exposed wall surfaces (K-SS-170 through K-SS-175). The results of the total and removable alpha contamination measurements are presented below in **Table 6.**

Table 6 - Concrete Wall Total and Removable Alpha Contamination Results

Sample ID	$DCGL_W$ (dpm/100cm^2)	Alpha (dpm/100cm^2)	Std. Error (dpm/100cm^2)	MDC (dpm/100cm^2)
Total Contamination				
A	944	163	91.7	110
B	944	64.7	68.7	110
C	944	94.2	76.3	110
D	944	-3.92	46.1	110
E	944	290	115	110
F	944	310	118	110
G	944	526	149	110
H	944	64.7	68.7	110
I	944	-13.7	42.0	110
Removable Contamination				
K-SS-170	94.4	5.31	1.47	0.631
K-SS-171	94.4	2.36	1.07	0.631
K-SS-172	94.4	0.129	0.620	0.631
K-SS-173	94.4	0.308	0.688	0.631
K-SS-174	94.4	0.129	0.620	0.631
K-SS-175	94.4	0.219	0.644	0.631

Also in the south wall of the excavation, 4 small PVC pipes were uncovered in the southwest corner of the survey unit. The pipes were small diameter (2 to 6 inches) and could not be scanned with a gas proportional detector for gross alpha activity. The surface was scanned for gross gamma during the walkover survey for the entire survey unit. No activity above background was

detected in or around the pipes. Smear samples of removable alpha contamination were taken inside of each of the pipes. The results are presented in below in **Table 7.**

Table 7 – PVC Pipe Removable Alpha Contamination Results

Pipe ID	$DCGL_W$ (dpm/100cm^2)	Alpha (dpm/100cm^2)	Std. Error (dpm/100cm^2)	MDC (dpm/100cm^2)
1 – 6" Green (K-SS-166)	94.4	0.933	0.813	0.631
2 - 2" White (K-SS-167)	94.4	1.11	0.849	0.631
3 - 6" White (K-SS-168)	94.4	0.129	0.620	0.631
4 -2" White (K-SS-169)	94.4	0.129	0.620	0.631

In addition, 2 steel pipes (4-inch and 6-inch diameter) were encountered within the north wall of the excavation, east of the elevated area. The two pipes continue northward (approximately 40 feet) beneath the railroad tracks and terminate in Pond Parcel Survey Unit Kaiser-FSS-030 **(Figure E-2, Attachment E).** These two pipes were located approximately 5 feet below the existing ground-surface. A visual inspection and preliminary gross gamma survey of the pipes indicated the presence of a small amount of dross materials. As a result, the pipes were cleaned in-place to remove the gross dross material. Pre- and post-remedial gross gamma survey results are presented below in **Table 8.**

Table 8 – Steel Pipes Pre- and Post-Remedial Gross Gamma Survey Results

Location	**Inside Pipe (cpm)**	**At Pipe Opening (cpm)**
Survey Unit Kaiser-FSSFOA-006 (Local Gross Gamma Background 18,747 cpm)		
Pre-Remediation		
Inside 6-inch	Not Surveyed	Not Surveyed
Inside 4-inch	Not Surveyed	Not Surveyed
Post-Remediation		
Inside 6-inch	13,419	17,444
Inside 4-inch	12,324	16,308
Survey Unit Kaiser-FSS-030 (Local Gross Gamma Background 17,285 cpm)		
Pre-Remediation		
Inside 6-inch	72,098	36,980
Inside 4-inch	23,247	19,180
Post-Remediation		
Inside 6-inch	11,704	15,150
Inside 4-inch	9,889	14,655

Gross gamma results indicate that the decontamination efforts were successful. The results for total and removable alpha contamination provided below demonstrate compliance with the DCGL-GA for structural surfaces.

A post-remedial survey for total and removable alpha contamination was conducted at both accessible ends of each pipe. Static counts to determine total alpha contamination were taken outside of each pipe since the gas proportional detector could not fit inside either pipe. Smear samples of removable alpha contamination were taken on the inside and outside structural surfaces of both ends of the pipes. The results of the total and removable alpha contamination measurements are presented below in **Table 9.**

Table 9 – Steel Pipes Total and Removable Alpha Contamination Results

Sample ID	DCGL-GA (dpm/100cm^2)	Alpha (dpm/100cm^2)	Std. Error (dpm/100cm^2)	MDC (dpm/100cm^2)
Survey Unit Kaiser-FSSFOA-006 End of Pipes				
Total Contamination				
Outside 6-inch	944	98.1	51.6	69.5
Outside 4-inch	944	39.2	42.1	69.5
Removable Contamination				
K-SS-221	94.4	0.308	0.668	0.631
K-SS-222	94.4	0.884	0.793	0.631
K-SS-223	94.4	10.0	1.95	0.631
K-SS-224	94.4	9.86	1.93	0.631
Survey Unit Kaiser-FSS-030 End of Pipes				
Total Contamination				
Outside 6-inch	944	15.7	37.7	69.5
Outside 4-inch	944	51.0	44.2	69.5
Removable Contamination				
K-SS-227	94.4	1.02	0.831	0.631
K-SS-228	94.4	0.844	0.793	0.631
K-SS-225	94.4	0.487	0.712	0.631
K-SS-226	94.4	0.040	0.595	0.631

Upon completion of the survey activities, both pipes were grouted with cement.

3.0 SUMMARY OF FINDINGS

The removal of radiologically-affected soil from beneath the former Crusher Building and a paved concrete surface situated north of 41st Street and the former Crusher Building, south of the Union Pacific Railroad right-of-way, and west of the areas remediated during the ALRP resulted in an open land area consisting of an excavation approximately 2,550 m^2 in area **(Figure 3)**. This open land area, identified as Survey Unit Kaiser-FSSFOA-006, is considered a Class 1 survey unit. This section of the sub-report presents a summary of the final status survey findings, an elevated measurement comparison, and an overall summation of fractions for the survey unit including the identified embedded structures.

3.1 Excavation Bottom/Side Wall Surface Soil

The acceptance criterion for open land areas (FOA excavation surface soil) at the Tulsa facility is the DCGLw of 3.0 pCi/g net Th-232 activity concentration. Final status survey activities for Survey Unit Kaiser-FSSFOA-006 consisted of a gross gamma scan of the exposed surface soil of the survey unit (excavation bottom and side walls) and systematic soil sampling. The results of the final status survey activities were as follows:

- The 100 percent coverage gamma scan of the excavation bottom (final as-left condition) did not indicate the presence of small areas of elevated activity (above the $DCGL_W$ for the site). One area of elevated activity was identified along the excavation's north wall (discussed in **Section 3.2**)
- All 13 systematic soil sample results (gross and net) were below the open land area surrogate value of 3.0 pCi/g net Th-232 activity concentration ($DCGL_W$).
- The analytical results meet the DP statistical criterion based on the first statistical evaluation of the data (WRS Test procedure).

3.2 Elevated Measurement Comparison

Consistent with the MARSSIM and the DP, elevated areas and the total dose from soil are evaluated as follows. Analytical results of soil samples are used to complete the elevated measurement comparison. If residual radioactivity is found in a localized area of elevated activity--in addition to the residual radioactivity distributed relatively uniformly across the survey unit--the Unity Rule is used to ensure that the release criterion has been met as follows:

$$\frac{\delta}{DCGL} + \sum_{x+1}^{n} \frac{(\delta_{EMC} - \delta)}{DCGL_{EMC}} \leq 1$$

where:

δ = is the average concentration of Th-232 over the entire survey unit,
δ_{EMC} = the average concentration of Th-232 over the elevated area (x) within the survey unit,
DCGL = the $DCGL_W$ for Th-232,
$DCGL_{EMC}$ = (area factor for elevated area x) X ($DCGL_W$),

x = refers to one of the elevated areas within the survey unit, and
n = the total number of elevated areas within the survey unit.

The calculation for Survey Unit Kaiser-FSSFOA-006 including the elevated area is summarized below in **Table 10.**

Table 10 - Elevated Measurement Comparison and Fraction Summary

Sample Date	Unit / EMC unit	Unit Area (m^2)	Gross Th-232 (pCi/g)	Net Th-232 (pCi/g)	Net DCGL (pCi/g)	Fraction (-)	Sample Number
7/20/05	FSSFOA-006	2,550	0.749	0.000	3.00	0.00	K-809 through K-821
6/28/05	EMC	1	10.1	9.35	37.5	0.25	K-756, K-757, and K-768

3.3 Sum of Fractions for Entire Survey Unit

To evaluate the status of Survey Unit Kaiser-FSSFOA-006 prior to backfill with clean import borrow material, as a whole (excavation bottom/side wall surface soil, elevated areas, and embedded structures), the fraction of each survey element's average net activity divided by the applicable acceptance criteria is calculated for inclusion in the Sum of Fractions for the entire survey unit. The Total Sum of Fractions for surface soil, elevated areas, and embedded structures respectively is presented below in **Table 11.**

Table 11 – Fraction of Applicable Acceptance Criteria per Survey Unit Element

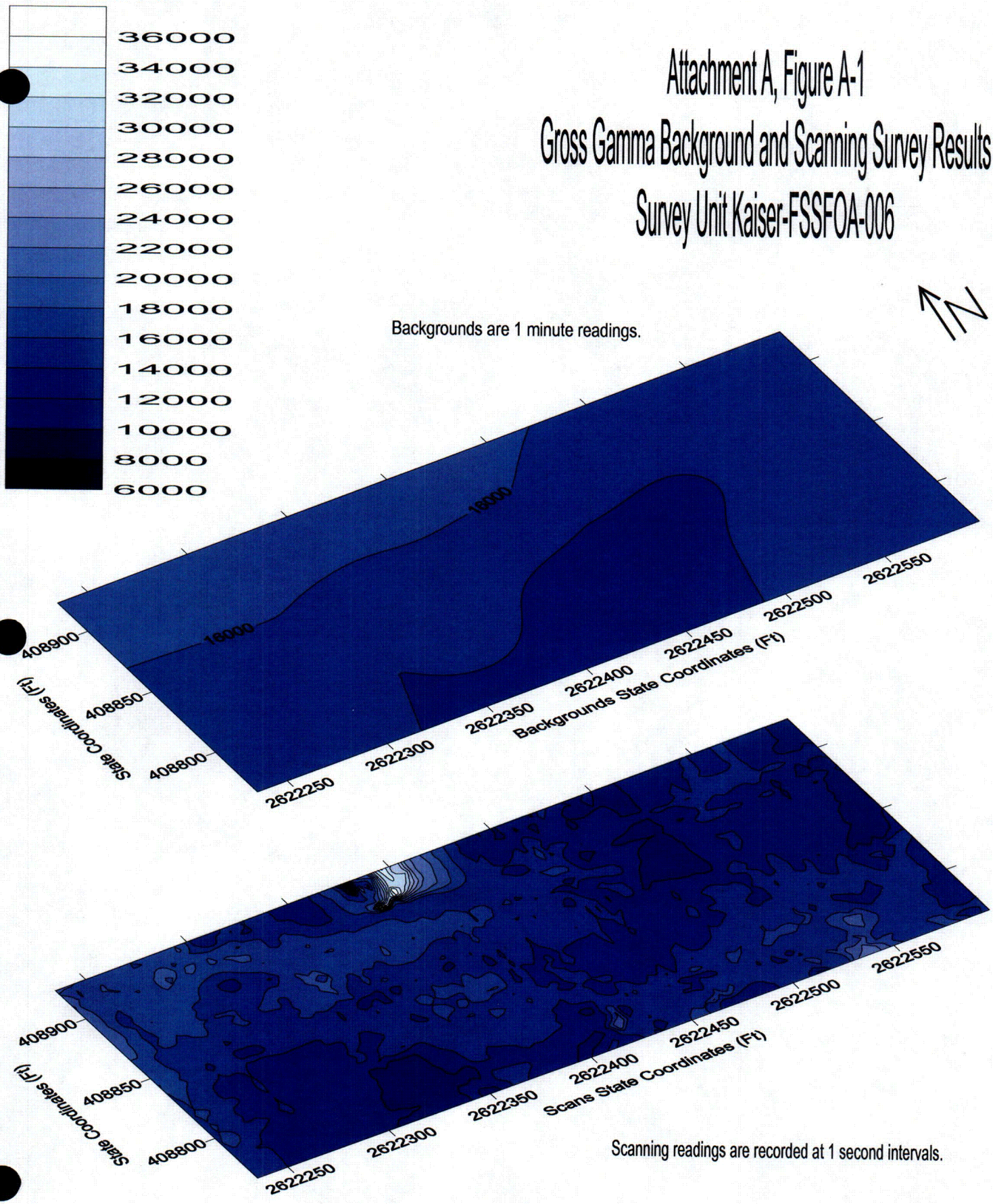
Survey Unit Element	Units	Average Activity	Acceptance Criteria	Fraction
-FSSFOA-006 Excavation Surface Soil	pCi/g	0	3.0	0.00
-Elevated Area EMC (Soil)	pCi/g	9.35	37.5	0.25
Concrete Wall (Total Contamination)	dpm/100cm^2	166	944	0.18
Concrete Wall (Removable Contamination)	dpm/100cm^2	1.41	94.4	0.02
PVC Pipes (Removable Contamination)	dpm/100cm^2	0.575	94.4	0.01
Steel Pipes (Total Contamination)	dpm/100cm^2	68.7	944	0.07
Steel Pipes (Removable Cont.)	dpm/100cm^2	5.26	94.4	0.06
TOTAL SUM OF FRACTIONS				***0.59***

The Sum of Fractions provides a conservative assessment of the survey unit without backfill. The results of the Sum of Fractions assessment show that Survey Unit Kaiser-FSSFOA-006 meets the DP acceptance criteria.

ATTACHMENT A
TABLE OF CONTENTS

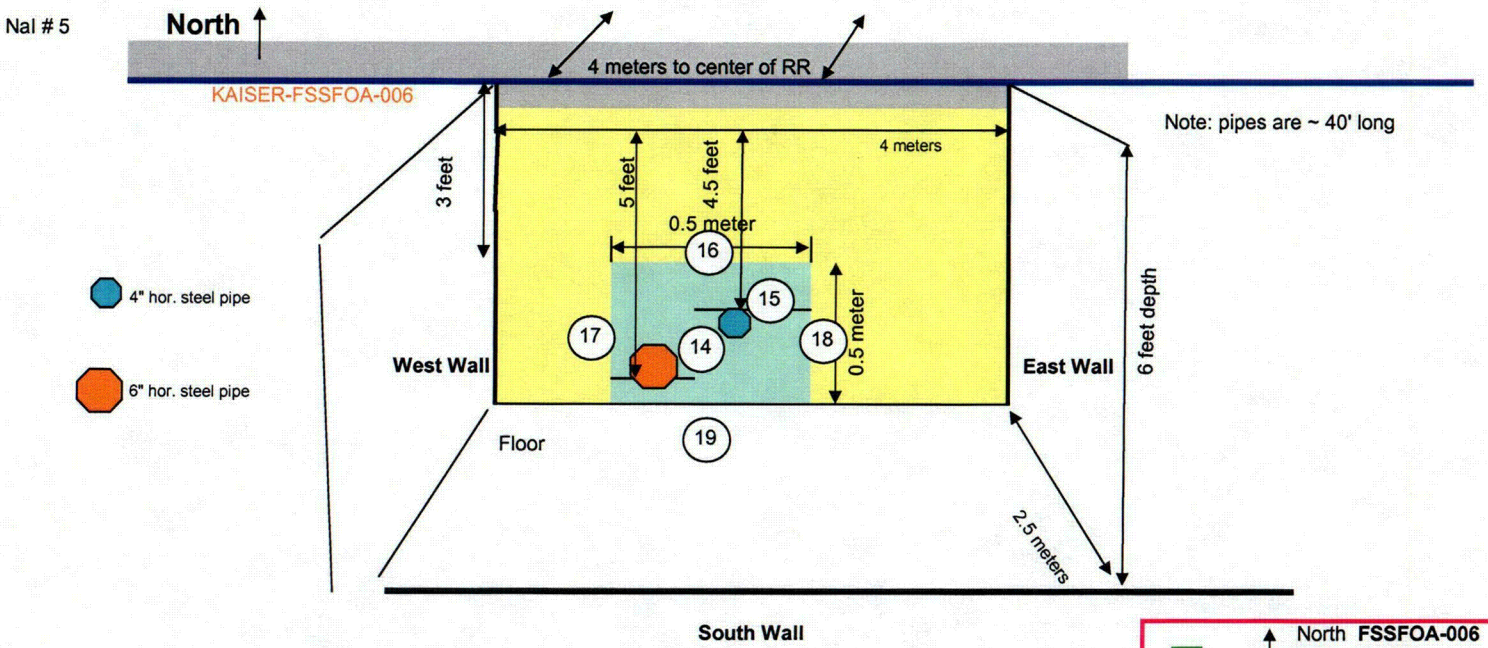
- **FIGURE A-1 Gross Gamma Background and Scanning Survey Results**
- **FIGURE A-2 Biased Soil Sampling Locations**
- **FIGURE A-3 Systematic Soil Sampling Locations**

Attachment A, Figure A-1
Gross Gamma Background and Scanning Survey Results
Survey Unit Kaiser-FSSFOA-006

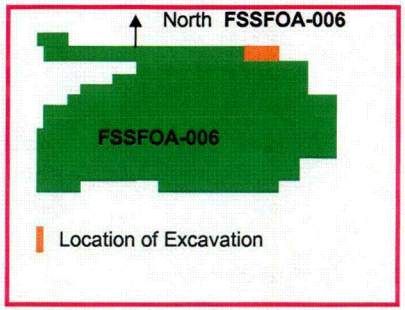


Attachment A, Figure A-2
Biased Soil Sampling Locations
Survey Unit Kaiser-FSSFOA-006
Final Status Survey
Thorium Remediaiton Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

North Wall Metal Pipes and Biased Sample Locations



Front View Looking North

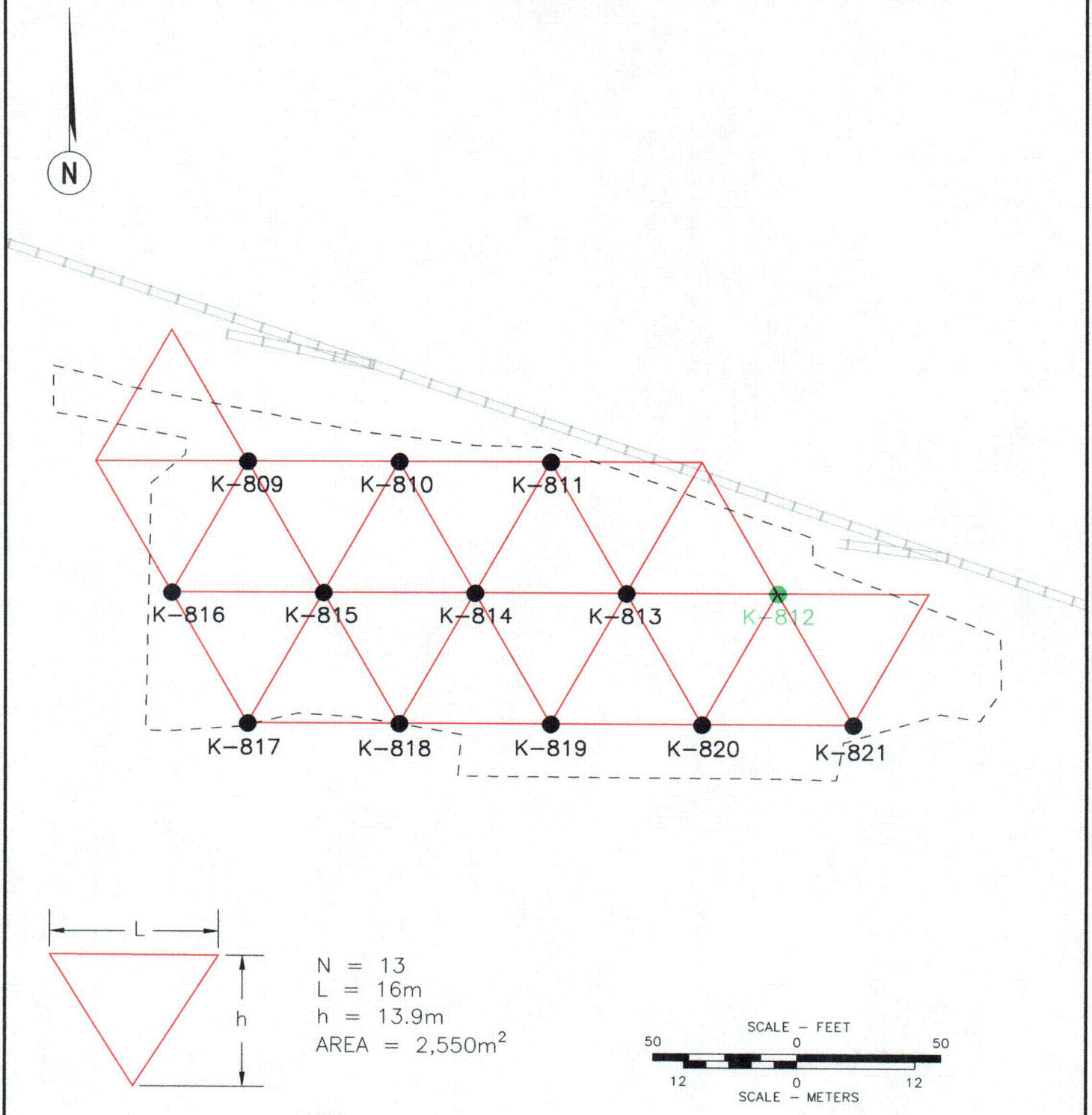


Sample Locations

Material	Location	Sample No.
Soil	14	K-1426
Soil	15	K-1427
Soil	16	K-1428
Soil	17	K-1429
Soil	18	K-1430
Soil	19	K-1431

Q:\P4000\PA4072\FSS Reports\Volume II\Survey Unit FSSFOA-006\Attachment A\Figure A-2

C16



N = 13
L = 16m
h = 13.9m
AREA = 2,550m^2

SCALE – FEET
50 0 50
12 0 12
SCALE – METERS

K–809
● SYSTEMATIC SOIL SAMPLING LOCATION BASED ON RANDOM START POINT AND AN EQUAL DISTANT TRIANGULAR GRID

K–812
● RANDOM START POINT

FIGURE A–3
SYSTEMATIC SOIL SAMPLING LOCATIONS
SURVEY UNIT KAISER – FSSFOA–006
FINAL STATUS SURVEY
THORIUM REMEDIATION PROJECT
TULSA, OKLAHOMA FACILITY

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
TULSA, OKLAHOMA

APPROVED	RD 3.3.06
CHECKED	RD 3.3.06
DRAWN	DEB 12/27/05
DRAWING NUMBER	PA4072066

Penn E&R
Environmental & Remediation, Inc.

ATTACHMENT B
TABLE OF CONTENTS

- **Soil Survey Unit Worksheet No. 1**
- **Soil Survey Unit Worksheet No. 2**

Soil Survey Unit Work Sheet No. 1
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

1. Soil Survey Unit: KAISER-FSSFOA-006

2. Description: Former Operational Area, Former Crusher Building Area

3. Net Th-232 Acceptance Criteria (pCi/g): 3.0

4. Dimensions (m): Excavation Bottom – 80 meters x 32 meters; Area, A (m^2): 2,550

5. Estimate of Gross Gamma Scan Background Readings (cpm)
Average: 20,000 Minimum: 10,000 Maximum: 50,000

6. Based on the maximum background gross gamma scan reading, the scan MDC (Minimum Detectable Concentration of Th-232), the corresponding N (Minimum Number of Required Samples) and L (Triangular Grid Node Length) for a standard 2,000 m^2 Class 1 survey unit are:

- Gross Gamma Scan MDC (pCi/g): 4.0
- Minimum Number of Samples (N): 9 Triangular Grid Node Length (L): 16.0 m

7. If the area of the Survey Unit is less than 2,000 m^2, recalculate the corresponding Triangular Grid Node Length (L_1) for the Survey Unit Area (A), using the following formula: $L_1 = (A/(0.866 \times 9))^{1/2}$: N/A

8. If N is greater than 9 and the A is other than 2,000 m^2, recalculate the corresponding Triangular Grid Node Length (L_1) using the following formula $L_1 = (A/(0.866 \times N))^{1/2}$: N/A

9. If A is greater than 2,000 m^2 and N is equal to 9, recalculate the minimum number of samples (N_1) corresponding to a Triangular Grid Node Length (L) of 16 m using the following formula $N_1 = A / (0.866 \times 16^2)$, N_1: 13

10. Calculate the height (h) of the equilateral triangle with side length equal to L (or (L_1) using the following formula: $h = ((L^2 - (L/2)^2)^{1/2}$: 13.9 m.

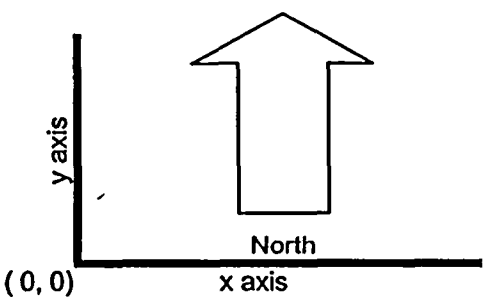
Soil Survey Unit Worksheet No. 2
Random Number Generator for Start Point
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

SURVEY UNIT: KAISER-FSSFOA-006

RANDOM START POINT

x axis (Meters)	y axis (Meters)
63	21

	x axis	y axis
lower bound	0	0
upper bound	102	43



ATTACHMENT C

LABORATORY ANALYTICAL RESULTS

Outreach Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Invoice was fd.
11188
8/29/05

August 22, 2005

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20050569

Dear Mr. Weyant:

Please find enclosed an amended report for the above captioned project. At your request, sample #2 was reanalyzed to provide a number instead of ND. The new result for #2 is included in the attached amended report. No other changes were made.

Thank you for choosing Outreach Laboratory and if you have any questions, please call us at 918-251-2515.

Laboratory Director

ODEQ ID #9517
DEQ LIC. #27522-01

ACCREDITED IN ACCORDANCE WITH nelac
CERT. ID #OK001

Outreach Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

AMENDED

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050569
Date Reported:	8/22/05
Date Received:	7/21/05
Page Number:	1 of 4

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050569-01**						
Client ID:	**K-809**						
Date Sampled:	**7/20/05 2:15:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.706 +/- 0.052	pCi/g	0.223		7/22/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	19.9	%		7/21/05	7/22/05	MD
Lab ID:	**20050569-02**						
Client ID:	**K-810**						
Date Sampled:	**7/20/05 2:20:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.528 +/- 0.042	pCi/g	0.271		8/19/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	20.6	%		7/21/05	7/22/05	MD
Lab ID:	**20050569-03**						
Client ID:	**K-811**						
Date Sampled:	**7/20/05 2:25:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.786 +/- 0.072	pCi/g	0.247		7/22/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	20.5	%		7/21/05	7/22/05	MD
Lab ID:	**20050569-04**						
Client ID:	**K-812**						
Date Sampled:	**7/20/05 2:30:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.576 +/- 0.086	pCi/g	0.388		7/22/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	12.7	%		7/21/05	7/22/05	MD

BDL = Below Detection Limit

Outreach Laboratory
4 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

AMENDED

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050569
Date Reported:	8/22/05
Date Received:	7/21/05
Page Number:	2 of 4

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050569-05**						
Client ID:	**K-813**						
Date Sampled:	**7/20/05 2:35:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.662 +/- 0.026	pCi/g	0.248		7/22/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	8.7	%		7/21/05	7/22/05	MD
Lab ID:	**20050569-06**						
Client ID:	**K-814**						
Date Sampled:	**7/20/05 2:40:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.563 +/- 0.082	pCi/g	0.382		7/22/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	8.5	%		7/21/05	7/22/05	MD
Lab ID:	**20050569-07**						
Client ID:	**K-815**						
Date Sampled:	**7/20/05 2:45:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.719 +/- 0.068	pCi/g	0.391		7/22/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	10.4	%		7/21/05	7/22/05	MD
Lab ID:	**20050569-08**						
Client ID:	**K-816**						
Date Sampled:	**7/20/05 2:50:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.657 +/- 0.099	pCi/g	0.426		7/24/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	4.1	%		7/21/05	7/22/05	MD

BDL = Below Detection Limit

Outreach Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

AMENDED

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050569
Date Reported:	8/22/05
Date Received:	7/21/05
Page Number:	3 of 4

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050569-09**						
Client ID:	**K-817**						
Date Sampled:	**7/20/05 2:55:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.822 +/- 0.047	pCi/g	0.251		7/25/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	3.8	%		7/21/05	7/22/05	MD
Lab ID:	**20050569-10**						
Client ID:	**K-818**						
Date Sampled:	**7/20/05 3:00:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.703 +/- 0.087	pCi/g	0.415		7/25/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	6.4	%		7/21/05	7/22/05	MD
Lab ID:	**20050569-11**						
Client ID:	**K-819**						
Date Sampled:	**7/20/05 3:05:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.945 +/- 0.028	pCi/g	0.236		7/25/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	5.2	%		7/21/05	7/22/05	MD
Lab ID:	**20050569-12**						
Client ID:	**K-820**						
Date Sampled:	**7/20/05 3:10:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.925 +/- 0.110	pCi/g	0.402		7/25/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	15.5	%		7/21/05	7/22/05	MD

BDL = Below Detection Limit

Outreach Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

AMENDED

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050569
Date Reported:	8/22/05
Date Received:	7/21/05
Page Number:	4 of 4

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050569-13**						
Client ID:	**K-821**						
Date Sampled:	**7/20/05 3:15:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	1.14 +/- 0.085	pCi/g	0.413		7/25/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	9.7	%		7/21/05	7/22/05	MD

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Ac228					4.0				7/22/05
Am-241		93.0	94.0	0.9					7/22/05
Co-60		94.0	96.0	1.9					7/22/05
Cs-137		95.0	96.0	1.0					7/22/05
Percent Moisture					2.7				7/22/05

Lab Approval: _____

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
Company: KAISER-Alum & Chem Inc.
Name: DAVID G. WEYAND
Address: 7311 E. 41st St.
City: TULSA State: OK Zip: 74145
Phone: 724-934-3530 Fax #: 918-384-3171
LOCAL: 918-384-0566
Cell: 724-799-0071

Bill To:
Company: KAISER/Ravenswood
Name: PAUL HANDA/DAVID G. WEYAND
Address: 7311 E. 41st St.
City: TULSA State: OK Zip: 74145

ANALYSIS REQUESTED

PO # KAISER-4072
PROJECT # PA-4000-4072
PROJECT NAME KAISER-Hamlin Plant, Prod.
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY) 5 DAY
SAMPLER: Signature DAVID G. WEYAND

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	Gamma Spec (HL-232)	Uranium + Target Analytes	MDC < 0.5 pCi/g	Ra-226 + Th-232 Assay	REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
1	K-809	7-20	14:15	Soil	1	Plastic	None	X	X	X	X	Grab
2	K-810		14:20		1			X	X	X	X	
3	K-811		14:25		1			X	X	X	X	
4	K-812		14:30		1			X	X	X	X	
5	K-813		14:35		1			X	X	X	X	
6	K-814		14:40		1			X	X	X	X	
7	K-815		14:45		1			X	X	X	X	
8	K-816		14:50		1			X	X	X	X	
9	K-817		14:55		1			X	X	X	X	
10	K-818		15:00		1			X	X	X	X	
11	K-819		15:05		1			X	X	X	X	
12	K-820		15:10		1			X	X	X	X	
13	K-821		15:15		1			X	X	X	X	
	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

RELINQUISHED BY: DAVID G. WEYAND DATE 7/21/05 TIME 1315 RECEIVED BY: Michelle Dutton DATE 7/21/05 TIME 1315

RELINQUISHED BY: _____ DATE _____ TIME _____ RECEIVED BY: _____ DATE _____ TIME _____

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

SAMPLE RETURN/DISPOSAL: All non-hazardous samples shall be disposed of 30 days after issue of final report. All others will be returned at client's expense.

FOR LABORATORY USE ONLY: 1-005-0369
Sample Condition Upon Receipt: Good

SAMPLE[illegible] IN

Date Received: *7/21/05 1:37:27 P* **Lab Number:** 20050569 **Due:** 7/28/05

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20050569-01 A	K-809	Soil	07/20/05	Plastic	16 oz	None	No	No
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050569-02 A	K-810	Soil	07/20/05	Plastic	16 oz	None	No	No
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050569-03 A	K-811	Soil	07/20/05	Plastic	16 oz	None	No	No
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050569-04 A	K-812	Soil	07/20/05	Plastic	16 oz	None	No	No
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050569-05 A	K-813	Soil	07/20/05	Plastic	16 oz	None	No	No
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050569-06 A	K-814	Soil	07/20/05	Plastic	16 oz	None	No	No
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050569-07 A	K-815	Soil	07/20/05	Plastic	16 oz	None	No	No
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050569-08 A	K-816	Soil	07/20/05	Plastic	16 oz	None	No	No
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050569-09 A	K-817	Soil	07/20/05	Plastic	16 oz	None	No	No
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050569-10 A	K-818	Soil	07/20/05	Plastic	16 oz	None	No	No

Percent ire (LOD) Th-232 l. mma Spec								
20050569-11 A Percent Moisture (LOD) Th-232 by Gamma Spec	K-819	Soil	07/20/05	Plastic	16 oz	None	No	No
20050569-12 A Percent Moisture (LOD) Th-232 by Gamma Spec	K-820	Soil	07/20/05	Plastic	16 oz	None	No	No
20050569-13 A Percent Moisture (LOD) Th-232 by Gamma Spec	K-821	Soil	07/20/05	Plastic	16 oz	None	No	No

CONTAINER INSPECTION

 # Coolers 1 **Custody Seals Broken -** Y/N/A **Temperature** _____ **Blue Ice / Wet Ice** **Radiation Survey** 300 **fixed** _____ **removable**

SAMPLE INSPECTION

Custody Seals Broken - Y/N/A **Chain of Custody Record** Y/N **Labels in Tact** Y/N **Radiation Survey Complete** Y/N

Anomalies: _____

Inspected By: Michelle Sutton **DATE** 07/21/05

QA or Designee Review: _____ **DATE** _____

Sample Custodian Review: Rosie Gregory **DATE** 7/21/05

Project Notes:

Outreach
Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Invoice # 11131 D/- 07/8/05

July 7, 2005

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20050506

Dear Mr. Weyant:

Please find enclosed the analytical report for your samples received in our laboratory on June 29, 2005. Eight soil samples were received in good condition and analyzed for Thorium-232 by Gamma Spectroscopy without drying and grinding and percent moisture with an expedited 5 work-day turn. Results were faxed on time.

All Quality Control for the requested analyses is reported on the analytical report. The laboratory control standard and duplicates for all analyses were within method control limits.

Your samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions, please call us at 918-251-2515.

Laboratory Director

ODEQ ID #9517
DEQ LIC. #27522-01

ACCREDITED IN ACCORDANCE WITH nelac
CERT. ID #OK001

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050506
Date Reported:	7/7/05
Date Received:	6/29/05
Page Number:	1 of 3

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050506-01**						
Client ID:	**K-756**						
Date Sampled:	**6/28/05 9:35:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	13.5 +/- 0.412	pCi/g	0.574		7/5/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	24.9	%		7/5/05	7/6/05	RT
Lab ID:	**20050506-02**						
Client ID:	**K-757**						
Date Sampled:	**6/28/05 9:45:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	10.1 +/- 0.276	pCi/g	0.417		7/5/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	23.8	%		7/5/05	7/6/05	RT
Lab ID:	**20050506-03**						
Client ID:	**K-758**						
Date Sampled:	**6/28/05 9:55:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	1.91 +/- 0.121	pCi/g	0.488		7/5/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	19.4	%		7/5/05	7/6/05	RT
Lab ID:	**20050506-04**						
Client ID:	**K-760**						
Date Sampled:	**6/28/05 10:15:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.546 +/- 0.096	pCi/g	0.300		7/5/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	4.9	%		7/5/05	7/6/05	RT

BDL = Below Detection Limit

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0003

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050506
Date Reported:	7/7/05
Date Received:	6/29/05
Page Number:	2 of 3

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050506-05**						
Client ID:	**K-768**						
Date Sampled:	**6/28/05 10:25:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	6.74 +/- 0.231	pCi/g	0.361		7/5/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	25.2	%		7/5/05	7/6/05	RT
Lab ID:	**20050506-06**						
Client ID:	**K-769**						
Date Sampled:	**6/28/05 10:35:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.737 +/- 0.064	pCi/g	0.250		7/5/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	5.7	%		7/5/05	7/6/05	RT
Lab ID:	**20050506-07**						
Client ID:	**K-770**						
Date Sampled:	**6/28/05 10:45:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	3.18 +/- 0.154	pCi/g	0.250		7/5/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	27.3	%		7/5/05	7/6/05	RT
Lab ID:	**20050506-08**						
Client ID:	**K-771**						
Date Sampled:	**6/28/05 10:55:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	3.88 +/- 0.206	pCi/g	0.542		7/5/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	9.0	%		7/5/05	7/6/05	RT

BDL = Below Detection Limit

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050506
Date Reported:	7/7/05
Date Received:	6/29/05
Page Number:	3 of 3

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Ac228					9.3				7/5/05
Am-241		94.0	87.0	8.2					7/5/05
Co-60		95.0	93.0	1.9					7/5/05
Cs-137		94.0	95.0	0.3					7/5/05
Percent Moisture					8.3				7/5/05

Lab Approval: _____

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
Company: Kaiser-Alum & Chem Corp.
Name: DAVID B. WEYAND
Address: 7211 E. 41st St.
City: TULSA State: OK Zip: 74145
Phone: 724-934-3330 Fax #: 918-384-3171
LOCAL: 918-384-0561
CELL: 724-799-8071

Bill To:
Company: Kaiser Penn Era
Name: DAVID B. WEYAND / PAUL HAGAN
Address: 7211 E. 41st St.
City: TULSA State: OK Zip: 74145

ANALYSIS REQUESTED

PO #: Kaiser-4072
PROJECT #: PA-4000-4072
PROJECT NAME: Kaiser-Thorium Remo.
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY): 5 DAY
SAMPLER: David B. Weyand
Signature: DAVID B. WEYAND

LAB SAMPLE NUMBER	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	Gamma Spec (Ac-227)	Radon + Client for Analysis	MDC <0.5 pCi/L	ASTM D2216.92 Moisture Content					REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
	K-756	6-28-01	0935	Soil	1	Plastic	None	X	X	X	X					Grab
	K-757		0945		1			X	X	X	X					
	K-758		0955		1			X	X	X	X					
	K-760		10:15		1			X	X	X	X					
	K-768		10:25		1			X	X	X	X					
	K-769		10:35		1			X	X	X	X					
	K-770		10:45		1			X	X	X	X					
	K-771		10:55		1			X	X	X	X					

RELINQUISHED BY: David B. Weyand DATE 6/29/01 TIME 1215 RECEIVED BY: Ron Ginsen DATE 6/29/01 TIME 1215
RELINQUISHED BY: DAVID B. WEYAND DATE TIME RECEIVED BY: DATE TIME

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

SAMPLE RETURN/DISPOSAL: All non-hazardous samples shall be disposed of 30 days after issue of final report. All others will be returned at client's expense.

FOR LABORATORY USE ONLY

SAMPLE LOGIN

Date Received: *6/29/05 2:24:19 P* Lab Number: 20050506 Due: 7/8/05

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20050506-01 A	K-756	Soil	06/28/05	Plastic	16 oz	None	No	No
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050506-02 A	K-757	Soil	06/28/05	Plastic	16 oz	None	No	No
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050506-03 A	K-758	Soil	06/28/05	Plastic	16 oz	None	No	No
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050506-04 A	K-760	Soil	06/28/05	Plastic	16 oz	None	No	No
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050506-05 A	K-768	Soil	06/28/05	Plastic	16 oz	None	No	No
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050506-06 A	K-769	Soil	06/28/05	Plastic	16 oz	None	No	No
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050506-07 A	K-770	Soil	06/28/05	Plastic	16 oz	None	No	No
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050506-08 A	K-771	Soil	06/28/05	Plastic	16 oz	None	No	No
Percent Moisture (LOD)								
Th-232 by Gamma Spec								

CONTAINER INSPECTION

Coolers 1 Custody Seals Broken - Y/N/A Temperature -NA- Blue Ice / Wet Ice Radiation Survey 300 fixed _____ removable

SAMPLE INSPECTION

Custody Seals Broken - Y/N/A Chain of Custody Record Y/N Labels in Tact Y/N Radiation Survey Complete Y/N

Anomalies: _____

Inspected By: Michelle Sutton DATE 6-29-05

QA or Designee Review: Raymond Thomas DATE 06/29/05

Sample Custodian Review: Delene Gregg DATE 6-27-05

Project Notes:

Outreach
Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Invoice # 11704 dt. 1/30/06

January 25, 2006

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20060045

Dear Mr. Weyant:

Please find enclosed the analytical report for your samples received in our laboratory on January 17, 2006 for the above captioned project. Seven soil samples were received in good condition and analyzed by Gamma Spectroscopy without drying and grinding and Percent Moisture with an expedited 5-work day turn.

All Quality Control for the requested analyses is reported on the analytical report. The laboratory control standard and duplicates for all analyses were within method control limits.

Your samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions, please call us at 918-251-2515.

Laboratory Director

ODEQ ID #9517
DEQ LIC. #27522-01

ACCREDITED IN ACCORDANCE WITH nelac
CERT. ID #OK001

Outreach
boratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20060045
Date Reported:	1/25/06
Date Received:	1/17/06
Page Number:	1 of 2

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20060045-01**						
Client ID:	**K-1407**						
Date Sampled:	**1/16/06 10:40:00 AM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Thorium 232	HASL 300	0.662 +/- 0.147	pCi/g	0.383		1/18/06	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	15.4	%		1/17/06	1/18/06	RT
Lab ID:	**20060045-02**						
Client ID:	**K-1426**						
Date Sampled:	**1/14/06 10:25:00 AM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Thorium 232	HASL 300	2.52 +/- 0.119	pCi/g	0.155		1/18/06	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	28.1	%		1/17/06	1/18/06	RT
Lab ID:	**20060045-03**						
Client ID:	**K-1427**						
Date Sampled:	**1/14/06 10:30:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Thorium 232	HASL 300	2.68 +/- 0.261	pCi/g	0.175		1/18/06	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	23.6	%		1/17/06	1/18/06	RT
Lab ID:	**20060045-04**						
Client ID:	**K-1428**						
Date Sampled:	**1/14/06 10:35:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Thorium 232	HASL 300	1.13 +/- 0.246	pCi/g	0.319		1/18/06	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	17.2	%		1/17/06	1/18/06	RT
Lab ID:	**20060045-05**						
Client ID:	**K-1429**						
Date Sampled:	**1/14/06 10:40:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					

BDL = Below Detection Limit

Outreach Laboratory
311 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20060045
Date Reported:	1/25/06
Date Received:	1/17/06
Page Number:	2 of 2

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Thorium 232	HASL 300	0.664 +/- 0.181	pCi/g	0.443		1/18/06	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	17.7	%		1/17/06	1/18/06	RT
Lab ID:	**20060045-06**						
Client ID:	**K-1430**						
Date Sampled:	***1/14/06 10:45:00 AM***						
Matrix:	**Soil**						
		Radiochemical Analyses					
Thorium 232	HASL 300	0.744 +/- 0.100	pCi/g	0.189		1/18/06	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	21.8	%		1/17/06	1/18/06	RT
Lab ID:	**20060045-07**						
Client ID:	**K-1431**						
Date Sampled:	***1/14/06 10:50:00 AM***						
Matrix:	**Soil**						
		Radiochemical Analyses					
Thorium 232	HASL 300	0.977 +/- 0.188	pCi/g	0.391		1/18/06	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	17.0	%		1/17/06	1/18/06	RT

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Ac-228					7.0				1/17/06
Am-241		87.0	88.0	0.9					1/17/06
Co-60		94.0	91.0	2.9					1/17/06
Cs-137		95.0	93.0	2.3					1/17/06
Percent Moisture					6.9				1/18/06

Lab Approval: _____

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

11/24

Results To:
LOCAL: 918-394-0566
Cell: 724-799-0071

Company KAISER-Alum & Chem, LLC
Name DAVID B. WEYANT
Address 7311 E. 41st ST.
City TULSA State OK Zip 74145
Phone 724-934-353 Fax # 918-394-3171

Bill To:
Company KAISER / PENN ERA
Name PAUL HARRIS / DAVID B. WEYANT
Address 7311 E. 41st ST.
City TULSA State OK Zip 74145

ANALYSIS REQUESTED

PO # KAISER-4272
PROJECT # PA-4500-4272
PROJECT NAME KAISER-TROY, PENN. PROJ
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY) 5 DAY
SAMPLER DAVID B. WEYANT (Signature)

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE #	Gamma Spec (Ra-226)	Total Th-232	Pb-210	Ash, Fusion, Moist Content				REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
	K-1407	1-16-06	1040	Soil	1	500ml Plastic	None	X	X	X	X				Composite
	K-1426	1-14-06	1025		1			X	X	X	X		A		Grab
	K-1427		1030		1			X	X	X	X				
	K-1428		1035		1			X	X	X	X				
	K-1429		1040		1			X	X	X	X				
	K-1430		1045		1			X	X	X	X				
	K-1431		1050		1			X	X	X	X				
		N		A				N	A			N		A	

RELINQUISHED BY: DAVID B. WEYANT DATE 11/17/06 TIME 915 RECEIVED BY: Donna Eidson DATE 11/17/06 TIME 915

RELINQUISHED BY: DAVID B. WEYANT DATE ____ TIME ____ RECEIVED BY: ____ DATE ____ TIME ____

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

SAMPLE RETURN/DISPOSAL: All non-hazardous samples shall be disposed of 30 days after issue of final report. All others will be returned at client's expense.

FOR LABORATORY USE ONLY

SAMPLE L[illegible]N

Date Received: *1/17/06 10:14:12* Lab Number: 20060045 Due: 1/24/06

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20060045-01 A	K-1407	Swipe	01/16/06	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20060045-02 A	K-1426	Swipe	01/14/06	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20060045-03 A	K-1427	Soil	01/14/06	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20060045-04 A	K-1428	Soil	01/14/06	Plastic	16 oz	None	Yes	Yes
Gamma Spec - Thorium 232								
Percent Moisture (LOD)								
20060045-05 A	K-1429	Soil	01/14/06	Plastic	16 oz	None	Yes	Yes
Gamma Spec - Thorium 232								
Percent Moisture (LOD)								
20060045-06 A	K-1430	Soil	01/14/06	Plastic	16 oz	None	Yes	Yes
Gamma Spec - Thorium 232								
Percent Moisture (LOD)								
20060045-07 A	K-1431	Soil	01/14/06	Plastic	16 oz	None	Yes	Yes
Gamma Spec - Thorium 232								
Percent Moisture (LOD)								

CONTAINER INSPECTION

Coolers 0 Custody Seals Broken ☐ Temperature: 3 C Ice Radiation Survey: <300 cpm

SAMPLE INSPECTION

Sample Seal Broken NA Chain of Custody Record ☑ Labels in Tact ☑ Radiation Survey Complete ☐

Anomalies

Inspected By: _____ DATE _____

QA or Designee Review: Ranjana Kumar DATE 01/17/06

Sample Custodian Review: K Gregory DATE 1/17/06

Project Notes:

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

11209

D/- 8/1/05

August 01, 2005

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20050581

Dear Mr. Weyant,

Please find enclosed the analytical report for your samples received in our laboratory on July 26, 2005 for the above captioned project. Four swipes were received in good condition and analyzed for Gross Alpha/Beta with an expedited 5 work-day turn time. Results were faxed on 8/1/05.

All Quality Control for the requested analyses is reported on the analytical report. The method blank, laboratory control standard and matrix spikes and spike duplicates for all analyses were within method control limits.

Your samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions feel free to call.

Laboratory Director

ODEQ ID #9517
NRC ODEQ LIC. #27522-01

ACCREDITED IN ACCORDANCE WITH nelac
C
CERT. ID# OK001

Outreach Laboratory
11 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client: Kaiser Aluminum
Client Project: Thorium Remediation
Lab Number: 20050581
Date Reported: 8/1/05
Date Received: 7/26/05

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050581-01**						
Client ID:	**K-SS-166**						
Date Sampled:	**7/21/05 3:08:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.933 +/- 0.813	dpm/100cm 2	0.631		7/28/05	SD
Gross Beta	EPA 900/9310	1.66 +/- 2.50	dpm/100cm 2	2.57		7/28/05	SD
Lab ID:	**20050581-02**						
Client ID:	**K-SS-167**						
Date Sampled:	**7/21/05 3:10:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	1.11 +/- 0.849	dpm/100cm 2	0.631		7/28/05	SD
Gross Beta	EPA 900/9310	2.64 +/- 2.57	dpm/100cm 2	2.57		7/28/05	SD
Lab ID:	**20050581-03**						
Client ID:	**K-SS-168**						
Date Sampled:	**7/21/05 3:20:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.129 +/- 0.620	dpm/100cm 2	0.631		7/29/05	SD
Gross Beta	EPA 900/9310	1.66 +/- 2.50	dpm/100cm 2	2.57		7/29/05	SD
Lab ID:	**20050581-04**						
Client ID:	**K-SS-169**						
Date Sampled:	**7/21/05 3:25:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.129 +/- 0.620	dpm/100cm 2	0.631		7/29/05	SD
Gross Beta	EPA 900/9310	2.74 +/- 2.58	dpm/100cm 2	2.57		7/29/05	SD

BDL = Below Detection Limit

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050581
Date Reported:	8/1/05
Date Received:	7/26/05
Page Number:	2 of 2

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Gross Alpha	0.2+/-0.6	111.0	121.0	8.4	NC				7/29/05
Gross Beta	8+/-3	89.0	87.0	2.6	NC				7/29/05

Lab Approval:

BDL = Below Detection Limit

Outreach Laboratory
11 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Lmit # 11208
D/ 8/1/05

August 01, 2005

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20050582

Dear Mr. Weyant,

Please find enclosed the analytical report for your samples received in our laboratory on July 26, 2005 for the above captioned project. Six swipes were received in good condition and analyzed for Gross Alpha/Beta with an expedited 5 work-day turn time. Results were faxed on 8/1/05.

All Quality Control for the requested analyses is reported on the analytical report. The method blank, laboratory control standard and matrix spikes and spike duplicates for all analyses were within method control limits.

Your samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions feel free to call.

Laboratory Director

ODEQ ID #9517
NRC ODEQ LIC. #27522-01

ACCREDITED IN ACCORDANCE WITH nelac
C
CERT. ID# OK001

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050582
Date Reported:	8/1/05
Date Received:	7/26/05
Page Number:	1 of 2

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050582-01**						
Client ID:	**K-SS-170**						
Date Sampled:	**7/22/05 7:30:00 AM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	5.31 +/- 1.47	dpm/100cm 2	0.631		7/29/05	SD
Gross Beta	EPA 900/9310	7.32 +/- 2.89	dpm/100cm 2	2.57		7/29/05	SD
Lab ID:	**20050582-02**						
Client ID:	**K-SS-171**						
Date Sampled:	**7/22/05 7:32:00 AM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	2.36 +/- 1.07	dpm/100cm 2	0.631		7/29/05	SD
Gross Beta	EPA 900/9310	4.10 +/- 2.68	dpm/100cm 2	2.57		7/29/05	SD
Lab ID:	**20050582-03**						
Client ID:	**K-SS-172**						
Date Sampled:	**7/22/05 7:34:00 AM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.129 +/- 0.620	dpm/100cm 2	0.631		7/29/05	SD
Gross Beta	EPA 900/9310	2.44 +/- 2.56	dpm/100cm 2	2.57		7/29/05	SD
Lab ID:	**20050582-04**						
Client ID:	**K-SS-173**						
Date Sampled:	**7/22/05 7:36:00 AM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.308 +/- 0.688	dpm/100cm 2	0.631		7/29/05	SD
Gross Beta	EPA 900/9310	1.27 +/- 2.47	dpm/100cm 2	2.57		7/29/05	SD

BDL = Below Detection Limit

Outreach Laboratory
111 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050582
Date Reported:	8/1/05
Date Received:	7/26/05
Page Number:	2 of 2

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050582-05**						
Client ID:	**K-SS-174**						
Date Sampled:	**7/22/05 7:38:00 AM**						
Matrix:	**Swipe**						
	Radiochemical Analyses						
Gross Alpha	EPA 900/9310	0.129 +/- 0.620	dpm/100cm 2	0.631		7/29/05	SD
Gross Beta	EPA 900/9310	1.86 +/- 2.52	dpm/100cm 2	2.57		7/29/05	SD
Lab ID:	**20050582-06**						
Client ID:	**K-SS-175**						
Date Sampled:	**7/22/05 7:40:00 AM**						
Matrix:	**Swipe**						
	Radiochemical Analyses						
Gross Alpha	EPA 900/9310	0.219 +/- 0.644	dpm/100cm 2	0.631		7/29/05	SD
Gross Beta	EPA 900/9310	1.76 +/- 2.51	dpm/100cm 2	2.57		7/29/05	SD

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Gross Alpha	0.2+/-0.6	111.0	121.0	8.4	NC				7/29/05
Gross Beta	8+/-3	89.0	87.0	2.6	NC				7/29/05

Lab Approval: _____

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
Local: 918-384-0556
Cell: 724-799-0071
Company: KAISER Alum & Chem Inc
Name: DAVID B. WEYANT
Address: 7211 E. 41st St.
City: TULSA State: OK Zip: 74145
Phone: 724-934-5536 Fax #: 918-384-7171

Bill To:
Company: KAISER / PAUL E&E
Name: DAVID B. WEYANT / PAUL HANDY
Address: 7211 E. 41st St.
City: TULSA State: OK Zip: 74145

ANALYSIS REQUESTED

PO #: KAISER-4072
PROJECT #: PA-4000-4072
PROJECT NAME: KAISER Alum & Therium Plant.
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY): See Request
SAMPLER: Signature DAVID B. WEYANT

LAB SAMPLE #	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	Gross α/β	α rad < 1 pCi/100cm²	β-rad < 1 pCi/100cm²	Ra 226 < 1 pCi/100cm²	Return to client for disp.	5 DAY T.A.T.	20 DAY T.A.T.		REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
	K-SS-170	7-22-05	07:30	Soil	1	Cloth	None	X	X	X	X	X	X			Grab
	K-SS-171		07:32		1			X	X	X	X	X	X			
	K-SS-172		07:34		1			X	X	X	X	X	X			
	K-SS-173		07:36		1			X	X	X	X	X	X			
	K-SS-174		07:38		1			X	X	X	X	X	X			
	K-SS-175		07:40		1			X	X	X	X	X	X			
	K-SS-176		08:09		1			X	X	X	X	X		X		
	K-SS-177		08:33		1			X	X	X	X	X		X		
	K-SS-178		08:35		1			X	X	X	X	X		X		
		N				N		N					N			
			A						A						A	

RELINQUISHED BY: DAVID B. WEYANT DATE 7/26/05 TIME 0500 RECEIVED BY: DATE 7/26/05 TIME 0500
RELINQUISHED BY: DATE TIME RECEIVED BY: DATE TIME

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

SAMPLE RETURN/DISPOSAL: All non-hazardous samples shall be disposed of 30 days after issue of final report. All others will be returned at client's expense.

FOR LABORATORY USE ONLY: 2005058

SAMPLE[illegible]IN

Date Received: *7/26/05 9:13:12 A* **Lab Number:** 20050582 **Due:** 8/1/05

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20050582-01 A Gross Alpha/Beta	K-SS-170	Swipe	07/22/05	Plastic	Sm Zip Bag	None	No	No
20050582-02 A Gross Alpha/Beta	K-SS-171	Swipe	07/22/05	Plastic	Sm Zip Bag	None	No	No
20050582-03 A Gross Alpha/Beta	K-SS-172	Swipe	07/22/05	Plastic	Sm Zip Bag	None	No	No
20050582-04 A Gross Alpha/Beta	K-SS-173	Swipe	07/22/05	Plastic	Sm Zip Bag	None	No	No
20050582-05 A Gross Alpha/Beta	K-SS-174	Swipe	07/22/05	Plastic	Sm Zip Bag	None	No	No
20050582-06 A Gross Alpha/Beta	K-SS-175	Swipe	07/22/05	Plastic	Sm Zip Bag	None	No	No

CONTAIN NSPECTION.

Coolers N/A Custody Seals Broken - Y/N N/A Temperature AMB Blue Ice / Wet Ice Radiation Survey 1800 fixed _____ removable

SAMPLE INSPECTION

Custody Seals Broken - Y/N N/A Chain of Custody Record Y/N Labels in Tact Y/N Radiation Survey Complete Y/N

Anomalies: _____

Inspected By: _____ DATE _____

QA or Designee Review: _____ DATE 7/26/05

Sample Custodian Review: Desiree Hyer DATE 7/26/05

Project Notes:

Outreach Laboratory
311 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Invoice # 11706
Dt. 1/30/06

January 26, 2006

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20060046

Dear Mr. Weyant,

Please find enclosed the analytical report for your samples received in our laboratory on January 17, 2006 for the above captioned project. Nine swipes were received in good condition and analyzed for Gross Alpha/Beta with an expedited 5 work-day turn time.

All Quality Control for the requested analyses is reported on the analytical report. The method blank, laboratory control standard and matrix spikes and spike duplicates for all analyses were within method control limits.

Your samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions feel free to call.

Laboratory Director

ODEQ ID #9517
NRC ODEQ LIC. #27522-01

ACCREDITED IN ACCORDANCE WITH
C
ERT. ID# OK001

Outreach Laboratory
311 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20060046
Date Reported:	1/26/06
Date Received:	1/17/06
Page Number:	1 of 3

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20060046-01**						
Client ID:	**K-SS-221**						
Date Sampled:	**1/14/06 9:10:00 AM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.308 +/- 0.668	dpm/100cm 2	0.631		1/23/06	SD
Gross Beta	EPA 900/9310	1.37 +/- 2.48	dpm/100cm 2	2.57		1/23/06	SD
Lab ID:	**20060046-02**						
Client ID:	**K-SS-222**						
Date Sampled:	**1/14/06 9:11:00 AM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.884 +/- 0.793	dpm/100cm 2	0.631		1/23/06	SD
Gross Beta	EPA 900/9310	1.76 +/- 2.51	dpm/100cm 2	2.57		1/23/06	SD
Lab ID:	**20060046-03**						
Client ID:	**K-SS-223**						
Date Sampled:	**1/14/06 9:12:00 AM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	10.0 +/- 1.95	dpm/100cm 2	0.631		1/23/06	SD
Gross Beta	EPA 900/9310	10.1 +/- 3.07	dpm/100cm 2	2.57		1/23/06	SD
Lab ID:	**20060046-04**						
Client ID:	**K-SS-224**						
Date Sampled:	**1/14/06 9:13:00 AM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	9.86 +/- 1.93	dpm/100cm 2	0.631		1/23/06	SD
Gross Beta	EPA 900/9310	11.3 +/- 3.14	dpm/100cm 2	2.57		1/23/06	SD

BDL = Below Detection Limit

Outreach Laboratory
311 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20060046
Date Reported:	1/26/06
Date Received:	1/17/06
Page Number:	2 of 3

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20060046-05**						
Client ID:	**K-SS-225**						
Date Sampled:	**1/14/06 1:22:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.487 +/- 0.712	dpm/100cm 2	0.631		1/23/06	SD
Gross Beta	EPA 900/9310	1.47 +/- 2.49	dpm/100cm 2	2.57		1/23/06	SD
Lab ID:	**20060046-06**						
Client ID:	**K-SS-226**						
Date Sampled:	**1/14/06 1:23:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.040 +/- 0.595	dpm/100cm 2	0.631		1/23/06	SD
Gross Beta	EPA 900/9310	1.37 +/- 2.48	dpm/100cm 2	2.57		1/23/06	SD
Lab ID:	**20060046-07**						
Client ID:	**K-SS-227**						
Date Sampled:	**1/14/06 1:24:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	1.02 +/- 0.831	dpm/100cm 2	0.631		1/23/06	SD
Gross Beta	EPA 900/9310	3.62 +/- 2.64	dpm/100cm 2	2.57		1/23/06	SD
Lab ID:	**20060046-08**						
Client ID:	**K-SS-228**						
Date Sampled:	**1/14/06 1:25:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.844 +/- 0.793	dpm/100cm 2	0.631		1/23/06	SD
Gross Beta	EPA 900/9310	3.23 +/- 2.62	dpm/100cm 2	2.57		1/23/06	SD

BDL = Below Detection Limit

Outreach Laboratory
311 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20060046
Date Reported:	1/26/06
Date Received:	1/17/06
Page Number:	3 of 3

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20060046-09**						
Client ID:	**K-SS-229**						
Date Sampled:	**1/16/06 12:53:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0 +/- 0.569	dpm/100cm 2	0.631		1/24/06	SD
Gross Beta	EPA 900/9310	1.08 +/- 2.46	dpm/100cm 2	2.57		1/24/06	SD

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Gross Alpha	0.3+/-0.7	109.0	97.0	12.6	NC				1/23/06
Gross Beta	3.4+/-2.7	80.0	86.0	6.2	NC				1/23/06

Lab Approval:

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
Company Kaiser-Alumg Chem Corp.
Name David B. Weyant
Address 7311 E. 41st St.
City Tulsa State OK Zip 74145
Phone 224-974-3330 Fax # 918-394-3171

Bill To:
Company Kaiser / Ponca Ext
Name Paul Hamad / David B. Weyant
Address 7311 E. 41st St.
City Tulsa State OK Zip 74145

LOCAL: 918 384-0561 Cell: 724-799-0071

ANALYSIS REQUESTED

PO # Kaiser-4072
PROJECT # PA-4000-4072
PROJECT NAME Kaiser. Alumg Chem Ponca
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY) 5 DAY T.A.T.
SAMPLER Signature David B. Weyant

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # 1. HNO_3 pH<2 2. Ice <4°C 3. HCl pH<2 4. H_2SO_4 pH<2 5. NaOH pH>11	Gross Alpha/Beta	Ra-226 <1 pCi/L	Ra-228 <3 pCi/L	226+228 <5 pCi/L	Ra-226 + 228 Analysis by GEL	REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
	K-SS-221	1-14-06	0910	Solid	1	Cloth	None	X	X	X	X	X	Grab
	K-SS-222		0911		1			X	X	X	X	X	
	K-SS-223		0912		1			X	X	X	X	X	
	K-SS-224		0913		1			X	X	X	X	X	
	K-SS-225		1322		1			X	X	X	X	X	
	K-SS-226		1323		1			X	X	X	X	X	
	K-SS-227		1324		1			X	X	X	X	X	
	K-SS-228		1325		1			X	X	X	X	X	
	K-SS-229	1-16-06	12:53		1			X	X	X	X	X	

RELINQUISHED BY: David B. Weyant DATE 1/17/06 TIME 915 RECEIVED BY: Donna Eidson DATE 1/17/06 TIME 915

RELINQUISHED BY: _____ DATE _____ TIME _____ RECEIVED BY: _____ DATE _____ TIME _____

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

SAMPLE RETURN/DISPOSAL: All non-hazardous samples shall be disposed of 30 days after issue of final report. All others will be returned at client's expense.

FOR LABORATORY USE ONLY: 20060046
Sample Condition Upon Receipt Good
Custody Seals Intact (Y) N

SAMPLE LOGIN

Date Received: *1/17/06 10:20:08* **Lab Number:** 20060046 **Due:** 1/24/06

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20060046-01 A Gross Alpha/Beta	K-SS-221	Swipe	01/14/06	Plastic	Sm Zip Bag	None	No	No
20060046-02 A Gross Alpha/Beta	K-SS-222	Swipe	01/14/06	Plastic	Sm Zip Bag	None	No	No
20060046-03 A Gross Alpha/Beta	K-SS-223	Swipe	01/14/06	Plastic	Sm Zip Bag	None	No	No
20060046-04 A Gross Alpha/Beta	K-SS-224	Swipe	01/14/06	Plastic	Sm Zip Bag	None	No	No
20060046-05 A Gross Alpha/Beta	K-SS-225	Swipe	01/14/06	Plastic	Sm Zip Bag	None	No	No
20060046-06 A Gross Alpha/Beta	K-SS-226	Swipe	01/14/06	Plastic	Sm Zip Bag	None	No	No
20060046-07 A Gross Alpha/Beta	K-SS-227	Swipe	01/14/06	Plastic	Sm Zip Bag	None	No	No
20060046-08 A Gross Alpha/Beta	K-SS-228	Swipe	01/14/06	Plastic	Sm Zip Bag	None	No	No
20060046-09 A Gross Alpha/Beta	K-SS-229	Swipe	01/16/06	Plastic	Sm Zip Bag	None	No	No

CONTAINER INSPECTION

Coolers NA Custody Seals Broken ☐ Temperature: C Ice Radiation Survey: <300 cpm

SAMPLE INSPECTION

Sample Seal Broken NA Chain of Custody Record ☑ Labels in Tact ☑ Radiation Survey Complete ☑

Anomalies

Inspected By: _____ DATE _____

QA or Designee Review: Raymond Thomas DATE 1/17/06

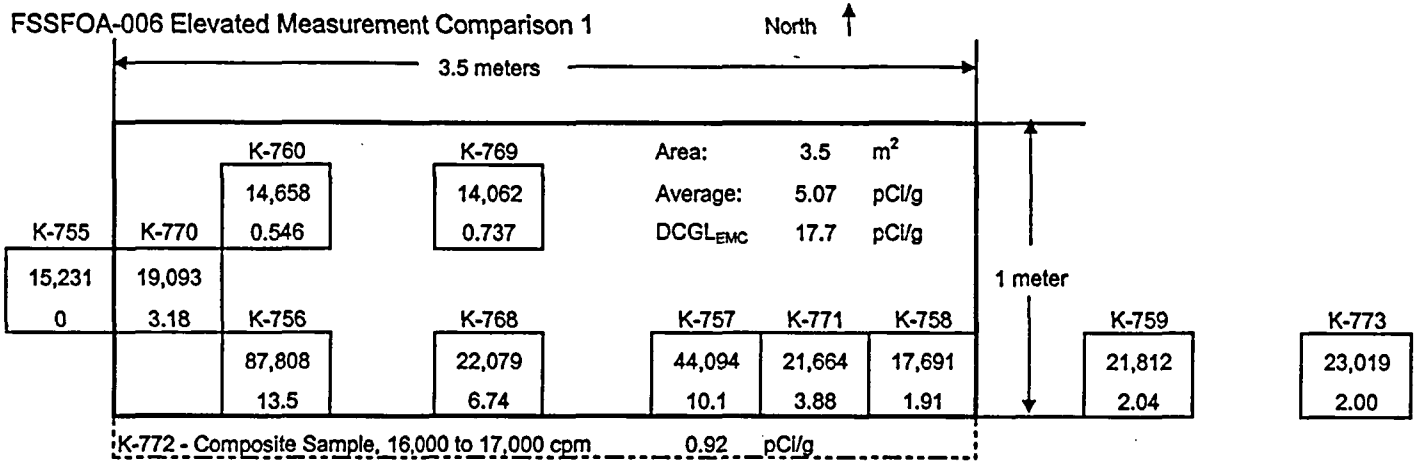
Sample Custodian Review: Gregory Rey DATE 1/17/06

Project Notes:

ATTACHMENT D
TABLE OF CONTENTS

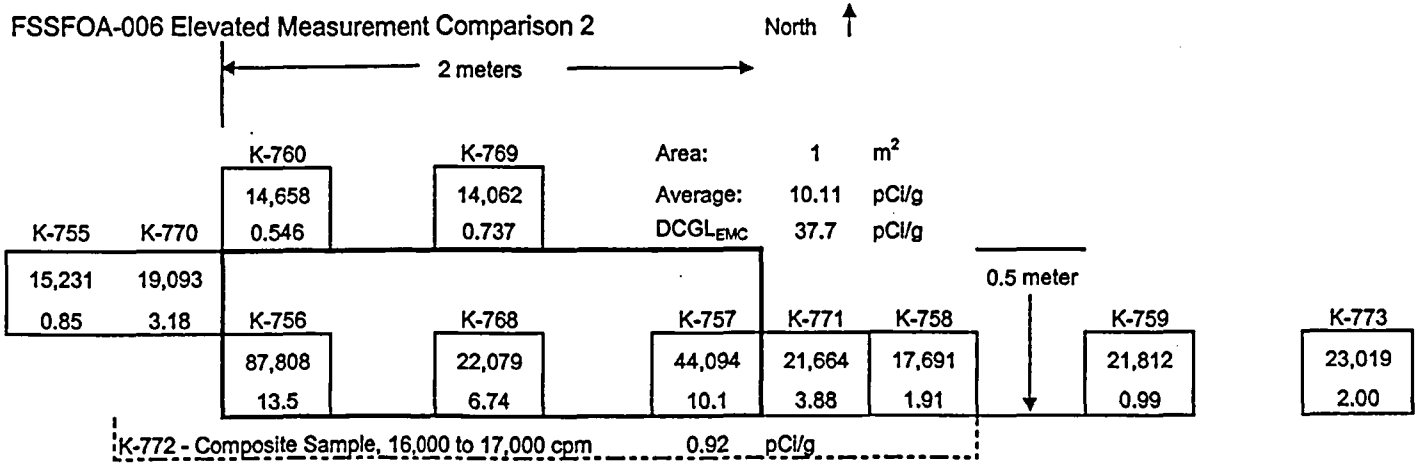
- **FIGURE D-1 Elevated Measurement Comparison Map**
- **Elevated Measurement Comparison Worksheet**

Attachment D, Figure D-1
Elevated Measurement Comparison Map
Survey Unit Kaiser-FSSFOA-006
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation



Key:

#	Sample number
xx.xxx	contact count rate in cpm
y.yy	Th-232 pCi/g value from sample analysis



Attachment D
Elevated Measurement Comparison Worksheet
Survey Unit Kaiser-FSSFOA-006
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

$DCGL_{EMC}$ = Area Factor * $DCGL_W$

Area Factors									
Radio-nuclide	1 m2 (11 ft2)	3 m2 (32 ft2)	10 m2 (108 ft2)	30 m2 (323 ft2)	100 m2 (1,076 ft2)	300 m2 (3,229 ft2)	1,000 m2 (10,764 ft2)	3,000 m2 (32,292 ft2)	10,000 m2 (107,639 ft2)
Th-232	12.5	6.2	3.2	2.3	1.8	1.5	1.1	1	1

$DCGL_{EMC}$ (pCi/g)									
Radio-nuclide	1 m2 (11 ft2)	3 m2 (32 ft2)	10 m2 (108 ft2)	30 m2 (323 ft2)	100 m2 (1,076 ft2)	300 m2 (3,229 ft2)	1,000 m2 (10,764 ft2)	3,000 m2 (32,292 ft2)	10,000 m2 (107,639 ft2)
Th-232	37.5	18.6	9.6	6.9	5.4	4.5	3.3	3	3

$$\frac{\delta}{DCGL} + \sum_{x+1}^{n} \frac{(\delta_{EMC} - \delta)}{DCGL_{EMC}} \leq 1$$

where:
δ = is the average concentration of Th-232 over the entire survey unit,
δ_{EMC} = the average concentration of Th-232 over the elevated area x within the survey unit,
DCGL = the $DCGL_W$ or DCCL for Th-232,
$DCGL_{EMC}$ = (area factor for elevated area x) X (DCGL or DCCL),
x = refers to one of the elevated areas within the survey unit, and
n = the total number of elevated areas within the survey unit.

Elevated Measurement Comparison EMC-1

Sample Date	Unit / EMC unit	Unit Area (m^2)	Gross Th-232 (pCi/g)	Net Th-232 (pCi/g)	DCGL (pCi/g)	Fraction (-)
	FOA-006	2550	0.749	0	3	0.00
	EMC-1	3.5	5.07	4.32	17.7	0.24
					Sum of Fractions:	**0.24**

Elevated Measurement Comparison EMC-2

Sample Date	Unit / EMC unit	Unit Area (m^2)	Gross Th-232 (pCi/g)	Net Th-232 (pCi/g)	DCGL (pCi/g)	Fraction (-)
	FOA-006	2550	0.749	0	3	0.00
	EMC-2	1	10.1	9.35	37.5	0.25
					Sum of Fractions:	**0.25**

ATTACHMENT E
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- **FIGURE E-1 Embedded Structures Location Map**
- **FIGURE E-2 Concrete Wall Survey Map**
- **Alpha Scan MDC Calculation Form**
- **Total Alpha Contamination Survey Data Conversion Forms**
- **TABLE E-1 Gross Alpha Scan Summary, Concrete Wall**
- **TABLE E-2 Gross Alpha Scan Summary, Metal Pipes**

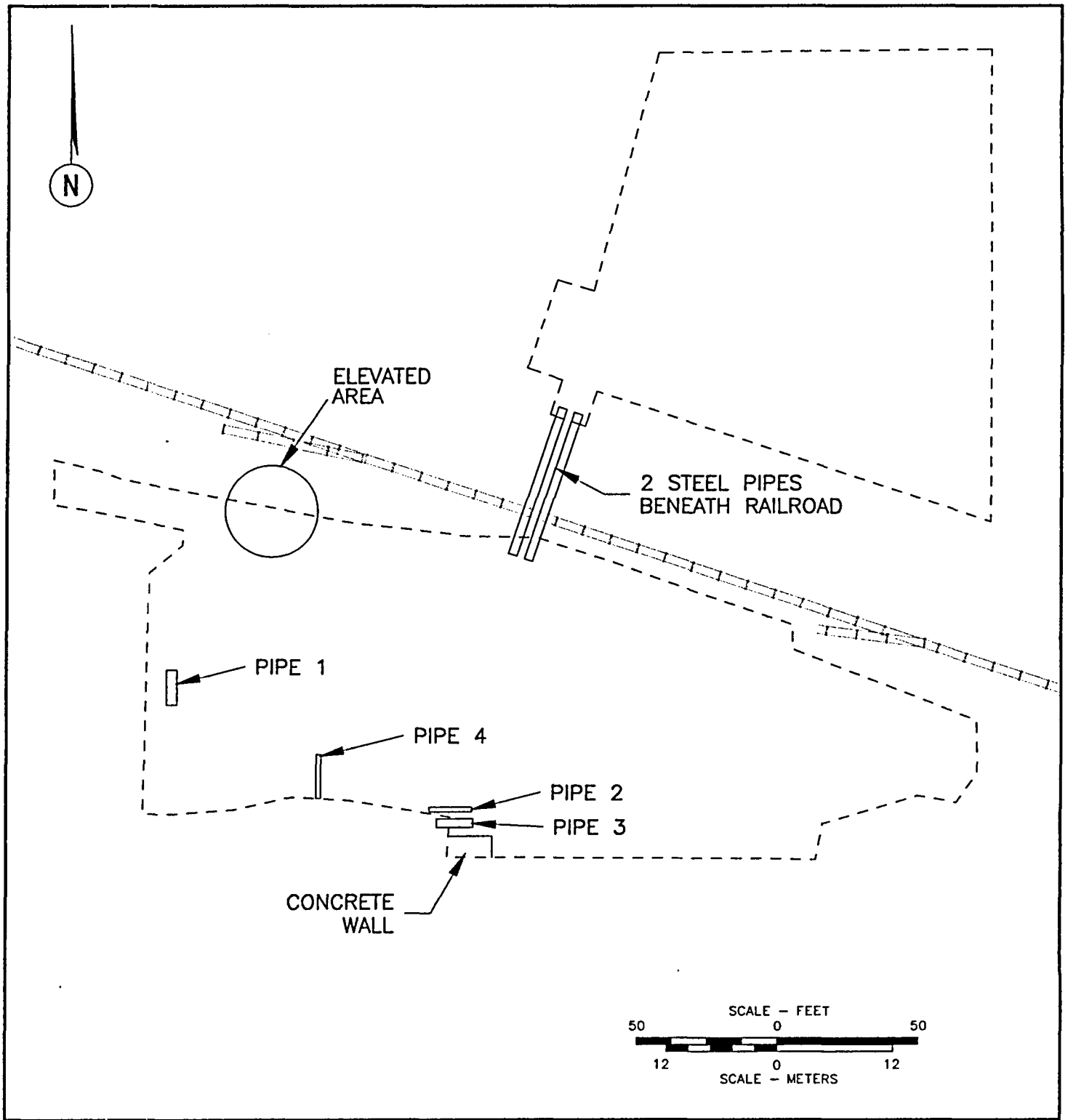


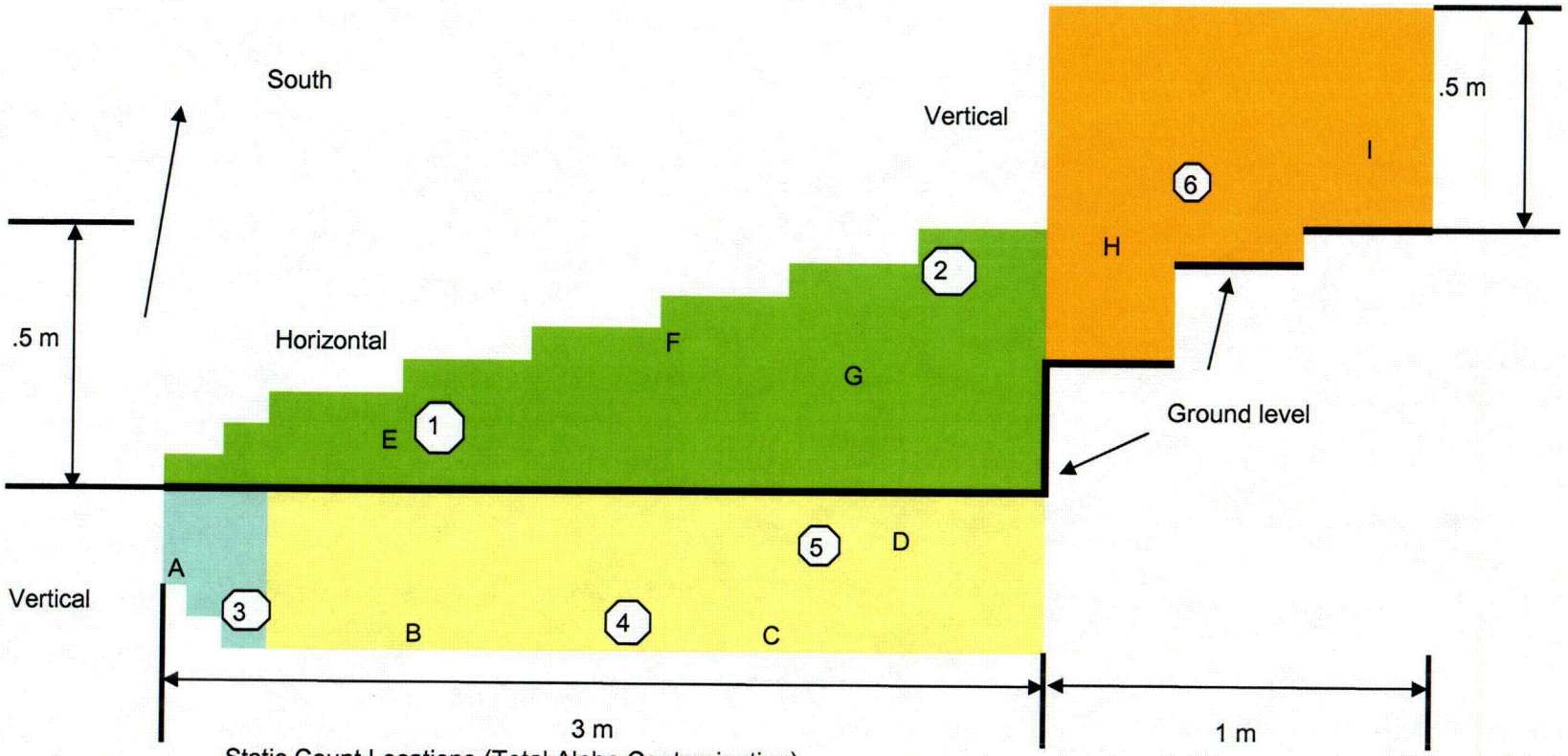
FIGURE E–1
EMBEDDED STRUCTURES LOCATION MAP
SURVEY UNIT KAISER – FSSFOA–006
FINAL STATUS SURVEY
THORIUM REMEDIATION PROJECT
TULSA, OKLAHOMA FACILITY

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
TULSA, OKLAHOMA

APPROVED	RFO 3·3·06
CHECKED	RFO 3·3·06
DRAWN	DEB 01/20/06
DRAWING NUMBER	PA4072066A

Penn E&R
Environmental & Remediation, Inc.

Attachment E, Figure E-2
Concrete Wall Survey Map
Survey Unit Kaiser-FSSFOA-006
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation



Static Count Locations (Total Alpha Contamination)

A	Lower Vertical Surface
B	Lower Vertical Surface
C	Lower Vertical Surface
D	Lower Vertical Surface
E	Horizontal Surface
G	Horizontal Surface
F	Horizontal Surface
H	Upper Vertical Surface
I	Upper Vertical Surface

Removable Alpha Contamination

#	Smear	Sample #
1		K-SS-170
2		K-SS-171
3		K-SS-172
4		K-SS-173
5		K-SS-174
6		K-SS-175

Alpha Scan MDC Calculation

Instrument Serial Number:	193686	Cal. Due:	5/5/2006
Detector Serial Number:	PR190485	Cal. Due:	5/5/2006
Radiation Detected:	Alpha	For < 3 count background	

Probability of observing 2 or more counts:

$$P(n \geq 2) = 1 - \left(1 + \frac{(GE+B)d}{60v}\right)\left(e^{\frac{(GE+B)d}{60v}}\right)$$

Probability of observing a single count:

$$P(n \geq 1) = 1 - e^{\frac{-GEd}{60v}}$$

	D Date	G Activity (dpm)	d Detector Width (cm)	E Instrument Efficiency (cpm)	v Scan Speed (cm/s)	B Background Countrate (cpm)	P Probability (-)
1	7/23/2005	380	11.7	0.1618	3.90	N/A	0.95
2	1/14/2006	1080	11.7	0.1618	11.7	N/A	0.95
3	7/23/2005	380	11.7	0.1618	3.90	N/A	0.95
4	1/14/2006	1080	11.7	0.1618	11.7	N/A	0.95
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							

Comments:	Survey Unit Kaiser-FSSFOA-006		
Prepared By:	David B. Weyant	Date:	1/16/06
Reviewed By:	Andrew J. Lombardo	Date:	1/16/06

Notes:

1.) Instrument Efficiency is the 4π instrument efficiency.

Total Alpha Contamination
Survey Unit Kaiser-FSSFOA-006
Survey Data Conversion Form
Form ESC/HPM/M-3-2-2

Date of Survey:	7/23/2005	Type of Radiation:	Alpha
Instrument Serial #:	193686	Calibration Due Date:	5/5/2006
Detector Serial #:	PR190485	Calibration Due Date:	5/5/2006
E_s (Surface Efficiency):	0.25	E_i (Instrument Efficiency):	0.1618
BKG Counts:	11	BKG Count Time (min):	5
Active Area of Detector Probe (cm^2):	126	MDC ($dpm/100cm^2$):	110

Map	Wall Location	Survey Point Count Time (min)	Gross Counts (cts)	Gross Count Rate (cpm)	Net Count Rate (cpm)	Total Contamination ($dpm/100cm^2$)	95% CL Uncertainty ($dpm/100cm^2$)
B	Lower Vertical	2	11	5.50	3.30	64.7	68.7
C	Lower Vertical	2	14	7.00	4.80	94.2	76.3
D	Lower Vertical	2	4	2.00	-0.20	-3.92	46.1
H	Upper Vertical	2	11	5.50	3.30	64.7	68.7
I	Upper Vertical	2	3	1.50	-0.70	-13.7	42.0
E	Horizontal	2	34	17.0	14.8	290	115
F	Horizontal	2	36	18.0	15.8	310	118
G	Horizontal	2	58	29.0	26.8	526	149
A	Lower Vertical	2	21	10.50	8.30	163	91.7

Comments: Concrete Wall

Prepared By: David B. Weyant	Date: 7/23/2005
Reviewed By: Andrew J. Lombardo	Date: 1/11/2006

Total Alpha Contamination
Survey Unit Kaiser-FSSFOA-006
Survey Data Conversion Form
Form ESC/HPM/M-3-2-2

Date of Survey:	1/14/2006	Type of Radiation:	Alpha
Instrument Serial #: 193686		Calibration Due Date:	5/5/2006
Detector Serial #: PR190485		Calibration Due Date:	5/5/2006
E_s (Surface Efficiency):	0.25	E_i (Instrument Efficiency):	0.1618
BKG Counts:	10	BKG Count Time (min):	5
Active Area of Detector Probe (cm^2):	126	MDC ($dpm/100cm^2$):	69.5

FSS Swipe Number	Survey Location	Survey Point Count Time (min)	Gross Counts (cts)	Gross Count Rate (cpm)	Net Count Rate (cpm)	Total Contamination ($dpm/100cm^2$)	95% CL Uncertainty ($dpm/100cm^2$)
FSSFOA-006 End of Pipes							
K-SS-223	6" pipe I/S*	5	35	7.00	5.00	98.1	51.6
K-SS-224	6" pipe O/S	5	25	5.00	3.00	58.9	45.5
K-SS-221	4" pipe I/S	N/A	N/A	N/A	N/A	N/A	N/A
K-SS-222	4" pipe O/S	5	20	4.00	2.00	39.2	42.1
FSS-030 End of Pipes							
K-SS-227	6" pipe I/S*	5	37	7.40	5.40	106	52.7
K-SS-228	6" pipe O/S	5	14	2.80	0.80	15.7	37.7
K-SS-225	4" pipe I/S	N/A	N/A	N/A	N/A	N/A	N/A
K-SS-226	4" pipe O/S	5	23	4.60	2.60	51.0	44.2

Comments

* Counting geometry for the measurement of total alpha inside of pipe was not optimal i.e., the detector was not flush to the inside of the pipe surface.

Prepared By: David B. Weyant	Date: 1/18/2006
Reviewed By: Andrew J. Lombardo	Date: 1/18/2006

Attachment E, Table E-1
Gross Alpha Scan Summary
Survey Unit Kaiser-FSSFOA-006
Concrete Wall
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Survey Number	KAISER-FSSFOA-006	43-68 # 4		s/n: 193686/PR190485					
	S. Concrete Wall			Alpha Eff: 16.18%					
	Tech:DBW	7/23/2005							
		ALPHA							
		Scan				weighted	weighted	Bgrd	
		cpm	dpm/100cm^2	cpm	dpm/100cm^2	cpm	dpm/100cm^2	cpm	
Location	Structure	min	min	max	max	ave	ave	(5 min)	Date
Lower West Vertical	S. Concrete Wall	0	-43	10	153	1	-24	11	7/23/2005
Upper Vertical	S. Concrete Wall	0	-43	10	153	1	-24	11	7/23/2005
Horizontal	S. Concrete Wall	0	-43	40	742	1	-24	11	7/23/2005
Lower East Vertical	S. Concrete Wall	0	-43	10	153	1	-24	11	7/23/2005
Notes:									
1. The weighted cpm is determined by the surveyor. Since alpha counts (clicks on audible) are infrequent, and 1 count may equal 10 cpm,									
the surveyor determines the "weighted average".									
2. The acceptance criteria for Total Contamination is 944 dpm/100cm^2. 10 cpm is approximately 150 dpm/100cm^2.									
3. Scans are used to identify elevated area above the acceptance criteria.									
4. Compliance is demonstrated by static counts and smear (sample) results.									

Attachment E, Table E-2
Gross Alpha Scan Summary
Survey Unit Kaiser-FSSFOA-006
Metal Pipes
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Survey Number	KAISER-FSSFOA-006	43-68 # 4		s/n: 193686/PR190485					
	Metal Pipes Under RR			Alpha Eff: 16.18%					
	Tech:DBW	1/14/2006							
ALPHA									
		Scan				weighted	weighted	Bgrd	
Smear		cpm	dpm/100cm^2	cpm	dpm/100cm^2	cpm	dpm/100cm^2	counts	
Number	Structure	min	min	max	max	ave	ave	(5 min)	Date
FSSFOA-006 End of Pipes									
K-SS-223	6" Metal Pipe I/S	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
K-SS-224	6" Metal Pipe O/S	0	-39	10	157	2	0.0	10	1/14/2006
K-SS-221	4" Metal Pipe I/S	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
K-SS-222	4" Metal Pipe O/S	0	-39	10	157	1	-20	10	1/14/2006
FSS-030 End of Pipes									
K-SS-227	6" Metal Pipe I/S	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
K-SS-228	6" Metal Pipe O/S	0	-31	10	165	2	7.8	8	1/14/2006
K-SS-225	4" Metal Pipe I/S	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
K-SS-226	4" Metal Pipe O/S	0	-31	10	165	1	-12	8	1/14/2006
Notes:									
1. The weighted cpm is determined by the surveyor. Since alpha counts (clicks on audible) are infrequent, and 1 count may equal 10 cpm,									
the surveyor determines the "weighted average".									
2. The acceptance criteria for Total Contamination is 944 dpm/100cm^2. 10 cpm is approximately 150 dpm/100cm^2.									
3. Scans are used to identify elevated area above the acceptance criteria.									
4. Compliance is demonstrated by static counts and smear (sample) results.									

SUB-REPORT

SURVEY UNIT KAISER-FSSFOA-007

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ATTACHMENTS

ATTACHMENT A: Figure A-1 Gross Alpha Scan Grid Layout
Figure A-2 Systematic Sampling Locations
Alpha Scan MDC Calculation Form
Total Alpha Contamination Survey Data Conversion Form
Table A-1 Gross Alpha Scan Results Summary

ATTACHMENT B: Survey Unit Worksheet No. 1
Survey Unit Worksheet No. 2

ATTACHMENT C: Laboratory Analytical Results

Final Status Survey Report
Volume II – Former Operational Area
Sub-Report No. EB-037
Survey Unit Kaiser-FSSFOA-007
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation
March 22, 2006

1.0 BACKGROUND

This sub-report documents the results of Former Operational Area (FOA) excavation final status survey activities completed as part of the Thorium Remediation Project at the Tulsa, Oklahoma facility (**Figure 1**). Specifically, this technical report addresses the final status survey of Survey Unit Kaiser-FSSFOA-007, a structure (concrete wall) encountered during the removal of radiologically-affected soil from the Survey Unit Kaiser-FSSFOA-005 (**Figure 3**). Survey Unit Kaiser-FSSFOA-007 consists of the concrete wall's structural surface. It is considered a Class 1 survey unit with an approximate surface area of 81.5 m^2. No elevated areas were left in-place, therefore, no elevated measurement comparisons were required for this unit.

2.0 SURVEY ACTIVITIES AND RESULTS

This section of the sub-report presents the final status survey data for the structural surface of the concrete wall defined as Survey Unit Kaiser-FSSFOA-007. The final status survey consisted of a gross alpha scan of the concrete surface and systematic measurements of total and removable alpha contamination. The supporting documentation for the final status survey of the concrete wall's structural surface is contained in **Attachment A** and includes the following:

- **Figure A-1,** Gross Alpha Scan Grid Layout
- **Figure A-2,** Systematic Sampling Locations
- Alpha Scan MDC Calculation
- Total Alpha Contamination Survey Data Conversion Form
- **Table A-1,** Gross Alpha Scan Results Summary

2.1 Gross Alpha Scan of Structural Surface

The structural surface of the Class 1 survey unit was surveyed through a 100 percent coverage gross alpha scan, to confirm acceptable radiological conditions and identify any elevated areas. The concrete surface was divided into 1-meter by 1-meter grids for recording the results of the 100 percent coverage gross alpha scan **(Figure A-1, Attachment A).** Minimum, maximum, and average scan rates for alpha activity in gross counts per minute (cpm) were recorded for each grid. The results of the scanning activities are summarized in **Table A-1** contained in **Attachment A.** The 100 percent coverage gross alpha scan of the concrete surface did not indicate the presence of small areas of elevated activity (above the DCGL-GA for the site).

2.2 Systematic Measurements of Total and Removable Alpha Contamination

The final status survey also consisted of systematic measurements of total and removable alpha contamination based on a random start point and an equal-distant triangular grid. Since the DCGL values for total and removable contamination contained in the DPA have been revised (and approved by the NRC), the minimum number of sample points for the measurement of total and removable alpha contamination has been recalculated. Since scanning measures total alpha contamination, the minimum number of sample points required (N) is re-determined if the alpha scan minimum detectable concentration (MDC) is greater than the total contamination DCGL.

2.2.1 Determination of the Minimum Number of Sample Points (N)

Paramount to determining the minimum number of sample points is the determination of the relative shift, delta over sigma (Δ/σ). Delta is equal to the difference between the DCGL and the lower-bound gray region (LBGR) value. The LBGR value is arbitrarily set at one-half the DCGL value to start the determination. Sigma is an estimate of the variability in a set of sample analysis results from a survey unit. The estimate of sigma used in the determination is based on the standard deviation of a set of total alpha contamination results from the final status survey of

the Flux Building (Survey Unit FB-001 Floor Surface: 45.9). Since the gross alpha activity of 944 dpm/100cm^2 is the revised DGCL-GA, Δ is equal to 944 - 472, or 472. Delta divided by the sigma of 45.9 results in a relative shift of 10.3. The minimum number of samples (looked up in Table 5.3 of MARSSIM) corresponding to alpha and beta error rates of 0.05 and a relative shift of 10.3 is 9.

2.2.2 Adjusting N based on Scan Minimum Detectable Contamination (MDC)

The scan of structural surfaces is used to detect elevated areas. The total contamination DCGL value applicable to final status surveys of structures for the Tulsa site is the DCGL-GA (DCGL gross alpha) and the value is 944 dpm/100cm^2 of total alpha contamination. Since the background count rate for gross alpha is usually very low, e.g., 1 cpm, MARSSIM provides guidance for determining the scanning MDC for gross alpha based on the probability of detecting very small increments in gross alpha count rate, i.e., one of two counts. For a typical alpha background level of less than 3 cpm, the probability of detecting a single count while passing over the contaminated area is:

$$P(n \geq 1) = 1 - e^{\frac{-GEd}{60v}}$$

where:

P(n ≥ 1) = probability of observing a single count,
G = activity (dpm),
E = 4π detector efficiency (cpd),
d = width of detector in direction of scan (cm), and
v = scan speed (cm/s).

Increase the value of G until the corresponding probability equals the desired confidence level, e.g., 95 percent, and the resulting dpm is the MDC. (The dpm value may be divided by the active area of the detector, e.g., 100 cm^2 to yield an MDC result in dpm/100cm^2.) This method of determining the alpha scan MDC is not background dependent (assuming the background alpha count rate is low). However, the calculated MDC is dependent on the scan speed. Using this formula and typical alpha efficiencies for gas proportional detectors, the calculated scan MDC range from 330 to 1,000 dpm/100cm^2 based on scan speeds of a third of a detector width to one detector width per second. *This range of MDC values is the same magnitude as the DCGL-GA and does not result in an increase in the minimum number of samples required.*

The Minimum Number of Samples Required (N) was determined to be 9 as documented on Survey Unit Worksheet No. 1 (**Attachment B**). However, the number of sample points used for the survey unit was 18. The Survey Unit Area (A) of 81.5 m^2 along with the N of 18 were used to calculate the Triangular Grid Node Length (L) of 2.3 meters and the Height of the Equilateral Triangle (h) of 2.0 meters. A random start point was generated using the random number feature of Excel and documented on Survey Unit Worksheet No. 2 (**Attachment B**).

2.2.3 Total and Removable Alpha Contamination Measurement Results

A layout of the total and removable alpha contamination measurement locations is provided on **Figure A-2** contained in **Attachment A.** At each of the 18 locations, a measurement (static count with a gas proportional detector) of total alpha contamination (identified as MARSSIM-001 through MARSSIM-018) and a smear sample for determination of removable alpha contamination (identified as K-SS-126 through K-SS-143) were collected on the concrete surface. The smear samples were forwarded to Outreach for analysis of alpha activity (per the 100 cm^2 surface area sampled). Total alpha contamination measurement results are provided below in **Table 1.**

Table 1 – Systematic Total Alpha Contamination Measurement Results

Sample ID	DCGL-GA (dpm/100cm^2)	Total Alpha Contamination (dpm/100cm^2)	Std. Error .. (dpm/100cm^2)	MDC (dpm/100cm^2)
MARSSIM-001	944	51.8	66.3	112
MARSSIM-002	944	61.6	69.0	112
MARSSIM-003	944	297	117	112
MARSSIM-004	944	150	90.0	112
MARSSIM-005	944	81.2	74.2	112
MARSSIM-006	944	32.2	60.5	112
MARSSIM-007	944	51.8	66.3	112
MARSSIM-008	944	12.6	54.0	112
MARSSIM-009	944	81.2	74.2	112
MARSSIM-010	944	42.0	63.4	112
MARSSIM-011	944	51.8	66.3	112
MARSSIM-012	944	81.2	74.2	112
MARSSIM-013	944	120	83.6	112
MARSSIM-014	944	22.4	57.3	112
MARSSIM-015	944	12.6	54.0	112
MARSSIM-016	944	-16.9	42.5	112
MARSSIM-017	944	32.2	60.5	112
MARSSIM-018	944	-26.7	37.9	112
Average		***63.2***		
Standard Dev.		***72.9***		
Minimum		***-26.7***		
Maximum		***297***		
Median		***51.8***		

All 18 systematic total alpha contamination measurements were below the DCGL-GA of 944 dpm/100cm^2. The maximum total alpha contamination result was 297 dpm/100cm^2. The average total alpha contamination result was 63.2 dpm/100cm^2.

The standard deviation of the 18 equal-distant samples was 72.9, greater than the estimated standard deviation of 45.9 (based on the Flux Building Survey Unit FB-001 final status survey results) used to calculate the minimum number of samples (N) required. Using the observed standard deviation of 72.9 and the same methodology to determine N as presented in **Section**

2.2.1 above, a relative shift of 6.5 results. The N from Table 5.3 (MARSSIM) corresponding to a relative shift of 6.5 is 9 for a 100 m^2 survey unit.

Analytical results of the smear samples are provided below in **Table 2.** The analytical data reports are contained in **Attachment C.**

Table 2 – Systematic Removable Alpha Contamination Smear Sample Results

Sample ID	DCGL-GA (dpm/100cm^2)	Removable Alpha Contamination (dpm/100cm^2)	Std. Error (dpm/100cm^2)	MDC (dpm/100cm^2)
MARSSIM-001 (K-SS-126)	94.4	0.308	0.668	0.631
MARSSIM-002 (K-SS-127)	94.4	0.487	0.712	0.631
MARSSIM-003 (K-SS-128)	94.4	0.129	0.620	0.631
MARSSIM-004 (K-SS-129)	94.4	1.20	0.87	0.631
MARSSIM-005 (K-SS-130)	94.4	0.397	0.690	0.631
MARSSIM-006 (K-SS-131)	94.4	0.576	0.733	0.631
MARSSIM-007 (K-SS-132)	94.4	0.219	0.644	0.631
MARSSIM-008 (K-SS-133)	94.4	0.397	0.690	0.631
MARSSIM-009 (K-SS-134)	94.4	0.576	0.733	0.631
MARSSIM-010 (K-SS-135)	94.4	0	0.569	0.631
MARSSIM-011 (K-SS-136)	94.4	0.308	0.668	0.631
MARSSIM-012 (K-SS-137)	94.4	0.397	0.690	0.631
MARSSIM-013 (K-SS-138)	94.4	0.040	0.595	0.631
MARSSIM-014 (K-SS-139)	94.4	0	0.541	0.631
MARSSIM-015 (K-SS-140)	94.4	0.755	0.774	0.631
MARSSIM-016 (K-SS-141)	94.4	0	0.569	0.631
MARSSIM-017 (K-SS-142)	94.4	0.308	0.668	0.631
MARSSIM-018 (K-SS-143)	94.4	0.219	0.644	0.631
Average		*0.351*		
Standard Dev.		*0.304*		
Minimum		*0*		
Maximum		*1.20*		
Median		*0.308*		

All 18 smear sample results were below the removable alpha contamination DCGL-GA of 94.4 dpm/100cm^2 (10% of the total contamination DCGL-GA value). The maximum removable alpha contamination result was 1.20 dpm/100cm^2. The average removable alpha contamination result was 0.351 dpm/100cm^2, less than 1% of the average total alpha contamination result.

2.3 Wilcoxon Rank Sum (WRS) Testing

The total alpha contamination results were evaluated using the procedure contained in **Appendix C, Volume I** of this Final Status Survey Report (Wilcoxon Rank Sum Test). The evaluation showed that the survey unit total alpha contamination results meet the DP statistical criterion based on the first statistical test described below.

If the difference (283.2 dpm/100cm^2) between the maximum survey unit total alpha contamination result (297 dpm/100cm^2) and the minimum reference background area total alpha contamination result (13.8 dpm/100cm^2) is less than DCGL-GA (944 dpm/100cm^2), then the survey unit meets the release criterion. **Table 3** presents a summary of the data used to complete the statistical evaluation of the survey unit.

Table 3 – Reference Area and Survey Unit Total Alpha Contamination Results

Reference Group	Sample ID	Total Alpha Contamination (dpm/100cm^2)	Survey Unit Group	Sample ID	Total Alpha Contamination (dpm/100cm^2)
R1	69	102	S1	MARSSIM-001	51.8
R2	35	43.2	S2	MARSSIM-002	61.6
R3	57	66.4	S3	MARSSIM-003	297
R4	25	72.7	S4	MARSSIM-004	150
R5	71	72.7	S5	MARSSIM-005	81.2
R6	46	151	S6	MARSSIM-006	32.2
R7	41	80.5	S7	MARSSIM-007	51.8
R8	43	72.7	S8	MARSSIM-008	12.6
R9	29	269	S9	MARSSIM-009	81.2
R10	23	72.7	S10	MARSSIM-010	42.0
R11	46	151	S11	MARSSIM-011	51.8
R12	12	50.3	S12	MARSSIM-012	81.2
R13	75	62.9	S13	MARSSIM-013	120
R14	28	161	S14	MARSSIM-014	22.4
R15	74	13.8	S15	MARSSIM-015	12.6
R16	17	102	S16	MARSSIM-016	-16.9
R17	53	66.4	S17	MARSSIM-017	32.2
R18	19	72.7	S18	MARSSIM-018	-26.7
	Average:	***93.5***		***Average:***	***63.2***
	Standard Dev.	***58.2***		***Standard Dev.***	***72.9***
	Minimum:	***13.8***		***Minimum:***	***-26.7***
	Maximum:	***269***		***Maximum:***	***297***
	Median:	***72.7***		***Median:***	***51.8***

3.0 SUMMARY OF FINDINGS

A structure (concrete wall) was encountered during the removal of radiologically-affected soil from FOA Survey Unit Kaiser-FSSFOA-005 (**Figure 3**). This structure, identified as Survey Unit Kaiser-FSSFOA-007, is considered a Class 1 survey unit with an approximate surface area of 81.5 m^2. This section of the sub-report presents a summary of the final status survey findings and an overall summation of fractions for the survey unit.

3.1 Structural Surface - Total and Removable Alpha Contamination

The acceptance criterion for structures remaining at the Tulsa facility is the DCGL-GA of 944 dpm/100cm^2 for total alpha contamination and 94.4 dpm/100cm^2 for removable alpha contamination. Final status survey activities for Survey Unit Kaiser-FSSFOA-007 consisted of a gross alpha scan of the exposed concrete surface of the survey unit and systematic measurements of total and removable alpha contamination. The results of the final status survey activities were as follows:

- The 100 percent coverage gross alpha scan of the concrete surface did not indicate the presence of small areas of elevated activity (above the DCGL-GA for the site).
- All 18 systematic measurements of total alpha contamination were below the DCGL-GA of 944 dpm/100cm^2.
- All 18 smear sample results were below the DCGL-GA of 94.4 dpm/100cm^2 for removable alpha contamination.
- The total alpha contamination results meet the DP statistical criterion based on the first statistical evaluation of the data (WRS Test procedure).
- No elevated areas were left in-place, therefore, no elevated measurement comparisons were required for this unit.

3.2 Sum of Fractions for Entire Survey Unit

To evaluate the status of Survey Unit Kaiser-FSSFOA-007 as a whole, the fraction of each survey element's average activity divided by the applicable acceptance criteria is calculated for inclusion in the Sum of Fractions for the entire survey unit. The Total Sum of Fractions for total alpha contamination, removable alpha contamination, and the elevated areas is presented below in **Table 4.** As previously mentioned, no elevated areas were left in-place for the survey unit.

Table 4 – Fraction of Applicable Acceptance Criteria per Survey Unit Element

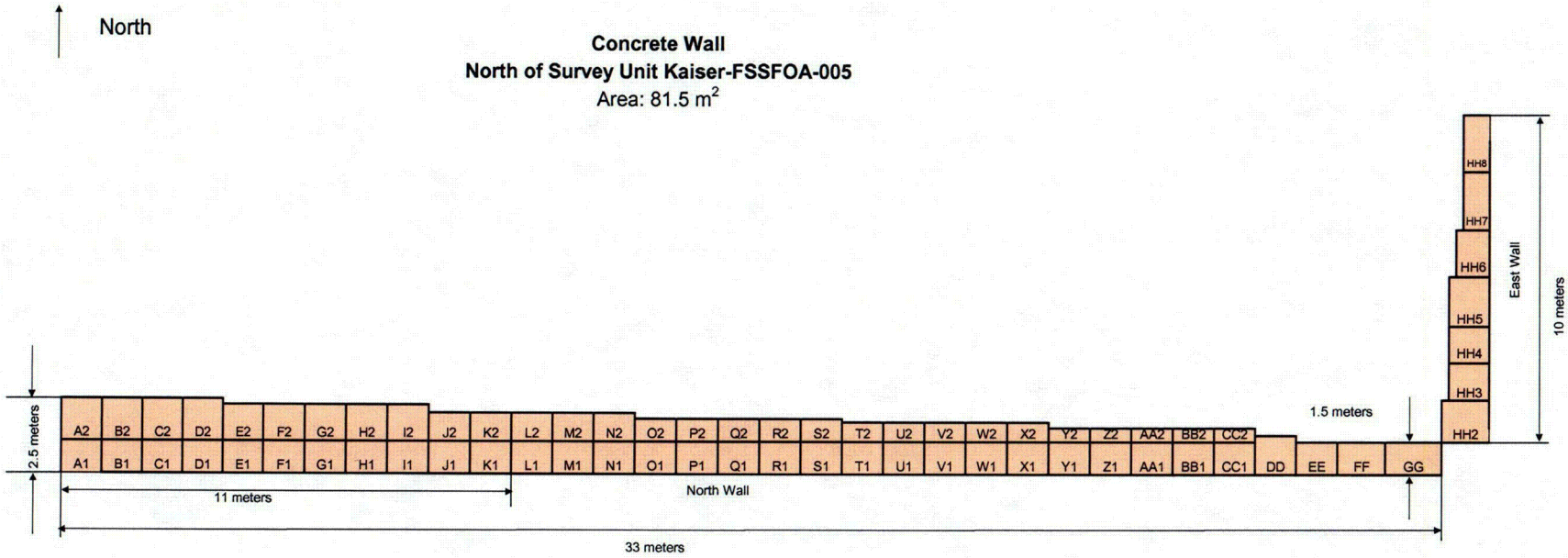
Survey Unit Element	Units	Average Activity	Acceptance Criteria	Fraction
FSSFOA-007 Total Alpha Contamination	dpm/100cm^2	63.2	944	0.07
FSSFOA-007 Removable Alpha Contamination	dpm/100cm^2	0.351	94.4	0.00
Elevated Areas (None Left In-Place)	dpm/100cm^2			0.00
TOTAL SUM OF FRACTIONS				***0.07***

The Sum of Fractions provides a conservative assessment of the survey unit without backfill. The results of the Sum of Fractions assessment show that Survey Unit Kaiser-FSSFOA-007 meets the DP acceptance criteria.

ATTACHMENT A
TABLE OF CONTENTS

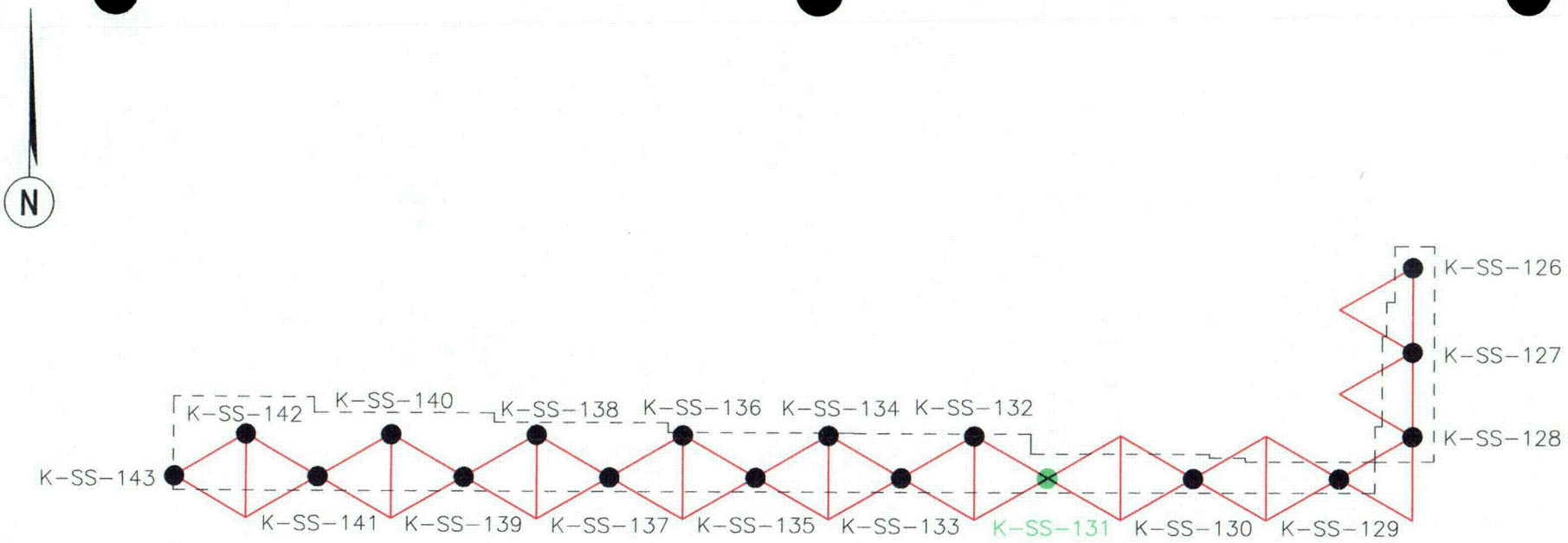
- **FIGURE A-1 Gross Alpha Scan Grid Layout**
- **FIGURE A-2 Systematic Sampling Locations**
- **Alpha Scan MDC Calculation Form**
- **Total Alpha Contamination Survey Data Conversion Form**
- **Table A-1 Gross Alpha Scan Results Summary**

Attachment A, Figure A-1
Gross Alpha Scan Grid Layout
Survey Unit Kaiser-FSSFOA-007
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation



Q:\P4000\PA4072\FSS Reports\Volume II\Survey Unit FSSFOA-007\Attachment A\KAISER-FSSFOA-007 Figure A-1

C19



SCALE – FEET

15 0 15

3 0 3

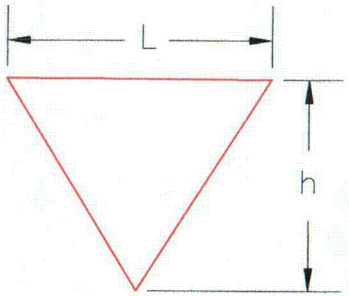
SCALE – METERS

K-SS-130

● SYSTEMATIC SAMPLING LOCATION BASED ON RANDOM START POINT AND AN EQUAL DISTANT TRIANGULAR GRID

K-SS-131

● RANDOM START POINT



N = 18
L = 2.3m
h = 2.0m
AREA = 81.5m^2

FIGURE A-2
SYSTEMATIC SAMPLING LOCATIONS
SURVEY UNIT KAISER – FSSFOA-007
FINAL STATUS SURVEY
THORIUM REMEDIATION PROJECT
TULSA, OKLAHOMA FACILITY

PREPARED FOR

KAISER ALUMINUM & CHEMICAL CORPORATION
TULSA, OKLAHOMA

APPROVED	RAD 3-3-06
CHECKED	RAD 3-3-06
DRAWN	DEB 01/13/06
DRAWING NUMBER	PA4072065

Penn E&R
Environmental & Remediation, Inc.

C20

Form HPM/M-2-2-3
Alpha Scan MDC Calculation

Instrument Serial Number:	193686	Cal. Due:	5/6/2006
Detector Serial Number:	PR190485	Cal. Due:	5/6/2006
Radiation Detected:	Alpha	**For < 3 count background**	

Probability of observing 2 or more counts:

$$P(n \geq 2) = 1 - \left(1 + \frac{(GE+B)d}{60v}\right)\left(e^{-\frac{(GE+B)d}{60v}}\right)$$

Probability of observing a single count:

$$P(n \geq 1) = 1 - e^{\frac{-GEd}{60v}}$$

	D Date	G Activity (dpm)	d Detector Width (cm)	E Instrument Efficiency (cpm)	v Scan Speed (cm/s)	B Background Countrate (cpm)	P Probability (-)
1	6/29/2005	538	11.7	0.1618	5.85	N/A	0.95
2	7/7/2005	538	11.7	0.1618	5.85	N/A	0.95
3	7/9/2005	538	11.7	0.1618	5.85	N/A	0.95
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

Comments:

Prepared By:	David B. Weyant	Date:	6/29/05
Reviewed By:	Andrew J. Lombardo	Date:	7/9/05

Notes:
1.) Instrument Efficiency is the 4π instrument efficiency.

Total Alpha Contamination
Survey Unit Kaiser-FSSFOA-007
Survey Data Conversion Form
Form ESC/HPM/M-3-2-2

Date of Survey:	6/29/2005	Type of Radiation:	Alpha
Instrument Serial #:	193686	Calibration Due Date:	5/5/2006
Detector Serial #:	PR190485	Calibration Due Date:	5/5/2006
E_s (Surface Efficiency):	0.25	E_i (Insturment Efficiency):	0.1618
BKG Counts:	11.8	BKG Count Time (min):	5
Active Area of Detector Probe (cm^2):	126	MDC ($dpm/100cm^2$):	112

FSS Number	Survey Point Count Time (min)	Gross Counts (cts)	Gross Count Rate (cpm)	Net Count Rate (cpm)	Total Contamination ($dpm/100cm^2$)	95% CL Uncertainty ($dpm/100cm^2$)
MARSSIM-001	2	10	5.00	2.64	51.8	66.3
MARSSIM-002	2	11	5.50	3.14	61.6	69.0
MARSSIM-003	2	35	17.5	15.1	297	117
MARSSIM-004	2	20	10.0	7.64	150	90.0
MARSSIM-005	2	13	6.50	4.14	81.2	74.2
MARSSIM-006	2	8	4.00	1.64	32.2	60.5
MARSSIM-007	2	10	5.00	2.64	51.8	66.3
MARSSIM-008	2	6	3.00	0.64	12.6	54.0
MARSSIM-009	2	13	6.50	4.14	81.2	74.2
MARSSIM-010	2	9	4.50	2.14	42.0	63.4
MARSSIM-011	2	10	5.00	2.64	51.8	66.3
MARSSIM-012	2	13	6.50	4.14	81.2	74.2
MARSSIM-013	2	17	8.50	6.14	120	83.6
MARSSIM-014	2	7	3.50	1.14	22.4	57.3
MARSSIM-015	2	6	3.00	0.64	12.6	54.0
MARSSIM-016	2	3	1.50	-0.86	-16.9	42.5
MARSSIM-017	2	8	4.00	1.64	32.2	60.5
MARSSIM-018	2	2	1.00	-1.36	-26.7	37.9

Comments:

Prepared By: David B. Weyant	Date: 6/29/2005
Reviewed By: Andrew J. Lombardo	Date: 7/11/2005

Attachment A, Table A-1
Gross Alpha Scan Results Summary
Survey Unit Kaiser-FSSFOA-007
Concrete Wall
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Survey Number:	KAISER-FSSFOA-007	Instrument Serial Number:	193686	Cal. Due:	5/5/2006
Tech:DBW	Alpha Eff: 16.18%	Detector Serial Number:	PR190485	Cal. Due:	5/5/2006

			Scan		weighted		Average
		Survey	cpm	cpm	cpm	cpm	(dpm/100cm^2)
Grid Number	Material Type	Date	Minimum	Maximum	Average	Background	net
A1	Concrete	6/29/05	0	10	0	1.1	-22
A2	Concrete	6/29/05	0	10	0	1.1	-22
B1	Concrete	6/29/05	0	10	0	1.1	-22
B2	Concrete	6/29/05	0	10	0	1.1	-22
C1	Concrete	6/29/05	0	10	0	1.1	-22
C2	Concrete	6/29/05	0	10	0	1.1	-22
D1	Concrete	6/29/05	0	10	0	1.1	-22
D2	Concrete	6/29/05	0	10	0	1.1	-22
E1	Concrete	6/29/05	0	10	0	1.1	-22
E2	Concrete	6/29/05	0	10	0	1.1	-22

Attachment A, Table A-1
Gross Alpha Scan Results Summary
Survey Unit Kaiser-FSSFOA-007
Concrete Wall
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Survey Number:	KAISER-FSSFOA-007	Instrument Serial Number:	193686	Cal. Due:	5/5/2006
Tech:DBW	Alpha Eff: 16.18%	Detector Serial Number:	PR190485	Cal. Due:	5/5/2006

Grid Number	Material Type	Survey Date	Scan cpm Minimum	Scan cpm Maximum	weighted cpm Average	cpm Background	Average (dpm/100cm²) net
F1	Concrete	6/29/05	0	10	0	1.1	-22
F2	Concrete	6/29/05	0	30	1	1.5	-10
G1	Concrete	6/29/05	0	10	0	1.5	-29
G2	Concrete	6/29/05	0	10	0	1.5	-29
H1	Concrete	6/29/05	0	10	0	1.5	-29
H2	Concrete	6/29/05	0	10	0	1.5	-29
I1	Concrete	6/29/05	0	20	5	1.5	69
I2	Concrete	6/29/05	0	10	0	1.5	-29
J1	Concrete	6/29/05	0	20	5	1.5	69
J2	Concrete	6/29/05	0	10	0	1.4	-27
K1	Concrete	6/29/05	0	10	5	1.4	71

Attachment A, Table A-1
Gross Alpha Scan Results Summary
Survey Unit Kaiser-FSSFOA-007
Concrete Wall
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Survey Number:	KAISER-FSSFOA-007	Instrument Serial Number:	193686	Cal. Due:	5/5/2006
Tech:DBW	Alpha Eff: 16.18%	Detector Serial Number:	PR190485	Cal. Due:	5/5/2006

Grid Number	Material Type	Survey Date	Scan cpm Minimum	Scan cpm Maximum	weighted cpm Average	cpm Background	Average (dpm/100cm^2) net
K2	Concrete	6/29/05	0	10	0	1.4	-27
L1	Concrete	6/29/05	0	10	0	1.4	-27
L2	Concrete	6/29/05	0	10	0	1.4	-27
M1	Concrete	7/7/05	0	10	0	1.4	-27
M2	Concrete	6/29/05	0	10	0	1.4	-27
N1	Concrete	6/29/05	0	10	0	1.4	-27
N2	Concrete	6/29/05	0	10	0	1.4	-27
O1	Concrete	6/29/05	0	10	0	1.4	-27
O2	Concrete	6/29/05	0	10	0	1.4	-27
P1	Concrete	6/29/05	0	20	5	1.4	71
P2	Concrete	6/29/05	0	10	0	2	-39

Attachment A, Table A-1
Gross Alpha Scan Results Summary
Survey Unit Kaiser-FSSFOA-007
Concrete Wall
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Survey Number:	KAISER-FSSFOA-007	Instrument Serial Number:	193686	Cal. Due:	5/5/2006
Tech:DBW	Alpha Eff: 16.18%	Detector Serial Number:	PR190485	Cal. Due:	5/5/2006

			Scan		weighted		Average
		Survey	cpm	cpm	cpm	cpm	(dpm/100cm^2)
Grid Number	Material Type	Date	Minimum	Maximum	Average	Background	net
Q1	Concrete	6/29/05	0	10	0	2	-39
Q2	Concrete	6/29/05	0	10	0	2	-39
R1	Concrete	6/29/05	0	10	0	2	-39
R2	Concrete	6/29/05	0	10	0	2	-39
S1	Concrete	6/29/05	0	10	0	2	-39
S2	Concrete	6/29/05	0	30	10	2	157
T1	Concrete	6/29/05	0	20	5	2	59
T2	Concrete	6/29/05	0	10	0	2	-39
U1	Concrete	6/29/05	0	10	0	2.7	-53
U2	Concrete	6/29/05	0	10	0	2.7	-53
V1	Concrete	6/29/05	0	10	0	2.7	-53

Attachment A, Table A-1
Gross Alpha Scan Results Summary
Survey Unit Kaiser-FSSFOA-007
Concrete Wall
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Survey Number:	KAISER-FSSFOA-007	Instrument Serial Number:	193686	Cal. Due:	5/5/2006
Tech:DBW	Alpha Eff: 16.18%	Detector Serial Number:	PR190485	Cal. Due:	5/5/2006

			Scan		weighted		Average
Grid Number	Material Type	Survey Date	cpm Minimum	cpm Maximum	cpm Average	cpm Background	(dpm/100cm^2) net
V2	Concrete	6/29/05	0	10	0	2.7	-53
W1	Concrete	6/29/05	0	10	0	2.7	-53
W2	Concrete	6/29/05	0	10	0	2.7	-53
X1	Concrete	6/29/05	0	10	0	2.7	-53
X2	Concrete	6/29/05	0	10	0	2.7	-53
Y1	Concrete	6/29/05	0	20	5	2.7	45
Y2	Concrete	6/29/05	0	10	0	2.7	-53
Z1	Concrete	6/29/05	0	20	5	2.7	45
Z2	Concrete	6/29/05	0	10	0	3	-59
AA1	Concrete	6/29/05	0	10	0	3	-59
AA2	Concrete	6/29/05	0	20	0	3	-59

Attachment A, Table A-1
Gross Alpha Scan Results Summary
Survey Unit Kaiser-FSSFOA-007
Concrete Wall
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Survey Number:	KAISER-FSSFOA-007	Instrument Serial Number:	193686	Cal. Due:	5/5/2006
Tech:DBW	Alpha Eff: 16.18%	Detector Serial Number:	PR190485	Cal. Due:	5/5/2006

			Scan		weighted		Average
		Survey	cpm	cpm	cpm	cpm	(dpm/100cm^2)
Grid Number	Material Type	Date	Minimum	Maximum	Average	Background	net
BB1	Concrete	6/29/05	0	30	5	3	39
BB2	Concrete	6/29/05	0	10	0	3	-59
CC1	Concrete	7/9/05	0	10	0	3	-59
CC2	Concrete	6/29/05	0	10	0	3	-59
DD1	Concrete	6/29/05	0	30	5	3	39
EE1	Concrete	6/29/05	0	30	5	2.2	55
FF1	Concrete	6/29/05	0	20	5	2.2	55
GG1	Concrete	6/29/05	0	20	5	2.2	55
HH2	Concrete	6/29/05	0	20	0	2.2	-43
HH3	Concrete	6/29/05	0	20	0	2.2	-43
HH4	Concrete	6/29/05	0	10	0	1.4	-27

Attachment A, Table A-1
Gross Alpha Scan Results Summary
Survey Unit Kaiser-FSSFOA-007
Concrete Wall
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Survey Number:	KAISER-FSSFOA-007	Instrument Serial Number:	193686	Cal. Due:	5/5/2006
Tech:DBW	Alpha Eff: 16.18%	Detector Serial Number:	PR190485	Cal. Due:	5/5/2006

Grid Number	Material Type	Survey Date	Scan cpm Minimum	Scan cpm Maximum	weighted cpm Average	cpm Background	Average (dpm/100cm^2) net
HH5	Concrete	6/29/05	0	30	5	1.4	71
HH6	Concrete	6/29/05	0	30	5	1.4	71
HH7	Concrete	6/29/05	0	10	0	1.4	-27
HH8	Concrete	6/29/05	0	10	0	1.4	-27

Notes:

1. The weighted cpm is determined by the surveyor. Since alpha counts (clicks on audible) are infrequent, and 1 count may equal 10 cpm, the surveyor determines the "weighted average".

2. The acceptance criteria for Total Contamination is 944 dpm/100cm^2. 10 cpm is approximately 150 dpm/100cm^2.

3. Scans are used to identify elevated area above the acceptance criteria.

4. Compliance is demonstrated by static counts and smear (sample) results.

ATTACHMENT B
TABLE OF CONTENTS

- **Survey Unit Worksheet No. 1**
- **Survey Unit Worksheet No. 2**

Survey Unit Work Sheet No. 1
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

1. Structure Survey Unit: KAISER-FSSFOA-007

2. Description: Former Operational Area, Concrete Wall, North of Survey Unit Kaiser-FSSFOA-005

3. Dimensions (m): Approximately. 43 meters x 2 meters; Area, A (m^2): 81.5

4. Alpha Background: 1.91 cpm MDC (dpm/100cm^2): 538

5. Minimum Number of Samples (N): 9 and Corresponding Triangular Grid Node Length (L) in meters: 3.6.

6. If the area of the survey unit floor is less than 100 m^2, recalculate the number of samples (N_1) corresponding to L that provides the same coverage in the smaller survey unit as N samples does in 100 m^2 using the following formula: $N_1 = A / (0.866 \times L^2)$,
N_1: N/A

7. If N_1 is less than 18, use the default N (18) and recalculate the corresponding Triangular Grid Node Length (L_1) for the survey unit floor Area (A) less than 100 m^2, using the following formula: $L_1 = (A/(0.866 \times 18))^{1/2}$:
2.3 m

8. Calculate the height (h) of the equilateral triangle with side length equal to L (or L_1) using the following formula: $h = ((L^2 - (L/2)^2)^{1/2}$: 2.0 m

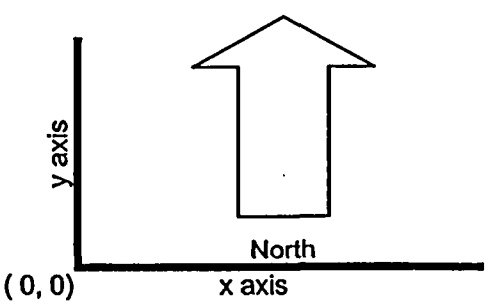
Survey Unit Worksheet No. 2
Random Number Generator for Start Point
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

SURVEY UNIT: KAISER-FSSFOA-007

RANDOM START POINT

x axis (Meters)	y axis (Meters)
24	1

	x axis	y axis
lower bound	0	0
upper bound	34.5	11.5



ATTACHMENT C

LABORATORY ANALYTICAL RESULTS

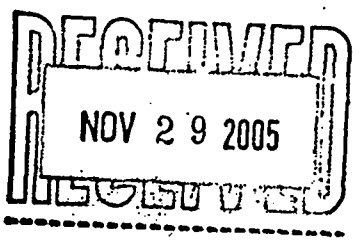
Outreach
Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Invoice # 11122
D/. 7/5/05

July 1, 2005

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20050494



Dear Mr. Weyant,

Please find enclosed the analytical report for your samples received in our laboratory on June 20, 2005 for the above captioned project. Eighteen filters were received in good condition and analyzed for Gross Alpha/Beta with an expedited 5 work-day turn time.

All Quality Control for the requested analyses is reported on the analytical report. The method blank, laboratory control standard and matrix spikes and spike duplicates for all analyses were within method control limits.

Your samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions feel free to call.

Laboratory Director

ODEQ ID #9517
NRC ODEQ LIC. #27522-01

C
ERT. ID# OK001

Outreach Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client: Kaiser Aluminum
Client Project: Thorium Remediation
Lab Number: 20050494
Date Reported: 7/1/05
Date Received: 6/28/05

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050494-01**						
Client ID:	**K-SS-126**						
Date Sampled:	**6/27/05 12:30:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.308 +/- 0.668	DPM/F	0.631		6/29/05	SD
Gross Beta	EPA 900/9310	3.13 +/- 2.61	DPM/F	2.57		6/29/05	SD
Lab ID:	**20050494-02**						
Client ID:	**K-SS-127**						
Date Sampled:	**6/27/05 12:31:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.487 +/- 0.712	DPM/F	0.631		6/29/05	SD
Gross Beta	EPA 900/9310	2.35 +/- 2.55	DPM/F	2.57		6/29/05	SD
Lab ID:	**20050494-03**						
Client ID:	**K-SS-128**						
Date Sampled:	**6/27/05 12:38:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.129 +/- 0.620	DPM/F	0.631		6/29/05	SD
Gross Beta	EPA 900/9310	1.76 +/- 2.51	DPM/F	2.57		6/29/05	SD
Lab ID:	**20050494-04**						
Client ID:	**K-SS-129**						
Date Sampled:	**6/27/05 12:33:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	1.20 +/- 0.87	DPM/F	0.631		6/29/05	SD
Gross Beta	EPA 900/9310	0.688 +/- 2.43	DPM/F	2.57		6/29/05	SD
Lab ID:	**20050494-05**						
Client ID:	**K-SS-130**						
Date Sampled:	**6/27/05 12:34:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					

BDL = Below Detection Limit

Outreach Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Gross Alpha	EPA 900/9310	0.397 +/- 0.690	DPM/F	0.631		6/29/05	SD
Gross Beta	EPA 900/9310	2.05 +/- 2.53	DPM/F	2.57		6/29/05	SD
Lab ID:	**20050494-06**						
Client ID:	**K-SS-131**						
Date Sampled:	**6/27/05 12:35:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.576 +/- 0.733	DPM/F	0.631		6/29/05	SD
Gross Beta	EPA 900/9310	2.54 +/- 2.57	DPM/F	2.57		6/29/05	SD
Lab ID:	**20050494-07**						
Client ID:	**K-SS-132**						
Date Sampled:	**6/27/05 12:36:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.219 +/- 0.644	DPM/F	0.631		6/29/05	SD
Gross Beta	EPA 900/9310	2.05 +/- 2.53	DPM/F	2.57		6/29/05	SD
Lab ID:	**20050494-08**						
Client ID:	**K-SS-133**						
Date Sampled:	**6/27/05 12:37:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.397 +/- 0.690	DPM/F	0.631		6/29/05	SD
Gross Beta	EPA 900/9310	3.13 +/- 2.61	DPM/F	2.57		6/29/05	SD
Lab ID:	**20050494-09**						
Client ID:	**K-SS-134**						
Date Sampled:	**6/27/05 12:38:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.576 +/- 0.733	DPM/F	0.631		6/29/05	SD
Gross Beta	EPA 900/9310	1.47 +/- 2.49	DPM/F	2.57		6/29/05	SD

BDL = Below Detection Limit

Outreach Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
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Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050494
Date Reported:	7/1/05
Date Received:	6/28/05
Page Number:	3 of 5

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050494-10**						
Client ID:	**K-SS-135**						
Date Sampled:	**6/27/05 12:39:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0 +/- 0.569	DPM/F	0.631		6/29/05	SD
Gross Beta	EPA 900/9310	0.981 +/- 2.45	DPM/F	2.57		6/29/05	SD
Lab ID:	**20050494-11**						
Client ID:	**K-SS-136**						
Date Sampled:	**6/27/05 12:40:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.308 +/- 0.668	DPM/F	0.631		6/29/05	SD
Gross Beta	EPA 900/9310	2.05 +/- 2.53	DPM/F	2.57		6/29/05	SD
Lab ID:	**20050494-12**						
Client ID:	**K-SS-137**						
Date Sampled:	**6/27/05 12:41:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.397 +/- 0.690	DPM/F	0.631		6/29/05	SD
Gross Beta	EPA 900/9310	2.54 +/- 2.57	DPM/F	2.57		6/29/05	SD
Lab ID:	**20050494-13**						
Client ID:	**K-SS-138**						
Date Sampled:	**6/27/05 12:42:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.040 +/- 0.595	DPM/F	0.631		6/29/05	SD
Gross Beta	EPA 900/9310	1.86 +/- 2.52	DPM/F	2.57		6/29/05	SD
Lab ID:	**20050494-14**						
Client ID:	**K-SS-139**						
Date Sampled:	**6/27/05 12:43:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					

BDL = Below Detection Limit

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North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050494
Date Reported:	7/1/05
Date Received:	6/28/05
Page Number:	4 of 5

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Gross Alpha	EPA 900/9310	0 +/- 0.541	DPM/F	0.631		6/29/05	SD
Gross Beta	EPA 900/9310	0.786 +/- 2.43	DPM/F	2.57		6/29/05	SD
Lab ID:	**20050494-15**						
Client ID:	**K-SS-140**						
Date Sampled:	**6/27/05 12:44:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.755 +/- 0.774	DPM/F	0.631		6/29/05	SD
Gross Beta	EPA 900/9310	2.54 +/- 2.57	DPM/F	2.57		6/29/05	SD
Lab ID:	**20050494-16**						
Client ID:	**K-SS-141**						
Date Sampled:	**6/27/05 12:45:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0 +/- 0.569	DPM/F	0.631		6/29/05	SD
Gross Beta	EPA 900/9310	1.76 +/- 2.51	DPM/F	2.57		6/29/05	SD
Lab ID:	**20050494-17**						
Client ID:	**K-SS-142**						
Date Sampled:	**6/27/05 12:46:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.308 +/- 0.668	DPM/F	0.631		6/29/05	SD
Gross Beta	EPA 900/9310	0.786 +/- 2.43	DPM/F	2.57		6/29/05	SD
Lab ID:	**20050494-18**						
Client ID:	**K-SS-143**						
Date Sampled:	**6/27/05 12:47:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.219 +/- 0.644	DPM/F	0.631		6/29/05	SD
Gross Beta	EPA 900/9310	2.54 +/- 2.57	DPM/F	2.57		6/29/05	SD

BDL = Below Detection Limit

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Broken Arrow, OK 74012
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FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050494
Date Reported:	7/1/05
Date Received:	6/28/05
Page Number:	5 of 5

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Gross Alpha	0.2+/-0.6	109.0	116.0	7.2	NC				6/29/05
Gross Beta	4.9+/-2.7	87.0	93.0	6.7	NC				6/29/05

Lab Approval:

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
Company: KAISER ALUM & CHEM INC.
Name: DAVID B. WEYAND
Address: 7311 E. 41ST.
City: TULSA State: OK Zip: 74145
Phone: 274-934-3320 Fax #: 918-384-3171

LOCAL: 918-384-0516
CELL: 724-744-0071

Bill To:
Company: KAISER/PAUL EGR
Name: PAUL BARR/DAVID WEYAND
Address: 7311 E. 41ST ST.
City: TULSA State: OK Zip: 74145

ANALYSIS REQUESTED

PO #: KAISER-4072
PROJECT #: PA-4000-4072
PROJECT NAME: KAISER-THORIUM REMED PROJ.
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY): 5 DAY
SAMPLER: Signature DAVID B. WEYAND

LAB SAMPLE #	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	Gamma Rad pCi/g	Th-232 pCi/g	Ra-226 pCi/g	Ra-228 pCi/g	Total U DPM/100 cm²	REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
1	K-SS-126	6-27-05	1230	Soil	1	Cloth	None						GRAB
2	K-SS-127		1231		1								
3	K-SS-128		1232		1								
4	K-SS-129		1233		1								
5	K-SS-130		1234		1								
6	K-SS-131		1235		1								
7	K-SS-132		1236		1								
8	K-SS-133		1237		1								
9	K-SS-134		1238		1								
10	K-SS-135		1239		1								
11	K-SS-136		1240		1								
12	K-SS-137		1241		1								
13	K-SS-138		1242		1								
14	K-SS-139		1243		1								

RELINQUISHED BY: DAVID B. WEYAND DATE 6-28-05 TIME 730 RECEIVED BY: DATE 6/28/05 TIME 730

RELINQUISHED BY: DATE TIME RECEIVED BY: DATE TIME

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company

FOR LABORATORY USE ONLY
Sample Condition Upon Receipt: GOOD

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
Company Kaiser-Alum & Chem Co.
Name David G. Weyant
Address 7211 E. 41st Street
City Tulsa State OK Zip 74145
Phone 924-934-3370 Fax # 918-384-7171
Local: 918-394-0065 Cell: 724-799-0071

Bill To:
Company Kaiser / Ron Gr
Name David G. Weyant / Paul Haas
Address 7211 E. 41st St.
City Tulsa State OK Zip 74145

ANALYSIS REQUESTED

PO # Kaiser-4072
PROJECT # PA-4000-4072
PROJECT NAME Kaiser-Thorium Remed. Proj.
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY) 5 DAY
SAMPLER David G. Weyant
Signature David G. Weyant

LEAD SAMPLE ID	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	Gross α/β	Ra-226 by Rn-222 Emanation	Ra-228 by Ac-228 Gamma Spectrometry	Pb-210 by Rn-222 Daughter Ingrowth	REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
12	K-SS-140	6-27-05	1244	Solid	1	Cloth	None	X	X	X	X	GRAB
13	K-SS-141	"	1245	"	1	"	"	X	X	X	X	"
14	K-SS-142	"	1246	"	1	"	"	X	X	X	X	"
15	K-SS-143	"	1247	"	1	"	"	X	X	X	X	"

RELINQUISHED BY: David G. Weyant DATE 6/28/05 TIME 720 RECEIVED BY: Ron Gidson DATE 6/28/05 TIME 0730
RELINQUISHED BY: _____ DATE _____ TIME _____ RECEIVED BY: _____ DATE _____ TIME _____

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

FOR LABORATORY USE ONLY: 0605364002
Sample condition upon receipt: Good
Custody seal intact: N/A

SAMPLE LOGIN

Date Received: *6/28/05 8:25:31 A* Lab Number: 20050494 Due: 7/5/05

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20050494-01 A Gross Alpha/Beta	K-SS-126	Swipe	06/27/05	Plastic	Sm Zip Bag	None	No	No
20050494-02 A Gross Alpha/Beta	K-SS-127	Swipe	06/27/05	Plastic	Sm Zip Bag	None	No	No
20050494-03 A Gross Alpha/Beta	K-SS-128	Swipe	06/27/05	Plastic	Sm Zip Bag	None	No	No
20050494-04 A Gross Alpha/Beta	K-SS-129	Swipe	06/27/05	Plastic	Sm Zip Bag	None	No	No
20050494-05 A Gross Alpha/Beta	K-SS-130	Swipe	06/27/05	Plastic	Sm Zip Bag	None	No	No
20050494-06 A Gross Alpha/Beta	K-SS-131	Swipe	06/27/05	Plastic	Sm Zip Bag	None	No	No
20050494-07 A Gross Alpha/Beta	K-SS-132	Swipe	06/27/05	Plastic	Sm Zip Bag	None	No	No
20050494-08 A Gross Alpha/Beta	K-SS-133	Swipe	06/27/05	Plastic	Sm Zip Bag	None	No	No
20050494-09 A Gross Alpha/Beta	K-SS-134	Swipe	06/27/05	Plastic	Sm Zip Bag	None	No	No
20050494-10 A Gross Alpha/Beta	K-SS-135	Swipe	06/27/05	Plastic	Sm Zip Bag	None	No	No
20050494-11 A Gross Alpha/Beta	K-SS-136	Swipe	06/27/05	Plastic	Sm Zip Bag	None	No	No
20050494-12 A	K-SS-137	Swipe	06/27/05	Plastic	Sm Zip Bag	None	No	No

Gross Alpha/Beta								
20050494-13 A Gross Alpha/Beta	K-SS-138	Swipe	06/27/05	Plastic	Sm Zip Bag	None	No	No
20050494-14 A Gross Alpha/Beta	K-SS-139	Swipe	06/27/05	Plastic	Sm Zip Bag	None	No	No
20050494-15 A Gross Alpha/Beta	K-SS-140	Swipe	06/27/05	Plastic	Sm Zip Bag	None	No	No
20050494-16 A Gross Alpha/Beta	K-SS-141	Swipe	06/27/05	Plastic	Sm Zip Bag	None	No	No
20050494-17 A Gross Alpha/Beta	K-SS-142	Swipe	06/27/05	Plastic	Sm Zip Bag	None	No	No
20050494-18 A Gross Alpha/Beta	K-SS-143	Swipe	06/27/05	Plastic	Sm Zip Bag	None	No	No

CONTAINER INSPECTION

Coolers N/A Custody Seals Broken - Y/N/A Temperature AMB - Blue Ice / Wet Ice Radiation Survey _____fixed_____removable

SAMPLE INSPECTION

Custody Seals Broken - Y/N/A Chain of Custody Record Y/N Labels in Tact Y/N Radiation Survey Complete Y/N

Anomalies: _____

_____

_____

Inspected By: _____ DATE_____

QA or Designee Review: _____DATE_____

Sample Custodian Review: Desiree Gregory DATE 6/28/05

Project Notes:

SUB-REPORT

SURVEY UNIT KAISER-FSSFOA-008

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ATTACHMENTS

ATTACHMENT A: Figure A-1 Gross Alpha Scan Grid Layout
Figure A-2 Systematic Sampling Locations
Alpha Scan MDC Calculation Form
Total Alpha Contamination Survey Data Conversion Form
Table A-1 Gross Alpha Scan Results Summary

ATTACHMENT B: Survey Unit Worksheet No. 1
Survey Unit Worksheet No. 2

ATTACHMENT C: Laboratory Analytical Results

Final Status Survey Report
Volume II – Former Operational Area
Sub-Report No. EB-038
Survey Unit Kaiser-FSSFOA-008
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation
March 22, 2006

1.0 BACKGROUND

This sub-report documents the results of Former Operational Area (FOA) excavation final status survey activities completed as part of the Thorium Remediation Project at the Tulsa, Oklahoma facility (**Figure 1**). Specifically, this technical report addresses the final status survey of Survey Unit Kaiser-FSSFOA-008, a structure (concrete wall) encountered during the removal of radiologically-affected soil from the Survey Unit Kaiser-FSSFOA-006 (**Figure 3**). Survey Unit Kaiser-FSSFOA-008 consists of the concrete wall's structural surface. It is considered a Class 1 survey unit with an approximate surface area of 9.3 m^2. No elevated areas were left in-place, therefore, no elevated measurement comparisons were required for this unit.

2.0 SURVEY ACTIVITIES AND RESULTS

This section of the sub-report presents the final status survey data for the structural surface of the concrete wall defined as Survey Unit Kaiser-FSSFOA-008. The final status survey consisted of a gross alpha scan of the concrete surface and systematic measurements of total and removable alpha contamination. The supporting documentation for the final status survey of the concrete wall's structural surface is contained in **Attachment A** and includes the following:

- **Figure A-1,** Gross Alpha Scan Grid Layout
- **Figure A-2,** Systematic Sampling Locations
- Alpha Scan MDC Calculation
- Total Alpha Contamination Survey Data Conversion Form
- **Table A-1,** Gross Alpha Scan Results Summary

2.1 Gross Alpha Scan of Structural Surface

The structural surface of the Class 1 survey unit was surveyed through a 100 percent coverage gross alpha scan, to confirm acceptable radiological conditions and identify any elevated areas. The concrete surface was divided into 1-meter by 1-meter grids for recording the results of the 100 percent coverage gross alpha scan (**Figure A-1, Attachment A**). Minimum, maximum, and average scan rates for alpha activity in gross counts per minute (cpm) were recorded for each grid. The results of the scanning activities are summarized in **Table A-1** contained in **Attachment A.** The 100 percent coverage gross alpha scan of the concrete surface did not indicate the presence of small areas of elevated activity (above the DCGL-GA for the site).

2.2 Systematic Measurements of Total and Removable Alpha Contamination

The final status survey also consisted of systematic measurements of total and removable alpha contamination based on a random start point and an equal-distant triangular grid. Since the DCGL values for total and removable contamination contained in the DPA have been revised (and approved by the NRC), the minimum number of sample points for the measurement of total and removable alpha contamination has been recalculated. Since scanning measures total alpha contamination, the minimum number of sample points required (N) is re-determined if the alpha scan minimum detectable concentration (MDC) is greater than the total contamination DCGL.

2.2.1 Determination of the Minimum Number of Sample Points (N)

Paramount to determining the minimum number of sample points is the determination of the relative shift, delta over sigma (Δ/σ). Delta is equal to the difference between the DCGL and the lower-bound gray region (LBGR) value. The LBGR value is arbitrarily set at one-half the DCGL value to start the determination. Sigma is an estimate of the variability in a set of sample analysis results from a survey unit. The estimate of sigma used in the determination is based on the standard deviation of a set of total alpha contamination results from the final status survey of

the Flux Building (Survey Unit FB-001 Floor Surface: 45.9). Since the gross alpha activity of 944 dpm/100cm^2 is the revised DGCL-GA, Δ is equal to 944 - 472, or 472. Delta divided by the sigma of 45.9 results in a relative shift of 10.3. The minimum number of samples (looked up in Table 5.3 of MARSSIM) corresponding to alpha and beta error rates of 0.05 and a relative shift of 10.3 is 9.

2.2.2 Adjusting N based on Scan Minimum Detectable Contamination (MDC)

The scan of structural surfaces is used to detect elevated areas. The total contamination DCGL value applicable to final status surveys of structures for the Tulsa site is the DCGL-GA (DCGL gross alpha) and the value is 944 dpm/100cm^2 of total alpha contamination. Since the background count rate for gross alpha is usually very low, e.g., 1 count per minute (cpm), MARSSIM provides guidance for determining the scanning MDC for gross alpha based on the probability of detecting very small increments in gross alpha count rate, i.e., one of two counts. For a typical alpha background level of less than 3 cpm, the probability of detecting a single count while passing over the contaminated area is:

$$P(n \geq 1) = 1 - e^{\frac{-GEd}{60v}}$$

where:

P(n ≥ 1) = probability of observing a single count,
G = activity (dpm),
E = 4π detector efficiency (cpd),
d = width of detector in direction of scan (cm), and
v = scan speed (cm/s).

Increase the value of G until the corresponding probability equals the desired confidence level, e.g., 95 percent, and the resulting dpm is the MDC. (The dpm value may be divided by the active area of the detector, e.g., 100 cm^2 to yield an MDC result in dpm/100cm^2.) This method of determining the alpha scan MDC is not background dependent (assuming the background alpha count rate is low). However, the calculated MDC is dependent on the scan speed. Using this formula and typical alpha efficiencies for gas proportional detectors, the calculated scan MDC range from 330 to 1,000 dpm/100cm^2 based on scan speeds of a third of a detector width to one detector width per second. *This range of MDC values is the same magnitude as the DCGL-GA and does not result in an increase in the minimum number of samples required.*

The Minimum Number of Samples Required (N) based on the scan MDC was determined to be 9 as documented on Survey Unit Worksheet No. 1 (**Attachment B**). However, the number of sample points used for the survey unit was 14. The Survey Unit Area (A) of 9.3 m^2 along with the N of 14 were used to calculate the Triangular Grid Node Length (L) of 0.9 meter and the Height of the Equilateral Triangle (h) of 0.8 meter. A random start point was generated using the random number feature of Excel and documented on Survey Unit Worksheet No. 2 (**Attachment B**).

2.2.3 Total and Removable Alpha Contamination Measurement Results

A layout of the total and removable alpha contamination measurement locations is provided on **Figure A-2** contained in **Attachment A.** At each of the 14 locations, a measurement (static count with a gas proportional detector) of total alpha contamination (identified as MARSSIM-001 through MARSSIM-014) and a smear sample for determination of removable alpha contamination (identified as K-SS-179 through K-SS-192) were collected on the concrete surface. The smear samples were forwarded to Outreach for analysis of alpha activity (per the 100 cm^2 surface area sampled). Total alpha contamination measurement results are provided below in **Table 1.**

Table 1 – Systematic Total Alpha Contamination Measurement Results

Sample ID	DCGL-GA (dpm/100cm^2)	Total Alpha Contamination (dpm/100cm^2)	Std. Error (dpm/100cm^2)	MDC (dpm/100cm^2)
MARSSIM-001	944	92.2	68.0	86.4
MARSSIM-002	944	62.8	59.3	86.4
MARSSIM-003	944	62.8	59.3	86.4
MARSSIM-004	944	72.6	62.4	86.4
MARSSIM-005	944	82.4	65.3	86.4
MARSSIM-006	944	62.8	59.3	86.4
MARSSIM-007	944	33.4	49.1	86.4
MARSSIM-008	944	13.7	40.9	86.4
MARSSIM-009	944	53.0	56.1	86.4
MARSSIM-010	944	33.4	49.1	86.4
MARSSIM-011	944	161	85.0	86.4
MARSSIM-012	944	72.6	62.4	86.4
MARSSIM-013	944	131	78.2	86.4
MARSSIM-014	944	230	99.0	86.4
Average		***83.1***		
Standard Dev.		***56.9***		
Minimum		***13.7***		
Maximum		***230***		
Median		***67.7***		

All 14 systematic total alpha contamination measurements were below the DCGL-GA of 944 dpm/100cm^2. The maximum total alpha contamination result was 230 dpm/100cm^2. The average total alpha contamination result was 83.1 dpm/100cm^2.

The standard deviation of the 14 equal-distant samples was 56.9, greater than the estimated standard deviation of 45.9 (based on the Flux Building Survey Unit FB-001 final status survey results) used to calculate the minimum number of samples (N) required. Using the observed standard deviation of 56.9 and the same methodology to determine N as presented in **Section 2.2.1** above, a relative shift of 8.3 results. The N from Table 5.3 (MARSSIM) corresponding to a relative shift of 8.3 is 9 for a 100 m^2 survey unit.

Analytical results of the smear samples are provided below in **Table 2.** The analytical data reports are contained in **Attachment C.**

Table 2 – Systematic Removable Alpha Contamination Smear Sample Results

Sample ID	DCGL-GA (dpm/100cm^2)	Removable Alpha Contamination (dpm/100cm^2)	Std. Error (dpm/100cm^2)	MDC (dpm/100cm^2)
MARSSIM-001 (K-SS-179)	94.4	0.308	0.668	0.631
MARSSIM-002 (K-SS-180)	94.4	0	0.569	0.631
MARSSIM-003 (K-SS-181)	94.4	0.219	0.644	0.631
MARSSIM-004 (K-SS-182)	94.4	0.308	0.668	0.631
MARSSIM-005 (K-SS-183)	94.4	0.308	0.668	0.631
MARSSIM-006 (K-SS-184)	94.4	1.65	0.951	0.631
MARSSIM-007 (K-SS-185)	94.4	0.755	0.774	0.631
MARSSIM-008 (K-SS-186)	94.4	0.397	0.690	0.631
MARSSIM-009 (K-SS-187)	94.4	0.755	0.774	0.631
MARSSIM-010 (K-SS-188)	94.4	0	0.541	0.631
MARSSIM-011 (K-SS-189)	94.4	0.308	0.67	0.631
MARSSIM-012 (K-SS-190)	94.4	1.20	0.87	0.631
MARSSIM-013 (K-SS-191)	94.4	0.219	0.644	0.631
MARSSIM-014 (K-SS-192)	94.4	0.040	0.595	0.631
Average		***0.462***		
Standard Dev.		***0.476***		
Minimum		***0***		
Maximum		***1.65***		
Median		***0.308***		

All 14 smear sample results were below the removable alpha contamination DCGL-GA of 94.4 dpm/100cm^2 (10% of the total contamination DCGL-GA value). The maximum removable alpha contamination result was 1.65 dpm/100cm^2. The average removable alpha contamination result was 0.462 dpm/100cm^2, less than 1% of the average total alpha contamination result.

2.3 Wilcoxon Rank Sum (WRS) Testing

The total alpha contamination results were evaluated using the procedure contained in **Appendix C, Volume I** of this Final Status Survey Report (Wilcoxon Rank Sum Test). The evaluation showed that the survey unit total alpha contamination results meet the DP statistical criterion based on the first statistical test described below.

If the difference (213.9 dpm/100cm^2) between the maximum survey unit total alpha contamination result (230 dpm/100cm^2) and the minimum reference background area total alpha contamination result (16.1 dpm/100cm^2) is less than DCGL-GA (944 dpm/100cm^2), then the survey unit meets the release criterion. **Table 3** presents a summary of the data used to complete the statistical evaluation of the survey unit.

Table 3 – Reference Area and Survey Unit Total Alpha Contamination Results

Reference Group	Sample ID	Total Alpha Contamination (dpm/100cm^2)	Survey Unit Group	Sample ID	Total Alpha Contamination (dpm/100cm^2)
R1	62	80.5	S1	MARSSIM-001	92.2
R2	48	102.0	S2	MARSSIM-002	62.8
R3	26	111.0	S3	MARSSIM-003	62.8
R4	68	60.4	S4	MARSSIM-004	72.6
R5	69	102.0	S5	MARSSIM-005	82.4
R6	36	101	S6	MARSSIM-006	62.8
R7	60	30.2	S7	MARSSIM-007	33.4
R8	69	102	S8	MARSSIM-008	13.7
R9	24	82.5	S9	MARSSIM-009	53.0
R10	55	16.1	S10	MARSSIM-010	33.4
R11	70	43.2	S11	MARSSIM-011	161
R12	40	72.7	S12	MARSSIM-012	72.6
R13	10	60.4	S13	MARSSIM-013	131
R14	25	72.7	S14	MARSSIM-014	230
	Average:	***74.1***		***Average:***	***83.1***
	Standard Dev.	***29.3***		***Standard Dev.***	***56.9***
	Minimum:	***16.1***		***Minimum:***	***13.7***
	Maximum:	***111***		***Maximum:***	***230***
	Median:	***76.6***		***Median:***	***67.7***

3.0 SUMMARY OF FINDINGS

A structure (concrete wall) was encountered during the removal of radiologically-affected soil from FOA Survey Unit Kaiser-FSSFOA-006 **(Figure 3)**. This structure, identified as Survey Unit Kaiser-FSSFOA-008, is considered a Class 1 survey unit with an approximate surface area of 9.3 m^2. This section of the sub-report presents a summary of the final status survey findings and an overall summation of fractions for the survey unit.

3.1 Structural Surface - Total and Removable Alpha Contamination

The acceptance criterion for structures remaining at the Tulsa facility is the DCGL-GA of 944 dpm/100cm^2 for total alpha contamination and 94.4 dpm/100cm^2 for removable alpha contamination. Final status survey activities for Survey Unit Kaiser-FSSFOA-008 consisted of a gross alpha scan of the exposed concrete surface of the survey unit and systematic measurements of total and removable alpha contamination. The results of the final status survey activities were as follows:

- The 100 percent coverage gross alpha scan of the concrete surface did not indicate the presence of small areas of elevated activity (above the DCGL-GA for the site).
- All 14 systematic measurements of total alpha contamination were below the DCGL-GA of 944 dpm/100cm^2.
- All 14 smear sample results were below the DCGL-GA of 94.4 dpm/100cm^2 for removable alpha contamination.
- The total alpha contamination results meet the DP statistical criterion based on the first statistical evaluation of the data (WRS Test procedure).
- No elevated areas were left in-place, therefore, no elevated measurement comparisons were required for this unit.

3.2 Sum of Fractions for Entire Survey Unit

To evaluate the status of Survey Unit Kaiser-FSSFOA-008 as a whole, the fraction of each survey element's average activity divided by the applicable acceptance criteria is calculated for inclusion in the Sum of Fractions for the entire survey unit. The Total Sum of Fractions for total alpha contamination, removable alpha contamination, and elevated areas is presented below in **Table 4.** As previously mentioned, no elevated areas were left in-place for the survey unit.

Table 4 – Fraction of Applicable Acceptance Criteria per Survey Unit Element

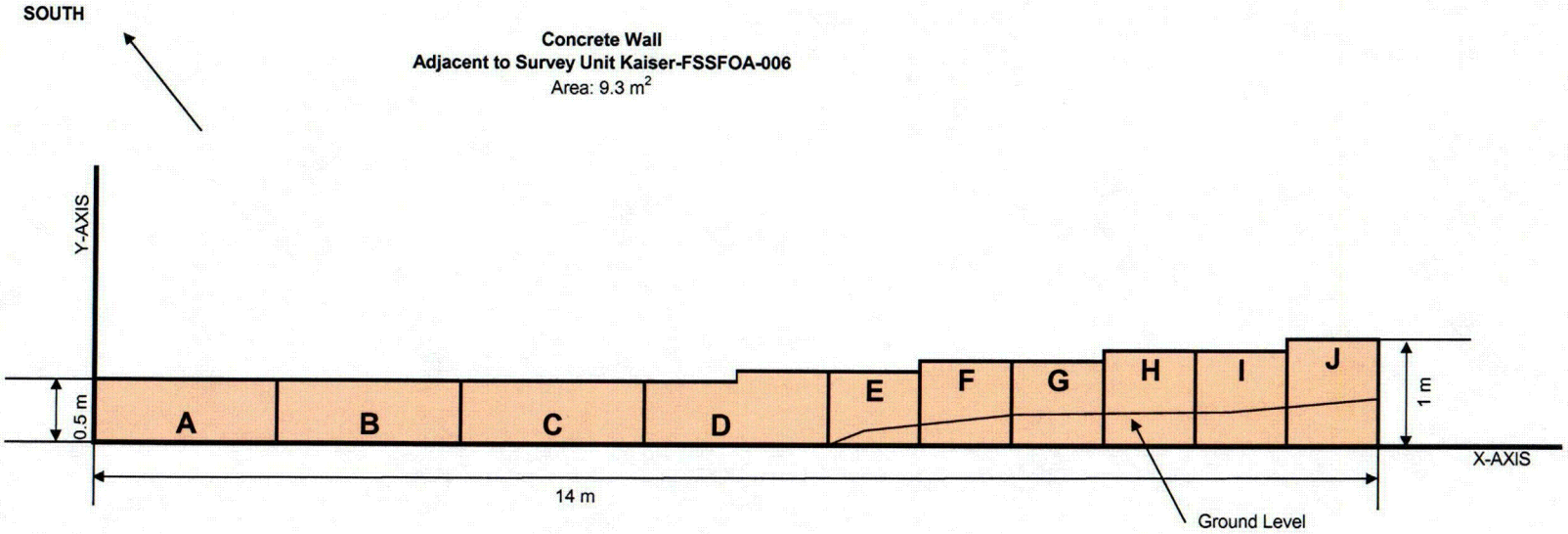
Survey Unit Element	Units	Average Activity	Acceptance Criteria	Fraction
FSSFOA-007 Total Alpha Contamination	dpm/100cm^2	83.1	944	0.09
FSSFOA-007 Removable Alpha Contamination	dpm/100cm^2	0.462	94.4	0.00
Elevated Areas (None Left In-Place)	dpm/100cm^2			0.00
TOTAL SUM OF FRACTIONS				***0.09***

The Sum of Fractions provides a conservative assessment of the survey unit without backfill. The results of the Sum of Fractions assessment show that Survey Unit Kaiser-FSSFOA-008 meets the DP acceptance criteria.

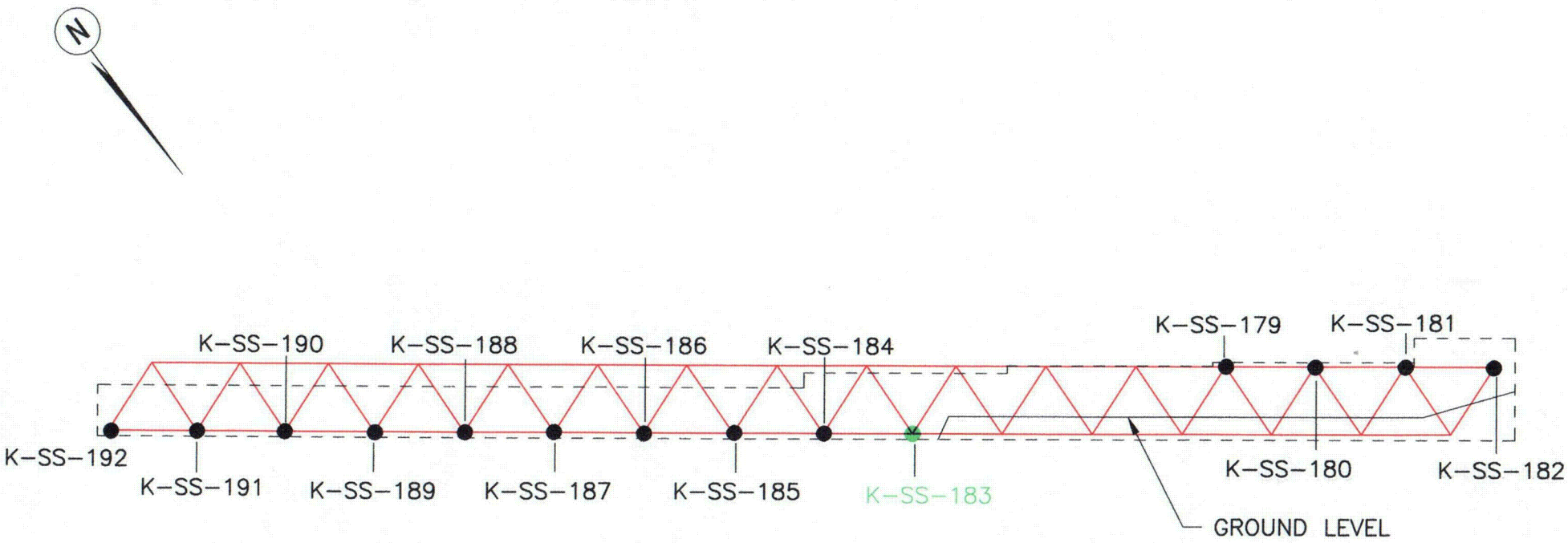
ATTACHMENT A
TABLE OF CONTENTS

- **FIGURE A-1 Gross Alpha Scan Grid Layout**
- **FIGURE A-2 Systematic Sampling Locations**
- **Alpha Scan MDC Calculation Form**
- **Total Alpha Contamination Survey Data Conversion Form**
- **Table A-1 Gross Alpha Scan Results Summary**

Attachment A, Figure A-1
Gross Alpha Scan Grid Layout
Survey Unit Kaiser-FSSFOA-008
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation



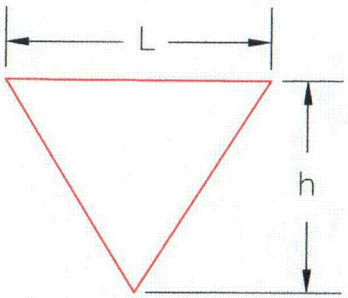
C21



SCALE – FEET
5 0 5
1 0 1
SCALE – METERS

K-SS-179
● SYSTEMATIC SAMPLING LOCATION BASED ON RANDOM START POINT AND AN EQUAL DISTANT TRIANGULAR GRID

K-SS-183
● RANDOM START POINT



N = 14
L = 0.9m
h = 0.8m
AREA = 9.3m^2

FIGURE A-2
SYSTEMATIC SAMPLING LOCATIONS SURVEY UNIT KAISER – FSSFOA-008 FINAL STATUS SURVEY THORIUM REMEDIATION PROJECT TULSA, OKLAHOMA FACILITY

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
TULSA, OKLAHOMA

APPROVED	RFD 3-3-06
CHECKED	RFD 3-3-06
DRAWN	DEB 1/13/06
DRAWING NUMBER	PA4072064

Penn E&R
Environmental & Remediation, Inc.

C22

Form HPM/M-2-2-3
Alpha Scan MDC Calculation

Instrument Serial Number:	193686	Cal. Due:	5/6/2006
Detector Serial Number:	PR190485	Cal. Due:	5/6/2006
Radiation Detected:	Alpha	**For < 3 count background**	

Probability of observing 2 or more counts:

$$P(n \geq 2) = 1 - \left(1 + \frac{(GE+B)d}{60v}\right)\left(e^{\frac{(GE+B)d}{60v}}\right)$$

Probability of observing a single count:

$$P(n \geq 1) = 1 - e^{\frac{-GEd}{60v}}$$

	D Date	G Activity (dpm)	d Detector Width (cm)	E Instrument Efficiency (cpm)	v Scan Speed (cm/s)	B Background Countrate (cpm)	P Probability (-)
1	7/21/2005	538	11.7	0.1618	5.85	N/A	0.95
2	7/27/2005	538	11.7	0.1618	5.85	N/A	0.95
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

Comments:

Prepared By:	David B. Weyant	Date:	7/21/05
Reviewed By:	Andrew J. Lombardo	Date:	7/27/05

Notes:
1.) Instrument Efficiency is the 4π instrument efficiency.

Kaiser Project
PA-4000-4072
Tulsa, Ok.

Total Alpha Contamination
Survey Unit Kaiser-FSSFOA-008
Survey Data Conversion Form
Form ESC/HPM/M-3-2-2

Date of Survey: 7/27/2005		Type of Radiation:	Alpha
Instrument Serial #: 193686		Calibration Due Date:	5/5/2006
Detector Serial #: PR190485		Calibration Due Date:	5/5/2006
E_s (Surface Efficiency):	0.25	E_i (Insturment Efficiency):	0.1618
BKG Counts:	13	BKG Count Time (min):	10
Active Area of Detector Probe (cm^2):	126	MDC ($dpm/100cm^2$):	86.4
Tech: DWD			

Sampling Location	Survey ID	Survey Point Count Time (min)	Gross Counts (cts)	Gross Count Rate (cpm)	Net Count Rate (cpm)	Total Contamination ($dpm/100cm^2$)	95% CL Uncertainty ($dpm/100cm^2$)
K-SS-179	MARSSIM-001	2	12	6.00	4.70	92.2	68.0
K-SS-180	MARSSIM-002	2	9	4.50	3.20	62.8	59.3
K-SS-181	MARSSIM-003	2	9	4.50	3.20	62.8	59.3
K-SS-182	MARSSIM-004	2	10	5.00	3.70	72.6	62.4
K-SS-183	MARSSIM-005	2	11	5.50	4.20	82.4	65.3
K-SS-184	MARSSIM-006	2	9	4.50	3.20	62.8	59.3
K-SS-185	MARSSIM-007	2	6	3.00	1.70	33.4	49.1
K-SS-186	MARSSIM-008	2	4	2.00	0.70	13.7	40.9
K-SS-187	MARSSIM-009	2	8	4.00	2.70	53.0	56.1
K-SS-188	MARSSIM-010	2	6	3.00	1.70	33.4	49.1
K-SS-189	MARSSIM-011	2	19	9.50	8.20	161	85.0
K-SS-190	MARSSIM-012	2	10	5.00	3.70	72.6	62.4
K-SS-191	MARSSIM-013	2	16	8.00	6.70	131	78.2
K-SS-192	MARSSIM-014	2	26	13.0	11.7	230	99.0

Comments: Concrete Wall

Prepared By: David B. Weyant	Date: 7/28/2005
Reviewed By: Andrew J. Lombardo	Date: 7/28/2005

Attachment .able A-1
Gross Alpha Scan Results Summary
Survey Unit Kaiser-FSSFOA-008
Concrete Wall
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Survey Number:	KAISER-FSSFOA-008	Instrument Serial Number:	193686	Cal. Due:	5/5/2006
Tech:DBW	Alpha Eff: 16.18%	Detector Serial Number:	PR190485	Cal. Due:	5/5/2006

			Scan		weighted		Average
		Survey	cpm	cpm	cpm	cpm	(dpm/100cm^2)
Grid Number	Material Type	Date	Minimum	Maximum	Average	Background	net
A1	Concrete	7/21/05	0	10	0	1.3	-26
B1	Concrete	7/21/05	0	10	0	1.3	-26
C1	Concrete	7/21/05	0	10	0	1.3	-26
D1	Concrete	7/21/05	0	10	0	1.3	-26
E1	Concrete	7/21/05	0	10	0	1.3	-26
F1	Concrete	7/27/05	0	30	10	2.6	145
G1	Concrete	7/27/05	0	50	20	2.6	341
H1	Concrete	7/27/05	0	10	0	2.6	-51
I1	Concrete	7/27/05	0	10	0	2.6	-51
J1	Concrete	7/21/05	0	10	0	1.3	-26

Notes:

1. The weighted cpm is determined by the surveyor. Since alpha counts (clicks on audible) are infrequent, and 1 count may equal 10 cpm, the surveyor determines the "weighted average".

2. The acceptance criteria for Total Contamination is 944 dpm/100cm^2. 10 cpm is approximately 150 dpm/100cm^2.

3. Scans are used to identify elevated area above the acceptance criteria.

4. Compliance is demonstrated by static counts and smear (sample) results.

ATTACHMENT B
TABLE OF CONTENTS

- **Survey Unit Worksheet No. 1**
- **Survey Unit Worksheet No. 2**

Survey Unit Work Sheet No. 1
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

1. Structure Survey Unit: KAISER-FSSFOA-008

2. Description: Former Operational Area, Concrete Wall Adjacent to Survey Unit Kaiser-FSS-FOA-006

3. Dimensions (m): Approximately. 14 meters x 0.7 meters; Area, A (m^2): 9.3

4. Alpha Background: 2.6 cpm MDC (dpm/100cm^2): 538

5. Minimum Number of Samples (N): 9 and Corresponding Triangular Grid Node Length (L) in meters: 3.6.

6. If the area of the survey unit floor is less than 100 m^2, recalculate the number of samples (N_1) corresponding to L that provides the same coverage in the smaller survey unit as N samples does in 100 m^2 using the following formula: $N_1 = A / (0.866 \times L^2)$,
N_1: N/A

7. If N_1 is less than 14, use the default N (14) and recalculate the corresponding Triangular Grid Node Length (L_1) for the survey unit floor Area (A) less than 100 m^2, using the following formula: $L_1 = (A/(0.866 \times 14))^{1/2}$: 0.9 m

8. Calculate the height (h) of the equilateral triangle with side length equal to L (or L_1) using the following formula: $h = ((L^2 - (L/2)^2)^{1/2}$: 0.8 m

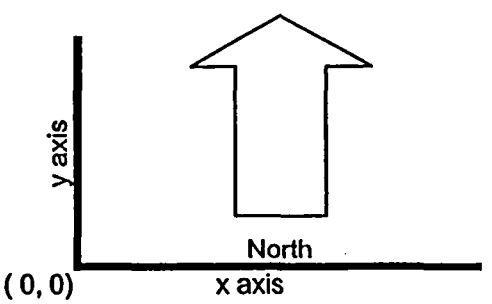
Survey Unit Worksheet No. 2
Random Number Generator for Start Point
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

SURVEY UNIT: KAISER-FSSFOA-008

RANDOM START POINT

x axis (Meters)	y axis (Meters)
8	0.1

	x axis	y axis
lower bound	0	0
upper bound	14	1



ATTACHMENT C

LABORATORY ANALYTICAL RESULTS

Outreach Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Invoice # 11207
DL - 8/1/05

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050590
Date Reported:	8/1/05
Date Received:	7/28/05
Page Number:	1 of 5

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050590-01**						
Client ID:	**K-SS-179**						
Date Sampled:	**7/27/05 1:00:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.308 +/- 0.668	dpm/100cm 2	0.631		7/28/05	SD
Gross Beta	EPA 900/9310	0.40 +/- 2.40	dpm/100cm 2	2.57		7/28/05	SD
Lab ID:	**20050590-02**						
Client ID:	**K-SS-180**						
Date Sampled:	**7/27/05 1:01:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
ross Alpha	EPA 900/9310	0 +/- 0.569	dpm/100cm 2	0.631		7/29/05	SD
Gross Beta	EPA 900/9310	2.83 +/- 2.59	dpm/100cm 2	2.57		7/29/05	SD
Lab ID:	**20050590-03**						
Client ID:	**K-SS-181**						
Date Sampled:	**7/27/05 1:02:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.219 +/- 0.644	dpm/100cm 2	0.631		7/29/05	SD
Gross Beta	EPA 900/9310	4.40 +/- 2.70	dpm/100cm 2	2.57		7/29/05	SD
Lab ID:	**20050590-04**						
Client ID:	**K-SS-182**						
Date Sampled:	**7/27/05 1:03:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.308 +/- 0.668	dpm/100cm 2	0.631		7/29/05	SD
Gross Beta	EPA 900/9310	1.18 +/- 2.46	dpm/100cm 2	2.57		7/29/05	SD

BDL = Below Detection Limit

Outreach Laboratory
3... North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050590
Date Reported:	8/1/05
Date Received:	7/28/05
Page Number:	2 of 5

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050590-05**						
Client ID:	**K-SS-183**						
Date Sampled:	**7/27/05 1:04:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.308 +/- 0.668	dpm/100cm 2	0.631		7/29/05	SD
Gross Beta	EPA 900/9310	1.27 +/- 2.47	dpm/100cm 2	2.57		7/29/05	SD
Lab ID:	**20050590-06**						
Client ID:	**K-SS-184**						
Date Sampled:	**7/27/05 1:05:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	1.65 +/- 0.951	dpm/100cm 2	0.631		7/30/05	SD
Gross Beta	EPA 900/9310	2.05 +/- 2.53	dpm/100cm 2	2.57		7/30/05	SD
Lab ID:	**20050590-07**						
Client ID:	**K-SS-185**						
Date Sampled:	**7/27/05 1:06:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.755 +/- 0.774	dpm/100cm 2	0.631		7/30/05	SD
Gross Beta	EPA 900/9310	1.47 +/- 2.49	dpm/100cm 2	2.57		7/30/05	SD
Lab ID:	**20050590-08**						
Client ID:	**K-SS-186**						
Date Sampled:	**7/27/05 1:07:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.397 +/- 0.690	dpm/100cm 2	0.631		7/30/05	SD

BDL = Below Detection Limit

Outreach Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050590
Date Reported:	8/1/05
Date Received:	7/28/05
Page Number:	3 of 5

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Gross Beta	EPA 900/9310	3.03 +/- 2.60	dpm/100cm 2	2.57		7/30/05	SD
Lab ID:	**20050590-09**						
Client ID:	**K-SS-187**						
Date Sampled:	**7/27/05 1:08:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.755 +/- 0.774	dpm/100cm 2	0.631		7/30/05	SD
Gross Beta	EPA 900/9310	1.27 +/- 2.47	dpm/100cm 2	2.57		7/30/05	SD
Lab ID:	**20050590-10**						
Client ID:	**K-SS-188**						
Date Sampled:	**7/27/05 1:09:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0 +/- 0.541	dpm/100cm 2	0.631		7/30/05	SD
Gross Beta	EPA 900/9310	1.27 +/- 2.47	dpm/100cm 2	2.57		7/30/05	SD
Lab ID:	**20050590-11**						
Client ID:	**K-SS-189**						
Date Sampled:	**7/27/05 1:10:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					
Gross Alpha	EPA 900/9310	0.308 +/- 0.67	dpm/100cm 2	0.631		7/30/05	SD
Gross Beta	EPA 900/9310	1.86 +/- 2.52	dpm/100cm 2	2.57		7/30/05	SD
Lab ID:	**20050590-12**						
Client ID:	**K-SS-190**						
Date Sampled:	**7/27/05 1:11:00 PM**						
Matrix:	**Swipe**						
		Radiochemical Analyses					

BDL = Below Detection Limit

Outreach
boratory
. North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050590
Date Reported:	8/1/05
Date Received:	7/28/05
Page Number:	4 of 5

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Gross Alpha	EPA 900/9310	1.20 +/- 0.87	dpm/100cm 2	0.631		7/30/05	SD
Gross Beta	EPA 900/9310	1.86 +/- 2.52	dpm/100cm 2	2.57		7/30/05	SD

Lab ID: 20050590-13
Client ID: K-SS-191
Date Sampled: 7/27/05 1:12:00 PM
Matrix: Swipe

Radiochemical Analyses

Gross Alpha	EPA 900/9310	0.219 +/- 0.644	dpm/100cm 2	0.631		7/30/05	SD
Gross Beta	EPA 900/9310	2.74 +/- 2.58	dpm/100cm 2	2.57		7/30/05	SD

Lab ID: 20050590-14
Client ID: K-SS-192
Date Sampled: 7/27/05 1:13:00 PM
Matrix: Swipe

Radiochemical Analyses

Gross Alpha	EPA 900/9310	0.040 +/- 0.595	dpm/100cm 2	0.631		7/30/05	SD
Gross Beta	EPA 900/9310	2.74 +/- 2.58	dpm/100cm 2	2.57		7/30/05	SD

BDL = Below Detection Limit

Outreach
boratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050590
Date Reported:	8/1/05
Date Received:	7/28/05
Page Number:	5 of 5

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Gross Alpha	0+/-0.5	107.0			NC				7/28/05
Gross Beta	2+/-2	82.0			NC				7/28/05

Lab Approval: _____

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
Local: 918-384-0466
Cell: 724-799-0091

Company: Kaiser Alum & Chem. Co.
Name: David B. Weyant
Address: 7211 E. 41st Street
City: Tulsa State: OK Zip: 74145-
Phone: 724-934-3330 Fax #: 918-384-3171

Bill To:
Company: Kaiser/Penn Era
Name: Paul Hughes/David Weyant
Address: 7211 E. 41st St.
City: Tulsa State: OK Zip: 74145

ANALYSIS REQUESTED

PO #: Kaiser 4-77
PROJECT #: PA - Yorm - Yard
PROJECT NAME: Kaiser Alum & Chem Proj.
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY): 5 DAY
SAMPLER: Signature: David Duffey

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	Gross α / β	α RAC < 1 pCi/l or 1 pCi/100 cm²	Ra-226 < 3 pCi/l or 1 pCi/100 cm²	Th-232 < 2 pCi/l or 1 pCi/100 cm²	Pb-210 + Client for Analysis				REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
1	K-SS-179	7-27-05	1300	Solids	1	Clear	None	X	X	X	X	X				Grab
2	K-SS-180		1301		1			X	X	X	X	X				
3	K-SS-181		1303		1			X	X	X	X	X				
4	K-SS-182		1305		1			X	X	X	X	X				
5	K-SS-183		1304		1			X	X	X	X	X				
6	K-SS-184		1305		1			X	X	X	X	X				
7	K-SS-185		1306		1			X	X	X	X	X				
8	K-SS-186		1307	184	1			X	X	X	X	X				
9	K-SS-187		1308		1			X	X	X	X	X				
10	K-SS-188		1309		1			X	X	X	X	X				
11	K-SS-189		1310		1			X	X	X	X	X				
12	K-SS-190		1311		1			X	X	X	X	X				
13	K-SS-191		1312		1			X	X	X	X	X				
14	K-SS-192		1313		1			X	X	X	X	X				

RELINQUISHED BY: David B. Weyant / DBW DATE 7/28/05 TIME 1005 RECEIVED BY: [signature] DATE 7/28/05 TIME 1005

RELINQUISHED BY: _____ DATE _____ TIME _____ RECEIVED BY: _____ DATE _____ TIME _____

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company [illegible] reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

FOR LABORATORY USE ONLY
Sample Condition Upon Receipt:
Custody Seal Intact:

SUB-REPORT

SURVEY UNIT KAISER-FSSFOA-009

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2.0 SURVEY ACTIVITIES AND RESULTS	2
2.1 Gross Gamma Scan	2
2.2 Systematic Soil Sampling – Excavation Side Wall Surface Soil	2
2.3 Wilcoxon Rank Sum (WRS) Testing	4
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3.1 Excavation Side Wall Surface Soil	5
3.2 Sum of Fractions for Entire Survey Unit	5

ATTACHMENTS

ATTACHMENT A: Figure A-1 Gross Gamma Background and Scanning Survey Results
Figure A-2 Systematic Soil Sampling Locations

ATTACHMENT B: Soil Survey Unit Worksheet No. 1
Soil Survey Unit Worksheet No. 2

ATTACHMENT C: Laboratory Analytical Results

Final Status Survey Report
Volume II – Former Operational Area
Sub-Report No. EB-039
Survey Unit Kaiser-FSSFOA-009
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation
March 22, 2006

1.0 BACKGROUND

This sub-report documents the results of Former Operational Area (FOA) excavation final status survey activities completed as part of the Thorium Remediation Project at the Tulsa, Oklahoma facility (**Figure 1**). Specifically, this technical report addresses the final status survey of Survey Unit Kaiser-FSSFOA-009, an open land area (excavation surface soil) resulting from the removal of radiologically-affected soil located adjacent to the former Warehouse Building's southern wall (**Figure 3**). The non-impacted Warehouse Building was deconstructed as a pre-decommissioning activity to facilitate the excavation of radiologically-affected soil located beneath the buildings' concrete floor slab.

Survey Unit Kaiser-FSSFOA-009 is considered a Class 1 survey unit with an approximate surface area of 19.5 m^2. Survey Unit Kaiser-FSSFOA-009 consists of an excavation side wall only (south wall). No elevated areas were left in-place, therefore, no elevated measurement comparisons were required for this unit. No embedded "structures" were encountered during the removal of the radiologically-affected soil.

2.0 SURVEY ACTIVITIES AND RESULTS

This section of the sub-report presents the final status survey data for the excavation side wall defined as Survey Unit Kaiser-FSSFOA-009. The final status survey consisted of a gross gamma scan of the exposed surface soil of the survey unit and systematic soil sampling.

2.1 Gross Gamma Scan

The exposed surface soil of the Class 1 survey unit (excavation side wall) was surveyed through a 100 percent coverage gamma scan to confirm acceptable radiological conditions and identify any elevated areas. During the scanning of the soil, the detector was held close to the exposed surface (1 to 2 inches) and moved in a serpentine pattern. Background measurements were obtained at 1-meter above the exposed soil surface at 10 approximately equal-distant locations in the survey unit. The statistics for the 10 background measurements are provided below in **Table 1.** Background measurements ranged from 10,301 counts per minute (cpm) to 12,003 cpm.

A total of 13 area-averaged measurements of gross count rate were made across the survey unit's 19.5 m^2 surface area. The results ranged from 10,800 cpm to 14,500 cpm. A statistical summary of the 100 percent coverage gamma scan of the survey unit is provided below in **Table 1.**

Table 1 – Gross Gamma Scan Results Summary

Survey Area:	19.5 m^2	
Number of Scan Measurements (Recorded Average per 1 m^2 grid area)	13	
Scan Rate: (Swinging the detector a width of 1-meter side to side)	0.5 m/s (MARSSIM recommends 0.5m/s)	
Results Summary:	**Background (Gross cpm)**	**Scan (Gross cpm)**
Minimum	10,301	10,800
Maximum	12,003	14,500
Average	10,755	12,600
Standard Deviation	599	1,180
Median	10,530	12,200

Contour maps of the gross gamma background and final (as-left condition) scanning survey results are presented on **Figure A-1** contained in **Attachment A.** The 100 percent coverage gross gamma scan did not indicate the presence of small areas of elevated activity (above the $DCGL_W$ for the site).

2.2 Systematic Soil Sampling – Excavation Side Wall Surface Soil

The final status survey also consisted of systematic soil sampling based on a random start point and an equal-distant triangular grid. The Minimum Number of Samples Required (N) based on

the scan MDC was determined to be 9 as documented on Soil Survey Unit Worksheet No. 1 **(Attachment B)**. Once N was determined, the Survey Unit Area (A) of 19.5 m^2 along with the N of 9 were used to calculate the Triangular Grid Node Length (L) of 1.6 meters and the Height of the Equilateral Triangle (h) of 1.4 meters. A random start point was generated using the random number feature of Excel and documented on Soil Survey Unit Worksheet No. 2 **(Attachment B)**.

A layout of the soil sampling locations is provided on **Figure A-2** contained in **Attachment A**. A total of 10 soil samples (identified as K-887 through K-896) were collected at the excavation side wall surface (0-6-inch depth interval) level using a clean, decontaminated sampling auger or sharpshooter shovel. The samples were forwarded to Outreach for analysis of Th-232 activity concentration. Analytical results are provided below in **Table 2**. Analytical data reports are contained in **Attachment C**.

Table 2 – Systematic Soil Sample Results

Soil Sample ID	Gross Th-232 (pCi/g)	Std. Error (pCi/g)	MDC (pCi/g)	Net Th-232 (pCi/g)	Net DCGL (pCi/g)
K-887	1.47	0.071	0.263	0.37	3.0
K-888	0.986	0.129	0.416	0	3.0
K-889	0.855	0.061	0.334	0	3.0
K-890	1.22	0.136	0.387	0.12	3.0
K-891	0.913	0.115	0.601	0	3.0
K-892	1.26	0.080	0.250	0.16	3.0
K-893	0.736	0.067	0.199	0	3.0
K-894	1.03	0.101	0.472	0	3.0
K-895	1.23	0.083	0.331	0.13	3.0
K-896	1.13	0.249	0.453	0.03	3.0
Average	***1.08***				
Standard Dev.	***0.220***				
Minimum	***0.736***				
Maximum	***1.47***				
Median	***1.08***				

All 10 systematic soil sample results (gross and net) were below the open land area surrogate value of 3.0 pCi/g net Th-232 activity concentration ($DCGL_W$). The maximum gross Th-232 activity concentration was 1.47 pCi/g, which fell slightly above the background Th-232 activity of 1.1 pCi/g for the site. The average gross Th-232 activity concentration was 1.08 pCi/g. The standard deviation of the 10 equal-distant samples was 0.220, which fell below the estimated standard deviation of 0.42 (based on the adjacent land final status survey results) used to calculate the minimum number of samples required.

2.3 Wilcoxon Rank Sum (WRS) Testing

The analytical results for the systematic soil samples were evaluated using the procedure contained in **Appendix C, Volume I** of this Final Status Survey Report (Wilcoxon Rank Sum Test). The evaluation showed that the survey unit soil sample results meet the DP statistical criterion based on the first statistical test as described below.

If the difference (0.51 pCi/g) between the maximum survey unit soil sample activity concentration (1.47 pCi/g) and the minimum reference background area soil sample activity concentration (0.96 pCi/g) is less than $DCGL_W$ (3.0 pCi/g), then the survey unit meets the release criterion. **Table 3** presents a summary of the data used to complete the statistical evaluation of the survey unit.

Table 3 – Reference Group and Survey Unit Sample Results

Reference Group	Sample ID	Th-232 (pCi/g)	Survey Unit Group	Sample ID	Th-232 (pCi/g)
R1	169	1.19	S1	K-887	1.47
R2	290	1.31	S2	K-888	0.986
R3	201	1.03	S3	K-889	0.855
R4	164	1.88	S4	K-890	1.22
R5	242	1.01	S5	K-891	0.913
R6	94	1.17	S6	K-892	1.26
R7	12	0.96	S7	K-893	0.736
R8	204	1.35	S8	K-894	1.03
R9	251	1.32	S9	K-895	1.23
R10	103	1.12	S10	K-896	1.13
	Average	***1.23***		***Average***	***1.08***
	Standard Dev.	***0.26***		***Standard Dev.***	***0.220***
	Minimum	***0.96***		***Minimum***	***0.736***
	Maximum	***1.88***		***Maximum***	***1.47***
	Median	***1.18***		***Median***	***1.08***

3.0 SUMMARY OF FINDINGS

The removal of radiologically-affected soil that was located adjacent to the former Warehouse Building's southern wall resulted in an open land area consisting of an excavation side wall approximately 19.5 m^2 in area. This open land area, identified as Survey Unit Kaiser-FSSFOA-009, is considered a Class 1 survey unit (**Figure 3**). The non-impacted Warehouse Building was deconstructed as a pre-decommissioning activity to facilitate the excavation of radiologically-affected soil located beneath the building's floor slab. This section of the sub-report presents a summary of the final status survey findings and an overall summation of fractions for the survey unit.

3.1 Excavation Side Wall Surface Soil

The acceptance criterion for open land areas (FOA excavation surface soil) at the Tulsa facility is the $DCGL_W$ of 3.0 pCi/g net Th-232 activity concentration. Final status survey activities for Survey Unit Kaiser-FSSFOA-009 consisted of a gross gamma scan of the exposed surface soil of the survey unit (excavation side wall) and systematic soil sampling. The results of the final status survey activities were as follows:

- The 100 percent coverage gamma scan (final as-left condition) did not indicate the presence of small areas of elevated activity (above the $DCGL_W$ for the site).
- All 10 systematic soil sample results (gross and net) were below the open land area surrogate value of 3.0 pCi/g net Th-232 activity concentration ($DCGL_W$).
- The analytical results meet the DP statistical criterion based on the first statistical evaluation of the data (WRS Test procedure).
- No elevated areas were left in-place, therefore, no elevated measurement comparisons were required for this unit.

3.2 Sum of Fractions for Entire Survey Unit

To evaluate the status of Survey Unit Kaiser-FSSFOA-009 as a whole (excavation side wall surface soil, elevated areas, and embedded structures), the fraction of each survey element's average net activity divided by the applicable acceptance criteria is calculated for inclusion in the Sum of Fractions for the entire survey unit. The Total Sum of Fractions for surface soil, elevated areas, and embedded structures respectively is presented below in **Table 4.** As previously mentioned, no embedded structures were encountered within the survey unit and no elevated areas were left in-place for the survey unit.

Table 4 – Fraction of Applicable Acceptance Criteria per Survey Unit Element

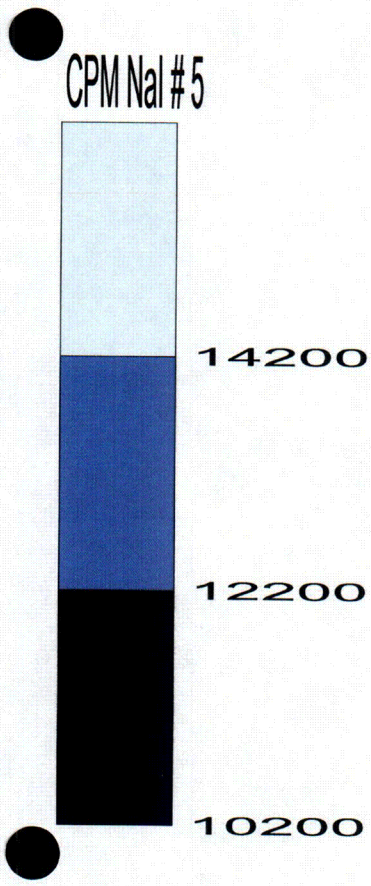
Survey Unit Element	Units	Average Net Activity	Acceptance Criteria	Fraction
-FSSFOA-009 Excavation Surface Soil	pCi/g	0	3.0	0.00
-Elevated Areas (None Left In-Place)	pCi/g	0		0.00
-Embedded Structures (None Encountered)	dpm/100cm^2	0		0.00
TOTAL SUM OF FRACTIONS				***0.00***

The Sum of Fractions provides a conservative assessment of the survey unit without backfill. The results of the Sum of Fractions assessment show that Survey Unit Kaiser-FSSFOA-009 meets the DP acceptance criteria.

ATTACHMENT A
TABLE OF CONTENTS

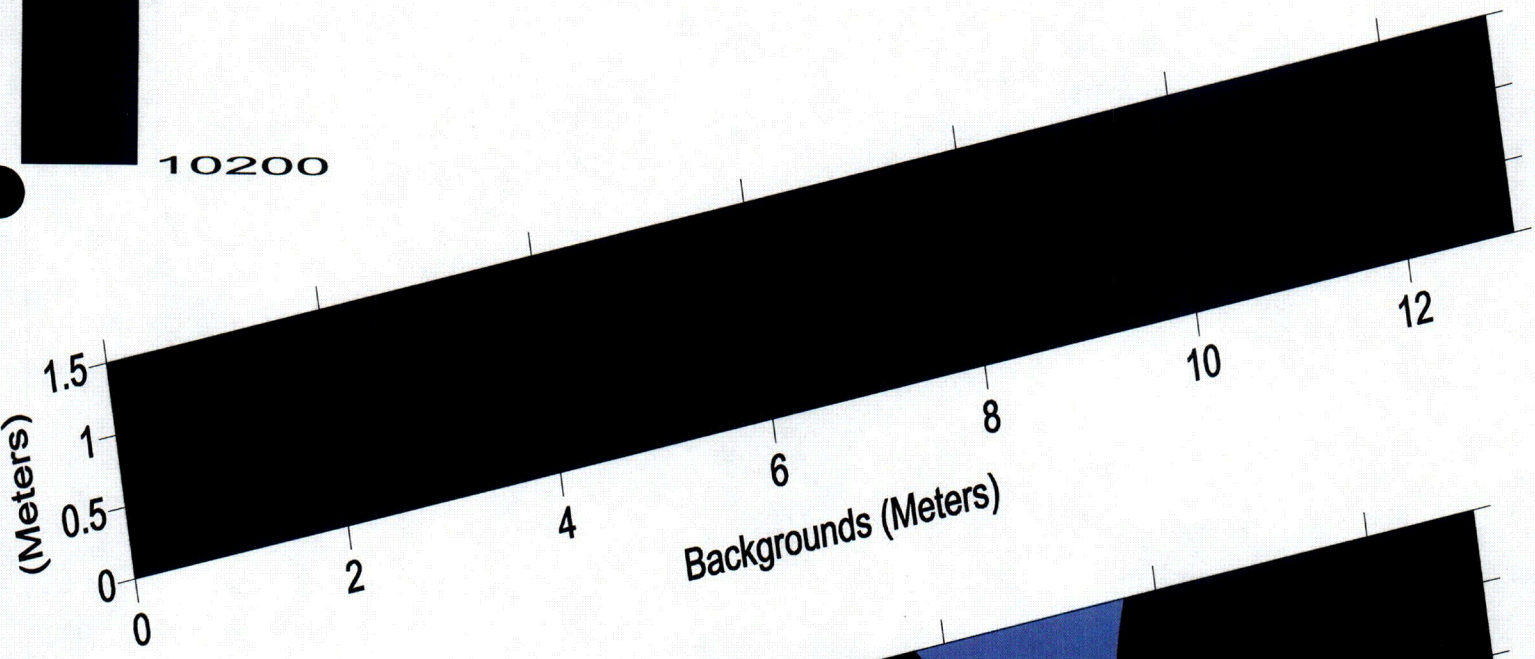
- **FIGURE A-1 Gross Gamma Background and Scanning Survey Results**
- **FIGURE A-2 Systematic Soil Sampling Locations**

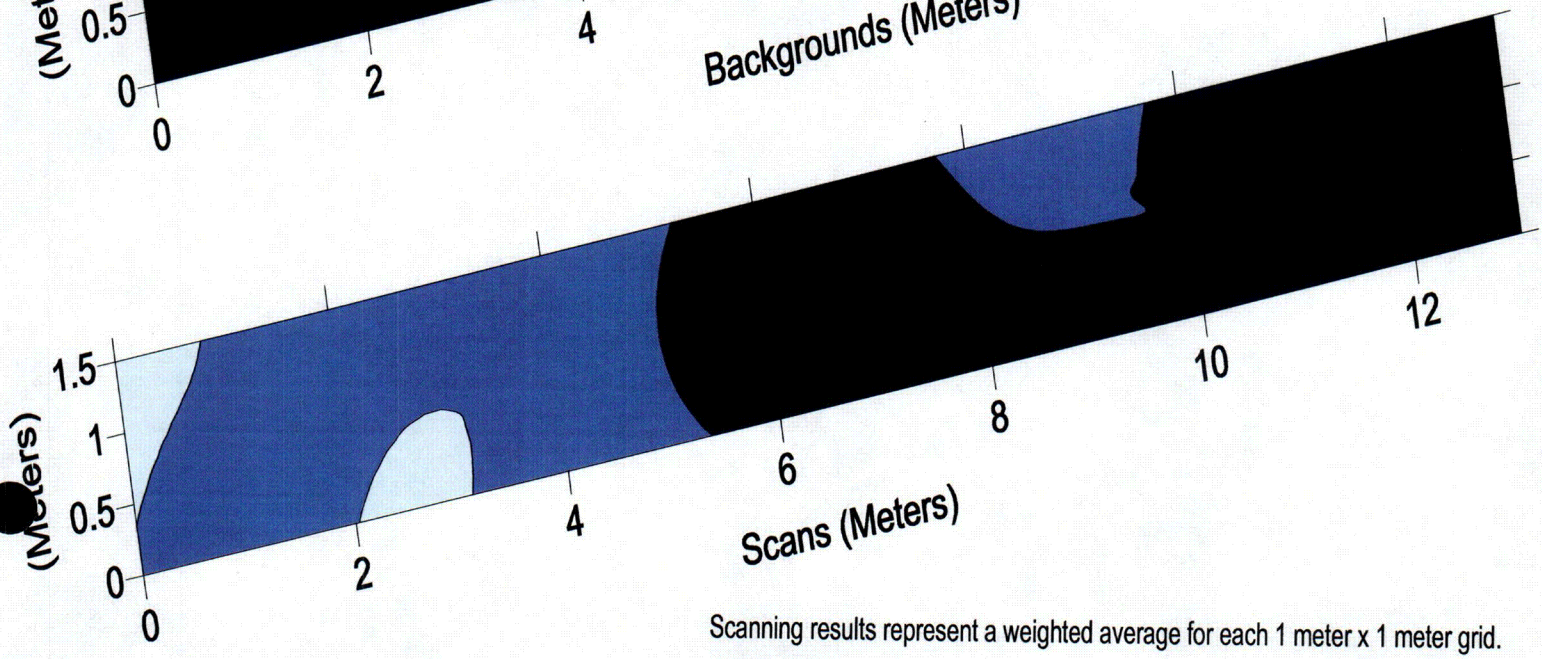
Attachment A, Figure A-1
Gross Gamma Background and Scanning Survey Results
Survey Unit Kaiser-FSSFOA-009



View of Vertical Wall Looking South

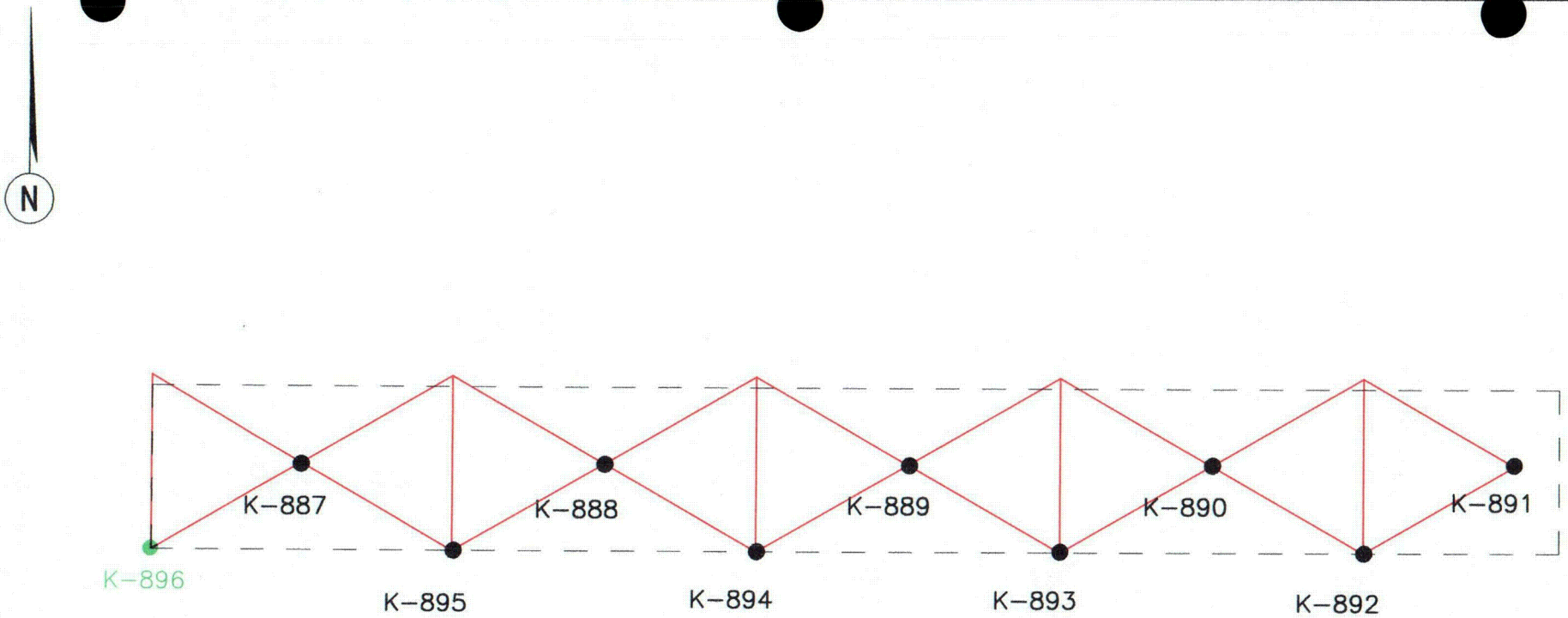
Backgrounds are 1 minute readings.





Scanning results represent a weighted average for each 1 meter x 1 meter grid.

C23



SCALE – FEET

5 0 5

1 0 1

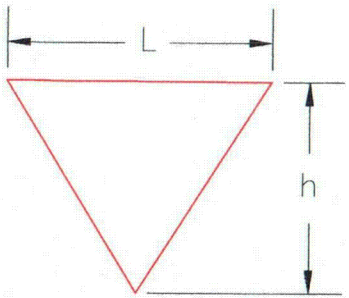
SCALE – METERS

K-895

● SYSTEMATIC SAMPLING LOCATION BASED ON RANDOM START POINT AND AN EQUAL-DISTANT TRIANGULAR GRID

K-896

● RANDOM START POINT



N = 9 (COLLECTED 10)
L = 1.6m
h = 1.4m
AREA = 19.5m^2

FIGURE A-2
SYSTEMATIC SOIL SAMPLING LOCATIONS SURVEY UNIT KAISER – FSSFOA-009 FINAL STATUS SURVEY THORIUM REMEDIATION PROJECT TULSA, OKLAHOMA FACILITY

PREPARED FOR

KAISER ALUMINUM & CHEMICAL CORPORATION
TULSA, OKLAHOMA

APPROVED	RD 3.3.06
CHECKED	RD 3.3.06
DRAWN	DEB 1/13/06
DRAWING NUMBER	PA4072063

Penn E&R
Environmental & Remediation, Inc.

C24

ATTACHMENT B
TABLE OF CONTENTS

- **Soil Survey Unit Worksheet No. 1**
- **Soil Survey Unit Worksheet No. 2**

Soil Survey Unit Work Sheet No. 1
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

1. Soil Survey Unit: KAISER-FSSFOA-009

2. Description: Former Operational Area, Adjacent to Former Warehouse Building's South Wall

3. Net Th-232 Acceptance Criteria (pCi/g): 3.0

4. Dimensions (m): Excavation Side Wall – Approx. 13 meters x 1.5 meters; Area, A (m^2): 19.5

5. Estimate of Gross Gamma Scan Background Readings (cpm)
Average: 15,000 Minimum: 10,000 Maximum: 30,000

6. Based on the maximum background gross gamma scan reading, the scan MDC (Minimum Detectable Concentration of Th-232), the corresponding N (Minimum Number of Required Samples) and L (Triangular Grid Node Length) for a standard 2,000 m^2 Class 1 survey unit are:

- Gross Gamma Scan MDC (pCi/g): 3.1
- Minimum Number of Samples (N): 9 Triangular Grid Node Length (L): 16.0 m

7. If the area of the Survey Unit is less than 2,000 m^2, recalculate the corresponding Triangular Grid Node Length (L_1) for the Survey Unit Area (A), using the following formula: $L_1 = (A/(0.866 \times 9))^{1/2}$: 1.6 m

8. If N is greater than 9 and the A is other than 2,000 m^2, recalculate the corresponding Triangular Grid Node Length (L_1) using the following formula $L_1 = (A/(0.866 \times N))^{1/2}$: N/A

9. If A is greater than 2,000 m^2 and N is equal to 9, recalculate the minimum number of samples (N_1) corresponding to a Triangular Grid Node Length (L) of 16 m using the following formula $N_1 = A / (0.866 \times 16^2)$, N_1: N/A

10. Calculate the height (h) of the equilateral triangle with side length equal to L (or (L_1) using the following formula: $h = ((L^2 - (L/2)^2)^{1/2}$: 1.4 m.

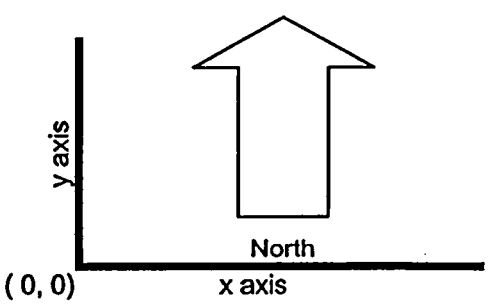
Soil Survey Unit Worksheet No. 2
Random Number Generator for Start Point
Final Status Survey
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

SURVEY UNIT: KAISER-FSSFOA-009

RANDOM START POINT

x axis (Meters)	y axis (Meters)
0	0

	x axis	y axis
lower bound	0	0
upper bound	13	1.5



ATTACHMENT C

LABORATORY ANALYTICAL RESULTS

Outreach
Laboratory
[illegible] North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

August 10, 2005

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20050620

Dear Mr. Weyant:

Please find enclosed the analytical report for your samples received in our laboratory on August 04, 2005 for the above captioned project. Nine soil samples were received in good condition and analyzed by Gamma Spectroscopy without drying and grinding and Percent Moisture with an expedited 5-work day turn. Results were faxed early on 8/10/05.

All Quality Control for the requested analyses is reported on the analytical report. The laboratory control standard and duplicates for all analyses were within method control limits.

Your samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions, please call us at 918-251-2515.

Laboratory Director

ODEQ ID #9517
DEQ LIC. #27522-01

ACCREDITED IN ACCORDANCE WITH nelac
CERT. ID #OK001

Outreach Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client: Kaiser Aluminum
Client Project: Thorium Remediation
Lab Number: 20050620
Date Reported: 8/10/05
Date Received: 8/4/05

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050620-01**						
Client ID:	**K-887**						
Date Sampled:	**8/3/05 8:00:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	1.47 +/- 0.071	pCi/g	0.263		8/5/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	3.2	%		8/8/05	8/9/05	RT
Lab ID:	**20050620-02**						
Client ID:	**K-888**						
Date Sampled:	**8/3/05 8:05:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.986 +/- 0.129	pCi/g	0.416		8/5/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	5.4	%		8/8/05	8/9/05	RT
Lab ID:	**20050620-03**						
Client ID:	**K-889**						
Date Sampled:	**8/3/05 8:10:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.855 +/- 0.061	pCi/g	0.334		8/5/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	5.1	%		8/8/05	8/9/05	RT
Lab ID:	**20050620-04**						
Client ID:	**K-890**						
Date Sampled:	**8/3/05 8:15:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	1.22 +/- 0.136	pCi/g	0.387		8/5/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	4.3	%		8/8/05	8/9/05	RT

BDL = Below Detection Limit

Outreach
Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20050620
Date Reported:	8/10/05
Date Received:	8/4/05
Page Number:	2 of 3

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20050620-05**						
Client ID:	**K-891**						
Date Sampled:	**8/3/05 8:20:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.913 +/- 0.115	pCi/g	0.601		8/6/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	2.1	%		8/8/05	8/9/05	RT
Lab ID:	**20050620-06**						
Client ID:	**K-892**						
Date Sampled:	**8/3/05 8:25:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	1.26 +/- 0.080	pCi/g	0.250		8/6/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	5.6	%		8/8/05	8/9/05	RT
Lab ID:	**20050620-07**						
Client ID:	**K-893**						
Date Sampled:	**8/3/05 8:30:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	0.736 +/- 0.067	pCi/g	0.199		8/6/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	7.9	%		8/8/05	8/9/05	RT
Lab ID:	**20050620-08**						
Client ID:	**K-894**						
Date Sampled:	**8/3/05 8:35:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Th-232	HASL 300	1.03 +/- 0.101	pCi/g	0.472		8/8/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	9.4	%		8/8/05	8/9/05	RT

BDL = Below Detection Limit

Outreach
Laboratory
North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

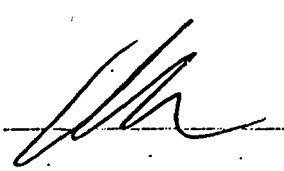
Client: Kaiser Aluminum
Client Project: Thorium Remediation
Lab Number: 20050620
Date Reported: 8/10/05
Date Received: 8/4/05

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	20050620-09						
Client ID:	K-895						
Date Sampled:	8/3/05 8:40:00 AM						
Matrix:	Soil						
		Radiochemical Analyses					
Th-232	HASL 300	1.23 +/- 0.083	pCi/g	0.331		8/6/05	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	9.0	%		8/8/05	8/9/05	RT

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Ac-228					51.8				8/5/05
Am-241		97.0	90.0	7.1					8/5/05
Bi-212					NC				8/5/05
Bi-214					NC				8/5/05
Co-60		100.0	94.0	6.2					8/5/05
Cs-137		98.0	96.0	1.6					8/5/05
K-40					16.4				8/5/05
Pb-212					34.4				8/5/05
Pb-214					1.4				8/5/05
Percent Moisture					6.6				8/9/05
Th-234					NC				8/5/05
Tl-208					NC				8/5/05
U-235					NC				8/5/05

Lab Approval: 

BDL = Below Detection Limit

FOA-009

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Cell:

Results To:
LOCAL: 918-384-0966
724-799-8071
Company: N Aisle - Alm & Chem Inc.
Name: David B. Weyant
Address: 7311 E. 41st St.
City: Tulsa State: OK Zip: 74145
Phone: 724-934-3530 Fax #: 918-794-2171

Bill To:
Company: N Aisle / Peak Env
Name: David B. Weyant / Paul Hanna
Address: 7311 E. 41st St.
City: Tulsa State: OK Zip: 74145

ANALYSIS REQUESTED

PO #: N Aisle - 4072
PROJECT #: PA - 4000 - 4072
PROJECT NAME: N Aisle - Alum & Titanium Rem
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY): 5 DAY
SAMPLER: David B. Weyant
Signature: David B. Weyant

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE #	Grain Size	Cr(VI) 7196	Perchlorate + Chlorate Ion Analysis	MOC 6010	RCRA 8 Metals 6010	ASTM Moisture Content	REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
K	K-887	8-3-05	08:00	Soil	1	500ml Plastic	None							GRAB
K	K-888		08:05		1									
K	K-889		08:10		1									
K	K-890		08:15		1									
K	K-891		08:20		1									
K	K-892		08:25		1									
K	K-893		08:30		1									
K	K-894		08:35		1									
K	K-895	"	08:40	"	1	"	"							"
N/A	N/A	N/A	N/A	N/A				N	N	N	N	N	N	N
								A	A	A	A	A	A	A

RELINQUISHED BY: David B. Weyant DATE 8/4/05 TIME 930 RECEIVED BY: Donna Eidson DATE 8/4/05 TIME 930

RELINQUISHED BY: DESIREE GREGORY DATE 9/26/05 TIME 1300 RECEIVED BY: _____ DATE _____ TIME _____

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

FOR LABORATORY USE ONLY: 2005062-20
Temp. Cond. or Ice Present
Custody Seal Intact

SAMPLE L IN

Date Received: *8/4/05 10:02:53 A* **Lab Number:** 20050620 **Due:** 8/11/05

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20050620-01 A	K-887	Soil	08/03/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050620-02 A	K-888	Soil	08/03/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050620-03 A	K-889	Soil	08/03/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050620-04 A	K-890	Soil	08/03/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050620-05 A	K-891	Soil	08/03/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050620-06 A	K-892	Soil	08/03/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050620-07 A	K-893	Soil	08/03/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050620-08 A	K-894	Soil	08/03/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20050620-09 A	K-895	Soil	08/03/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								

CONTAIN NSPECTION

Coolers 1 Custody Seals Broken - Y/N/~~NA~~ Temperature _____ Blue Ice / Wet Ice Radiation Survey _____fixed_____removable

SAMPLE INSPECTION

Custody Seals Broken - Y/N/~~NA~~ Chain of Custody Record (Y)N Labels in Tact (Y)/N Radiation Survey Complete Y/N

Anomalies: _____

_____

_____

Inspected By: Michelle Booth DATE 08/04/05

QA or Designee Review: [signature] DATE 8/4/05

Sample Custodian Review: [signature] DATE 8-4-05

Project Notes:

Outreach Laboratory
1 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Invoice # 11681
01. 1/20/06

January 19, 2006

David Weyant
Kaiser Aluminum & Chemical
7311 E. 41st Street
Tulsa, OK 74145

Project: Kaiser Thorium Remediation PA-4000-4072
OUTREACH LAB ID: 20060018

Dear Mr. Weyant:

Please find enclosed the analytical report for your samples received in our laboratory on January 10, 2005 for the above captioned project. Four soil samples were received in good condition and analyzed by Gamma Spectroscopy without drying and grinding and Percent Moisture with an expedited 5-work day turn.

All Quality Control for the requested analyses is reported on the analytical report. The laboratory control standard and duplicates for all analyses were within method control limits.

Your samples will be returned as requested.

Thank you for choosing Outreach Laboratory and if you have any questions, please call us at 918-251-2515.

Laboratory Director

ODEQ ID #9517
DEQ LIC. #27522-01

ACCREDITED IN ACCORDANCE WITH nelac
CERT. ID #OK001

Outreach Laboratory
311 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20060018
Date Reported:	1/19/06
Date Received:	1/10/06
Page Number:	1 of 2

Analytical Report

	Method	Result	Units	DL	Prep Date	Analysis Date	Analyst
Lab ID:	**20060018-01**						
Client ID:	**K-484**						
Date Sampled:	**1/19/05 2:25:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Thorium 232	HASL 300	2.01 +/- 0.355	pCi/g	0.757		1/10/06	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	18.2	%		1/11/06	1/12/06	RT
Lab ID:	**20060018-02**						
Client ID:	**K-499**						
Date Sampled:	**1/25/05 2:15:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Thorium 232	HASL 300	1.13 +/- 0.235	pCi/g	0.506		1/10/06	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	7.4	%		1/11/06	1/12/06	RT
Lab ID:	**20060018-03**						
Client ID:	**K-810**						
Date Sampled:	**7/20/05 2:20:00 PM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Thorium 232	HASL 300	0.819 +/- 0.184	pCi/g	0.258		1/10/06	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	21.8	%		1/11/06	1/12/06	RT
Lab ID:	**20060018-04**						
Client ID:	**K-896**						
Date Sampled:	**8/3/05 8:45:00 AM**						
Matrix:	**Soil**						
		Radiochemical Analyses					
Thorium 232	HASL 300	1.13 +/- 0.249	pCi/g	0.453		1/10/06	SD
		Inorganics Analyses					
Percent Moisture	ASTM D2216-92	6.6	%		1/11/06	1/12/06	RT

BDL = Below Detection Limit

Outreach Laboratory
11 North Aspen
Broken Arrow, OK 74012
(918) 251-2515
FAX (918) 251-0008

Client:	Kaiser Aluminum
Client Project:	Thorium Remediation
Lab Number:	20060018
Date Reported:	1/19/06
Date Received:	1/10/06
Page Number:	2 of 2

QC Report

Parameter	Blank	LCS %REC	LCSD %REC	LCSD RPD	DUP RPD	MS %REC	MSD %REC	MSD RPD	Date
Ac228					NC				1/10/06
Am-241		82.0	81.0	1.0					1/10/06
Co-60		95.0	94.0	1.3					1/10/06
Cs-137		94.0	94.0	0.7					1/10/06
Percent Moisture					7.0				1/12/06

Lab Approval:

BDL = Below Detection Limit

OUTREACH LABORATORY

311 North Aspen
Broken Arrow, OK 74012
Phone: (918) 251-2515
Fax: (918) 251-0008

CHAIN OF CUSTODY

Results To:
Company Kaiser-Alum & Chem, Inc.
Name DAVID G. WEYANT
Address 7311 E. 41st St.
City Tulsa State OK Zip 74145
Phone 724-934-3330 Fax # 918-394-3171

Bill To:
Company Kaiser / Paul Dada & Eng
Name Paul Dada / David G. Weyant
Address 7311 E. 41st St.
City Tulsa State OK Zip 74145

ANALYSIS REQUESTED

PO # Kaiser-4072
PROJECT # PA-4055-4072
PROJECT NAME Kaiser-Thorium Remo.
REQUESTED TURNAROUND TIME (ADDITIONAL CHARGES MAY APPLY) 5 DAY T.A.T.
SAMPLER David G. Weyant Signature
DAVID G. WEYANT

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	# CONTAINERS	CONTAINER SIZE / PLASTIC OR GLASS	PRESERVATIVE # (1. HNO_3 pH<2; 2. Ice <4°C; 3. HCl pH<2; 4. H_2SO_4 pH<2; 5. NaOH pH>11)	Gamma Spec (Ra-226, Ra-232)	Radon Flux (Method 115.1 for Cl-Soil)	Th-230 by Acetic Acid Leach (Method 160.3 mod)	Ash 226.92 Assay Content				REMARKS (I.E. FILTERED, UNFILTERED, GRAB, COMPOSITE)
	K-484	1-19-05	1425	Soil	1	Plastic	None	X	X	X	X			A	Grab
	K-499	1-25-05	1415		1			X	X	X	X				
	K-510	7-26-05	1420		1			X	X	X	X				
	K-596	6-3-05	0845		1			X	X	X	X				

RELINQUISHED BY: David G. Weyant DATE 11/8/06 TIME 1200 RECEIVED BY: Donna Edison DATE 11/10/06 TIME 1200
DAVID G. WEYANT

RELINQUISHED BY: _____ DATE _____ TIME _____ RECEIVED BY: _____ DATE _____ TIME _____

My signature on this chain of custody form indicates that I am authorized by the above company to release samples for analysis. The company agrees to pay the entire balance upon receipt of sample data and it is understood and agreed that any balance carried over thirty (30) days is subject to a 1.5% per month (18% per annum) late charge. In the event of default, the company becomes legally liable for any reasonable attorney and/or collection fees and all related costs necessary to remit the entire balance to Outreach Technologies, Inc. (Outreach Laboratory).

SAMPLE RETURN/DISPOSAL: All non-hazardous samples shall be disposed of 30 days after issue of final report. All others will be returned at client's expense.

FOR LABORATORY USE ONLY: 2006018
Sample Condition Upon Receipt: Good
Custody Seals Intact: Yes / No
Cooler Temperature: 4

SAMPLE [illegible]

Date Received: *1/10/06 12:52:08* Lab Number: 20060018 Due: 1/17/06

Sample Number	Client Sample ID	Matrix	Date Sampled	Container Type	Container Size	Preservation	Custody Seal	Seal Intact
20060018-01 A	K-484	Soil	01/19/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20060018-02 A	K-499	Soil	01/25/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20060018-03 A	K-810	Soil	07/20/05	Plastic	16 oz	None	Yes	Yes
Percent Moisture (LOD)								
Th-232 by Gamma Spec								
20060018-04 A	K-896	Soil	08/03/05	Plastic	16 oz	None	Yes	Yes
Gamma Spec - Thorium 232								
Percent Moisture (LOD)								

CONTAINER INSPECTION

Coolers 0 Custody Seals Broken ☐ Temperature Ice Radiation Survey: <300 cpm

SAMPLE INSPECTION

Sample Seal Broken NA Chain of Custody Record ☑ Labels in Tact ☑ Radiation Survey Complete ☑

Anomalies

Inspected By: [signature] DATE 01/10/06

QA or Designee Review: Raymond Thomas DATE 01/10/06

Sample Custodian Review: [signature] DATE 1-10-06

Project Notes:

APPENDIX A

SURVEY INSTRUMENTATION QA/QC

APPENDIX A-1

SURVEY UNIT KAISER-FSSFOA-001

Appendix A-1, Table A-1-1
Final Status Survey Instrument Summary
Survey Unit Kaiser-FSSFOA-001
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Instrument Model and Detector Model/Type	Instrument Serial Number	Detector Serial Number	Calibration Period	In-Service Period Survey of Unit Kaiser-FSSFOA-001	Usage
Ludlum 2221 Scaler/ Rate Meter with 44-10 2" X 2" NaI Scintillation Gamma Detector	206873	PR211675	05/17/04 to 05/17/05	01/10/05 & 01/17/05	Field analysis, high-energy gamma detection - Instrument was used to evaluate remediation progress and scan land areas for the Final Status Survey.

APPENDIX A-1-1

Ludlum Model 2221 Scaler/Rate Meter
With Model 44-10 2-inch x 2-inch NaI Scintillation Gamma Detector
Serial Nos. 206873 (meter) and PR211675 (detector)

CERTIFICATE OF CALIBRATION

ENERCON Services, Inc.
650-1 Seco Road
Monroeville, PA 15146
Ph. 412-373-8455
Fax 412-373-5930

Customer: Enercon Services Inc. Order No.N/A

Mfg.: Ludlum Model 2221 Serial No.:206873

Cal Date: 05/17/04 Cal Due Date: 05/17/05 Cal. Interval 12 mo.'s Meterface 202-159

Check mark ☒ applies to applicable instruments and/or detector IAW Mfg. Spec. T 76.1 °F RH 44 % Alt. 1120 Ft.

☒ New Instrument Instrument Received ☐ Within Toler +/-10% ☐ 0-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See Comment

☒ Mechanical Ck.	☒ Meter Zeroed	☐ Background Subtract	☒ Input Sens. Linearity
☒ F/S Resp. OK	☒ Reset Ck.	☒ Window Operation	☒ Geotropism
☒ Audio. Ck.	☐ Alarm Setting Ck.	☒ Batt. Ck. (Min. Volt) 6.2 VDC	

☒ Calibrated in accordance with ECL 205-1 Rev. 0 1/23/03

Instrument Volt Set 900 V Input Sens. 10 MV

Det. Oper. N/A V at N/A mV Threshold Dial Ratio 10 = 100

☐ HV Readout (2 points) Ref./Inst. 669 /670 V Ref./Inst. 995 / 1000

COMMENTS: *Digital Calibration done using a 0.1 minute count time. Results reflect that count time.*

Gamma Calibration: GM detectors positioned perpendicular to source except for M44-9 in which the front of probe faces source.

RANGE/ MULTIPLER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X1K	400 Kcpm	395000 cpm	395000 cpm
X1K	100 kcpm	100000 cpm	100000 cpm
X100	40 Kcpm	39500 cpm	39500 cpm
X100	10 Kcpm	10000 cpm	10000 cpm
X10	4 Kcpm	3950 cpm	3950 cpm
X10	1 Kcpm	1000 cpm	1000 cpm
X1	400 cpm	400 cpm	400 cpm
X1	100 cpm	100 cpm	100 cpm

*Uncertainty within ±20%

	REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING
Digital Readout	400 cpm	38 cpm	38 cpm	Log Scale	50 cpm	60 cpm	60 cpm
	400 Kcpm	39116 cpm	39116 cpm		500 Kcpm	500000 cpm	500000 cpm
	40 Kcpm	3917 cpm	3917 cpm		50 Kcpm	50000 cpm	50000 cpm
	4 Kcpm	392 cpm	392 cpm		5 Kcpm	5000 cpm	5000 cpm
	40 cpm	4 cpm	4 cpm		500 cpm	475 cpm	475 cpm

ENERCON Services, inc. certified that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology or to the calibration facility other International Standards Organization members, or have been derived from accepted values or natural physical constraints or have been derived by the ratio type of calibration technology. The calibration system conforms to the requirements of ANSI /NCSL Z540-1-1994 and ANSI N323-1978.

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 6205GF

☐ Alpha S/N ☐ Beta S/N ☐ Other Cs137 2485

☒ M 500 S/N 187460 ☐ Oscilloscope S/N ☐ Multimeter S/N 020513278

Calibrated By: R. Shank Date: 05/17/04

Reviewed By: Date: 5/17/04

AC Inst. ☐ Passed Dielectric (hi-Pot) and Continuity Only ☐ Failed

PLATEAU

Instrument :	Ludlum	**DATE:**	5/17/2004
Model No,	2221	**Source:**	Cs137
Serial No.	206783	**Serial no.**	2485
Probe:	44-10	**Strength:**	I uci
Serial No.	PR 211675		

	Background Count (cpm)	Source Count (cpm)	H.V.
1	4777	95849	700
2	5385	98961	750
3	5517	104186	800
4	5600	108132	850
5	5675	108795	900
6	5832	109020	950
7	5680	111082	1000
8	5849	111402	1050
9	6073	112078	1100
10	5782	115675	1150
11	N/A	N/A	1200
12	N/A	N/A	1250

Form HPM/M-2-6-1
Daily Check Log for Ludlum Model 2221 with 44-10 Detector
Instrument 3

Instrument Model:	2221
Instrument S/N:	206873
Detector Model:	44-10
Detector S/N:	PR211675
Calibration Due:	5/17/05

CONTACT

Source S/N:	Cs-137 sn: 547		
Source DPM:	N/A		
Radiation Detected:	gamma		
Acceptable Range: (Refer to Penn E&R/HPM/M-2-1-1)	232,512 + 2σ		238,680 + 3σ
	207,841 - 2σ		201,672 - 3σ

	Time	Date	Background Count Rate	Source Count Rate	Net Source Count Rate	Technician	W/IN +/- 2σ	Batt check (volts)	W/IN +/- 3σ
1	13:00	1/10/2005	9,653	228,250	218,597	DSB	YES	5.6	YES
2	7:38	1/17/2005	9,025	229,063	220,038	DBW	YES	5.7	YES

Comments: Background 5 minute count. Source count 1 minute.
Recalibrated by Enercon to Cs-137.

Form HPM/M-2-6-1
Daily Check Log for Ludlum Model 2221 with 44-10 Detector
Instrument 3

Instrument Model:	2221
Instrument S/N:	206873
Detector Model:	44-10
Detector S/N:	PR211675
Calibration Due:	5/17/05

6 INCHES

Source S/N:	Cs-137 sn: 547	
Source DPM:	N/A	
Radiation Detected:	gamma	
Acceptable Range: (Refer to Penn E&R/HPM/M-2-1-1)	8,206 + 2σ	8,347 + 3σ
	7,637 - 2σ	7,495 - 3σ

	Time	Date	Background Count Rate	Source Count Rate	Net Source Count Rate	Technician	W/IN +/- 2σ	Batt check (volts)	W/IN +/- 3σ
1	13:00	1/10/2005	9,653	17,764	8,111	DSB	YES	5.6	YES
2	7:38	1/17/2005	9,025	16,609	7,584	DBW	NO	5.7	YES

Comments: Background 5 minute count. Source count 1 minute.

Recalibrated to Cs-137 by Enercon.

APPENDIX A-2

SURVEY UNIT KAISER-FSSFOA-002

Appendix A-2, Table A-2-1
Final Status Survey Instrument Summary
Survey Unit Kaiser-FSSFOA-002
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Instrument Model and Detector Model/Type	Instrument Serial Number	Detector Serial Number	Calibration Period	In-Service Period Survey of Unit Kaiser-FSSFOA-002	Usage
Ludlum 2221 Scaler/ Rate Meter with 44-10 2" X 2" NaI Scintillation Gamma Detector	206873	PR211675	05/17/04 to 05/17/05	12/14/04 to 12/15/04	Field analysis, high-energy gamma detection - Instrument was used to evaluate remediation progress and scan land areas for the Final Status Survey.

APPENDIX A-2-1

Ludlum Model 2221 Scaler/Rate Meter
With Model 44-10 2-inch x 2-inch NaI Scintillation Gamma Detector
Serial Nos. 206873 (meter) and PR211675 (detector)

CERTIFICATE OF CALIBRATION

ENERCON Services, Inc.
650-I Seco Road
Monroeville, PA 15146
Ph. 412-373-8455
Fax 412-373-5930

Customer: Enercon Services Inc. Order No.N/A

Mfg.: Ludlum Model 2221 Serial No.:206873

Cal Date: 05/17/04 Cal Due Date: 05/17/05 Cal. Interval 12 mo.'s Meterface 202-159

Check mark ☒ applies to applicable instruments and/or detector IAW Mfg. Spec. T 76.1 °F RH 44 % Alt. 1120 Ft.

☒ New Instrument Instrument Received ☐ Within Toler +/-10% ☐ 0-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See Comment

☒ Mechanical Ck.	☒ Meter Zeroed	☐ Background Subtract	☒ Input Sens. Linearity
☒ F/S Resp. OK	☒ Reset Ck.	☒ Window Operation	☒ Geotropism
☒ Audio. Ck.	☐ Alarm Setting Ck.	☒ Batt. Ck. (Min. Volt) 6.2 VDC	

☒ Calibrated in accordance with ECL 205-1 Rev. 0 1/23/03

Instrument Volt Set 900 V Input Sens. 10 MV

Det. Oper. N/A V at N/A mV Threshold Dial Ratio 10 = 100

☐ HV Readout (2 points) Ref./Inst. 669 /670 V Ref./Inst. 995 / 1000

COMMENTS: Digital Calibration done using a 0.1 minute count time. Results reflect that count time.

Gamma Calibration: GM detectors positioned perpendicular to source except for M44-9 in which the front of probe faces source.

RANGE/ MULTIPLER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X1K	400 Kcpm	395000 cpm	395000 cpm
X1K	100 kcpm	100000 cpm	100000 cpm
X100	40 Kcpm	39500 cpm	39500 cpm
X100	10 Kcpm	10000 cpm	10000 cpm
X10	4 Kcpm	3950 cpm	3950 cpm
X10	1 Kcpm	1000 cpm	1000 cpm
X1	400 cpm	400 cpm	400 cpm
X1	100 cpm	100 cpm	100 cpm

*Uncertainty within ±20%

	REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING
Digital Readout	400 cpm	38 cpm	38 cpm	Log Scale	50 cpm	60 cpm	60 cpm
	400 Kcpm	39116 cpm	39116 cpm		500 Kcpm	500000 cpm	500000 cpm
	40 Kcpm	3917 cpm	3917 cpm		50 Kcpm	50000 cpm	50000 cpm
	4 Kcpm	392 cpm	392 cpm		5 Kcpm	5000 cpm	5000 cpm
	40 cpm	4 cpm	4 cpm		500 cpm	475 cpm	475 cpm

ENERCON Services, inc. certified that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology or to the calibration facility other International Standards Organization members, or have been derived from accepted values or natural physical constraints or have been derived by the ratio type of calibration technology. The calibration system conforms to the requirements of ANSI /NCSL Z540-1-1994 and ANSI N323-1978.

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 6205GF

☐ Alpha S/N ☐ Beta S/N ☐ Other Cs137 2485

☒ M 500 S/N 187460 ☐ Oscilloscope S/N ☐ Multimeter S/N 020513278

Calibrated By: R. Shank Date: 05/17/04

Reviewed By: Date: 5/17/04

AC Inst. ☐ Passed Dielectric (hi-Pot) and Continuity Only ☐ Failed

PLATEAU

Instrument: Ludlum
Model No, 2221
Serial No. 206783 873 HA
Probe: 44-10
Serial No. PR 211675

DATE: 5/17/2004
Source: Cs137
Serial no. 2485
Strength: I uci

	Background Count (cpm)	Source Count (cpm)	H.V.
1	4777	95849	700
2	5385	98961	750
3	5517	104186	800
4	5600	108132	850
5	5675	108795	900
6	5832	109020	950
7	5680	111082	1000
8	5849	111402	1050
9	6073	112078	1100
10	5782	115675	1150
11	N/A	N/A	1200
12	N/A	N/A	1250

Form HPM/M-2-6-1
Daily Check Log for Ludlum Model 2221 with 44-10 Detector
Instrument 3

Instrument Model:	2221
Instrument S/N:	206873
Detector Model:	44-10
Detector S/N:	PR211675
Calibration Due:	5/17/05

CONTACT

Source S/N:	Cs-137 sn: 547
Source DPM:	N/A
Radiation Detected:	gamma
Acceptable Range: (Refer to Penn E&R/HPM/M-2-1-1)	232,512 + 2σ
	207,841 - 2σ

	Time	Date	Background Count Rate	Source Count Rate	Net Source Count Rate	Technician	W/IN +/- 2σ	Batt check (volts)	W/IN +/- 3σ
1	8:00	12/14/2004	8,880	230,308	221,428	DSB	YES	6.0	YES
2	8:00	12/15/2004	9,119	233,062	223,943	DSB	YES	5.8	YES

Comments: Background 5 minute count. Source count 1 minute.
Recalibrated by Enercon to Cs-137.

Form HPM/M-2-6-1
Daily Check Log for Ludlum Model 2221 with 44-10 Detector
Instrument 3

Instrument Model:	2221
Instrument S/N:	206873
Detector Model:	44-10
Detector S/N:	PR211675
Calibration Due:	5/17/05

6 INCHES

Source S/N:	Cs-137 sn: 547
Source DPM:	N/A
Radiation Detected:	gamma
Acceptable Range: (Refer to Penn E&R/HPM/M-2-1-1)	8,206 + 2σ
	7,637 - 2σ

	Time	Date	Background Count Rate	Source Count Rate	Net Source Count Rate	Technician	W/IN +/- 2σ	Batt check (volts)	W/IN +/- 3σ
1	8:00	12/14/2004	8,880	16,861	7,981	DSB	YES	6.0	YES
2	8:00	12/15/2004	9,119	16,853	7,734	DSB	YES	5.8	YES

Comments: Background 5 minute count. Source count 1 minute.

Recalibrated to Cs-137 by Enercon.

APPENDIX A-3

SURVEY UNIT KAISER-FSSFOA-003

Appendix A-3, Table A-3-1
Final Status Survey Instrument Summary
Survey Unit Kaiser-FSSFOA-003
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Instrument Model and Detector Model/Type	Instrument Serial Number	Detector Serial Number	Calibration Period	In-Service Period Survey of Unit Kaiser-FSSFOA-003	Usage
Ludlum 2360 Alpha-Beta Scaler /Rate Meter with a 43-68 100 cm^2 Gas Proportional Alpha-Beta Detector	193686	PR190485	05/04/04 to 05/04/05	01/20/05 to 02/01/05	Simultaneous alpha-beta counting and discrimination - Instrument was used to survey embedded structures.

APPENDIX A-3-1

Ludlum Model 2360 Alpha-Beta Scaler/Rate Meter
with Model 43-68 100 cm² Gas Proportional Alpha-Beta Detector
Serial Nos. 193686 (meter) and PR190485 (detector)

Designer and Manufacturer of Scientific and Industrial Instruments

6/29

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER KAISER ALUMINUM ORDER NO. 215373/281348

Ludlum Measurements, Inc. Model 2360 Serial No. 193686

e. Ludlum Measurements, Inc. Model 43-68 Serial No. PR-190485

Cal. Date 4-May-04 Cal Due Date 4-May-05 Cal. Interval 1 Year Meterface 202-855

heck mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 75 °F RH 28 % Alt 705.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☐ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 2.2 VDC
☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

strument Volt Set 1575 V

☑ HV Readout (2 points) Ref./Inst. 500 / 491 V Ref./Inst. 1500 / 1992 V

Firmware Version: 39010N24 (EEPROM Settings)
Alpha Threshold: 120mv User Time: 001.0
Beta Threshold: 3.5mv Alpha Alarm: 050000
Beta Window: 50mv Beta Alarm: 050000
Overload Checked But not set A/B Alarm: 050000
Instrument calibrated with a 39" cable. Model 2360 Date: 4 May 04
High voltage set with detector Connected Calibration Date Due: 4 May 05

COMMENTS:
Eff. for Th230 ≈ 35.5% 2pi, Background count 1cpm, Source count 1036cpm, Source Size 2910cpm
Eff. for Th232 ≈ 46.6% 2pi, Background count 1cpm, Source count 64cpm, Source Size 135cpm
Eff. for Tc99 ≈ 48.0% 2pi, Background count 93cpm, Source count 6865cpm, Source Size 14100cpm

peration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
x1000	400kcpm	400	400
x1000	100kcpm	100	100
x100	40kcpm	400	400
x100	10kcpm	100	100
x10	4kcpm	400	400
x10	1kcpm	100	100
x1	400kcpm	400	400
x1	100kcpm	100	100

*Uncertainty within ± 10% C.F. within ± 20% ALL Range(s) Calibrated Electronically

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
gital adout	400kcpm	399856	399856	Log Scale			
	40kcpm	3999	3999				
	4kcpm	400	400				
	400cpm	40	40				
	40cpm	4	4				

lum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of er International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-1963

eference Instruments and/or Sources:

s-137 Gamma S/N ☐ 1162 ☐ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

pha S/N Th230 #5020-03/Th232 #3153 ☑ Beta S/N Tc99 SN: NT-EV ☐ Other

500 S/N 50800 ☐ Oscilloscope S/N ☑ Multimeter S/N 83990502

Calibrated By: Charles Robb Date 4 May 04

Reviewed By: WJ Robbins Date 5 may 04

his certificate shall not be reproduced except in full, without the written approval of Ludlum Measurements, Inc.
ORM C22S 11/26/2003

AC Inst. ☐ Passed Dielectric (Hi-Pot) and Continuity Test

Designer and Manufacturer
of
Scientific and Industrial
Instruments

POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

8/29

Bench Test Data For Detector

Detector 43-68 Serial No. PR-190485 Order #. 215373/281348

Customer KAISER ALUMINUM Alpha Input Sensitivity 120 mV

Counter 2360 Serial No. 193686 Beta Input Sensitivity 3.5 mV

Count Time 1 Minute Beta Window 50 mV

Other _____ Distance Source to Detector Surface

High Voltage	Background Alpha	Background Beta	Isotope Th230 Size 2910 cpm Alpha	Isotope Th230 Size 2910 cpm Beta	Isotope Th232 Size 135 cpm Alpha	Isotope Th232 Size 135 cpm Beta	Isotope Tc99 Size 14100 cpm Alpha	Isotope Tc99 Size 14100 cpm Beta
1575	2	99	943	411	51	185	0	6731
1550	0	124	1116	428	47	197	0	7566
1575	1	93	1036	500	64	251	1	6865
1600	2	208	1075	526	55	306	18	7471
1625	0	202	1174	483	55	287	149	6722

☑ Gas Proportional detector count rate decreased ≤ 10% after 15 hour static test using 39" cable.

☐ Gas proportional detector count rate decreased ≤ 10% after 5 hour static test using 39" cable and alpha/beta counter.

Signature Charles Disk Date 4 May 04

Form HPM/M-2-8-1
Daily Check Log for Ludlum Model 2360 with 43-68 Detector
Instrument 2 Alpha

Instrument/SN: Ludlum Model 2360 193686					*Check Source(s) Used:* Th-230, S/N 5053-03						
Detector/SN: Model 43-68 /PR190485											
EFF %: α= 17.78 % 4π					*source check acceptance criteria*		α				
CALIB. SOURCE USED: Th-230					**Average (NCPM):**		2,564				
DATE OF CALIB.: 5/4/2004					**+2 sigma:**		2,655				
CALIB. DUE DATE: 5/4/2005					**-2 sigma:**		2,474				
PERFORMED BY: Ludlum Measurements Inc.					**+3 sigma:**		2,700				
					-3 sigma:		2,429				
TECHNICIAN'S NAME		ALPHA/ BETA	RESPONSE CHECK	DATE	TIME	60 min Bkgrd (cpm)	1 min gross (cpm)	1 min net (cpm)	within +/- 2 sigma	within +/- 3 sigma	<10% drop
DB	1	Alpha	SAT	1/20/2005	10:00	1.57	2,494	2,492	YES	YES	NA
DBW	2	Alpha	SAT	1/20/2005	17:54	1.55	2,657	2,655	NO	YES	YES
DBW	3	Alpha	SAT	1/26/2005	13:51	0.85	2,500	2,499	YES	YES	NA
DBW	4	Alpha	SAT	1/26/2005	17:50	1.47	2,431	2,430	NO	YES	YES
DBW	5	Alpha	SAT	1/26/2005	18:05	1.47	2,492	2,491	YES	YES	YES
DBW	6	Alpha	SAT	1/27/2005	9:50	1.50	2,502	2,501	YES	YES	NA
DBW	7	Alpha	SAT	1/27/2005	16:14	0.58	2,482	2,481	YES	YES	YES
DBW	8	Alpha	SAT	1/31/2005	13:43	1.40	2,532	2,531	YES	YES	NA
DBW	9	Alpha	SAT	1/31/2005	17:38	1.62	2,493	2,491	YES	YES	YES
DBW	10	Alpha	SAT	2/1/2005	9:58	1.08	2,504	2,503	YES	YES	NA
DBW	11	Alpha	SAT	2/1/2005	8:22	0.83	2,494	2,493	YES	YES	YES

APPENDIX A-4

SURVEY UNIT KAISER-FSSFOA-004

Appendix A-4, Table A-4-1
Final Status Survey Instrument Summary
Survey Unit Kaiser-FSSFOA-004
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Instrument Model and Detector Model/Type	Instrument Serial Number	Detector Serial Number	Calibration Period	In-Service Period Survey of Unit Kaiser-FSSFOA-004	Usage
Ludlum 2221 Scaler/ Rate Meter with 44-10 2" X 2" NaI Scintillation Gamma Detector	172053	PR206815	11/15/04 to 11/15/05	01/25/05	Field analysis, high-energy gamma detection - Instrument was used to evaluate remediation progress and scan land areas for the Final Status Survey.
Ludlum 2360 Alpha-Beta Scaler /Rate Meter with 43-68 100cm^2 Gas Proportional Alpha-Beta Detector	193686	PR190485	05/04/04 to 05/04/05	01/27/05 to 02/01/05	Simultaneous alpha-beta counting and discrimination - Instrument was used to survey embedded structures.

APPENDIX A-4-1

Ludlum Model 2221 Scaler/Rate Meter
With Model 44-10 2-inch x 2-inch NaI Scintillation Gamma Detector
Serial Nos. 172053 (meter) and PR206815 (detector)

CERTIFICATE OF CALIBRATION

ENERCON Services, Inc.
650-I Seco Road
Monroeville, PA 15146
Ph. 412-373-8455
Fax 412-373-5930

Customer: Enercon Services Inc. Order No.N/A

Mfg.: Ludlum Model 2221 Serial No.:172053

Cal Date:11/15/04 Cal Due Date: 11/15/05 Cal. Interval 12 mo.'s Meterface 202-159

Check mark ☑ applies to applicable instruments and/or detector. IAW Mfg. Spec. T 71.5°F RH 27 % Alt. 1120 Ft.

☐ New Instrument Instrument Received ☐ Within Toler +/-10% ☑ 0-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See Comment

☑ Mechanical Ck. ☑ Meter Zeroed ☐ Background Subtract ☑ Input Sens. Linearity

☑ F/S Resp. OK ☑ Reset Ck. ☑ Window Operation ☑ Geotropism

☑ Audio. Ck. ☐ Alarm Setting Ck. ☑ Batt. Ck. (Min. Volt) 5.6 22 VDC

☑ Calibrated in accordance with ECL 205-1 Rev. 0 1/23/03

Instrument Volt Set 1000 V Input Sens. 10 MV

Det. Oper. N/A V at N/A mV Threshold Dial Ratio 10 = 100

☐ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 1500 / 1560

COMMENTS: Digital Calibration done using a 0.1 minute count time. Results reflect that count time.

Gamma Calibration: GM detectors positioned perpendicular to source except for M44-9 in which the front of probe faces source.

RANGE/ MULTIPLER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X1K	400K cpm	360K cpm	400K cpm
X1K	200K cpm	200K cpm	200K cpm
X1K	100K cpm	100K cpm	100Kcpm
X100	40K cpm	40K cpm	40K cpm
X100	20K cpm	20K cpm	20K cpm
X100	10K cpm	10K cpm	10K cpm
X10	4K cpm	4K cpm	4K cpm
X10	2K cpm	2K cpm	2K cpm
X10	1K cpm	1K cpm	1K cpm
X1	400 cpm	400 cpm	400 cpm
X1	200 cpm	200 cpm	200 cpm
X1	100 cpm	100 cpm	100 cpm

*Uncertainty within ±20%

	REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING
Digital Readout	400 cpm	39 cpm	39 cpm	Log Scale	50 cpm	50 cpm	50 cpm
	400 Kcpm	39522 cpm	396 cpm		500 Kcpm	500K cpm	500K cpm
	40 Kcpm	3952 cpm	3952 cpm		50 Kcpm	50K cpm	50K cpm
	4 Kcpm	395 cpm	395 cpm		5 Kcpm	5K cpm	5K cpm
	40 cpm	4 cpm	4 cpm		500 cpm	500 cpm	500 cpm

ENERCON Services, inc. certified that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology or to the calibration facility other International Standards Organization members, or have been derived from accepted values or natural physical constraints or have been derived by the ratio type of calibration technology. The calibration system conforms to the requirements of ANSI /NCSL Z540-1-1994 and ANSI N323-1978.

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☒ 6205GF

☐ Alpha S/N ☐ Beta S/N ☐ Other

☒ M 500 S/N 187460 ☐ Oscilloscope S/N ☐ Multimeter S/N 020513278

Calibrated By: R. Shank Date:11/15/04

Reviewed By: Date: 11/15/04

AC Inst. ☐ Passed Dielectric (hi-Pot) and Continuity Only ☐ Failed

PLATEAU

Instrument :	Ludlum	**DATE:**	11/15/2004	**Temp:**	71.5
Model No,	2221	**Source:**	Cs137	**R.H.**	27%
Serial No.	182053	**Serial No.**	1680-03		
Probe:	44-10				
Serial No.	PR206815				

	Background Count (cpm)	Source Count (cpm)	H.V.
1	8286	628904	800
2	8252	638527	825
3	8350	646838	850
4	8515	651203	875
5	8672	652901	900
6	8380	654723	925
7	8041	656254	950
8	8692	655617	975
9	8951	656943	1000
10			1025
11			1050
12			1075
13			1100
14			1150
15			1200
16			1250

Form HPM/M-2-6-1
Daily Check Log for Ludlum Model 2221 with 44-10 Detector
Instrument 4

	Instrument Model:	2221			Source S/N:	Cs-137 sn: 547			
	Instrument S/N:	172053			Source DPM:	N/A			
	Detector Model:	44-10			Radiation Detected:	gamma			
	Detector S/N:	PR206815			Acceptable Range:	282,153 + 2σ			286,274 + 3σ
	Calibration Due:	11/15/05		CONTACT	(Refer to Penn E&R/HPM/M-2-1-1)	265,669 - 2σ			261,548 - 3σ
	Time	**Date**	**Background Count Rate**	**Source Count Rate**	**Net Source Count Rate**	**Technician**	**W/IN +/- 2σ**	**Batt check (volts)**	**W/IN +/- 3σ**
1	10:38	1/25/2005	9,540	282,595	273,055	DBW	YES	5.3	YES
	Comments:	Background 5 minute check. Source check 1 minute.							

Form HPM/M-2-6-1
Daily Check Log for Ludlum Model 2221 with 44-10 Detector
Instrument 4

Instrument Model:	2221
Instrument S/N:	172053
Detector Model:	44-10
Detector S/N:	PR206815
Calibration Due:	11/15/05

6 INCHES

Source S/N:	Cs-137 sn: 547
Source DPM:	N/A
Radiation Detected:	gamma
Acceptable Range: (Refer to Penn E&R/HPM/M-2-1-1)	9,545 + 2σ
	9,035 - 2σ

	Time	Date	Background Count Rate	Source Count Rate	Net Source Count Rate	Technician	W/IN +/- 2σ	Batt check (volts)	W/IN +/- 3σ
1	10:38	1/25/2005	9,540	18,963	9,423	DBW	YES	5.3	YES

Comments: Background 5 minute count. Source check 1 minute.

APPENDIX A-4-2

Ludlum Model 2360 Alpha-Beta Scaler/Rate Meter
with Model 43-68 100 cm² Gas Proportional Alpha-Beta Detector
Serial Nos. 193686 (meter) and PR190485 (detector)

Designer and Manufacturer of Scientific and Industrial Instruments

6129

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER KAISER ALUMINUM ORDER NO. 215373/281348

Mfg. Ludlum Measurements, Inc. Model 2360 Serial No. 193686

Mfg. Ludlum Measurements, Inc. Model 43-68 Serial No. PR-190485

Cal. Date 4-May-04 Cal Due Date 4-May-05 Cal. Interval 1 Year Meterface 202-855

heck mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 75 °F RH 28 % Alt 705.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck.	☑ Meter Zeroed	☐ Background Subtract	☐ Input Sens. Linearity
☐ F/S Resp. ck	☑ Reset ck.	☑ Window Operation	☑ Geotropism
☑ Audio ck.	☐ Alarm Setting ck.	☑ Batt. ck. (Min. Volt) 2.2 VDC	

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

strument Volt Set 1575 V

☑ HV Readout (2 points) Ref./Inst. 500 / 491 V Ref./Inst. 1500 / 1992 V

Firmware Version: 39010N24
Alpha Threshold: 120mv
Beta Threshold: 3.5mv
Beta Window: 50mv
Overload Checked But not set
Instrument calibrated with a 39" cable.
High voltage set with detector Connected

(EEPROM Settings)
User Time: 001.0
Alpha Alarm: 050000
Beta Alarm: 050000
A/B Alarm: 050000
Model 2360 Date: 4 May 04
Calibration Date Due: 4 May 05

COMMENTS:
Eff. for Th230 ≈ 35.5% 2pi, Background count 1cpm, Source count 1036cpm, Source Size 2910cpm
Eff. for Th232 ≈ 46.6% 2pi, Background count 1cpm, Source count 64cpm, Source Size 135cpm
Eff. for Tc99 ≈ 48.0% 2pi, Background count 93cpm, Source count 6865cpm, Source Size 14100cpm

oration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
x1000	400kcpm	400	400
x1000	100kcpm	100	100
x100	40kcpm	400	400
x100	10kcpm	100	100
x10	4kcpm	400	400
x10	1kcpm	100	100
x1	400kcpm	400	400
x1	100kcpm	100	100

*Uncertainty within ± 10% C.F. within ± 20% ALL Range(s) Calibrated Electronically

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
gital adout	400kcpm	39985(0)	39985(0)
	40kcpm	3999	3999
	4kcpm	400	400
	400cpm	40	40
	40cpm	4	4

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Log Scale			

lum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of er International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-1963

eference Instruments and/or Sources:

s-137 Gamma S/N ☐ 1152 ☐ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

pha S/N Th230 #5020-03/Th232 #3153 ☑ Beta S/N Tc99 SN: NT-EV ☐ Other

☑ ...1 500 S/N 50800 ☐ Oscilloscope S/N ☑ Multimeter S/N 83990502

Calibrated By: Charles Robb Date 4 May 04

Reviewed By: WJ Robbins Date 5 may 04

his certificate shall not be reproduced except in full, without the written approval of Ludlum Measurements, Inc.
ORM C225 11/24/2003

☐ AC Inst. ☐ Passed Dielectric (Hi-Pot) and Continuity Test

Designe and Manufacturer
of
Scientific and Industrial
Instruments

POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

9mr+0
6/29

Bench Test Data For Detector

Detector 43-68 Serial No. PR-190485 Order #. 215373/281348

Customer KAISER ALUMINUM Alpha Input Sensitivity 120 mV

Counter 2360 Serial No. 193686 Beta Input Sensitivity 3.5 mV

Count Time 1 Minute Beta Window 50 mV

Other _____ Distance Source to Detector Surface

High Voltage	Background Alpha	Background Beta	Isotope Th230 Size 2910 cpm Alpha	Isotope Th230 Size 2910 cpm Beta	Isotope Th232 Size 135 cpm Alpha	Isotope Th232 Size 135 cpm Beta	Isotope Tc 99 Size 14100 cpm Alpha	Isotope Tc 99 Size 14100 cpm Beta
1525	2	99	943	411	51	185	0	6731
1550	0	124	1116	428	47	197	0	7566
1575	1	93	1036	500	64	251	1	6865
1600	2	208	1075	526	55	306	18	7471
1625	0	202	1174	483	55	287	149	6722

☑ Gas Proportional detector count rate decreased ≤ 10% after 15 hour static test using 39" cable.

☐ Gas proportional detector count rate decreased ≤ 10% after 5 hour static test using 39" cable and alpha/beta counter.

Signature Charles Lisk Date 4 May 04

FORM C4B 04/09/2003

Form HPM/M-2-8-1
Daily Check Log for Ludlum Model 2360 with 43-68 Detector
Instrument 2 Alpha

Instrument/SN: Ludlum Model **2360 193686**					*Check Source(s) Used:* Th-230, S/N 5053-03						
Detector/SN: Model 43-68 /PR190485											
EFF %: α= 17.78 % 4π					*source check acceptance criteria*		α				
CALIB. SOURCE USED: Th-230					**Average (NCPM):**		2,564				
DATE OF CALIB.: **5/4/2004**					**+2 sigma:**		2,655				
CALIB. DUE DATE: **5/4/2005**					**-2 sigma:**		2,474				
PERFORMED BY: **Ludlum Measurements Inc.**					**+3 sigma:**		2,700				
					-3 sigma:		2,429				
TECHNICIAN'S NAME		ALPHA/ BETA	RESPONSE CHECK	DATE	TIME	60 min Bkgrd (cpm)	1 min gross (cpm)	1 min net (cpm)	within +/- 2 sigma	within +/- 3 sigma	<10% drop
DBW	1	Alpha	SAT	1/27/2005	9:50	1.50	2,502	2,501	YES	YES	NA
DBW	2	Alpha	SAT	1/27/2005	16:14	0.58	2,482	2,481	YES	YES	YES
DBW	3	Alpha	SAT	1/31/2005	13:43	1.40	2,532	2,531	YES	YES	NA
DBW	4	Alpha	SAT	1/31/2005	17:38	1.62	2,493	2,491	YES	YES	YES
DBW	5	Alpha	SAT	2/1/2005	9:58	1.08	2,504	2,503	YES	YES	NA
DBW	6	Alpha	SAT	2/1/2005	8:22	0.83	2,494	2,493	YES	YES	YES

APPENDIX A-5

SURVEY UNIT KAISER-FSSFOA-005

Appendix A-5, Table A-5-1
Final Status Survey Instrument Summary
Survey Unit Kaiser-FSSFOA-005
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Instrument Model and Detector Model/Type	Instrument Serial Number	Detector Serial Number	Calibration Period	In-Service Period Survey of Unit Kaiser-FSSFOA-005	Usage
Ludlum 2221 Scaler/ Rate Meter with 44-10 2" X 2" Nal Scintillation Gamma Detector	86314	PR157366	01/20/05 to 01/20/06	05/16/05	Field analysis, high-energy gamma detection - Instrument was used to evaluate remediation progress and scan land areas for the Final Status Survey.
Ludlum 2221 Scaler/ Rate Meter with 44-10 2" X 2" Nal Scintillation Gamma Detector	216521	PR226935	05/17/05 to 05/17/06	06/03/05	Field analysis, high-energy gamma detection - Instrument was used to evaluate remediation progress and scan land areas for the Final Status Survey.

APPENDIX A-5-1

Ludlum Model 2221 Scaler/Rate Meter
With Model 44-10 2-inch x 2-inch NaI Scintillation Gamma Detector
Serial Nos. 86314 (meter) and PR157366 (detector)

Certificate of Calibration

Ratemeter / Scaler Certificate of Calibration

ERG
Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

LMS
1018

Manufacturer: Ludlum Model: 2221 Serial No.: 86314 (EDI #529)

All Ranges Calibrated Electronically; Ludlum Pulser Generator S.N. 97743

Reset ☑ Audio ☑ Mechanical ☑ Battery ☑ Window Operation ☑

High Voltage 500v ☑ 1000v ☑ 1500v ☑

Instrument found within tolerance (+/- 10%) Yes ☑ No ☐

Reference Setting	Ratemeter	Instrument "As found reading"
400 Kcpm	400 KCPM	+/- 10 %
100 Kcpm	100 KCPM	
40 Kcpm	40 KCPM	
10 Kcpm	10 KCPM	
4 Kcpm	4 KCPM	
1 Kcpm	1 KCPM	
400 cpm	400 CPM	
100 cpm	100 CPM	

Reference Setting	Integrated Counts. (1-minute count)	Log Scale Count Rate	Instrument "As found reading"
400 Kcpm	399040	400 KCPM	+/- 10 %
40 Kcpm	39909	40 KCPM	
4 Kcpm	3988	4 KCPM	
400 cpm	400	400 CPM	

Calibrated By: Charles P. Zu Calibration Date: 1/20/05

Calibration Due: 1/20/06

Reviewed By: Kenneth R. Bahr Date: 1/20/05

Certificate of Calibration

Voltage Plateau Form ZMS 1015

ERG
Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

Detector Mfg.: Ludlum Model: 44-10 Serial No.: PR157366 (EDI# 321)

Counter Mfg.: Ludlum Model: 2221 Serial No.: 86314 (EDI # 528)

Counter Threshold Setting: 10 mV Geometry / Distance to source: 6-inches

Source : ☐ Th230 @ 13,500 dpm sn: 4098-03 ☐ Tc99 @ 18,100 dpm sn: 4099-03

☑ Cs137 @ 6.5 µCi sn: 4097-03 ☐ Other: _____

Count Time: 1 minute(s) * CAL'D w/ 5' C-CABLE

High Voltage	Gross Source Counts	Background Counts
600	33506	
700	63766	
800	76783	
900	82564	
1000	83763	
1100	84290	
950	83038	11119

Recommended Operating Voltage: 950 volts

Calibrated By: Clark P. Tu Calibration Date: 1/20/05

Calibration Due: 1/20/06

Reviewed By: Kevin R Baker Date: 1/20/05

Form HPM/M-2-6-1
Daily Check Log for Ludlum Model 2221 with 44-10 Detector
Instrument 6

Instrument Model:	2221
Instrument S/N:	86314
Detector Model:	44-10
Detector S/N:	PR157366
Calibration Due:	1/20/06

CONTACT

Source S/N:	Cs-137 sn: 547	
Source DPM:	N/A	
Radiation Detected:	gamma	
Acceptable Range: (Refer to Penn E&R/HPM/M-2-1-1)	282,107 + 2σ	284,447 + 3σ
	272,748 - 2σ	270,407 - 3σ

	Time	Date	Background Count Rate	Source Count Rate	Net Source Count Rate	Technician	W/IN +/- 2σ	Batt check (volts)	W/IN +/- 3σ
1	6:15	5/16/2005	9,719	287,970	278,211	DD	YES	7.0	YES

Comments: Background 5 minute count. Source count 1 minute.

Form HPM/M-2-6-1
Daily Check Log for Ludlum Model 2221 with 43-68 Detector
Instrument 6

Instrument Model:	2221
Instrument S/N:	86314
Detector Model:	44-10
Detector S/N:	PR157366
Calibration Due:	1/20/06

6 INCHES

Source S/N:	Cs-137 sn: 547
Source DPM:	N/A
Radiation Detected:	gamma
Acceptable Range: (Refer to Penn E&R/HPM/M-2-1-1)	9,741 + 2σ
	9,310 - 2σ

	Time	Date	Background Count Rate	Source Count Rate	Net Source Count Rate	Technician	W/IN +/- 2σ	Batt check (volts)	W/IN +/- 3σ
1	6:15	5/16/2005	9,719	19,143	9,424	DD	YES	7.0	YES

Comments: Background 5 minute count. Source count 1 minute.

APPENDIX A-5-2

Ludlum Model 2221 Scaler/Rate Meter
With Model 44-10 2-inch x 2-inch NaI Scintillation Gamma Detector
Serial Nos. 216521 (meter) and PR226935 (detector)

Designer and Manufacturer of Scientific and Industrial Instruments

Jones 6/24

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER WAYPOINT TECHNOLOGY GROUP ORDER NO. 235778

Ludlum Measurements, Inc. Model 2221 Serial No. 216521

Mfg. Ludlum Measurements, Inc. Model 44-10 Serial No. PR226935

Cal. Date 17-May-05 Cal Due Date 17-May-06 Cal. Interval 1 Year Meterface 202-159

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 71 °F RH 42 % Alt 701.8 mm Hg

☑ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☑ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 4.4 VDC

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set Comments V Input Sens. Comment mV Det. Oper. Comments V at Comment mV Threshold Dial Ratio ____ = ____ mV

☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 2000 / 1998 V

COMMENTS:

	Peak settings	Gross Counts
High Voltage:	625v	950
Threshold dial:	642	100 (10mv)
Window dial:	40	n/a
Window Position:	"IN"	"OUT"
Resolution for Cs137:	≈9.1 %	n/a

Model 2221 currently set for peaking.

High voltage set with detector connected.

Firmware:261072

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 1K	400kcpm		400
X 1K	100kcpm		100
X 100	40kcpm		400
X 100	10kcpm		100
X 10	4kcpm		400
X 10	1kcpm		100
X 1	400cpm		400
X 1	100cpm		40

*Uncertainty within ± 10% C.F. within ± 20% ALL Range(s) Calibrated Electronically

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout	400kcpm		40038 (0)	Log Scale	500kcpm		475k
	40kcpm		4006 (0)		50kcpm		50k
	4kcpm		400 (0)		5kcpm		5k
	400cpm		40 (0)		500cpm		590
	40cpm		4 (0)		50cpm		52

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☐ G112 ☐ M565 ☐ 5105 ☐ T1006 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ____ ☐ Beta S/N ____ ☑ Other Am241~1.66uCi

☑ RO-20 S/N 38120 ☐ Oscilloscope S/N ____ ☑ Multimeter S/N 78401030

Calibrated By: Lonnie Ortega Date 17-May-05

Reviewed By: Gloria Ortega Date 17 May 05

This certificate shall not be reproduced except in full, without the written approval of Ludlum Measurements, Inc.

AC Inst. ☐ Passed Dielectric (Hi-Pot) and Continuity Test

Designer and Manufacturer
of
Scientific and Industrial
Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

Bench Test Data For Detector

Detector 44-10 Serial No. PR 226935

Customer WAYPOINT TECHNOLOGY GROUP Order #. 235778

Counter 2221 Serial No. 216521 Counter Input Sensitivity 35 mV

Count Time 6 Second Distance Source to Detector ~2cm

Other

High Voltage	Background	Isotope Am241 Size ~1.66 µCi	Isotope Size	Isotope Size	Isotope Size
800	466	11281			
850	510	11728			
900	529	11637			
950	456	11958			
1000	530	11854			
1050	555	11730			
1100	601	11887			

Signature Jessica Ortega Date 17-May-05

Form HPM/M-2-6-1
Daily Check Log for Ludlum Model 2221 with 43-10 Detector
Instrument 7

	Instrument Model:	2221			Source S/N:	Cs-137 sn: 547			
	Instrument S/N:	216521			Source DPM:	N/A			
	Detector Model:	44-10			Radiation Detected:	gamma			
	Detector S/N:	PR226935			Acceptable Range:	287,854 + 2σ			293,373 + 3σ
	Calibration Due:	5/17/06	CONTACT		(Refer to Penn E&R/HPM/M-2-1-1)	265,777 - 2σ			260,259 - 3σ

	Time	Date	Background Count Rate	Source Count Rate	Net Source Count Rate	Technician	W/IN +/- 2σ	Batt check (volts)	W/IN +/- 3σ
1	7:25	6/3/2005	9,367	280,795	271,428	DD	2σ Calculation	6.0	YES

Comments: Background 5 minute count. Source check 1 minute count.

Form HPM/M-2-6-1
Daily Check Log for Ludlum Model 2221 with 44-10 Detector
Instrument 7

Instrument Model:	2221
Instrument S/N:	216521
Detector Model:	44-10
Detector S/N:	PR226935
Calibration Due:	5/17/06

6 INCHES

Source S/N:	Cs-137 sn: 547
Source DPM:	N/A
Radiation Detected:	gamma
Acceptable Range: (Refer to Penn E&R/HPM/M-2-1-1)	9,617 + 2σ
	9,096 - 2σ

	Time	Date	Background Count Rate	Source Count Rate	Net Source Count Rate	Technician	W/IN +/- 2σ	Batt check (volts)	W/IN +/- 3σ
1	7:25	6/3/2005	9,367	18,543	9,176	DD	2σ Calc	6.0	YES

9,747 + 3σ
8,967 - 3σ

Comments: Background 5 minute count. Source check 1 minute count.

APPENDIX A-6

SURVEY UNIT KAISER-FSSFOA-006

Appendix A-6, Table A-6-1
Final Status Survey Instrument Summary
Survey Unit Kaiser-FSSFOA-006
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Instrument Model and Detector Model/Type	Instrument Serial Number	Detector Serial Number	Calibration Period	In-Service Period Survey of Unit Kaiser-FSSFOA-006	Usage
Ludlum 2221 Scaler/ Rate Meter with 44-10 2" X 2" NaI Scintillation Gamma Detector	86314	PR157366	01/20/05 to 01/20/06	07/20/05	Field analysis, high-energy gamma detection - Instrument was used to evaluate remediation progress and scan land areas for the Final Status Survey.
Ludlum 2221 Scaler/ Rate Meter with 44-10 2" X 2" NaI Scintillation Gamma Detector	216521	PR226935	05/17/05 to 05/17/06	06/28/05 to 07/20/05	Field analysis, high-energy gamma detection - Instrument was used to evaluate remediation progress and scan land areas for the Final Status Survey.
Ludlum 2360 Alpha-Beta Scaler /Rate Meter with 43-68 100cm^2 Gas Proportional Alpha-Beta Detector	193686	PR190485	05/05/05 to 05/05/06	07/23/05 to 01/14/06	Simultaneous alpha-beta counting and discrimination - Instrument was used to survey embedded structures.

APPENDIX A-6-1

Ludlum Model 2221 Scaler/Rate Meter
With Model 44-10 2-inch x 2-inch NaI Scintillation Gamma Detector
Serial Nos. 86314 (meter) and PR157366 (detector)

Certificate of Calibration

Ratemeter / Scaler Certificate of Calibration

ERG
Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

LMS
1018

Manufacturer: Ludlum Model: 2221 Serial No.: 86314 (EDI #529)

All Ranges Calibrated Electronically; Ludlum Pulser Generator S.N. 97743

Reset ☑ Audio ☑ Mechanical ☑ Battery ☑ Window Operation ☑

High Voltage 500v ☑ 1000v ☑ 1500v ☑

Instrument found within tolerance (+/- 10%) Yes ☑ No ☐

Reference Setting	Ratemeter	Instrument "As found reading"
400 Kcpm	400 KCPM	+/- 10 %
100 Kcpm	100 KCPM	
40 Kcpm	40 KCPM	
10 Kcpm	10 KCPM	
4 Kcpm	4 KCPM	
1 Kcpm	1 KCPM	
400 cpm	400 CPM	
100 cpm	100 CPM	

Reference Setting	Integrated Counts (1-minute count)	Log Scale Count Rate	Instrument "As found reading"
400 Kcpm	399040	400 KCPM	+/- 10 %
40 Kcpm	39909	40 KCPM	
4 Kcpm	3988	4 KCPM	
400 cpm	400	400 CPM	

Calibrated By: Charles P. Fu Calibration Date: 1/20/05

Calibration Due: 1/20/06

Reviewed By: Kenneth C. Baker Date: 1/20/05

Certificate of Calibration

Voltage Plateau Form ZMS 1615

ERG
Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

Detector Mfg.: Ludlum Model: 44-10 Serial No.: PR157366 (EDI# 321)

Counter Mfg.: Ludlum Model: 2221 Serial No.: 86314 (EDI # 578)

Counter Threshold Setting: 10 mV Geometry / Distance to source: 6-inches

Source : ☐ Th230 @ 13,500 dpm sn: 4098-03 ☐ Tc99 @ 18,100 dpm sn: 4099-03

☑ Cs137 @ 6.5 µCi sn: 4097-03 ☐ Other:

Count Time: 1 minute(s) * CAL'D w/ 5' C-CABLE

High Voltage	Gross Source Counts	Background Counts
600	33506	
700	63766	
800	76783	
900	82564	
1000	83763	
1100	84290	
950	83038	11119

Recommended Operating Voltage: 950 volts

Calibrated By: Clark P. Jr Calibration Date: 1/20/05

Calibration Due: 1/20/06

Reviewed By: Kenneth R Barker Date: 1/20/05

Form HPM/M-2-6-1
Daily Check Log for Ludlum Model 2221 with 44-10 Detector
Instrument 6

	Instrument Model:	2221			Source S/N:	Cs-137 sn: 547			
	Instrument S/N:	86314			Source DPM:	N/A			
	Detector Model:	44-10			Radiation Detected:	gamma			
	Detector S/N:	PR157366			Acceptable Range:	282,107 + 2σ		284,447 + 3σ	
	Calibration Due:	1/20/06	CONTACT		(Refer to Penn E&R/HPM/M-2-1-1)	272,748 - 2σ		270,407 - 3σ	

	Time	Date	Background Count Rate	Source Count Rate	Net Source Count Rate	Technician	W/IN +/- 2σ	Batt check (volts)	W/IN +/- 3σ
1	10:00	7/20/2005	9,683	289,133	279,450	DD	YES	7.0	YES

Comments: Background 5 minute count. Source count 1 minute.

Form HPM/M-2-6-1
Daily Check Log for Ludlum Model 2221 with 44-10 Detector
Instrument 6

Instrument Model:	2221
Instrument S/N:	86314
Detector Model:	44-10
Detector S/N:	PR157366
Calibration Due:	1/20/06

6 INCHES

Source S/N:	Cs-137 sn: 547	
Source DPM:	N/A	
Radiation Detected:	gamma	
Acceptable Range: (Refer to Penn E&R/HPM/M-2-1-1)	9,741 + 2σ	9,849 + 3σ
	9,310 - 2σ	9,201 - 3σ

	Time	Date	Background Count Rate	Source Count Rate	Net Source Count Rate	Technician	W/IN +/- 2σ	Batt check (volts)	W/IN +/- 3σ
1	10:00	7/20/2005	9,683	19,386	9,703	DD	YES	7.0	YES

Comments: Background 5 minute count. Source count 1 minute.

APPENDIX A-6-2

Ludlum Model 2221 Scaler/Rate Meter
With Model 44-10 2-inch x 2-inch NaI Scintillation Gamma Detector
Serial Nos. 216521 (meter) and PR226935 (detector)

Designer and Manufacturer of Scientific and Industrial Instruments

Jones 6/24

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER WAYPOINT TECHNOLOGY GROUP ORDER NO. 235778

Ludlum Measurements, Inc. Model 2221 Serial No. 216521

Mfg. Ludlum Measurements, Inc. Model 44-10 Serial No. PR226935

Cal. Date 17-May-05 Cal Due Date 17-May-06 Cal. Interval 1 Year Meterface 202-159

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 71 °F RH 42 % Alt 701.8 mm Hg

☑ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☑ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 4.4 VDC

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set Comments V Input Sens. Comment mV Det. Oper. Comments V at Comment mV Threshold Dial Ratio ____ = ____ mV

☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 2000 / 1998 V

COMMENTS:

	Peak settings	Gross Counts
High Voltage:	625v	950
Threshold dial:	642	100(10mv)
Window dial:	40	n/a
Window Position:	"IN"	"OUT"
Resolution for Cs137:	≈9.1 %	n/a

Model 2221 currently set for peaking.

High voltage set with detector connected.

Firmware:261072

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 1K	400kcpm		400
X 1K	100kcpm		100
X 100	40kcpm		400
X 100	10kcpm		100
X 10	4kcpm		400
X 10	1kcpm		100
X 1	400cpm		400
X 1	100cpm		40

*Uncertainty within ± 10% C.F. within ± 20%

ALL Range(s) Calibrated Electronically

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout	400kcpm		40038 (0)
	40kcpm		40006 (0)
	4kcpm		400 (0)
	400cpm		40 (0)
	40cpm		4 (0)

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Log Scale	500kcpm		475k
	50kcpm		50k
	5kcpm		5k
	500cpm		510
	50cpm		52

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☐ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ____ ☐ Beta S/N ____ ☑ Other Am241-1.66uCi

☑ Ratemeter 500 S/N 38120 ☐ Oscilloscope S/N ____ ☑ Multimeter S/N 78401030

Calibrated By: Lonna Ortega Date 17-May-05

Reviewed By: Gloria Ortega Date 17 May 05

This certificate shall not be reproduced except in full, without the written approval of Ludlum Measurements, Inc.

AC Inst. ☐ Passed Dielectric (Hi-Pot) and Continuity Test

Designer and Manufacturer
of
Scientific and Industrial
Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

Bench Test Data For Detector

Detector 44-10 Serial No. PR 226935

Customer WAYPOINT TECHNOLOGY GROUP Order #. 235778

Counter 2221 Serial No. 216521 Counter Input Sensitivity 35 mV

Count Time 1 Second Distance Source to Detector ~2cm

Other

High Voltage	Background	Isotope Am241 Size ~1.66 µCi	Isotope Size	Isotope Size	Isotope Size
800	466	11281			
850	510	11728			
900	529	11637			
950	456	11958			
1000	530	11854			
1050	555	11730			
1100	601	11887			

Signature Steven Ashley Date 17-May-05

Form HPM/M-2-6-1
Daily Check Log for Ludlum Model 2221 with 44-10 Detector
Instrument 7

Instrument Model:	2221
Instrument S/N:	216521
Detector Model:	44-10
Detector S/N:	PR226935
Calibration Due:	5/17/06

CONTACT

Source S/N:	Cs-137 sn: 547		
Source DPM:	N/A		
Radiation Detected:	gamma		
Acceptable Range: (Refer to Penn E&R/HPM/M-2-1-1)	287,854 + 2σ		293,373 + 3σ
	265,777 - 2σ		260,259 - 3σ

	Time	Date	Background Count Rate	Source Count Rate	Net Source Count Rate	Technician	W/IN +/- 2σ	Batt check (volts)	W/IN +/- 3σ
1	6:55	6/28/2005	9,462	290,461	280,999	DD	YES	5.8	YES
2	6:50	7/13/2005	9,917	292,505	282,648	DD	YES	5.4	YES
3	6:35	7/15/2005	9,221	290,583	281,362	DD	YES	5.6	YES
4	6:25	7/20/2005	9,551	294,969	285,418	DD	YES	5.5	YES

Comments: Background 5 minute count. Source check 1 minute count.

Form HPM/M-2-6-1
Daily Check Log for Ludlum Model 2221 with 44-10 Detector
Instrument 7

Instrument Model:	2221
Instrument S/N:	216521
Detector Model:	44-10
Detector S/N:	PR226935
Calibration Due:	5/17/06

6 INCHES

Source S/N:	Cs-137 sn: 547		
Source DPM:	N/A		
Radiation Detected:	gamma		
Acceptable Range: (Refer to Penn E&R/HPM/M-2-1-1)	9,943 + 2σ		10,202 + 3σ
	8,908 - 2σ		8,648 - 3σ

	Time	Date	Background Count Rate	Source Count Rate	Net Source Count Rate	Technician	W/IN +/- 2σ	Batt check (volts)	W/IN +/- 3σ
1	6:55	6/28/2005	9,462	18,690	9,228	DD	YES	5.8	YES
2	6:50	7/13/2005	9,917	19,537	9,620	DD	YES	5.4	YES
3	6:35	7/15/2005	9,221	18,926	9,750	DD	YES	5.6	YES
4	6:25	7/20/2005	9,551	18,767	9,216	DD	YES	5.5	YES

Comments: Background 5 minute count. Source check 1 minute count.

APPENDIX A-6-3

Ludlum Model 2360 Alpha-Beta Scaler/Rate Meter with Model 43-68 100 cm² Gas Proportional Alpha-Beta Detector Serial Nos. 193686 (meter) and PR190485 (detector)

5 mR
10/26

Certificate of Calibration

Ratemeter Certificate of Calibration

ERG
Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

Manufacturer: Ludlum Model: 2360 Serial No.: 193686

All Ranges Calibrated Electronically; Ludlum Pulser Generator S.N. 97743

Reset ☑ Audio ☑ Mechanical ☑ Battery ☑

High Voltage 500v ☑ 1000v ☑ 1500v ☑

Instrument found within tolerance (+/- 10%) Yes ☑ No ☐

Alpha Threshold Setting: 120 mV

Beta Threshold Setting: 3.5 mV Beta Window: 50 mV

Reference Setting	Ratemeter	Instrument "As found reading"
400 Kcpm	400Kcpm	+/-10%
100 Kcpm	100Kcpm	
40 Kcpm	40Kcpm	
10 Kcpm	10Kcpm	
4 Kcpm	4Kcpm	
1 Kcpm	1Kcpm	
400 cpm	400cpm	
100 cpm	100cpm	

Reference Setting	Integrated Counts (1-minute count)	Instrument "As found reading"
400 Kcpm	400123 cpm	+/-10%
40 Kcpm	39742 cpm	
4 Kcpm	3965 cpm	
400 cpm	399 cpm	

Calibrated By: [signature] Calibration Date: 05/05/05

Calibration Due: 05/05/06

Reviewed By: [signature] Date: 5/5/05

Certificate of Calibration

Voltage Plateau Form

ERG
Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

Detector Mfg.: Ludlum Model: 43-68 Serial No.: PR 190485

Counter Mfg.: Ludlum Model: 2360 Serial No.: 193686

Alpha Threshold Setting: 120 mV

Beta Threshold Setting: 3.5 mV Beta Window: 50 mV

Alpha Source : ☑ [redacted] ☐ Other:

Beta Source: ☑ [redacted] ☐ Other:

Geometry / Distance to source: CONTACT

Count Time: 1 minute(s)

High Voltage	Alpha Source Counts		Beta Source Counts		Background Counts	
	Alpha	Beta	Alpha	Beta	Alpha	Beta
1425	1286	371	3	906	0	23
1450	1747	801	3	2297	2	52
1475	2038	954	3	2927	3	76
→ 1500	2219	964	1	3685	3	110
1525	2476	1079	6	4525	5	194
1550	2663	1108	15	4573	3	272
1575	2792	1058	48	4225	7	333

Recommended Operating Voltage: 1500 volts

Calibrated By: [signature] Calibration Date: 05/05/05

Calibration Due: 05/05/06

Reviewed By: [signature] Date: 5/5/05

Form HPM/M-2-8-1
Daily Check Log for Ludlum Model 2360 with 43-68 Detector
Instrument 4 Alpha

Instrument/SN: Ludlum Model **2360** **193686**	*Check Source(s) Used: Th-230, S/N 5053-03*		
Detector/SN: Model 43-68/PR 190485			
EFF %: α=16.8% 4π	*source check acceptance criteria*		α
CALIB. SOURCE USED: Th-230	**Average (NCPM):**		1,919
DATE OF CALIB.: **5/5/2005**	**+2 sigma:**		2,019
CALIB. DUE DATE: **5/5/2006**	**-2 sigma:**		1,819
PERFORMED BY: **ERG**	**+3 sigma:**		2,069
	-3 sigma:		1,769

TECHNICIAN'S NAME		ALPHA/ BETA	RESPONSE CHECK	DATE	TIME	60 min Bkgrd (cpm)	1 min gross (cpm)	1 min net (cpm)	within +/- 2 sigma	within +/- 3 sigma
DBW	1	Alpha	SAT	7/23/2005	11:50	0.93	NA	NA	NA	NA
DBW	2	Alpha	SAT	7/23/2005	12:05	0.93	1,861	1,860	YES	YES
DBW	3	Alpha	SAT	7/23/2005	14:30	1.53	1,871	1,870	YES	YES
DBW	4	Alpha	SAT	1/14/2006	15:04	1.30	1,920	1,919	YES	YES

APPENDIX A-7

SURVEY UNIT KAISER-FSSFOA-007

Appendix A-7, Table A-7-1
Final Status Survey Instrument Summary
Survey Unit Kaiser-FSSFOA-007
Thorium Remediation project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Instrument Model and Detector Model/Type	Instrument Serial Number	Detector Serial Number	Calibration Period	In-Service Period Survey of Unit Kaiser-FSSFOA-007	Usage
Ludlum 2360 Alpha-Beta Scaler /Rate Meter with 43-68 100cm^2 Gas Proportional Alpha-Beta Detector	193686	PR190485	05/05/05 to 05/05/06	06/29/05 to 07/09/05	Simultaneous alpha-beta counting and discrimination - Instrument was used to survey embedded structures.

APPENDIX A-7-1

Ludlum Model 2360 Alpha-Beta Scaler/Rate Meter with Model 43-68 100 cm^2 Gas Proportional Alpha-Beta Detector Serial Nos. 193686 (meter) and PR190485 (detector)

5 mR
10/26

Certificate of Calibration

Ratemeter Certificate of Calibration

ERG
Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

Manufacturer: Ludlum Model: 2360 Serial No.: 193686

All Ranges Calibrated Electronically; Ludlum Pulser Generator S.N. 97743

Reset ☑ Audio ☑ Mechanical ☑ Battery ☑

High Voltage 500v ☑ 1000v ☑ 1500v ☑

Instrument found within tolerance (+/- 10%) Yes ☑ No ☐

Alpha Threshold Setting: 120 mV

Beta Threshold Setting: 3.5 mV Beta Window: 50 mV

Reference Setting	Ratemeter	Instrument "As found reading"
400 Kcpm	400Kcpm	+/- 10%
100 Kcpm	100Kcpm	
40 Kcpm	40Kcpm	
10 Kcpm	10Kcpm	
4 Kcpm	4Kcpm	
1 Kcpm	1Kcpm	
400 cpm	400cpm	
100 cpm	100cpm	

Reference Setting	Integrated Counts (1-minute count)	Instrument "As found reading"
400 Kcpm	400123cpm	+/- 10%
40 Kcpm	39742cpm	
4 Kcpm	3965 cpm	
400 cpm	399cpm	

Calibrated By: [signature] Calibration Date: 05/05/05

Calibration Due: 05/05/06

Reviewed By: [signature] Date: 5/5/05

Certificate of Calibration

Voltage Plateau Form

ERG
Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

Detector Mfg.: Ludlum Model: 43-68 Serial No.: PR 190485

Counter Mfg.: Ludlum Model: 2360 Serial No.: 193686

Alpha Threshold Setting: 120 mV

Beta Threshold Setting: 3.5 mV Beta Window: 50 mV

Alpha Source : ☑ [redacted] Other:

Beta Source: ☑ [redacted] Other:

Geometry / Distance to source: CONTACT

Count Time: 1 minute(s)

High Voltage	Alpha Source Counts		Beta Source Counts		Background Counts	
	Alpha	Beta	Alpha	Beta	Alpha	Beta
1425	1286	371	3	906	0	23
1450	1747	801	3	2297	2	52
1475	2038	954	3	2927	3	72
→ 1500	2219	964	1	3685	3	110
1525	2476	1079	6	4525	5	194
1550	2663	1108	15	4573	3	272
1575	2792	1058	48	4225	7	333

Recommended Operating Voltage: 1500 volts

Calibrated By: [signature] Calibration Date: 05/05/05

Calibration Due: 05/05/06

Reviewed By: [signature] Date: 5/5/05

Form HPM/M-2-8-1
Daily Check Log for Ludlum Model 2360 with 43-68 Detector
Instrument 4 Alpha

Instrument/SN: Ludlum Model **2360** **193686**	*Check Source(s) Used: Th-230, S/N 5053-03*		
Detector/SN: Model 43-68/PR 190485			
EFF %: α =16.8% 4π	*source check acceptance criteria*		α
CALIB. SOURCE USED: Th-230	**Average (NCPM):**		1,919
DATE OF CALIB.: **5/5/2005**	**+2 sigma:**		2,019
CALIB. DUE DATE: **5/5/2006**	**-2 sigma:**		1,819
PERFORMED BY: **ERG**	**+3 sigma:**		2,069
	-3 sigma:		1,769

TECHNICIAN'S NAME		ALPHA/ BETA	RESPONSE CHECK	DATE	TIME	60 min Bkgrd (cpm)	1 min gross (cpm)	1 min net (cpm)	within +/- 2 sigma	within +/- 3 sigma	<10% drop
DD	1	Alpha	SAT	6/29/2005	6:40	0.80	1,779	1,778	NO	YES	NA
DD	2	Alpha	SAT	6/29/2005	13:10	1.80	1,897	1,895	YES	YES	YES
DD	3	Alpha	SAT	7/9/2005	7:55	0.95	1,957	1,956	YES	YES	NA
DD	4	Alpha	SAT	7/9/2005	9:25	1.20	1,852	1,851	YES	YES	YES

APPENDIX A-8

SURVEY UNIT KAISER-FSSFOA-008

Appendix A-8, Table A-8-1
Final Status Survey Instrument Summary
Survey Unit Kaiser-FSSFOA-008
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Instrument Model and Detector Model/Type	Instrument Serial Number	Detector Serial Number	Calibration Period	In-Service Period Survey of Unit Kaiser-FSSFOA-008	Usage
Ludlum 2360 Alpha-Beta Scaler /Rate Meter with 43-68 100cm^2 Gas Proportional Alpha-Beta Detector	193686	PR190485	05/05/05 to 05/05/06	07/21/05 to 07/27/05	Field analysis, high-energy gamma detection - Instrument was used to evaluate remediation progress and scan land areas for the Final Status Survey.

APPENDIX A-8-1

Ludlum Model 2360 Alpha-Beta Scaler/Rate Meter with Model 43-68 100 cm^2 Gas Proportional Alpha-Beta Detector Serial Nos. 193686 (meter) and PR190485 (detector)

5 mL
10/26

Certificate of Calibration

Ratemeter Certificate of Calibration

ERG
Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

Manufacturer: Ludlum Model: 2360 Serial No.: 193686

All Ranges Calibrated Electronically; Ludlum Pulser Generator S.N. 97743

Reset ☑ Audio ☑ Mechanical ☑ Battery ☑

High Voltage 500v ☑ 1000v ☑ 1500v ☑

Instrument found within tolerance (+/- 10%) Yes ☑ No ☐

Alpha Threshold Setting: 120 mV

Beta Threshold Setting: 3.5 mV Beta Window: 50 mV

Reference Setting	Ratemeter	Instrument "As found reading"
400 Kcpm	400Kcpm	+/-10%
100 Kcpm	100Kcpm	
40 Kcpm	40Kcpm	
10 Kcpm	10Kcpm	
4 Kcpm	4Kcpm	
1 Kcpm	1Kcpm	
400 cpm	400cpm	
100 cpm	100cpm	

Reference Setting	Integrated Counts (1-minute count)	Instrument "As found reading"
400 Kcpm	400123cpm	+/-10%
40 Kcpm	39742cpm	
4 Kcpm	3965 cpm	
400 cpm	399cpm	

Calibrated By: [signature] Calibration Date: 05/05/05

Calibration Due: 05/05/06

Reviewed By: [signature] Date: 5/5/05

Certificate of Calibration

Voltage Plateau Form

ERG
Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

Detector Mfg.: Ludlum Model: 43-68 Serial No.: PR 190485

Counter Mfg.: Ludlum Model: 2360 Serial No.: 193686

Alpha Threshold Setting: 120 mV

Beta Threshold Setting: 3.5 mV Beta Window: 50 mV

Alpha Source : ☑ [redacted] ☐ Other:

Beta Source: ☑ [redacted] ☐ Other:

Geometry / Distance to source: CONTACT

Count Time: 1 minute(s)

High Voltage	Alpha Source Counts		Beta Source Counts		Background Counts	
	Alpha	Beta	Alpha	Beta	Alpha	Beta
1425	1286	371	3	906	0	23
1450	1747	801	3	2297	2	52
1475	2038	954	3	2927	3	76
→ 1500	2219	964	1	3685	3	110
1525	2476	1079	6	4525	5	194
1550	2663	1108	15	4573	3	272
1575	2792	1058	48	4225	7	333

Recommended Operating Voltage: 1500 volts

Calibrated By: [signature] Calibration Date: 05/05/05

Calibration Due: 05/05/06

Reviewed By: [signature] Date: 5/5/05

Form HPM/M-2-8-1
Daily Check Log for Ludlum Model 2360 with 43-68 Detector
Instrument 4 Alpha

Instrument/SN: Ludlum Model **2360** **193686**	*Check Source(s) Used: Th-230, S/N 5053-03*		
Detector/SN: Model 43-68/PR 190485			
EFF %: α=16.8% 4π	*source check acceptance criteria*		α
CALIB. SOURCE USED: Th-230	**Average (NCPM):**		1,919
DATE OF CALIB.: **5/5/2005**	**+2 sigma:**		2,019
CALIB. DUE DATE: **5/5/2006**	**-2 sigma:**		1,819
PERFORMED BY: **ERG**	**+3 sigma:**		2,069
	-3 sigma:		1,769

TECHNICIAN'S NAME		ALPHA/ BETA	RESPONSE CHECK	DATE	TIME	60 min Bkgrd (cpm)	1 min gross (cpm)	1 min net (cpm)	within +/- 2 sigma	within +/- 3 sigma	<10% drop
DD	1	Alpha	SAT	7/21/2005	13:35	1.40	1,874	1,873	YES	YES	NA
DD	2	Alpha	SAT	7/21/2005	15:45	1.10	1,880	1,879	YES	YES	YES
DBW	3	Alpha	SAT	7/23/2005	11:50	0.93	NA	NA	NA	NA	NA
DBW	4	Alpha	SAT	7/23/2005	12:05	0.93	1,861	1,860	YES	YES	NA
DBW	5	Alpha	SAT	7/23/2005	14:30	1.53	1,871	1,870	YES	YES	YES
DD	6	Alpha	SAT	7/27/2005	11:25	0.90	1,908	1,907	YES	YES	NA
DD	7	Alpha	SAT	7/27/2005	15:15	1.00	1,910	1,909	YES	YES	YES

APPENDIX A-9

SURVEY UNIT KAISER-FSSFOA-009

Appendix A-9, Table A-9-1
Final Status Survey Instrument Summary
Survey Unit Kaiser-FSSFOA-009
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Instrument Model and Detector Model/Type	Instrument Serial Number	Detector Serial Number	Calibration Period	In-Service Period Survey of Unit Kaiser-FSSFOA-009	Usage
Ludlum 2221 Scaler/ Rate Meter with 44-10 2" X 2" Nal Scintillation Gamma Detector	157032	PR206809	02/14/05 to 02/14/06	08/03/05	Field analysis, high-energy gamma detection - Instrument was used to evaluate remediation progress and scan land areas for the Final Status Survey.

APPENDIX A-9-1

Ludlum Model 2221 Scaler/Rate Meter
With Model 44-10 2-inch x 2-inch NaI Scintillation Gamma Detector
Serial Nos. 157032 (meter) and PR206809 (detector)

CERTIFICATE OF CALIBRATION

ENERCON Services, Inc.
650-1 Seco Road
Monroeville, PA 15146
Ph. 412-373-8455
Fax 412-373-5930

Customer: Enercon Services Inc. Order No.P.O.# PA-400-4072

Mfg.: Ludlum Model 2221 Serial No.:157032

Cal Date: 02/14/05 Cal Due Date: 02/14/06 Cal. Interval 12 mo.'s Meterface 202-159

Check mark ☑ applies to applicable instruments and/or detector. IAW Mfg. Spec. T 72.5 °F RH 26 % Alt. 1120 Ft.

☒ ~~New Instrument~~/ Instrument Received ☑ Within Toler +/-10% ☐ 0-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See Comment

☑ Mechanical Ck. ☑ Meter Zeroed ☐ Background Subtract ☒ Input Sens. Linearity

☑ F/S Resp. OK ☑ Reset Ck. ☒ Window Operation ☒ Geotropism

☒ Audio. Ck. ☐ Alarm Setting Ck. ☒ Batt. Ck. (Min. Volt) 6.1 VDC

☒ Calibrated in accordance with ECL 205-1 Rev. 0 1/23/03

Instrument Volt Set 1000 V Input Sens. 10 MV

Det. Oper. N/A V at N/A mV Threshold Dial Ratio 10 = 100

☒ HV Readout (2 points) Ref./Inst. 504 / 500 V Ref./Inst. 2000 / 1999

COMMENTS: Digital Calibration done using a 0.1 minute count time. Results reflect that count time.

Gamma Calibration: GM detectors positioned perpendicular to source except for M44-9 in which the front of probe faces source.

RANGE/ MULTIPLER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X1K	400 Kcpm	400 Kcpm	400 Kcpm
X1K	200 Kcpm	200 Kcpm	200 Kcpm
X1K	100 Kcpm	90 Kcpm	90 Kcpm
X100	40 Kcpm	40 Kcpm	40 Kcpm
X100	20 Kcpm	20 Kcpm	20 Kcpm
X100	10 Kcpm	10 Kcpm	10 Kcpm
X10	4 Kcpm	4 Kcpm	4 Kcpm
X10	2 Kcpm	2 Kcpm	2 Kcpm
X10	1 Kcpm	1 Kcpm	1 Kcpm
X1	400 cpm	400 cpm	400 cpm
X1	200 cpm	200 cpm	200 cpm
X1	100 cpm	100 cpm	100 cpm

*Uncertainty within ±20%

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING
Digital Readout	400 cpm	40 cpm		Log Scale	50 cpm	50 cpm	50 cpm
	400 Kcpm	39557 cpm			500 Kcpm	500 Kcpm	500 Kcpm
	40 Kcpm	3956 cpm			50 Kcpm	50 Kcpm	50 Kcpm
	4 Kcpm	395 cpm			5 Kcpm	5 Kcpm	5 Kcpm
	40 cpm	4 cpm			500 cpm	500 cpm	500 cpm

ENERCON Services, Inc. certified that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology or to the calibration facility other International Standards Organization members, or have been derived from accepted values or natural physical constraints or have been derived by the ratio type of calibration technology. The calibration system conforms to the requirements of ANSI /NCSL Z540-1-1994 and ANSI N323-1978.

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 6205GF

☐ Alpha S/N _____ ☐ Beta S/N _____ ☐ Other _____

☒ M 500 S/N 187460 ☐ Oscilloscope S/N _____ ☐ Multimeter S/N 020513278

Calibrated By: R. Shank Date: 02/14/05

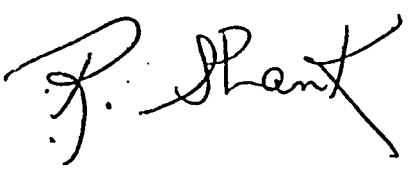
Reviewed By: _____ Date: _____

AC Inst. ☐ Passed Dielectric (hi-Pot) and Continuity Only ☐ Failed

PLATEAU

Instrument :	Ludlum	**DATE:**	2/14/2005
Model No,	2221	**Source:**	Cs137
Serial No.	157032	**Serial No.**	03-95 2485
Probe:	44-10	**Strength:**	0.79uCi
Serial No.	PR206809		

	Background Count (cpm)	Source Count (cpm)	H.V.
1	2110	83144	700
2	2023	85332	725
3	2145	86609	750
4	2193	88120	775
5	2275	91113	800
6	2514	94549	825
7	2456	94875	850
8	2488	95566	875
9	2562	96575	900
10	2512	96942	925
11	2529	96763	950
12	2416	97113	975
13	2514	97531	1000
14			1025
15			1050
16			1075
17			1100
18			1150
19			1200
20			1250



Form HPM/M-2-6-1
Daily Check Log for Ludlum Model 2221 with 44-10 Detector
Instrument 5

	Instrument Model:	2221		Source S/N:	Cs-137 sn: 547				
	Instrument S/N:	157032		Source DPM:	N/A				
	Detector Model:	44-10		Radiation Detected:	gamma				
	Detector S/N:	PR206809		Acceptable Range:	269,265 + 2σ			271,076 + 3σ	
	Calibration Due:	2/14/06	CONTACT	(Refer to Penn E&R/HPM/M-2-1-1)	262,026 - 2σ			260,216 - 3σ	
	Time	**Date**	**Background Count Rate**	**Source Count Rate**	**Net Source Count Rate**	**Technician**	**W/IN +/- 2σ**	**Batt check (volts)**	**W/IN +/- 3σ**
1	6:35	8/3/2005	9,343	279,914	270,076	DD	NO	5.4	YES
	Comments:	Background 5 minute count. Source count 1 minute.							

Form HPM/M-2-6-1
Daily Check Log for Ludlum Model 2221 with 44-10 Detector
Instrument 5

Instrument Model:	2221
Instrument S/N:	157032
Detector Model:	44-10
Detector S/N:	PR206809
Calibration Due:	2/14/06

6 INCHES

Source S/N:	Cs-137 sn: 547
Source DPM:	N/A
Radiation Detected:	gamma
Acceptable Range: (Refer to Penn E&R/HPM/M-2-1-1)	10,768 + 2σ
	8,334 - 2σ

	Time	Date	Background Count Rate	Source Count Rate	Net Source Count Rate	Technician	W/IN +/- 2σ	Batt check (volts)	W/IN +/- 3σ
1	6:35	8/3/2005	9,343	18,748	9,405	DD	YES	5.4	YES

11,378 + 3σ

7,724 - 3σ

Comments: Background 5 minute count. Source count 1 minute

APPENDIX B

DECOMMISSIONING PLAN CHAPTER 14.0

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14.0 Facility Radiation Surveys

This chapter presents the general framework for facility radiation surveys relative to the decommissioning of the Tulsa facility. The chapter focuses on the 14-acre Pond Parcel area. Supplemental information relative to facility radiation surveys for the "former operational area" of the facility is provided in Chapter 14.0 of the May 2002 DPA (Revised May 2003).

14.1 Release Criteria

The site will be remediated in accordance with decommissioning criteria of Subpart E, Radiological Criteria for License Termination of 10 CFR Part 20, Standards of Protection Against Radiation. Specifically, Subpart E, 10 CFR 20.1402, Radiological Criteria for Unrestricted Use, allows release of a site for unrestricted use if the residual radioactivity distinguishable from background results in a TEDE to an average member of the critical group that does not exceed 25 mrem/yr and the residual radioactivity has been reduced to levels that are ALARA.

Dose modeling is used to estimate the TEDE to the average member of the critical group (that group reasonably expected to receive the greatest exposure to residual radioactivity for any applicable circumstances). The concentration of residual radioactivity (per radionuclide) distinguishable from background that, if distributed uniformly throughout a survey unit, results in a TEDE of 25 mrem in 1 year to an average member of the critical group is the single-radionuclide $DCGL_W$. Preliminary $DCGL_W$ values for the radionuclides of concern at the Kaiser site have been calculated using the guidance provided in NUREG-1549, Decision Methods for Dose Assessment to Comply With Radiological Criteria for License Termination. In order to account for the presence of multiple radionuclides, the Unity Rule was applied, and $DCGL_W$ values adjusted as shown in Table 14-1.

Table 14-1
$DCGL_W$ Values

Radionuclide	Single Radionuclide $DCGL_W$ (pCi/g)	Ratio to Th-232 Assuming Equilibration	Average Concentration with Th-232 at Single Rad $DCGL_W$ (pCi/g)	Adjusted $DCGL_W$ to Meet Unity Rule (pCi/g)
Pb-210	1.751	0.043	0.15	0.12
Ra-226	5.9	0.082	0.28	0.24
Ra-228	4.3	1	3.4	3
Th-228	3.4	1	3.4	3
Th-230	102	3.5	12	10
Th-232	3.4	1	3.4	3

In developing the remedial action plan, a derived cutoff concentration level (DCCL) of 31.1 pCi/g Th-232 has been determined. This value represents the dividing line concentration between material which must be exported to an off-site disposal facility and material which can remain on site under an unrestricted release scenario. Based upon kriging analyses (Appendix A), on average, material above the DCCL is exempt. Moreover, the kriging volume estimates together with the dose assessment presented in Chapter 5.0 demonstrate that unrestricted release dose levels can be achieved when material below the DCCL is returned to the excavation as described in Chapter 8.0. The average concentration of below-criteria material remaining on site is termed herein as the Average Derived Concentration Level (ADCL). Based upon dose evaluations, the ADCL, rounded to 7 pCi/g Th-232, results in a postremediation TEDE well below 1 mrem/yr.

The three important threshold concentration criteria and their significance are summarized below in Table 14-2.

Table 14-2
Threshold Concentration Criteria

Parameter	Value (pCi/g Th-232)	Application
$DCGL_W$	3.0	Release criterion for soil stockpile/processing area
DCCL	31.1	Dividing line for off-site disposal of material
ADCL	7.0	Estimated average concentration of material left on site as backfill

Table 14-3 presents area factors (based upon MARSSIM guidance) to be used for elevated measurement comparisons (EMC) and to determine sampling requirements in situations where the scan instrument's minimum detectable concentration is greater than the $DCGL_W$ or DCCL depending on the survey area. The $DCGL_{EMC}$ values applicable to the stockpile/processing area are calculated by multiplying the $DCGL_W$ by the area factors presented in Table 14-3. $DCGL_{EMC}$ values are presented in Table 14-4.

$$DCGL_{EMC} = \text{Area Factor} * DCGL_W$$

For the segregated material below 31.1 pCi/g of Th-232 left onsite as backfill, the ADCL value was multiplied by the area factors presented in Table 14-3 and the results are presented in Table 14-5.

$ADCL_{EMC}$ = Area Factor * ADCL

However, since the material used as backfill is material below 31.1 pCi/g of Th-232, the elevated measurement comparison is only applicable to concentrations exceeding 31.1 pCi/g of Th-232. The ADCL value of 7 pCi/g of Th-232 was conservatively used to establish elevated measurement criteria for the backfill material greater than 31.1 pCi/g of Th-232, to maintain the average concentration of the backfill material ALARA.

Table 14-3
Area Factors

Area Factors									
Radio-nuclide	1 m^2 (11 ft^2)	3 m^2 (32 ft^2)	10 m^2 (108 ft^2)	30 m^2 (323 ft^2)	100 m^2 (1,076 ft^2)	300 m^2 (3,229 ft^2)	1,000 m^2 (10,764 ft^2)	3,000 m^2 (32,292 ft^2)	10,000 m^2 (107,639 ft^2)
Th-232	12.5	6.2	3.2	2.3	1.8	1.5	1.1	1.0	1.0

Table 14-4
$DCGL_{EMC}$ Values for Processing Area

$DCGL_{EMC}$ (pCi/g)									
Radio-nuclide	1 m^2 (11 ft^2)	3 m^2 (32 ft^2)	10 m^2 (108 ft^2)	30 m^2 (323 ft^2)	100 m^2 (1,076 ft^2)	300 m^2 (3,229 ft^2)	1,000 m^2 (10,764 ft^2)	3,000 m^2 (32,292 ft^2)	10,000 m^2 (107,639 ft^2)
Th-232	37.5	18.6	9.6	6.9	5.4	4.5	3.3	3.0	3.0

Table 14-5
$ADCL_{EMC}$ Values for Excavation Areas

$ADCL_{EMC}$ (pCi/g)									
Radio-nuclide	1 m^2 (11 ft^2)	3 m^2 (32 ft^2)	10 m^2 (108 ft^2)	30 m^2 (323 ft^2)	100 m^2 (1,076 ft^2)	300 m^2 (3,229 ft^2)	1,000 m^2 (10,764 ft^2)	3,000 m^2 (32,292 ft^2)	10,000 m^2 (107,639 ft^2)
Th-232	87.5	43.4	22.4	16.1	12.6	10.5	7.7	7.0	7.0

14.2 Characterization Surveys

A series of radiological characterization surveys of the site have been performed from 1994 to 2001. A summary of each survey is provided.

14.2.1 ADA 1994

In February of 1994, the site was divided into eight sections and a gamma walk-over survey was performed. Measurements were taken at 1 m above the ground every 15 feet. A Ludlum Model 3-97 Survey Meter (internal 1-inch-by-1-inch NaI [Tl] scintillator detector) calibrated to read micro-Roentgen per hour (μR/hr) was used. Background was established as 10 μR/hr, and readings of greater than twice background were observed in all eight sections of the site including a maximum of 400 μR/hr. Five 18-inch core boring samples, one background core boring, and four additional soil samples from test digs were taken. The samples were oven dried at approximately 50°C for 12 hours and then counted for a minimum of 100 minutes using an ORTEC Multichannel Analyzer connected to a Canberra High Purity Intrinsic Germanium Detector. Analytical results confirmed the presence of Th-228 in secular equilibrium with Th-232. Th-230 (from the natural uranium decay chain) also was identified. The Th-230 was 2.4 to 3.4 times the Th-232 activity.

14.2.2 ARS 1995

In October of 1994, a more extensive characterization of the site was performed. Two hundred and fifty samples were systematically collected from 90 borehole locations. Samples were collected in 500-ml Marinelli containers, weighed to the nearest 0.1 g, and counted for 10 minutes with a shielded 2-inch-by-2-inch NaI (Tl) scintillator detector. The instrument was a Bicron LabTech Dual Channel Analyzer.

Sixty 200-ml subsamples were taken from the 250 field samples. Subsamples were analyzed using a density compensating gamma spectroscopy system (Nuclear Fuel Systems, Inc.) for U-234, U-235, U-238, and Th-232. Referred to as the At Line Solution Assay System (ALSAS), it provided density corrected pCi/g values. A correlation coefficient (r) of 0.990 relating the total counts of the field 2-inch-by-2-inch NaI (Tl) detector field count to the analytical results (pCi/g) of the same sample was completed. Linear regression was used to determine an equation to calculate pCi/g values from counts. The results of the survey were total thorium (Th-232 + Th-228) pCi/g values ranging from below the MDA of 1 pCi/g to 425.6 pCi/g.

Alpha spectroscopy was performed on 11 of the samples and confirmed the previously established ratio of Th-232 to Th-230 in dross of between 1:2.4 and 1:3.4. The 11 samples were selected from 60 sample results that fell in the 1 to 50 pCi/g total thorium range. The 11 samples represented 3 of the 4 main areas surveyed including the Retention Pond, the Reserve Pond, and the land area between the railroad and the Retention Pond. The ratios calculated from these data ranged from 1:0.62 to 1:3.15. Data were consistent

with previous characterization survey results and were used to estimate volumes of contaminated material and to map contamination at depth.

Surface water from the Retention Pond (two samples) and from Fulton Creek (one sample) were collected and analyzed by gamma spectroscopy. Results were below the MDA value of approximately 1.0 pCi/l Th-232.

14.2.3 Adjacent Land Remediation Plan Appendix A

In 1999, 24 samples were selected (on site) to confirm the Th-232 to Th-230 ratio in the dross. The samples were selected based on geographical distribution and included both the Retention and Reserve ponds and a range of depths. The data approximate the ratio to be 1:3.5. This ratio was used to calculate the Th-230 activity based on the measured Th-232 activity during Phase I remediation of adjacent (to Kaiser property) land.

14.2.4 Summary

NUREG-1575 (MARSSIM) defines areas that have no reasonable potential for residual contamination as "nonimpacted." These areas have no radiological impact from site operations. Areas with some potential for residual contamination are defined as "impacted." Impacted areas are further divided into Class 1, 2, or 3 areas based on the potential for contamination.

The former Freshwater Pond area is nonimpacted. Results of characterization surveys indicate that the remainder of the pond parcel east of the former Freshwater Pond area is impacted. The land areas have been classified in accordance with MARSSIM based on the existing characterization survey data. The classification is provided in the Final Status Survey Design section below. In addition, part of the adjacent land was impacted and was remediated in 2000-2001. The adjacent land area was surveyed under NUREG/CR-5849 and the unrestricted release approved by the NRC in 2002. Therefore, the entire area adjacent to the site as delineated by grids in Figure 2-4, is not addressed in this phase of decommissioning.

In addition to the characterization events detailed in Sections 14.2.1, 14.2.2, and 14.2.3, composite samples of characterization core samples and final status samples were taken during adjacent land remediation surveys. The composite samples were analyzed by alpha spectroscopy to further evaluate the Th-232 to Th-230 activity ratio. The results yielded Th-232 to Th-230 ratios from 1:0.32 to 1:2.95. A summary of soil sample analyses performed to calculate the ratio of Th-232 to Th-230 activity is presented in the table below. A compilation of the analytical data used to calculate the ratio of Th-232 to

Th-230 is presented in Appendix E. The established ratio of Th-232 to Th-230 of 1:3.5 will continue to be used during Phase II of the decommissioning of the site because this is the most conservative (protective) approach. A summary of sample result Th-232 to Th-230 activity ratios for the Kaiser site is provided in Table 14-6 below.

Table 14-6

Measured Th-232 to Th-230 Ratios

Reference	Number of Samples	Minimum Ratio of Th-232:Th-230	Maximum Ratio of Th-232:Th-230	Average Ratio of Th-232:Th-230
ADA 1994	3	1:2.4	1:3.4	NA
ARS 1995	11	1:0.6	1:3.1	1:1.7
Kaiser 1999	24	1:1.5	1:6.4	1:3.4
ES 2002	14	1:0.32	1:3.0	1:2.1

Characterization activities concerning water sample analysis have also shown that the contaminated material is not soluble.

The characterization of the site is complete. Extensive characterization surveys and sample analysis have been reviewed to provide the initial classification of the site open land areas and structural surfaces. The majority of the land area is impacted and classified as Class 1. The only nonimpacted area is the Freshwater Pond parcel based on site history and the adjacent land based on final status survey results. The only identified subsurface structural surface is the spillway. The spillway is classified as impacted Class 1. All additional subsurface structures discovered during excavation in Class 1 open land areas will be classified as Class 1. Reclassification of any areas would be based on final status survey measurements secured as detailed in the following parts of Section 14.0.

14.3 Remedial Action Support Surveys

Segregation of impacted soil during remediation may be aided by an automated system equipped with NaI (or equivalent) gamma detectors. Alternatively, HPTs may segregate impacted soil using portable survey instruments equipped with NaI detectors. Both detection methods have the sensitivity to detect Th-232 (surrogate radionuclide) below the most restrictive threshold value of 3 pCi/g above background. Th-232 is an alpha emitter but is in secular equilibrium with several progeny that emit high-energy photons. Detection of Th-232 is based on the detection of these high-energy photons. Table 14-7 provides MDC values calculated using the guidance provided in NUREG-1575, MARSSIM, for increasing background values. The calculation of MDC is based on the detection of high-energy emitting Th-232 progeny.

Table 14-7
MARSSIM Calculated Minimum Detectable Concentration Values
For Increasing Background (2-inch-by-2-inch NaI Detectors)

Background (cpm)	Minimum Detectable Count Rate (ncpm)	Scan Minimum Detectable Concentration (μR/hr)	Scan Minimum Detectable Concentration (pCi/g Th-232)
3,000	585	1.00	1.0
5,000	756	1.29	1.3
7,000	894	1.52	1.5
9,000	1,014	1.73	1.7
11,000	1,121	1.91	1.9
13,000	1,219	2.08	2.1
15,000	1,309	2.23	2.2
16,000	1,352	2.30	2.3
17,000	1,394	2.37	2.3
18,000	1,434	2.44	2.4
19,000	1,473	2.51	2.5
20,000	1,512	2.58	2.5
21,000	1,549	2.64	2.6

Remedial action support surveys will be performed while remediation is being conducted and will guide the remedial action in a real-time mode. These surveys will be used to determine when a survey unit is ready for the final status survey. The remedial action surveys will rely principally on direct radiation measurement using gamma-sensitive instrumentation. Scan MDC will be determined for remediation survey instrumentation using the same protocol as final status surveys. The determination of a survey unit's readiness for a final status survey will rely on the on-site knowledge of the area (i.e., kriging information and area classification) and the results from the survey instrumentation.

During remediation, excavated material will be characterized into one of the following four categories based on physical description and/or radiological survey:

- Contaminated Soil (or soil-like material) – Soil above the $DCGL_W$ or DCCL value for the processing and Retention Pond areas respectively.
- Acceptable Backfill Soil (or soil-like material) – Soil containing radioactivity above the $DCGL_W$ but below the DCCL value.
- Suspect Contaminated Soil (or soil like material) – Soil which requires additional characterization for the determination of whether it is below the $DCGL_W$ or DCCL value.

- Debris (Structural Surface Survey Material) – Nonsoil material that is oversized (e.g., concrete fragments, bricks, and construction debris). Surveys of debris consist of surveys of structural surfaces for total (fixed) and removable contamination in units of disintegrations per minute per one hundred centimeters squared (dpm/100 cm^2).

Debris is subdivided into two categories: 1) removable debris that can be easily removed from an excavation and 2) permanent structures such as the concrete spillway contained beneath Characterization Grids 1-4 (ALRP). Removable debris will be segregated from soil to the extent practical by visual inspection. Debris buried within the dross and soil mixture will be evaluated in accordance with NRC Fuel Cycle Policy and Guidance Directive FC 83-23 to determine whether they are potential candidates for clearance surveys considering such factors as volumetric contamination and accessibility of surfaces for survey. Clearance surveys may be performed if large, nonporous, solid debris with only surface contamination are uncovered during residue excavation. In this case, clearance surveys for total and loose alpha will be performed on the debris to ensure that released items are released in accordance with NRC Fuel Cycle Policy and Guidance Directive FC 83-23. Otherwise, debris material will be packaged to meet the applicable disposal facility waste acceptance criteria. Permanent structures will be surveyed for unrestricted release in accordance with the guidance provided in the May 2002 DPA and the May 2005 Technical Addendum for structural surface surveys.

The area containing the Characterization Grids 1-4 (ALRP) is known to contain a concrete spillway. As shown in Figure 4-1, the spillway starts slightly west of Characterization Grid 1 and runs from west to east. The spillway turns north at Characterization Grid 4 and proceeds toward the Retention Pond. The spillway is considered a permanent structure and will be surveyed as a Class 1 structure.

Additional subsurface structures may be encountered during excavation. The structures will first be categorized as permanent or removable. If the structures are permanent, a final status survey of structural surfaces will be performed. Since thorium is highly insoluble, it is not anticipated that structures will be volumetrically contaminated. However, subsurface culverts and/or piping may be encountered. Structures with internal surfaces will receive final status surveys of both external and internal surfaces. Consideration will be given to nonaccessible surfaces. Residues, sediments, and/or liquids encountered will be collected and held for sampling. Based on the results of the sample analysis, the material will be dispositioned accordingly. Gas proportional detectors will be used to survey structural surfaces when possible. The final and clearance survey protocols for structures are detailed in subsequent parts of Chapter 14.0. Soil and/or soil like material surrounding structures will be segregated in accordance with this plan.

Based on survey instrument DCCL, $DCGL_W$, and ADCL values, survey instrumentation threshold values will be determined. The lower bound threshold is the value below which surveyed soil is acceptable backfill soil. The upper bound threshold is the value above which surveyed soil is contaminated soil. The two threshold values will be conservatively set based on empirical data (e.g., the lower bound threshold value will be set at the average net counts per minute [ncpm] value corresponding to the $DCGL_W$ less one standard deviation and the upper bound threshold will be set at the average plus one standard deviation) to ensure that soil is acceptable backfill or that soil is contaminated. The average ncpm value will be derived from empirical data and will be continually checked as survey and analytical data are collected. Soil surveyed with results between the two threshold values will be stockpiled as suspect contaminated soil and will be sampled for laboratory analysis to determine if the soil is acceptable backfill or contaminated.

14.4 Final Status Survey Design

14.4.1 Survey Objective

The objective of this survey is to demonstrate that residual radioactivity levels meet the site release criteria.

14.4.2 Basic Design

14.4.2.1 MARSSIM's Wilcoxon Rank Sum Test

The final status survey will use systematic grid sampling to determine the average radionuclide concentration in a survey unit and gross gamma scans to screen for elevated areas. At least the minimum number of samples (N/2) will be taken in each survey unit. Since the radionuclides of interest occur naturally in background, the minimum number of samples (N/2) from the reference background area will also be used to complete the Wilcoxon Rank Sum (WRS) Test.

Minimum Number of Samples (N/2)

When using the WRS test, the minimum number of samples (N/2) is the number of samples required in the survey unit and in the reference background area. Hence "N" is the total number of samples required to complete the WRS test. Paramount to determining the minimum number of samples is the determination of the relative shift, delta over sigma (Δ/σ). Delta is equal to the DCGL minus the lower bound gray region (LBGR) value. The LBGR value is arbitrarily set at one-half the DCGL value to start

the determination. Sigma is an estimate of the variability in a set of sample analysis results from a survey unit. The estimate of sigma used is based on the standard deviations in Th-232 activity measured in survey units during the final status sampling of the adjacent land remediation final survey (0.42). Sigma may be increased if the spatial variability of contaminants within a given survey unit is expected to be greater than 0.42. Since the Th-232 activity concentration of 3.0 pCi/g will be used as the surrogate DCGLw, Δ is equal to 3.0 – 1.5, or 1.5. Delta divided by the sigma of 0.42 results in a relative shift of 3.57 which is rounded to 3.5 for the purpose of determining the required number of samples. The number of samples can be calculated using the following formula or looked up in Table 5.3 of MARSSIM:

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{3(P_r - 0.5)^2}$$

where:

$Z_{1-\alpha}$ = percentile represented by selected value of α, Table 5.2 of MARSSIM
$Z_{1-\beta}$ = percentile represented by selected value of β, Table 5.2 of MARSSIM
P_r = value obtained from Table 5.1 of MARSSIM

Based on a relative shift of 3.5, the following number of samples are required to meet the DQOs:

Size of Survey Unit	Class	DQOs for α and β	Number of Sampling Locations
≥ 10 m^2 <2,000 m^2	1	0.05, 0.05	9
$\geq$ 2,000 m^2 and <10,000 m^2	2	0.05, 0.05	9
$\geq$ 10,000 m^2	3	0.05, 0.05	9

Likewise for surveys of the backfill material the number of samples is 9 corresponding to a relative shift of 3.5, based on the DCCL value of 31.1, the LBGR of 15.6 and a sigma estimate of 4.4 pCi/g.

The number of samples in the above table includes a factor to increase the number of required samples by 20 percent, as recommended by MARSSIM, to allow for lost or unusable data. The number of required samples may be further increased to increase the power level of the statistical tests. Additional sampling locations may also be necessary if characterization data and remedial action surveys and sampling indicate that there is greater than expected spatial variability (σ)of sample results within specific survey units.

14.4.2.2 Discrete Soil Sampling

The results of discrete soil sampling will be used to verify that the average soil concentration is less than the appropriate $DCGL_W$ or DCCL values. Regardless of the survey unit classification (Class 1, Class 2,

or Class 3), a predetermined minimum number of samples will be collected in each survey unit. A random-start triangular grid pattern will be used in Class 1 and Class 2 survey units. This sampling pattern is generally the most efficient means of identifying small areas of elevated activity. The distance between the grid nodes (L) will be determined by

$$L = [A/(0.866 \times n)]\ ½$$

where A is the survey unit area to be covered by the grid pattern and n is the number of samples.

The random start point will be selected by use of readily available random point generators such as provided by the spreadsheet Excel. Sample points will be located by use of a global positioning system (GPS) or equivalent survey equipment.

14.4.2.3 Scanning

Scanning surveys will be used to identify small areas of elevated activity. The percentage of the survey unit to be covered by scans will be based upon the survey unit classification in accordance with the following table.

Table 14-8

Survey Unit Classification	Scanning Coverage
Class 1	100 percent coverage
Class 2	10 to 100 percent Systematic and Judgmental
Class 3	Judgmental

One hundred percent coverage means that the entire surface area of the survey unit has been covered by the field of view of the detector. The scanning coverage for Class 1 areas will be 100 percent. The scanning coverage for Class 2 areas will be adjusted based on the level of confidence supplied by existing data. Whenever less than 100 percent of the survey unit is scanned, the Data Manager will determine the degree of scan coverage and which areas are to be scanned based on the information available at the time of survey. For example, if the potential for contamination in a section of the survey unit is higher than the rest, i.e., the section that borders a Class 1 survey unit, this section may receive 100 percent coverage, while the remaining section may receive 50 percent systematic coverage. If the survey unit has an equally unlikely potential for contamination, e.g., isolated with no previous history of contamination, a systematic coverage at 25 percent coverage may be appropriate.

14.4.2.4 Null Hypothesis

The null hypothesis (H_o) to be tested is that the residual contamination exceeds the remedial objective (release criteria are not met) and the alternative hypothesis (H_A) is that the residual contamination meets the remedial objective (release criteria is met).

14.4.2.5 Decision Error Rates

There are two types of decision errors as shown below:

		DECISION/OUTCOME OF STATISTICAL TEST	
		Reject H_o	Accept H_O
TRUE CONDITION OF SURVEY UNIT	Meets remedial objective (below $DCGL_W$)	No decision error (probability = 1 -α)	Incorrectly fail to release survey unit Type II error (probability = β)
	Exceeds remedial objective (exceeds $DCGL_W$)	Incorrectly release survey unit Type I error (probability = α)	No decision error (probability = 1 - β)

Examination of this table highlights the importance of limiting the Type I error rate (or α) in terms of protection of human health and the environment. The DQO selected for α is 0.05. The DQO selected for β is 0.05.

14.5 Use of a Surrogate Radionuclide

Characterization activities have verified that the primary radionuclides of concern are isotopes of thorium. Th-232 and Th-228 are part of the natural thorium decay chain and have been verified to be in secular equilibrium (i.e., the activity of Th-228 is equal to that of Th-232). Another isotope of thorium, Th-230, has been identified as a primary radionuclide of concern. Although Th-230 is part of the natural uranium decay chain, no uranium has been identified. However, in the estimated 55 years since Th-230 was separated from the uranium decay chain, some Ra-226, a member of the decay chain below Th-230, has grown in. The relationship of Th-230 activity to that of Th-232 has been established in previous characterization of the site. The relationship of Th-230 activity is 3.5 times Th-232 activity. Not all of the radionuclides present can be identified by real-time gamma surveys or by gamma spectroscopy of soil samples--the most efficient and cost-effective measurements. In addition, each of the radionuclides contributes to the total dose to varying degrees of magnitude. In order to save both time and resources, it is

desirable to select a surrogate radionuclide to demonstrate compliance for all the radionuclides and to guide remediation activities. Th-232 has been selected as the surrogate radionuclide.

14.6 Establishing Background

Appendix F contains the reference area, surface soil, and background data consisting of two different reference areas located approximately 1 mile apart. The results of 30 different sampling locations in each reference area presented in the *Adjacent Land Characterization*, Kaiser Aluminum Specialty Products, Appendix A, Estimate of Volume of Off-Site Contaminated Soil, Adjacent Land Characterization Report, ADA, March 1999. These data were also used for the background determination during the Kaiser Adjacent Land Area Remediation Project. Based on a review of the data in both reference areas, there appears to be no significant variability between the two reference areas that were sampled. The mean Th-232 concentration in the reference area located on the nonimpacted northwest Kaiser property is 0.94 +/- 0.11 pCi/g at the 95 percent confidence level, and mean Th-232 concentration in a reference area located approximately 1 mile away is 1.06 +/- 0.10 pCi/g at the 95 percent confidence level. The reference area data standard deviations were 0.30 and 0.28 respectively. According to NUREG 1727, "When there may be significant difference in backgrounds between different areas, a Kruskal-Wallis test...can be used to determine whether there are, in fact, significant differences in mean background concentrations among potential reference areas." Based on the agreement between the mean of both reference areas, it is not necessary to conduct a Kruskal-Wallis test on the reference area data, because there is no significant variability between the two reference areas that have been sampled. The established background value was 1.1 pCi/g Th-232.

14.7 Area Classifications

All of the areas have undergone either a characterization study or historical site assessment that is used as the basis for the initial determination of the area classification established in this section. The former Freshwater Pond area currently is not impacted. However, DPs call for use of this area (after closure) as a material processing area. Therefore, all areas in the Pond Parcel with the exception of the clean backfill cover have been designated as impacted for purposes of classification and survey. In addition, gamma surveys will be performed in areas adjacent to the dross pond to confirm that elevated gamma levels measured during the ALRP were due to gamma contribution from the pond.

Definitions

Class	Definition	Survey Unit Size
1 Land Areas	Areas known or expected to have radionuclide concentrations above the $DCGL_W$	Up to 2,000 m^2
2 Land Areas	Areas known or expected to have radionuclide concentrations above normal background concentrations but that are not expected to be above the $DCGL_W$	2,000 to 10,000 m^2
3 Land Areas	Areas that are not expected to have radionuclide concentrations detectable above normal background concentrations	No limit
1 Structural Surfaces	Areas known or expected to have radionuclide concentrations above the $DCGL_W$	Up to 100 m2 of floor area
2 Structural Surfaces	Areas known or expected to have radionuclide concentrations above normal background concentrations but that are not expected to be above the $DCGL_W$	100 to 1,000 m2
3 Structural Surfaces	Areas that are not expected to have radionuclide concentrations detectable above normal background concentrations	No limit

NUREG-1575, MARSSIM, recommends a maximum Class 1 survey unit area of 2,000 m^2 to ensure each survey unit is assigned an adequate number of sample points. For areas larger than 2.000 m^2 with uniform conditions, initial classification and exposure pathway modeling assumptions, the survey unit area may be increased providing the data quality objectives, specifically the sample point density is maintained. If it is determined during site remedial operations that site conditions warrant a survey unit to be greater than 2,000 m^2 in size, Kaiser will design the survey to comply with the data quality objectives of MARSSIM.

(Sept. 2005 Revision)

Initial Area Classifications

Area	Description	Classification
Processing Area (Fresh Water Pond)	Area currently occupied by a Freshwater Pond which will be used for processing/stockpiling excavated materials (≈9 survey units).	1
Former Retention Pond Area Bottom	Area formerly occupied by the dross Retention Pond and Reserve Pond, post excavation of dross (≈21 survey units).	1
Former Retention Pond Area	Area formerly occupied by the dross Retention Pond and Reserve Pond, backfilled with below-criteria material in 2-foot survey lifts (≈21 survey units per lift).	1
Former Operational Area	The triangular parcel of land north of 41st Street and south of the Union Pacific Railroad right-of-way in which plant processes and operations occurred.	1
Spillway/Other Permanent Structures	Structures (such as the spillway) located where thoriated material is known to exist. The total area of these structures cannot be determined until uncovered by excavation.	1

14.7.1 Process for Reassignment of Area Classifications

All areas will not have the same potential for residual contamination and, accordingly, will not need the same level of survey coverage to achieve the established release criteria. The initial area classifications are based on a combination of characterization data and historical information. Additional information obtained during the remediation process may lead to the determination that the initial classifications established should be revised to be consistent with the definitions given.

14.7.2 Classification Upgrades

Any area classification may be upgraded (e.g., from Class 2 to Class 1) by the Data Manager based on the receipt of additional survey or measurement information that justifies the need for such action.

14.7.3 Classification Downgrades

Any area classification may be downgraded (e.g., from Class 1 to Class 2) by the Data Manager based on the receipt of additional survey or measurement information that justifies the lower classification provided that the approval of the Kaiser RSO and the NRC is obtained.

14.7.4 Documentation of Classification Changes

All changes to the initial area classifications will be documented and included in the final soil remediation documentation.

14.8 Selection of Survey Units

Each impacted area will be divided into a number of survey units based on the classification defined above. Selection of the survey units will be based on areas having similar operational history or similar potential for residual radioactivity to the extent practical. Survey units also will have relatively compact shapes unless an unusual shape is appropriate for the site operational history or site conditions.

14.9 Field Instrumentation

The gamma-emitting progeny of the surrogate radionuclide Th-232 emit high-energy photons and are easily detected using survey instruments equipped with NaI scintillation crystal detectors. Scanning for gross gamma activity will be used to guide remediation activities and as part of the final status survey when remediation is complete. The following survey instruments (or equivalents) as appropriate will be used to scan soil:

Manufacturer and Meter	Manufacturer and Detector Model	Detector Type	Use
Ludlum 2221	Ludlum 44-10 2"-x-2" NaI scintillator	Sodium Iodide (unshielded)	Scans for Gamma-Emitting Radionuclides

Use of these field instruments or acceptable equivalents are evaluated against the goal of achieving MDCs of less than 75 percent of the $DCGL_W$ for direct measurements and/or scanning measurements. MDCs were calculated for scanning instruments using the method provided in MARSSIM for calculating MDCs that control both Type I and Type II errors (i.e., elimination of false negatives and false positives) as follows:

$$\text{Scan MDCR}_{\text{surveyor}} = \frac{\text{MDCR}}{\sqrt{p}\,\epsilon_i}$$

Where MDCR is the minimum detectable count rate in counts per minute (cpm), ϵ_i is the instrument efficiency (cpm/μR/hour), and p is the surveyor efficiency. The value of p has been estimated to be between 0.5 and 0.75. The value of 0.5 is conservative. In addition:

$$\text{MDCR} = s_i \times (60/i)$$

$$s_i = d'\sqrt{b_i}$$

where si is the minimal number of net source counts required for a specified level of performance for the interval i, in seconds; d′ is the value selected from MARSSIM Table 6.5 based on the required true positive and false positive rates; and bi is the number of background counts in the intervali. The value of d′ used to calculate the detector sensitivity values is 1.38, corresponding to an alpha of 0.05 and beta of 0.40. This value of d′ will result in less than 5 percent false negatives and about 40 percent false positives. Typical scan MDCs using the MARSSIM two stage scan methodology for survey instruments equipped with 2-inch-by-2-inch NaI detectors are summarized in Table 14-7 for increasing background count rates. Static and scan MDCs for surface contamination detectors are presented in Chapter 14.0 and Appendix D of the May 2002 DPA.

For surface contamination scanning and static measurements, the radionuclides of concern and/or their progeny emit alpha and/or beta particles that are easily detected using survey instruments equipped with gas proportional detectors and scalers. Scanning for gross alpha or gross beta activity will be used as part of status surveys of structural surface survey units to ensure elevated areas of activity are not missed. In addition, static counts of structural surfaces at predetermined sample points are used to assess total contamination of structural surfaces. The following survey instruments (or equivalents) will be used to scan structural surfaces:

Manufacturer and Meter	Manufacturer and Detector Model	Detector Type	Use
Ludlum 2224	Ludlum 43-89 Dual Phosphor Alpha/Beta Detector	Zinc Sulfide Scintillator	Scans and Static Counts for Alpha and Beta Emitting Radionuclides
Ludlum 2221	Ludlum 43-68 Gas Proportional	Gas Proportional	Scans and Static Counts for Alpha and Beta Emitting Radionuclides

Use of these field instruments or acceptable equivalents are evaluated against the goal of achieving MDCs of less than the $DCGL_w$s for direct measurements and/or scanning measurements. MDCs will be calculated for scanning instruments using the method provided in MARSSIM for calculating MDC that controls both Type I and Type II errors (i.e., elimination of false negatives and false positives) as follows:

Alpha Scan

There are two equations based on the MARSSIM two-stage scan methodology used to determine the alpha scanning MDC depending on the background level. For a typical alpha background level of less than 3 cpm, the probability of detecting a single count while passing over the contaminated area is:

$$P(n \geq 1) = 1 - e^{\frac{-GEd}{60v}}$$

where:

P(n ≥ 1) = probability of observing a single count,
G = activity (dpm),
E = 4π detector efficiency (cpd),
d = width of detector in direction of scan (cm), and
v = scan speed (cm/s).

Increase the value of G until the corresponding probability equals the desired confidence level, e.g., 95 percent. For a background level of 3 cpm to about 10 cpm, the probability of detecting two or more counts while passing over the contaminated area is:

$$P(n \geq 2) = 1 - \left(1 + \frac{(GE+B)d}{60v}\right)\left(e^{\frac{(GE+B)d}{60v}}\right)$$

where:

P(n ≥ 2) = probability of observing two or more counts,
G = activity (dpm),
E = 4π detector efficiency (cpd),
B = background count rate (cpm),
d = width of detector in direction of scan (cm), and

v = scan speed (cm/s).

Increase the value of G until the corresponding probability equals the desired confidence level, e.g., 95 percent.

Beta Scan

Based on the MARSSIM two-stage scan methodology, the beta scanning MDC at a 95 percent confidence level is calculated using the following equation which is a combination of MARSSIM Equations 6-8, 6-9, and 6-10:

$$MDC_{scan} = \frac{d'\sqrt{b_i}\left(\frac{60}{i}\right)}{\sqrt{p}\cdot E_{tot}\cdot\frac{A}{100\,cm^2}}$$

where:

MDC_{scan} = MDC level in dpm/100 cm^2,
d' = desired performance variable (usually 1.38 corresponding to alpha and beta errors of 0.05),
b_i = background counts during the residence interval,
i = residence interval in seconds,
p = surveyor efficiency (0.5 – 0.75, 0.5 is conservative),
A = detector probe physical (active) area in cm^2, and
E_{tot} = total detector efficiency for radionuclide emission of
= $E_i \times E_s$,
where:
E_i = 2π instrument efficiency in counts per disintegration (cpd) and
E_s = source (or surface contamination) efficiency.

Note: Es values can be determined or the default values provided in NUREG-1507 can be used as follows: 0.25 for all alpha energies and beta maximum energies between 0.15 and 0.4 MeV, 0.5 for all beta maximum energies greater than 0.4 MeV.

Alpha or Beta Static Counts

Minimum counting times for static counts of total and removable contamination will be chosen to provide a MDC that is a fraction (25 – 75 percent) of the survey unit-specific acceptance criteria. MARSSIM equations have been modified to convert to units of dpm/100 cm^2. Count times are determined using the following equation. Static counting MDCs at a 95 percent confidence level are calculated using the following equation which is an expansion of NUREG-1507, Equation 6-7 (Strom & Stansbury, 1992):

$$MDC_{static} = \frac{3 + 3.29\sqrt{B_r \cdot t_s \cdot (1 + \frac{t_s}{t_b})}}{t_s \cdot E_{tot} \cdot \frac{A}{100}}$$

where:

MDC_{static} = minimum detectable concentration level in dpm/100 cm^2,
B_R = background count rate in counts per minute,
t_B = background count time in minutes,
t_S = sample count time in minutes,
A = detector probe physical (active) area in cm^2, and
E_{tot} = total detector efficiency for radionuclide emission of
= E_i x E_s,
where:
E_i = 2π instrument efficiency in counts per disintegration (cpd) and
E_s = source (or surface contamination) efficiency.

Note: Es values can be determined or the default values provided in NUREG-1507 can be used as follows: 0.25 for all alpha energies and beta maximum energies between 0.15 and 0.4 MeV, 0.5 for all beta maximum energies greater than 0.4 MeV.

14.10 Laboratory Analysis

With the exception of radiation badge service, laboratory analytical services are expected to be provided by Outreach of Broken Arrow, Oklahoma. In the event that Outreach is not available, Kaiser will select another qualified analytical laboratory.

Soil samples will be analyzed by gamma spectroscopy. The MDC value required for each gamma spectroscopy analysis is 25 percent of the release criteria for Th-232. Characterization survey results confirm that Th-232 is in secular equilibrium with its short-lived progeny Ac-228 and Th-228. Th-232 activity will be identified based on the Ac-228 activity (primary gamma energy of 911.1 keV). The Th-228 activity will be calculated by multiplying the Th-232 activity by 1. The Th-230 activity will be calculated by multiplying the Th-232 activity by 3.5.

A minimum of five of the QC samples taken as part of the final status survey will also be analyzed by alpha spectroscopy for Th-232, Th-230, and Th-228. The data will be used to confirm the activity ratio of Th-232 to Th-230 of 1:3.5. The required MDC for the alpha spectroscopy analysis will be 0.5 pCi/g.

14.11 Sampling and Measurement Technique

A combination of the following techniques may be used to achieve the desired survey requirements for an area.

14.11.1 Surface Scans

Depending on the area classification (Class 1, Class 2, or Class 3), scanning coverage will range in accordance with Table 14-8, Section 14.4.2.3. When scanning soil, the detector is held close to the ground (1 to 2 inches) and moved in a serpentine pattern. A scan rate of 0.5 m per second will be used. In the scanning mode, the audio response will be used to prevent lack of detection of an elevated area due to meter response time. The "two-stage" scan methodology will be utilized.

14.11.2 On Site Gamma Spectrometry

An on-site gamma-ray spectroscopy system may be utilized to provide qualitative and quantitative analysis of the Th-232 content in waste samples and final status survey screening samples.

14.11.3 Soil Sampling

14.11.3.1 Surface Sampling

Surface soil sampling will be conducted to evaluate the average remaining activity concentration of excavation bottom survey units prior to backfill activity. Surface samples will be collected from the top 15 cm (6 inches) of soil that correspond to the soil mixing or plow depth in several environmental pathway models. Grass, rocks, sticks, and foreign objects will be removed from the soil samples to the degree practical at the time of sampling. If there is reason to believe these materials contain activity, they will be retained as separate samples.

14.11.3.2 Core Sampling

Core samples will be collected after backfilling of below-release criteria material is complete. For purposes of a final status survey, the entire backfilled retention pond area will be considered as a unit and divided into survey units based on m2, i.e., Class 1 survey units of less than 2,000 m^2. A random start, triangular grid pattern will be used to take the required number of samples (N/2) in each survey unit. The sample will consist of a core sample through the approximate 3-meter layer of placed material. The entire core will be scanned using a 2-inch-by-2-inch NaI detector in a low background area sufficient to achieve a scan-MDC of less than 3 pCi/g Th-232. The 3 meters will be subdivided into three consecutive 1-meter segments in accordance with Appendix E of the NMSS Decommissioning Standard Review Plan. Each

1-meter segment will be mixed and containerized. All three segments will be analyzed by gamma spectroscopy for Th-232. The MDC required will be 3 pCi/g.

14.12 Final Status Survey Implementation

The final status survey will be used to select/verify survey unit classification and to demonstrate that the objectives have been achieved. Two situations that require final status surveys are detailed in this section. The first involves the final status survey of remediated areas (e.g., the Retention/Reserve Pond Area), and the second involves the final status survey of the processing area. The surveys will be performed using gamma-sensitive instrumentation and analytical analyses described above.

14.12.1 Postremediation Surveys

The final status survey units will be defined and marked. When remediation activities in a survey unit are completed, the following will be performed.

14.12.1.1 Gamma Scans

A gamma scan as defined by classification will be performed in accordance with the area classification. For the Retention Pond area, each 2-foot-thick lift that is placed in an excavation will receive a 100 percent scan to ensure that there are no areas that exceed the elevated measurement comparison.

14.12.1.2 Grids

The sample grid and starting location will be established.

14.12.1.3 Sample Number

The required number of samples will be taken and analyzed as described above.

14.12.1.4 Data Evaluation

The data will be evaluated as described below.

14.12.2 Postremediation Surveys for Returned Overburden Material

When remediation activities in a survey unit that required the excavation of substantial overburden soil are completed, the following will be performed:

- The bottom of the excavation will be surveyed as detailed in 14.12.1.1 above.
- The sample grid and starting location will be established,
- The number of surface samples required will be taken and analyzed.
- A 2-foot layer of acceptable (below 31.1 pCi/g) backfill material will be placed in the excavation.
- A gamma scan as defined by classification will be performed.
- The sequence of 2-foot layers of acceptable backfill and subsequent survey will be repeated as necessary to fill excavation (prior to placement of off-site backfill).

Once the excavation is filled with below-criteria material:

- the sample grid and starting location will be established,
- the number of core samples required will be taken and analyzed, and
- the data will be evaluated as described below.

14.13 Data Evaluation

Data will be reviewed by the Data Manager to ensure that the requirements 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.

14.13.1 Preliminary Data Review

The Data Manager will review QA and QC reports, prepare graphs of the data, and calculate basic statistical quantities to analyze the structure of the data and identify patterns, relationships, or potential anomalies. The survey data shall be reviewed as it is collected. The preliminary data examination includes the following:

- Evaluation of data completeness.
- Verification of instrument calibration.
- Verification of sample identification and traceability back to sampling location.
- Measurement of precision using duplicates, replicates, or split samples.
- Measurement of bias using reference materials or spikes examination of blanks for contamination.

- Assessment of adherence to 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, including the results of analytical laboratory QA/QC reports related to the analysis of final status survey samples.

14.13.2 Data Evaluation and Conversion

For comparison of survey data to $DCGL_W$s or DCCLs, the survey data from field and laboratory measurements will be converted to $DCGL_W$ or DCCL units. The Data Manager will ensure data measurements retain traceability to NIST and conversion factors are appropriate for the radiation quantity. The preliminary data reports will be reviewed to ensure adequate measurement sensitivity is being achieved and to resolve any detector sensitivity problems. Analytical reports will be reviewed for proper MDC values. The results of analytical results will be reported whether the result is above or below the reported MDC value so that the MDC value is not used in the data assessment. Preliminary scan data will also be reviewed against the percent coverage requirement of the survey unit.

An evaluation will be made to determine 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 the following:

- Mean
- Standard deviation
- Median
- Minimum
- Maximum

The parameter of interest is the mean concentration in the survey unit. The two-sample statistical test (WRS Test) will be used. The two-sample WRS Test will evaluate whether the median of the data is above or below the $DCGL_W$ or DCCL.

Summary of Statistical Tests

Survey Result	Conclusion
Difference between maximum survey unit measurement and minimum reference area measurements is less than $DCGL_W/DCCL$	Survey unit meets release criterion
Difference of survey unit average and reference area average is greater than $DCGL_W/DCCL$	Survey unit does not meet release criterion
Difference between any survey unit measurement and any reference area measurement greater than $DCGL_W/DCCL$ and the difference of survey unit average and reference area average is less than $DCGL_W/DCCL$	Conduct WRS Test and elevated measurement comparison

The null hypothesis is assumed to be true unless the WRS test indicates that it should be rejected in favor of the alternative. The result of the hypothesis test determines whether or not the survey unit as a whole is deemed to meet the release criterion. The WRS test will be applied as outlined in the following steps.

1. Adjusted reference area measurements will be obtained by adding the $DCGL_W$ or DCCL to each reference area measurement.

2. The m adjusted reference area sample measurements and the n sample measurements from the survey unit will be pooled and ranked in order of increasing size from 1 to N, where $N = m + n$.

3. If measurements are tied in rank, each of the tied values will be assigned the same average rank of that group of tied measurements.

4. The ranks from the reference area will be summed as W_r.

5. The value of W_r will be compared with the critical value given in MARSSIM Table I.4 for the appropriate values of m and n at the required Type I error decision rate ($\alpha = 0.05$). If W_r is greater than the critical value, the null hypothesis that the survey unit exceeds the release criterion was rejected.

Both the measurements at discrete locations and the scans will be used to identify elevated areas within a survey unit. Analytical results of soil samples will be used to complete the elevated measurement comparison. If residual radioactivity is found in a localized area of elevated activity - in addition to the residual radioactivity distributed relatively uniformly across the survey unit - the unity rule discussed above will be used to ensure that the release criterion has been met as follows:

$$\frac{\delta}{DCGL} + \sum_{x+1}^{n} \frac{(\delta_{EMC} - \delta)}{DCGL_{EMC}} \leq 1$$

where:

δ = is the average concentration of Th-232 over the entire survey unit
δ_{EMC} = the average concentration of Th-232 over the elevated area x within the survey unit
DCGL = the $DCGL_w$ or DCCL for Th-232

$DCGL_{EMC}$ = (area factor for elevated area x) X (DCGL)
x = refers to one of the elevated areas within the survey unit
n = the total number of elevated areas within the survey unit

If there is more than one elevated area, a separate term will be included for each area. The result of the EMC will be used as a trigger for further investigation. 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 criterion. The investigation will provide adequate assurance, using the DQO process, 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 criterion. In some cases, this may lead to reclassifying a survey unit--unless the results of the investigation indicate that reclassification is not necessary.

14.13.3 Investigation Levels

The Data Manager will use radionuclide-specific investigation levels to indicate when additional investigations may be necessary. Investigation levels will also serve as a QC check to determine when a measurement process begins 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, remediation, and/or resurvey. The following table lists the investigation levels which will be used by the Data Manager.

Postremediation Survey Investigation Levels

Survey Unit Classification	Flag Direct Measurement or Sample Result When:	Flag Scanning Measurement Result When:
Class 1	>$DCGL_{EMC}$ / DCCL or > $DCGL_W$ / DCCL and the mean of the survey unit is greater than 0.75 of the $DCGL_W$ / DCCL	>$DCGL_{EMC}$ or >DCCL
Class 2	> $DCGL_W$	> $DCGL_W$ or >MDC
Class 3	> 0.5 of the $DCGL_W$ + background	> $DCGL_W$ or >MDC

If the data suggest that the survey unit was misclassified, the original DQOs will be redeveloped for the correct classification. The sampling design and data collection documentation will be reviewed for consistency with the DQOs.

14.14 Final Status Survey Report

A report will be prepared to document the final conditions of the site. The report will include information concerning the following:

- An overview of the results of the survey.
- A discussion of any changes that were made in the survey from what was proposed in the Soil Remediation Plan.
- 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 justification for these values.

The survey results for each survey unit including the following:

- The number of samples taken for the survey unit.
- A map or drawing of the survey unit showing the reference system and random-start systematic sample locations.
- The measured sample concentrations.
- The statistical evaluation of 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 $DCGL_W$ or DCCL.
- A statement that a given survey unit satisfied the $DCGL_W$ or DCCL and the elevated measurement comparison, if any sample points exceeded the $DCGL_W$ or DCCL.
- A description of any changes in initial survey unit assumptions relative to the extent of residual radioactivity.
- A discussion of a survey unit reclassification including applicable data.

References

1. ADA Consultants, Inc., April 1, 1994, Radiological Survey Report, Kaiser Aluminum & Chemical Corporation, Tulsa, Oklahoma.

2. Advanced Recovery Systems, 1995, Volume II, Plate 1, Field Characterization Report, Appendix F.

3. Advanced Recovery Systems/Nuclear Fuel Services, Inc., April 25, 1995, Kaiser Aluminum Specialty Products, Field Characterization Report, Tulsa, Oklahoma.

4. Earth Sciences Consultants, Inc., February 2002, Final Status Survey Report, Adjacent Land Area, Tulsa, Oklahoma Facility.

5. Earth Sciences Consultants, Inc., May 2002, Revised May 2003, Decommissioning Plan Addendum, Tulsa Facility, Tulsa, Oklahoma, Kaiser Aluminum & Chemical Corporation, Baton Rouge, Louisiana.

6. Kaiser, August 1998, Adjacent Land Remediation Plan for Kaiser Aluminum & Chemical Corporation, Tulsa, Oklahoma.

7. NMSS Decommissioning Standard Review Plan Appendix E – Rev 0, September 2000, Implementing the MARSSIM Approach for Conducting Final Radiological Survey.

8. Nuclear Regulatory Commission, July 1998, Draft NUREG-1549: Decision Methods for Dose Assessment to Comply with Radiological Criteria for License Termination.

9. NUREG-1507, December 1997, Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions.

10. NUREG/CR-1575, August 2000, MARSSIM, Rev. 1

APPENDIX C

WILCOXON RANK SUM TEST

APPENDIX C
Evaluation of Survey Unit Analytical Results
Wilcoxon Rank Sum Test
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

In accordance with the DP, final status survey activities included systematic grid sampling to determine the average radionuclide concentration in a survey unit and gross gamma scans to screen for elevated areas. At least the minimum number of samples required (N) was taken in each survey unit. Since the radionuclides of interest occur naturally in background, the minimum number of samples (N) from a survey unit and an appropriate reference background area was used to complete the Wilcoxon Rank Sum (WRS) Test.

Note: When the WRS Test is used, the minimum number of samples required in the survey unit and in the reference area is referred to as N/2 in MARSSIM so that the total number of samples required to complete the WRS test is N.

PROCEDURE

After N systematic samples have been taken within the survey unit, an equal number of samples results is randomly selected from the appropriate reference area data base. The random number function in Microsoft Excel is used to select the appropriate number of samples. The reference area databases are included in Appendix C as follows:

1. Appendix C, Table 1, Soil Reference Area Sample Results – The soil sample Th-232 activity concentration results (pCi/g) are from two sets of 30 core samples taken prior to the onset of decommissioning activities onsite. The first set of 30 cores was taken in a non-impacted area of the site. The second set of 30 cores was taken approximately one mile offsite. Each 6-inch segment of each core was analyzed for Th-232. There is no significant variability between the two sets of results. A discussion of the results and the data can be found in Chapter 14 and Appendix F of the DP.

2. Appendix C, Table 2, Concrete Structural Surface Reference Area Total Alpha Contamination Results – The total alpha contamination results (dpm/100cm^2) from the concrete floor of the Flux Building (Survey Unit FB-001) final survey were used as the concrete structural surface reference area. The results of the Flux Building survey were indistinguishable from background in accordance with the State of Oklahoma's criteria for allowing the concrete to be disposed of offsite in the State of Oklahoma.

3. Appendix C, Table 3, Cinderblock Structural Surface Reference Area Total Alpha Contamination Results – The total alpha contamination results (dpm/100cm^2) from the cinderblock wall of Flux Building (Survey Unit FB-001) final survey were used as the cinderblock structural surface reference area. The results of the Flux Building survey were indistinguishable from background in accordance with the State of Oklahoma's criteria for allowing the cinderblock to be disposed of offsite in the State of Oklahoma.

Once the reference area results are selected, the survey unit and reference area results are then complied in a table with the average, standard deviation, minimum, maximum, and median values for both sets of data being calculated. The results are evaluated using the following table.

Survey Result	Conclusion
If the difference between the maximum survey unit sample result and the minimum reference area sample result is less than the appropriate release criteria (DCGL$_W$/DCCL/DCGL-GA) then:	The survey unit meets release criterion.
If the difference of the survey unit sample results average and the reference area sample results average is greater than the appropriate release criteria (DCGL$_W$ /DCCL/DCGL-GA), then:	The survey unit does not meet release criterion.
If the difference between any survey unit sample result and any reference area sample result is greater than the appropriate release criteria (DCGL$_W$/DCCL/DCGL-GA), and the difference of the survey unit average and reference area average is less than the appropriate release criteria, then:	Conduct the Wilcoxon Rank Sum Test and Elevated Measurement Comparison (EMC) if necessary, to determine if the unit meets release criterion.

The null hypothesis (the survey unit exceeds the release criteria) is assumed to be true unless the WRS Test indicates that it should be rejected in favor of the alternative. The result of the hypothesis test determines whether or not the survey unit as a whole is deemed to meet the release criterion. The WRS Test is applied as outlined in the following steps.

1. Adjusted reference area measurements are obtained by adding the appropriate release criteria (DCGL$_W$ /DCCL/DCGL-GA) to each reference area measurement.

2. The m adjusted reference area sample measurements and the n sample measurements from the survey unit are pooled and ranked in order of increasing size from 1 to N, where N = m + n.

3. If measurements are tied in rank, each of the tied values is assigned the same average rank of that group of tied measurements.

4. The ranks from the reference area are summed as W_r.

5. The value of W_r is compared with the critical value given in MARSSIM Table I.4 for the appropriate values of m and n at the required Type I error decision rate ($\alpha = 0.05$). (If the values of m and n exceed 20, the critical value is calculated using the formulas I.1 and/or I.2 of MARSSIM Appendix I.) If W_r is greater than the critical value, the null hypothesis that the survey unit exceeds the release criterion is rejected.

A copy of MARSSIM Table I-4 and MARSSIM Appendix I formulas I.1 and I.2 is included as part of this appendix.

APPENDIX C

Table 1 - Soil Reference Area Sample Results

Reference Group Sample No.	Core Location[1]	Core Length[2]	Below Surface Depth	Th-232 (pCi/g)
1	1	46"	0" - 6"	0.98
2	2	36"	0" - 6"	0.80
3	3	40"	0" - 6"	0.35
4	4	37"	0" - 6"	0.61
5	5	43"	0" - 6"	0.90
6	6	39"	0" - 6"	0.95
7	7	40"	0" - 6"	0.70
8	8	41"	0" - 6"	1.24
9	9	38"	0" - 6"	0.86
10	10	37"	0" - 6"	0.57
11	11	41"	0" - 6"	0.97
12	12	39"	0" - 6"	0.96
13	13	42"	0" - 6"	1.31
14	14	46"	0" - 6"	1.13
15	15	36"	0" - 6"	1.11
16	16	34"	0" - 6"	0.53
17	17	38"	0" - 6"	0.91
18	18	38"	0" - 6"	0.60
19	19	40"	0" - 6"	0.36
20	20	41"	0" - 6"	1.38
21	21	39"	0" - 6"	1.25
22	22	40"	0" - 6"	1.07
23	23	46"	0" - 6"	1.08
24	24	33"	0" - 6"	0.85
25	25	46"	0" - 6"	0.56
26	26	42"	0" - 6"	1.47
27	27	42"	0" - 6"	1.24
28	28	44"	0" - 6"	1.18
29	29	39"	0" - 6"	0.90
30	30	41"	0" - 6"	1.25
31	31	42"	0" - 6"	1.33
32	32	46"	0" - 6"	1.36
33	33	46"	0" - 6"	0.92
34	34	46"	0" - 6"	1.12
35	35	42"	0" - 6"	1.07
36	36	38"	0" - 6"	0.41
37	37	46"	0" - 6"	0.86

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Table 1 - Soil Reference Area Sample Results

Reference Group Sample No.	Core Location[1]	Core Length[2]	Below Surface Depth	Th-232 (pCi/g)
38	38	39"	0" - 6"	1.02
39	39	46"	0" - 6"	0.70
40	40	46"	0" - 6"	1.13
41	41	41"	0" - 6"	0.92
42	42	33"	0" - 6"	0.90
43	43	46"	0" - 6"	0.96
44	44	34"	0" - 6"	1.29
45	45	46"	0" - 6"	1.23
46	46	36"	0" - 6"	0.58
47	47	39"	0" - 6"	0.63
48	48	40"	0" - 6"	1.10
49	49	28"	0" - 6"	0.99
50	50	26"	0" - 6"	0.97
51	51	46"	0" - 6"	1.72
52	52	46"	0" - 6"	1.63
53	53	46"	0" - 6"	1.29
54	54	46"	0" - 6"	1.24
55	55	46"	0" - 6"	1.31
56	56	46"	0" - 6"	1.17
57	57	46"	0" - 6"	0.96
58	58	46"	0" - 6"	1.04
59	59	46"	0" - 6"	0.96
60	60	46"	0" - 6"	1.00
61	1	46"	6" - 12"	0.92
62	2	36"	6" - 12"	1.34
63	3	40"	6" - 12"	0.66
64	4	37"	6" - 12"	1.06
65	5	43"	6" - 12"	0.94
66	6	39"	6" - 12"	0.84
67	7	40"	6" - 12"	1.18
68	8	41"	6" - 12"	1.33
69	9	38"	6" - 12"	0.82
70	10	37"	6" - 12"	0.47
71	11	41"	6" - 12"	1.07
72	12	39"	6" - 12"	1.21
73	13	42"	6" - 12"	1.09
74	14	46"	6" - 12"	0.87

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Table 1 - Soil Reference Area Sample Results

Reference Group Sample No.	Core Location[1]	Core Length[2]	Below Surface Depth	Th-232 (pCi/g)
75	15	36"	6" - 12"	1.27
76	16	34"	6" - 12"	0.97
77	17	38"	6" - 12"	0.80
78	18	38"	6" - 12"	1.04
79	19	40"	6" - 12"	0.57
80	20	41"	6" - 12"	1.25
81	21	39"	6" - 12"	1.25
82	22	40"	6" - 12"	1.43
83	23	46"	6" - 12"	1.22
84	24	33"	6" - 12"	0.79
85	25	46"	6" - 12"	1.18
86	26	42"	6" - 12"	0.88
87	27	42"	6" - 12"	0.98
88	28	44"	6" - 12"	1.46
89	29	39"	6" - 12"	0.87
90	30	41"	6" - 12"	1.37
91	31	42"	6" - 12"	0.97
92	32	46"	6" - 12"	1.37
93	33	46"	6" - 12"	0.67
94	34	46"	6" - 12"	1.17
95	35	42"	6" - 12"	0.89
96	36	38"	6" - 12"	0.57
97	37	46"	6" - 12"	1.09
98	38	39"	6" - 12"	1.39
99	39	46"	6" - 12"	1.37
100	40	46"	6" - 12"	1.01
101	41	41"	6" - 12"	0.91
102	42	33"	6" - 12"	1.04
103	43	46"	6" - 12"	1.12
104	44	34"	6" - 12"	1.45
105	45	46"	6" - 12"	0.95
106	46	36"	6" - 12"	0.98
107	47	39"	6" - 12"	1.00
108	48	40"	6" - 12"	1.01
109	49	28"	6" - 12"	1.27
110	50	26"	6" - 12"	1.26
111	51	46"	6" - 12"	1.16

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Table 1 - Soil Reference Area Sample Results

Reference Group Sample No.	Core Location[1]	Core Length[2]	Below Surface Depth	Th-232 (pCi/g)
112	52	46"	6" - 12"	1.50
113	53	46"	6" - 12"	1.28
114	54	46"	6" - 12"	0.82
115	55	46"	6" - 12"	1.29
116	56	46"	6" - 12"	0.65
117	57	46"	6" - 12"	1.10
118	58	46"	6" - 12"	1.20
119	59	46"	6" - 12"	1.32
120	60	46"	6" - 12"	1.08
121	1	46"	12" - 18"	1.47
122	2	36"	12" - 18"	1.24
123	3	40"	12" - 18"	0.57
124	4	37"	12" - 18"	1.07
125	5	43"	12" - 18"	0.81
126	6	39"	12" - 18"	1.29
127	7	40"	12" - 18"	1.26
128	8	41"	12" - 18"	1.07
129	9	38"	12" - 18"	0.93
130	10	37"	12" - 18"	0.94
131	11	41"	12" - 18"	1.26
132	12	39"	12" - 18"	1.48
133	13	42"	12" - 18"	1.43
134	14	46"	12" - 18"	0.75
135	15	36"	12" - 18"	0.99
136	16	34"	12" - 18"	1.25
137	17	38"	12" - 18"	1.22
138	18	38"	12" - 18"	0.86
139	19	40"	12" - 18"	0.70
140	20	41"	12" - 18"	1.42
141	21	39"	12" - 18"	0.97
142	22	40"	12" - 18"	1.36
143	23	46"	12" - 18"	1.03
144	24	33"	12" - 18"	1.28
145	25	46"	12" - 18"	0.86
146	26	42"	12" - 18"	1.23
147	27	42"	12" - 18"	1.06
148	28	44"	12" - 18"	1.37

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Table 1 - Soil Reference Area Sample Results

Reference Group Sample No.	Core Location[1]	Core Length[2]	Below Surface Depth	Th-232 (pCi/g)
149	29	39"	12" - 18"	0.98
150	30	41"	12" - 18"	1.50
151	31	42"	12" - 18"	1.52
152	32	46"	12" - 18"	1.27
153	33	46"	12" - 18"	0.85
154	34	46"	12" - 18"	1.06
155	35	42"	12" - 18"	1.04
156	36	38"	12" - 18"	0.96
157	37	46"	12" - 18"	0.91
158	38	39"	12" - 18"	1.22
159	39	46"	12" - 18"	1.46
160	40	46"	12" - 18"	1.20
161	41	41"	12" - 18"	1.20
162	42	33"	12" - 18"	1.00
163	43	46"	12" - 18"	1.09
164	44	34"	12" - 18"	1.88
165	45	46"	12" - 18"	0.54
166	46	36"	12" - 18"	1.32
167	47	39"	12" - 18"	1.45
168	48	40"	12" - 18"	1.30
169	49	28"	12" - 18"	1.19
170	50	26"	12" - 18"	1.20
171	51	46"	12" - 18"	1.16
172	52	46"	12" - 18"	1.07
173	53	46"	12" - 18"	0.86
174	54	46"	12" - 18"	0.78
175	55	46"	12" - 18"	1.12
176	56	46"	12" - 18"	0.92
177	57	46"	12" - 18"	0.64
178	58	46"	12" - 18"	0.71
179	59	46"	12" - 18"	1.24
180	60	46"	12" - 18"	0.96
181	1	46"	18" - 24"	1.35
182	2	36"	18" - 24"	1.16
183	3	40"	18" - 24"	0.81
184	4	37"	18" - 24"	1.08
185	5	43"	18" - 24"	0.90

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Table 1 - Soil Reference Area Sample Results

Reference Group Sample No.	Core Location[1]	Core Length[2]	Below Surface Depth	Th-232 (pCi/g)
186	6	39"	18" - 24"	1.36
187	7	40"	18" - 24"	1.30
188	8	41"	18" - 24"	1.25
189	9	38"	18" - 24"	1.03
190	10	37"	18" - 24"	0.49
191	11	41"	18" - 24"	1.47
192	12	39"	18" - 24"	1.32
193	13	42"	18" - 24"	1.16
194	14	46"	18" - 24"	0.89
195	15	36"	18" - 24"	1.48
196	16	34"	18" - 24"	0.91
197	17	38"	18" - 24"	1.52
198	18	38"	18" - 24"	0.92
199	19	40"	18" - 24"	0.66
200	20	41"	18" - 24"	1.41
201	21	39"	18" - 24"	1.03
202	22	40"	18" - 24"	1.51
203	23	46"	18" - 24"	1.43
204	24	33"	18" - 24"	1.35
205	25	46"	18" - 24"	1.05
206	26	42"	18" - 24"	1.02
207	27	42"	18" - 24"	1.56
208	28	44"	18" - 24"	0.79
209	29	39"	18" - 24"	0.90
210	30	41"	18" - 24"	1.22
211	31	42"	18" - 24"	1.62
212	32	46"	18" - 24"	1.29
213	33	46"	18" - 24"	0.94
214	34	46"	18" - 24"	1.45
215	35	42"	18" - 24"	1.13
216	36	38"	18" - 24"	0.64
217	37	46"	18" - 24"	1.28
218	38	39"	18" - 24"	1.32
219	39	46"	18" - 24"	1.01
220	40	46"	18" - 24"	0.86
221	41	41"	18" - 24"	1.19
222	42	33"	18" - 24"	1.19

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Table 1 - Soil Reference Area Sample Results

Reference Group Sample No.	Core Location[1]	Core Length[2]	Below Surface Depth	Th-232 (pCi/g)
223	43	46"	18" - 24"	1.02
224	44	34"	18" - 24"	1.59
225	45	46"	18" - 24"	0.73
226	46	36"	18" - 24"	0.99
227	47	39"	18" - 24"	2.25
228	48	40"	18" - 24"	1.62
229	49	28"	18" - 24"	1.22
230	50	26"	18" - 24"	1.31
231	51	46"	18" - 24"	1.38
232	52	46"	18" - 24"	1.25
233	53	46"	18" - 24"	1.20
234	54	46"	18" - 24"	0.57
235	55	46"	18" - 24"	1.18
236	56	46"	18" - 24"	1.14
237	57	46"	18" - 24"	0.70
238	58	46"	18" - 24"	0.60
239	59	46"	18" - 24"	1.29
240	60	46"	18" - 24"	1.08
241	1	46"	24" - 30"	1.49
242	2	36"	24" - 30"	1.01
243	3	40"	24" - 30"	0.77
244	4	37"	24" - 30"	1.50
245	5	43"	24" - 30"	1.11
246	6	39"	24" - 30"	1.46
247	7	40"	24" - 30"	1.33
248	8	41"	24" - 30"	1.63
249	9	38"	24" - 30"	1.27
250	10	37"	24" - 30"	1.18
251	11	41"	24" - 30"	1.32
252	12	39"	24" - 30"	1.63
253	13	42"	24" - 30"	1.27
254	14	46"	24" - 30"	1.16
255	15	36"	24" - 30"	1.42
256	16	34"	24" - 30"	1.49
257	17	38"	24" - 30"	1.31
258	18	38"	24" - 30"	0.81
259	19	40"	24" - 30"	0.60

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Table 1 - Soil Reference Area Sample Results

Reference Group Sample No.	Core Location[1]	Core Length[2]	Below Surface Depth	Th-232 (pCi/g)
260	20	41"	24" - 30"	2.06
261	21	39"	24" - 30"	1.30
262	22	40"	24" - 30"	1.63
263	23	46"	24" - 30"	1.54
264	24	33"	24" - 30"	1.41
265	25	46"	24" - 30"	1.18
266	26	42"	24" - 30"	1.62
267	27	42"	24" - 30"	1.37
268	28	44"	24" - 30"	2.32
269	29	39"	24" - 30"	0.97
270	30	41"	24" - 30"	1.46
271	31	42"	24" - 30"	1.49
272	32	46"	24" - 30"	1.43
273	33	46"	24" - 30"	0.84
274	34	46"	24" - 30"	1.37
275	35	42"	24" - 30"	1.25
276	36	38"	24" - 30"	0.70
277	37	46"	24" - 30"	1.12
278	38	39"	24" - 30"	1.25
279	39	46"	24" - 30"	1.03
280	40	46"	24" - 30"	1.17
281	41	41"	24" - 30"	1.39
282	42	33"	24" - 30"	0.87
283	43	46"	24" - 30"	1.18
284	44	34"	24" - 30"	1.20
285	45	46"	24" - 30"	0.64
286	46	36"	24" - 30"	1.13
287	47	39"	24" - 30"	1.02
288	48	40"	24" - 30"	1.37
289	51	46"	24" - 30"	1.19
290	52	46"	24" - 30"	1.31
291	53	46"	24" - 30"	1.29
292	54	46"	24" - 30"	0.93
293	55	46"	24" - 30"	0.89
294	56	46"	24" - 30"	0.96
295	57	46"	24" - 30"	1.26
296	58	46"	24" - 30"	0.79

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Table 1 - Soil Reference Area Sample Results

Reference Group Sample No.	Core Location[1]	Core Length[2]	Below Surface Depth	Th-232 (pCi/g)
297	59	46"	24" - 30"	0.85
298	60	46"	24" - 30"	1.38
299	1	46"	30" - 36"	1.24
300	2	36"	30" - 36"	0.67
301	3	40"	30" - 36"	0.76
302	4	37"	30" - 36"	1.16
303	5	43"	30" - 36"	0.98
304	6	39"	30" - 36"	0.99
305	7	40"	30" - 36"	1.50
306	8	41"	30" - 36"	1.41
307	9	38"	30" - 36"	1.02
308	10	37"	30" - 36"	0.38
309	11	41"	30" - 36"	2.04
310	12	39"	30" - 36"	1.42
311	13	42"	30" - 36"	1.42
312	14	46"	30" - 36"	1.26
313	15	36"	30" - 36"	0.56
314	17	38"	30" - 36"	1.16
315	19	40"	30" - 36"	0.84
316	20	41"	30" - 36"	1.13
317	21	39"	30" - 36"	1.21
318	22	40"	30" - 36"	1.47
319	23	46"	30" - 36"	1.31
320	25	46"	30" - 36"	0.93
321	26	42"	30" - 36"	1.03
322	27	42"	30" - 36"	1.38
323	28	44"	30" - 36"	0.87
324	29	39"	30" - 36"	1.12
325	30	41"	30" - 36"	1.50
326	31	42"	30" - 36"	1.72
327	32	46"	30" - 36"	1.32
328	33	46"	30" - 36"	1.25
329	34	46"	30" - 36"	1.21
330	35	42"	30" - 36"	1.22
331	36	38"	30" - 36"	0.55
332	37	46"	30" - 36"	0.95
333	38	39"	30" - 36"	0.89

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Table 1 - Soil Reference Area Sample Results

Reference Group Sample No.	Core Location[1]	Core Length[2]	Below Surface Depth	Th-232 (pCi/g)
334	39	46"	30" - 36"	0.82
335	40	46"	30" - 36"	1.11
336	41	41"	30" - 36"	1.36
337	43	46"	30" - 36"	1.21
338	45	46"	30" - 36"	1.04
339	46	36"	30" - 36"	0.46
340	47	39"	30" - 36"	1.10
341	48	40"	30" - 36"	1.61
342	51	46"	30" - 36"	1.26
343	52	46"	30" - 36"	1.14
344	53	46"	30" - 36"	1.61
345	54	46"	30" - 36"	0.86
346	55	46"	30" - 36"	0.84
347	56	46"	30" - 36"	0.90
348	57	46"	30" - 36"	0.87
349	58	46"	30" - 36"	0.82
350	59	46"	30" - 36"	1.16
351	60	46"	30" - 36"	1.07
352	1	46"	36" - 42"	1.09
353	5	43"	36" - 42"	0.79
354	13	42"	36" - 42"	0.96
355	14	46"	36" - 42"	0.96
356	23	46"	36" - 42"	1.45
357	25	46"	36" - 42"	0.94
358	26	42"	36" - 42"	0.74
359	27	42"	36" - 42"	0.74
360	28	44"	36" - 42"	1.08
361	31	42"	36" - 42"	0.47
362	32	46"	36" - 42"	1.18
363	33	46"	36" - 42"	0.97
364	34	46"	36" - 42"	1.31
365	35	42"	36" - 42"	0.74
366	37	46"	36" - 42"	0.99
367	39	46"	36" - 42"	1.02
368	40	46"	36" - 42"	1.26
369	43	46"	36" - 42"	1.21
370	45	46"	36" - 42"	0.79

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Table 1 - Soil Reference Area Sample Results

Reference Group Sample No.	Core Location[1]	Core Length[2]	Below Surface Depth	Th-232 (pCi/g)
371	51	46"	36" - 42"	0.84
372	52	46"	36" - 42"	1.06
373	53	46"	36" - 42"	1.32
374	54	46"	36" - 42"	0.95
375	55	46"	36" - 42"	0.99
376	56	46"	36" - 42"	0.96
377	57	46"	36" - 42"	0.99
378	58	46"	36" - 42"	0.77
379	59	46"	36" - 42"	1.02
380	60	46"	36" - 42"	1.20
			Average:	1.10
			Stdev.:	0.30
			Minimum:	0.35
			Maximum:	2.32
			Median:	1.11
			Count:	380

Notes:

[1]Numbers 1 through 30 taken on-site in an non-impacted area. Numbers 31 through 60 taken 1 mile offsite.

[2]Length is the actual length of the recovered core from a 4-foot increment.

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Table 2 - Concrete Structural Surface Reference Area Sample Results

Reference Group Sample No.	Flux Building Survey Unit	Location	Grid	Total Alpha Contamination (dpm/100cm^2)
1	FB-001	Concrete Floor	A3	90.6
2	FB-001	Concrete Floor	A4	53.0
3	FB-001	Concrete Floor	A5	92.3
4	FB-001	Concrete Floor	A6	33.4
5	FB-001	Concrete Floor	A7	43.2
6	FB-001	Concrete Floor	B3	102
7	FB-001	Concrete Floor	B4	60.4
8	FB-001	Concrete Floor	B5	60.4
9	FB-001	Concrete Floor	B6	50.3
10	FB-001	Concrete Floor	B7	60.4
11	FB-001	Concrete Floor	C3	171
12	FB-001	Concrete Floor	C4	50.3
13	FB-001	Concrete Floor	C5	141
14	FB-001	Concrete Floor	C6	161
15	FB-001	Concrete Floor	C7	62.9
16	FB-001	Concrete Floor	D3	70.5
17	FB-001	Concrete Floor	D4	102
18	FB-001	Concrete Floor	D5	72.7
19	FB-001	Concrete Floor	D6	72.7
20	FB-001	Concrete Floor	D7	92.3
21	FB-001	Concrete Floor	E3	80.5
22	FB-001	Concrete Floor	E4	82.5
23	FB-001	Concrete Floor	E5	72.7
24	FB-001	Concrete Floor	E6	82.5
25	FB-001	Concrete Floor	E7	72.7
26	FB-001	Concrete Floor	F3	111
27	FB-001	Concrete Floor	F4	141
28	FB-001	Concrete Floor	F5	161
29	FB-001	Concrete Floor	F6	269
30	FB-001	Concrete Floor	F7	92.3
31	FB-001	Concrete Floor	G3	-10.1
32	FB-001	Concrete Floor	G4	82.5
33	FB-001	Concrete Floor	G5	122
34	FB-001	Concrete Floor	G6	43.2
35	FB-001	Concrete Floor	G7	43.2
36	FB-001	Concrete Floor	H3	101
37	FB-001	Concrete Floor	H4	33.4

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Table 2 - Concrete Structural Surface Reference Area Sample Results

Reference Group Sample No.	Flux Building Survey Unit	Location	Grid	Total Alpha Contamination (dpm/100cm^2)
38	FB-001	Concrete Floor	H5	72.7
39	FB-001	Concrete Floor	H6	33.4
40	FB-001	Concrete Floor	H7	72.7
41	FB-001	Concrete Floor	I3	80.5
42	FB-001	Concrete Floor	I4	92.3
43	FB-001	Concrete Floor	I5	72.7
44	FB-001	Concrete Floor	I6	102
45	FB-001	Concrete Floor	I7	62.9
46	FB-001	Concrete Floor	J3	151
47	FB-001	Concrete Floor	J4	141
48	FB-001	Concrete Floor	J5	102
49	FB-001	Concrete Floor	J6	102
50	FB-001	Concrete Floor	J7	33.4
51	FB-002	Concrete Floor	FSS-002	107
52	FB-002	Concrete Floor	FSS-004	56.4
53	FB-002	Concrete Floor	FSS-006	66.4
54	FB-002	Concrete Floor	FSS-008	66.4
55	FB-002	Concrete Floor	FSS-010	16.1
56	FB-002	Concrete Floor	FSS-012	36.2
57	FB-002	Concrete Floor	FSS-014	66.4
58	FB-002	Concrete Floor	FSS-016	127
59	FB-003	Concrete Floor	FSS-001	50.3
60	FB-003	Concrete Floor	FSS-002	30.2
61	FB-003	Concrete Floor	FSS-004	50.3
62	FB-003	Concrete Floor	FSS-005	80.5
63	FB-003	Concrete Floor	FSS-008	40.3
64	FB-003	Concrete Floor	FSS-009	40.3
65	FB-003	Concrete Floor	FSS-012	30.2
66	FB-003	Concrete Floor	FSS-013	80.5
67	FB-003	Concrete Floor	FSS-016	151
68	FB-003	Concrete Floor	FSS-017	60.4
69	FB-003	Concrete Floor	FSS-003	102
70	FB-003	Concrete Floor	FSS-006	43.2
71	FB-003	Concrete Floor	FSS-007	72.7
72	FB-003	Concrete Floor	FSS-010	62.9
73	FB-003	Concrete Floor	FSS-011	112
74	FB-003	Concrete Floor	FSS-014	13.8

APPENDIX C

Table 2 - Concrete Structural Surface Reference Area Sample Results

Reference Group Sample No.	Flux Building Survey Unit	Location	Grid	Total Alpha Contamination (dpm/100cm^2)
75	FB-003	Concrete Floor	FSS-015	62.9
76	FB-007	Concrete Floor	FSS-004	72.5
77	FB-007	Concrete Floor	FSS-006	82.5
78	FB-007	Concrete Floor	FSS-009	123
79	FB-007	Concrete Floor	FSS-010	52.3
			Average:	79.7
			Stdev.:	42.5
			Minimum:	-10.1
			Maximum:	269
			Median:	72.7
			Count:	79

APPENDIX C

Table 3 - Cinderblock Structural Surface Reference Area Sample Results

Reference Group Sample No.	Flux Building Survey Unit	Location	Grid	Total Alpha Contamination (dpm/100cm^2)
1	FB-001	Painted Cinderblock Wall	A1	10.1
2	FB-001	Painted Cinderblock Wall	A2	20.1
3	FB-001	Painted Cinderblock Wall	B1	13.8
4	FB-001	Painted Cinderblock Wall	B2	13.8
5	FB-001	Painted Cinderblock Wall	C1	30.2
6	FB-001	Painted Cinderblock Wall	C2	111
7	FB-001	Painted Cinderblock Wall	D1	60.4
8	FB-001	Painted Cinderblock Wall	D2	30.2
9	FB-001	Painted Cinderblock Wall	E1	-10.1
10	FB-001	Painted Cinderblock Wall	E2	0.0
11	FB-001	Painted Cinderblock Wall	F1	0.0
12	FB-001	Painted Cinderblock Wall	F2	30.2
13	FB-001	Painted Cinderblock Wall	G1	40.3
14	FB-001	Painted Cinderblock Wall	G2	-10.1
15	FB-001	Painted Cinderblock Wall	H1	20.1
16	FB-001	Painted Cinderblock Wall	H2	80.5
17	FB-001	Painted Cinderblock Wall	I1	40.3
18	FB-001	Painted Cinderblock Wall	I2	20.1
19	FB-001	Painted Cinderblock Wall	J1	0.0
20	FB-001	Painted Cinderblock Wall	J2	40.3
21	FB-001	Painted Cinderblock Wall	K3	10.1
22	FB-001	Painted Cinderblock Wall	K4	33.4
23	FB-001	Painted Cinderblock Wall	K5	23.6
24	FB-001	Painted Cinderblock Wall	K6	20.1
25	FB-001	Painted Cinderblock Wall	K7	40.3
26	FB-001	Painted Cinderblock Wall	L3	30.2
27	FB-001	Painted Cinderblock Wall	L4	10.1
28	FB-001	Painted Cinderblock Wall	L5	10.1
29	FB-001	Painted Cinderblock Wall	L6	10.1
30	FB-001	Painted Cinderblock Wall	L7	20.1
31	FB-002	Painted Cinderblock Wall	FSS-001	5.89
32	FB-002	Painted Cinderblock Wall	FSS-003	15.7
33	FB-002	Painted Cinderblock Wall	FSS-005	25.5
34	FB-002	Painted Cinderblock Wall	FSS-007	15.7

APPENDIX C

Table 3 - Cinderblock Structural Surface Reference Area Sample Results

Reference Group Sample No.	Flux Building Survey Unit	Location	Grid	Total Alpha Contamination (dpm/100cm^2)
1	FB-001	Painted Cinderblock Wall	A1	10.1
35	FB-002	Painted Cinderblock Wall	FSS-009	5.89
36	FB-002	Painted Cinderblock Wall	FSS-011	5.89
37	FB-002	Painted Cinderblock Wall	FSS-013	15.7
38	FB-002	Painted Cinderblock Wall	FSS-015	45.2
39	FB-002	Painted Cinderblock Wall	FSS-017	45.2
40	FB-004	Painted Cinderblock Wall	3	20.1
41	FB-004	Painted Cinderblock Wall	7	0.0
42	FB-004	Painted Cinderblock Wall	9	40.3
43	FB-004	Painted Cinderblock Wall	11	-10.1
44	FB-004	Painted Cinderblock Wall	13	10.1
45	FB-004	Painted Cinderblock Wall	2	3.93
46	FB-004	Painted Cinderblock Wall	6	3.93
47	FB-004	Painted Cinderblock Wall	8	62.9
48	FB-004	Painted Cinderblock Wall	10	43.2
49	FB-004	Painted Cinderblock Wall	12	33.4
50	FB-004	Painted Cinderblock Wall	14	3.93
51	FB-006	Painted Cinderblock Wall	FSS-011	78.6
52	FB-006	Painted Cinderblock Wall	FSS-012	29.5
53	FB-006	Painted Cinderblock Wall	FSS-013	88.4
54	FB-006	Painted Cinderblock Wall	FSS-014	68.8
55	FB-007	Painted Cinderblock Wall	FSS-001	12.1
56	FB-007	Painted Cinderblock Wall	FSS-002	2.01
57	FB-007	Painted Cinderblock Wall	FSS-005	32.2
58	FB-007	Painted Cinderblock Wall	FSS-007	2.01
59	FB-007	Painted Cinderblock Wall	FSS-008	22.1
60	FB-007	Painted Cinderblock Wall	FSS-011	2.01
61	FB-007	Painted Cinderblock Wall	FSS-012	12.1
62	FB-007	Painted Cinderblock Wall	FSS-014	12.1
63	FB-008	Painted Cinderblock Wall	FSS-001	6.04
64	FB-008	Painted Cinderblock Wall	FSS-002	-4.03
65	FB-008	Painted Cinderblock Wall	FSS-003	26.2
66	FB-008	Painted Cinderblock Wall	FSS-005	26.2
67	FB-008	Painted Cinderblock Wall	FSS-007	26.2

APPENDIX C

Table 3 - Cinderblock Structural Surface Reference Area Sample Results

Reference Group Sample No.	Flux Building Survey Unit	Location	Grid	Total Alpha Contamination (dpm/100cm^2)
1	FB-001	Painted Cinderblock Wall	A1	10.1
68	FB-008	Painted Cinderblock Wall	FSS-008	36.2
69	FB-008	Painted Cinderblock Wall	FSS-011	26.2
70	FB-008	Painted Cinderblock Wall	FSS-012	16.1
71	FB-008	Painted Cinderblock Wall	FSS-013	6.04
72	FB-008	Painted Cinderblock Wall	FSS-014	16.1
			Average:	23.4
			Stdev.:	23.4
			Minimum:	-10.1
			Maximum:	111
			Median:	20.1
			Count:	72

I.4 Critical Values for the WRS Test

Table I.4 Critical Values for the WRS test

m is the number of reference area samples and n is the number of survey unit samples.

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 2	α=0.001	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43
	α=0.005	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	40	42
	α=0.01	7	9	11	13	15	17	19	21	23	25	27	28	30	32	34	36	38	39	41
	α=0.025	7	9	11	13	15	17	18	20	22	23	25	27	29	31	33	34	36	38	40
	α=0.05	7	9	11	12	14	16	17	19	21	23	24	26	27	29	31	33	34	36	38
	α=0.1	7	8	10	11	13	15	16	18	19	21	22	24	26	27	29	30	32	33	35

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 3	α=0.001	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	56	59	62	65
	α=0.005	12	15	18	21	24	27	30	32	35	38	40	43	46	48	51	54	57	59	62
	α=0.01	12	15	18	21	24	26	29	31	34	37	39	42	45	47	50	52	55	58	60
	α=0.025	12	15	18	20	22	25	27	30	32	35	37	40	42	45	47	50	52	55	57
	α=0.05	12	14	17	19	21	24	26	28	31	33	36	38	40	43	45	47	50	52	54
	α=0.1	11	13	16	18	20	22	24	27	29	31	33	35	37	40	42	44	46	48	50

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 4	α=0.001	18	22	26	30	34	38	42	46	49	53	57	60	64	68	71	75	78	82	86
	α=0.005	18	22	26	30	33	37	40	44	47	51	54	58	61	64	68	71	75	78	81
	α=0.01	18	22	26	29	32	36	39	42	46	49	52	56	59	62	66	69	72	76	79
	α=0.025	18	22	25	28	31	34	37	41	44	47	50	53	56	59	62	66	69	72	75
	α=0.05	18	21	24	27	30	33	36	39	42	45	48	51	54	57	59	62	65	68	71
	α=0.1	17	20	22	25	28	31	34	36	39	42	45	48	50	53	56	59	61	64	67

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 5	α=0.001	25	30	35	40	45	50	54	58	63	67	72	76	81	85	89	94	98	102	107
	α=0.005	25	30	35	39	43	48	52	56	60	64	68	72	77	81	85	89	93	97	101
	α=0.01	25	30	34	38	42	46	50	54	58	62	66	70	74	78	82	86	90	94	98
	α=0.025	25	29	33	37	41	44	48	52	56	60	63	67	71	75	79	82	86	90	94
	α=0.05	24	28	32	35	39	43	46	50	53	57	61	64	68	71	75	79	82	86	89
	α=0.1	23	27	30	34	37	41	44	47	51	54	57	61	64	67	71	74	77	81	84

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 6	α=0.001	33	39	45	51	57	63	67	72	77	82	88	93	98	103	108	113	118	123	128
	α=0.005	33	39	44	49	54	59	64	69	74	79	83	88	93	98	103	107	112	117	122
	α=0.01	33	39	43	48	53	58	62	67	72	77	81	86	91	95	100	104	109	114	118
	α=0.025	33	37	42	47	51	56	60	64	69	73	78	82	87	91	95	100	104	109	113
	α=0.05	32	36	41	45	49	54	58	62	66	70	75	79	83	87	91	96	100	104	108
	α=0.1	31	35	39	43	47	51	55	59	63	67	71	75	79	83	87	91	94	98	102

Table I.4 Critical Values for the WRS Test (continued)

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 7	α=0.001	42	49	56	63	69	75	81	87	92	98	104	110	116	122	128	133	139	145	151
	α=0.005	42	49	55	61	66	72	77	83	88	94	99	105	110	116	121	127	132	138	143
	α=0.01	42	48	54	59	65	70	76	81	86	92	97	102	108	113	118	123	129	134	139
	α=0.025	42	47	52	57	63	68	73	78	83	88	93	98	103	108	113	118	123	128	133
	α=0.05	41	46	51	56	61	65	70	75	80	85	90	94	99	104	109	113	118	123	128
	α=0.1	40	44	49	54	58	63	67	72	76	81	85	90	94	99	103	108	112	117	121

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 8	α=0.001	52	60	68	75	82	89	95	102	109	115	122	128	135	141	148	154	161	167	174
	α=0.005	52	60	66	73	79	85	92	98	104	110	116	122	129	135	141	147	153	159	165
	α=0.01	52	59	65	71	77	84	90	96	102	108	114	120	125	131	137	143	149	155	161
	α=0.025	51	57	63	69	75	81	86	92	98	104	109	115	121	126	132	137	143	149	154
	α=0.05	50	56	62	67	73	78	84	89	95	100	105	111	116	122	127	132	138	143	148
	α=0.1	49	54	60	65	70	75	80	85	91	96	101	106	111	116	121	126	131	136	141

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 9	α=0.001	63	72	81	88	96	104	111	118	126	133	140	147	155	162	169	176	183	190	198
	α=0.005	63	71	79	86	93	100	107	114	121	127	134	141	148	155	161	168	175	182	188
	α=0.01	63	70	77	84	91	98	105	111	118	125	131	138	144	151	157	164	170	177	184
	α=0.025	62	69	76	82	88	95	101	108	114	120	126	133	139	145	151	158	164	170	176
	α=0.05	61	67	74	80	86	92	98	104	110	116	122	128	134	140	146	152	158	164	170
	α=0.1	60	66	71	77	83	89	94	100	106	112	117	123	129	134	140	145	151	157	162

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 10	α=0.001	75	85	94	103	111	119	128	136	144	152	160	167	175	183	191	199	207	215	222
	α=0.005	75	84	92	100	108	115	123	131	138	146	153	160	168	175	183	190	197	205	212
	α=0.01	75	83	91	98	106	113	121	128	135	142	150	157	164	171	178	186	193	200	207
	α=0.025	74	81	89	96	103	110	117	124	131	138	145	151	158	165	172	179	186	192	199
	α=0.05	73	80	87	93	100	107	114	120	127	133	140	147	153	160	166	173	179	186	192
	α=0.1	71	78	84	91	97	103	110	116	122	128	135	141	147	153	160	166	172	178	184

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 11	α=0.001	88	99	109	118	127	136	145	154	163	171	180	188	197	206	214	223	231	240	248
	α=0.005	88	98	107	115	124	132	140	148	157	165	173	181	189	197	205	213	221	229	237
	α=0.01	88	97	105	113	122	130	138	146	153	161	169	177	185	193	200	208	216	224	232
	α=0.025	87	95	103	111	118	126	134	141	149	156	164	171	179	186	194	201	208	216	223
	α=0.05	86	93	101	108	115	123	130	137	144	152	159	166	173	180	187	195	202	209	216
	α=0.1	84	91	98	105	112	119	126	133	139	146	153	160	167	173	180	187	194	201	207

Table I.4 Critical Values for the WRS Test (continued)

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 12	α=0.001	102	114	125	135	145	154	164	173	183	192	202	210	220	230	238	247	256	266	275
	α=0.005	102	112	122	131	140	149	158	167	176	185	194	202	211	220	228	237	246	254	263
	α=0.01	102	111	120	129	138	147	156	164	173	181	190	198	207	215	223	232	240	249	257
	α=0.025	100	109	118	126	135	143	151	159	168	176	184	192	200	208	216	224	232	240	248
	α=0.05	99	108	116	124	132	140	147	155	165	171	179	186	194	202	209	217	225	233	240
	α=0.1	97	105	113	120	128	135	143	150	158	165	172	180	187	194	202	209	216	224	231

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 13	α=0.001	117	130	141	152	163	173	183	193	203	213	223	233	243	253	263	273	282	292	302
	α=0.005	117	128	139	148	158	168	177	187	196	206	215	225	234	243	253	262	271	280	290
	α=0.01	116	127	137	146	156	165	174	184	193	202	211	220	229	238	247	256	265	274	283
	α=0.025	115	125	134	143	152	161	170	179	187	196	205	214	222	231	239	248	257	265	274
	α=0.05	114	123	132	140	149	157	166	174	183	191	199	208	216	224	233	241	249	257	266
	α=0.1	112	120	129	137	145	153	161	169	177	185	193	201	209	217	224	232	240	248	256

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 14	α=0.001	133	147	159	171	182	193	204	215	225	236	247	257	268	278	289	299	310	320	330
	α=0.005	133	145	156	167	177	187	198	208	218	228	238	248	258	268	278	288	298	307	317
	α=0.01	132	144	154	164	175	185	194	204	214	224	234	243	253	263	272	282	291	301	311
	α=0.025	131	141	151	161	171	180	190	199	208	218	227	236	245	255	264	273	282	292	301
	α=0.05	129	139	149	158	167	176	185	194	203	212	221	230	239	248	257	265	274	283	292
	α=0.1	128	136	145	154	163	171	180	189	197	206	214	223	231	240	248	257	265	273	282

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 15	α=0.001	150	165	178	190	202	212	225	237	248	260	271	282	293	304	316	327	338	349	360
	α=0.005	150	162	174	186	197	208	219	230	240	251	262	272	283	293	304	314	325	335	346
	α=0.01	149	161	172	183	194	205	215	226	236	247	257	267	278	288	298	308	319	329	339
	α=0.025	148	159	169	180	190	200	210	220	230	240	250	260	270	280	289	299	309	319	329
	α=0.05	146	157	167	176	186	196	206	215	225	234	244	253	263	272	282	291	301	310	319
	α=0.1	144	154	163	172	182	191	200	209	218	227	236	246	255	264	273	282	291	300	309

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 16	α=0.001	168	184	197	210	223	236	248	260	272	284	296	308	320	332	343	355	367	379	390
	α=0.005	168	181	194	206	218	229	241	252	264	275	286	298	309	320	331	342	353	365	376
	α=0.01	167	180	192	203	215	226	237	248	259	270	281	292	303	314	325	336	347	357	368
	α=0.025	166	177	188	200	210	221	232	242	253	264	274	284	295	305	316	326	337	347	357
	α=0.05	164	175	185	196	206	217	227	237	247	257	267	278	288	298	308	318	328	338	348
	α=0.1	162	172	182	192	202	211	221	231	241	250	260	269	279	289	298	308	317	327	336

Table I.4 Critical Values for the WRS Test (continued)

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 17	α=0.001	187	203	218	232	245	258	271	284	297	310	322	335	347	360	372	384	397	409	422
	α=0.005	187	201	214	227	239	252	264	276	288	300	312	324	336	347	359	371	383	394	406
	α=0.01	186	199	212	224	236	248	260	272	284	295	307	318	330	341	353	364	376	387	399
	α=0.025	184	197	209	220	232	243	254	266	277	288	299	310	321	332	343	354	365	376	387
	α=0.05	183	194	205	217	228	238	249	260	271	282	292	303	313	324	335	345	356	366	377
	α=0.1	180	191	202	212	223	233	243	253	264	274	284	294	305	315	325	335	345	355	365

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 18	α=0.001	207	224	239	254	268	282	296	309	323	336	349	362	376	389	402	415	428	441	454
	α=0.005	207	222	236	249	262	275	288	301	313	326	339	351	364	376	388	401	413	425	438
	α=0.01	206	220	233	246	259	272	284	296	309	321	333	345	357	370	382	394	406	418	430
	α=0.025	204	217	230	242	254	266	278	290	302	313	325	337	348	360	372	383	395	406	418
	α=0.05	202	215	226	238	250	261	273	284	295	307	318	329	340	352	363	374	385	396	407
	α=0.1	200	211	222	233	244	255	266	277	288	299	309	320	331	342	352	363	374	384	395

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 19	α=0.001	228	246	262	277	292	307	321	335	350	364	377	391	405	419	433	446	460	473	487
	α=0.005	227	243	258	272	286	300	313	327	340	353	366	379	392	405	419	431	444	457	470
	α=0.01	226	242	256	269	283	296	309	322	335	348	361	373	386	399	411	424	437	449	462
	α=0.025	225	239	252	265	278	290	303	315	327	340	352	364	377	389	401	413	425	437	450
	α=0.05	223	236	248	261	273	285	297	309	321	333	345	356	368	380	392	403	415	427	439
	α=0.1	220	232	244	256	267	279	290	302	313	325	336	347	358	370	381	392	403	415	426

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 20	α=0.001	250	269	286	302	317	333	348	363	377	392	407	421	435	450	464	479	493	507	521
	α=0.005	249	266	281	296	311	325	339	353	367	381	395	409	422	436	450	463	477	490	504
	α=0.01	248	264	279	293	307	321	335	349	362	376	389	402	416	429	442	456	469	482	495
	α=0.025	247	261	275	289	302	315	329	341	354	367	380	393	406	419	431	444	457	470	482
	α=0.05	245	258	271	284	297	310	322	335	347	360	372	385	397	409	422	434	446	459	471
	α=0.1	242	254	267	279	291	303	315	327	339	351	363	375	387	399	410	422	434	446	458

Reject the null hypothesis if the test statistic (W_r) is greater than the table (critical) value. For n or m greater than 20, the table (critical) value can be calculated from:

$$m(n+m+1)/2 + z\sqrt{nm(n+m+1)/12} \tag{I.1}$$

if there are few or no ties, and from

$$m(n+m+1)/2 + z\sqrt{\frac{nm}{12}[(n+m+1) - \sum_{j=1}^{g} \frac{t_j(t_j^2-1)}{(n+m)(n+m-1)}]} \tag{I.2}$$

if there are many ties, where g is the number of groups of tied measurements and t_j is the number of tied measurements in the jth group. z is the (1-α) percentile of a standard normal distribution, which can be found in the following table:

α	z
0.001	3.09
0.005	2.575
0.01	2.326
0.025	1.960
0.05	1.645
0.1	1.282

Other values can be found in Table I-1.

APPENDIX D

CAVE COUNTER CALIBRATION AND SOIL SAMPLE RESULTS

Appendix D
On-Site Cave Counter
Final Status Survey Report
Thorium Remediation Project
Tulsa, Oklahoma Facility
Kaiser Aluminum & Chemical Corporation

Certain soil samples collected as part of the final status survey process are screened for Th-232 activity concentration using an on-site cave counter (counter). The on-site cave counter for the Thorium Remediation Project consists of a 2-inch by 2-inch NaI Ludlum Model 44-10 detector coupled with a Ludlum Model 2221 Scaler/Ratemeter instrument, mounted inside a shielded box with room for a standard soil sample container to be placed on the face (bottom, non-wire connecting end) of the detector. Two detectors (numbered NaI # 4 and NaI #8) have been used as part of the counter. The detectors were all calibrated annually off-site by a qualified vendor to verify their response to high energy photons. The detectors, including their use as part of the counter, are utilized to obtain gross gamma readings from soil samples in units of counts per minute (cpm). The detector response is checked daily when in use to a Cs-137 source.

In addition to the off site calibration, Detectors NaI #4 and NaI #8 have been calibrated on-site to verify the response of the detector to soil (or soil like material) containing Th-232 in equilibrium with all progeny. A well characterized sample of material used to calibrate another on-site counter system (the SMCM system) was used to calibrate both detectors. The documentation of the calibrations is included in this appendix.

The result of the on-site calibration is a detector specific calibration factor (CF) in units of pico-Curies of Th-232 per net counts per minute (pCi/cpm). The inverse of the CF is referred to as the instrument efficiency in units of cpm/pCi and is used to convert the gross gamma response of the detector in cpm to pCi/g of Th-232 within a standard soil sample as follows:

1. A standard soil sample of background soil is counted. Usually for 5 minutes each day the counter is used. The time and total counts are recorded as "BKG Count Time" and "BKG Counts." In addition, the sample is weighed (net) and the resulting weight is recorded. Since the same sample is used each day, the resulting weight is consistently 570 or 571 grams. The value of 570 grams yield a more conservative MDC result, and therefore is used daily.
2. A standard soil sample is weighed in units of grams (g) and recorded as "Sample Weight". A standard empty soil container is also weighed. The sample weight is the net of the soil sample less the empty container weight.
3. The sample is placed inside the lead shielded box (standard repeatable counting geometry) and the NaI detector is placed on top of the container. Usually, a one minute count is performed and recorded as "Gross Count Rate Top".
4. The sample is re-placed in the standard counting geometry upside down. Another 1 minute count is performed and recorded as "Gross Count Rate Bottom".

5. The background count rate is subtracted from the average of the top and bottom sample count rates and recorded as "Net Count Rate Average".
6. The net count rate is then converted to pCi/g of Th-232 by dividing the net count rate average by the instrument efficiency (cpm/pCi) and the sample weight (g) and recorded as "Th-232". The instrument efficiency is equal to 1 / CF (in units of pCi/cpm).
7. The standard error for the count is then calculated and recorded as "95% CL Uncertainty" as follows:

$$Unc_{95\%cl} = \frac{1.96\sqrt{\left(\frac{CR_{sb}}{t_{sb}} + \frac{CR_{st}}{t_{st}} + \frac{CR_b}{t_b}\right)}}{\cdot E \cdot W}$$

where:

$Unc_{95\%cl}$ = 95% confidence level (2 sigma) uncertainty in pCi/g,
CR_{sb} = sample bottom count rate in counts per minute,
t_{sb} = sample bottom count time in minutes,
CR_{st} = sample top count rate in counts per minute,
t_{st} = sample top count time in minutes,
CR_b = background count rate in counts per minute,
t_b = background count time in minutes,
W = sample weight in g, and
E = detector efficiency (= 1/CF) in cpm/pCi

8. The minimum detectable concentration is calculated and recorded as "MDC" as follows:

$$MDC = \frac{3 + 3.29\sqrt{B_r \cdot t_s \cdot \left(1 + \frac{t_s}{t_b}\right)}}{t_s \cdot E \cdot W}$$

where:

MDC = minimum detectable concentration in pCi/g,
B_R = background count rate in counts per minute,
t_B = background count time in minutes,
t_S = sample count time in minutes,
W = sample weight in g, and
E = detector efficiency in cpm/pCi

A summary of the two instrument/detectors used for cave counts is presented below in **Table D-1.**

The conversion of count data to a result in pCi/g of Th-232, the 95% confidence uncertainty (standard 2 sigma error) and the Minimum Detectable Concentration (MDC) for the count, all in units of pCi/g, for various samples (not analyzed by Outreach) are presented in the attached **Appendix D, Table D-2.**

Table D-1 – Cave Counter Detector Summary

Number	Instrument Serial #:	Detector Serial #:	On-Site Calibration Date	Calibration Factor (cpm/pCi/g)	Efficiency = 1/CF (pCi/g/cpm)
4	172053	PR206815	12/03/04	4.41	0.227
8	216513	PR230093	11/03/05	4.46	0.224

Appendix D, Table D-2
Cave Counter Data
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Count Date	Det. #:	Detector Efficiency (cpm / pCi/g)	Sample No.	Sample Type	Survey Unit	Sample Count Time (min)	Net Sample Weight (g)	Gross Count Rate Top (cpm)	Gross Count Rate Bottom (cpm)	BKG Count Time (min)	BKG Counts	BKG Sample Weight (g)	Net Count Rate Average (cpm)	Th-232 (pCi/g)	95% CL Unc. (pCi/g)	MDC (pCi/g)
1/12/05	4	0.227	K-466	Biased	FOA-001	1	752	3,059	3,192	5	14,476	570	230	1.35	0.950	1.52
1/12/05	4	0.227	K-467	Biased	FOA-001	1	715	2,817	3,143	5	14,476	570	85	0.523	0.978	1.52
1/12/05	4	0.227	K-468	Biased	FOA-001	1	822	3,014	3,330	5	14,476	570	277	1.49	0.875	1.52
1/12/05	4	0.227	K-469	Biased	FOA-001	1	817	3,107	3,257	5	14,476	570	287	1.55	0.882	1.52
1/17/05	4	0.227	K-471	Biased	FOA-001	1	846	3,028	3,440	5	15,127	570	209	1.09	0.859	1.56
5/16/05	4	0.227	K-658	Biased	FOA-005	1	568	2,880	2,952	5	15,215	570	-127	-0.986	1.22	1.56
5/16/05	4	0.227	K-659	Biased	FOA-005	1	576	2,861	3,028	5	15,215	570	-99	-0.754	1.21	1.56
5/16/05	4	0.227	K-660	Biased	FOA-005	1	666	3,262	3,098	5	15,215	570	137	0.907	1.08	1.56
5/16/05	4	0.227	K-661	Biased	FOA-005	1	682	3,066	3,252	5	15,215	570	116	0.750	1.05	1.56
6/1/05	4	0.227	K-710	Biased	FOA-005	1	732	3,542	3,562	5	15,360	570	480	2.89	1.04	1.57
5/31/05	4	0.227	K-711	Biased	FOA-005	1	718	3,353	3,343	5	15,165	570	315	1.93	1.03	1.56
5/31/05	4	0.227	K-712	Biased	FOA-005	1	648	3,142	3,433	5	15,165	570	255	1.73	1.13	1.56
6/28/05	4	0.227	K-755	Biased	FOA-006	1	775	2,745	2,882	5	14,865	570	-160	-0.908	0.880	1.54
6/28/05	4	0.227	K-759	Biased	FOA-006	1	805	3,359	3,331	5	14,865	570	372	2.04	0.916	1.54
6/28/05	4	0.227	K-772	Biased	FOA-006	1	645	3,074	3,141	5	14,865	570	135	0.920	1.11	1.54
6/27/05	4	0.227	K-773	Biased	FOA-006	1	653	3,215	3,419	5	15,105	570	296	2.00	1.13	1.56
2/14/05	4	0.227	K-524	Biased	FSS-013	1	712	3,573	3,436	5	14,534	570	598	3.70	1.06	1.53

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Count Date	Det. #:	Detector Efficiency (cpm / pCi/g)	Sample No.	Sample Type	Survey Unit	Sample Count Time (min)	Net Sample Weight (g)	Gross Count Rate Top (cpm)	Gross Count Rate Bottom (cpm)	BKG Count Time (min)	BKG Counts	BKG Sample Weight (g)	Net Count Rate Average (cpm)	Th-232 (pCi/g)	95% CL Unc. (pCi/g)	MDC (pCi/g)
12/6/05	8	0.224	K-552	Biased	FSS-014	10	696	26,779	28,659	10	28,220	570	-50	-0.321	0.363	0.614
4/14/05	4	0.227	K-570	Biased	FSS-015	1	836	3,427	3,105	5	14,870	570	292	1.54	0.873	1.54
4/14/05	4	0.227	K-571	Biased	FSS-015	1	838	3,279	3,311	5	14,870	570	321	1.69	0.874	1.54
4/14/05	4	0.227	K-572	Biased	FSS-015	1	706	3,122	3,113	5	14,870	570	144	0.896	1.01	1.54
4/18/05	4	0.227	K-574	Biased	FSS-015	1	734	3,218	3,273	5	14,703	570	305	1.83	0.991	1.54
4/18/05	4	0.227	K-575	Biased	FSS-015	1	616	2,996	3,126	5	14,703	570	121	0.863	1.15	1.54
4/18/05	4	0.227	K-576	Biased	FSS-015	1	635	3,132	3,073	5	14,703	570	162	1.13	1.12	1.54
12/6/05	8	0.224	K-625	Biased	FSS-015	10	673	28,765	29,472	10	28,220	570	90	0.595	0.382	0.614
4/26/05	4	0.227	K-626	Biased	FSS-015	1	581	3,359	3,397	5	16,175	570	143	1.09	1.28	1.61
12/6/05	8	0.224	K-627	Biased	FSS-015	10	539	26,779	28,659	10	28,220	570	-50	-0.415	0.469	0.614
4/26/05	4	0.227	K-630	Biased	FSS-015	1	224	3,317	3,225	5	16,175	570	36	0.709	3.27	1.61
6/15/05	4	0.227	K-716	Biased	FSS-016	1	825	3,883	3,624	5	15,310	570	692	3.70	0.944	1.57
6/15/05	4	0.227	K-718	Biased	FSS-016	1	777	4,169	3,884	5	15,310	570	965	5.47	1.04	1.57
6/15/05	4	0.227	K-720	Biased	FSS-016	1	635	3,598	3,886	5	15,310	570	680	4.72	1.22	1.57
6/15/05	4	0.227	K-721	Biased	FSS-016	1	644	3,823	3,675	5	15,310	570	687	4.70	1.21	1.57
11/29/05	8	0.224	K-751	Biased	FSS-016	1	849	2,789	2,811	5	13,695	570	61	0.320	0.807	1.50
11/29/05	8	0.224	K-753	Biased	FSS-016	1	785	2,702	2,889	5	13,695	570	57	0.321	0.872	1.50

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Count Date	Det. #:	Detector Efficiency (cpm / pCi/g)	Sample No.	Sample Type	Survey Unit	Sample Count Time (min)	Net Sample Weight (g)	Gross Count Rate Top (cpm)	Gross Count Rate Bottom (cpm)	BKG Count Time (min)	BKG Counts	BKG Sample Weight (g)	Net Count Rate Average (cpm)	Th-232 (pCi/g)	95% CL Unc. (pCi/g)	MDC (pCi/g)
11/29/05	8	0.224	K-754	Biased	FSS-016	1	883	2,707	2,918	5	13,695	570	74	0.371	0.778	1.50
11/29/05	8	0.224	K-762	Biased	FSS-016	1	624	2,696	2,862	5	13,695	570	40	0.286	1.09	1.50
11/29/05	8	0.224	K-763	Biased	FSS-016	1	568	2,974	2,766	5	13,695	570	131	1.03	1.22	1.50
11/29/05	8	0.224	K-764	Biased	FSS-016	1	570	2,613	2,976	5	13,695	570	56	0.434	1.20	1.50
11/29/05	8	0.224	K-765	Biased	FSS-016	1	571	2,689	2,880	5	13,695	570	46	0.355	1.20	1.50
11/29/05	8	0.224	K-766	Biased	FSS-016	1	685	2,559	2,809	5	13,695	570	-55	-0.358	0.982	1.50
11/29/05	8	0.224	K-767	Biased	FSS-016	1	721	3,000	2,976	5	13,695	570	249	1.54	0.979	1.50
12/6/05	8	0.224	K-799	Biased	FSS-017	10	665	29,213	28,894	10	28,220	570	83	0.559	0.386	0.614
12/6/05	8	0.224	K-800	Biased	FSS-017	10	677	27,951	29,213	10	28,220	570	36	0.238	0.377	0.614
12/6/05	8	0.224	K-801	Biased	FSS-017	10	623	28,764	29,627	10	28,220	570	98	0.698	0.413	0.614
12/6/05	8	0.224	K-945	Biased	FSS-018	10	694	28,008	29,067	10	28,220	570	32	0.204	0.368	0.614
12/6/05	8	0.224	K-946	Biased	FSS-018	10	703	29,244	29,137	10	28,220	570	97	0.616	0.366	0.614
8/8/05	4	0.227	K-941	Biased	FSS-019	1	653	3,255	3,085	5	15,130	570	144	0.972	1.10	1.56
8/8/05	4	0.227	K-942	Biased	FSS-019	1	917	3,527	3,235	5	15,130	570	355	1.71	0.809	1.56
8/8/05	4	0.227	K-943	Biased	FSS-019	1	738	3,008	3,196	5	15,130	570	76	0.454	0.966	1.56
8/8/05	4	0.227	K-944	Biased	FSS-019	1	657	2,930	3,146	5	15,130	570	12	0.081	1.08	1.56
9/29/05	4	0.227	K-1058	Biased	FSS-020	1	892	3,632	3,555	5	15,160	570	562	2.78	0.855	1.56

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Count Date	Det. #:	Detector Efficiency (cpm / pCi/g)	Sample No.	Sample Type	Survey Unit	Sample Count Time (min)	Net Sample Weight (g)	Gross Count Rate Top (cpm)	Gross Count Rate Bottom (cpm)	BKG Count Time (min)	BKG Counts	BKG Sample Weight (g)	Net Count Rate Average (cpm)	Th-232 (pCi/g)	95% CL Unc. (pCi/g)	MDC (pCi/g)
9/29/05	4	0.227	K-1059	Biased	FSS-020	1	827	3,513	3,256	5	15,160	570	353	1.88	0.898	1.56
10/8/05	4	0.227	K-1163	Biased	FSS-020	1	665	2,948	3,121	5	14,550	570	125	0.826	1.06	1.53
10/8/05	4	0.227	K-1164	Biased	FSS-020	1	603	2,911	2,919	5	14,550	570	5	0.037	1.15	1.53
9/30/05	4	0.227	K-1203	Biased	FSS-020	1	612	3,422	3,141	5	15,110	570	260	1.87	1.20	1.56
9/30/05	4	0.227	K-1204	Biased	FSS-020	1	604	3,339	3,159	5	15,110	570	227	1.66	1.21	1.56
10/3/05	4	0.227	K-1205	Biased	FSS-020	1	668	3,104	2,983	5	14,975	570	49	0.320	1.06	1.55
10/4/05	4	0.227	K-1206	Biased	FSS-020	1	616	3,285	2,982	5	14,875	570	159	1.13	1.16	1.54
10/4/05	4	0.227	K-1207	Biased	FSS-020	1	612	2,995	3,026	5	14,875	570	36	0.256	1.15	1.54
10/4/05	4	0.227	K-1208	Biased	FSS-020	1	918	3,072	3,222	5	14,875	570	172	0.826	0.782	1.54
10/4/05	4	0.227	K-1209	Biased	FSS-020	1	719	3,032	3,288	5	14,875	570	185	1.13	1.00	1.54
10/4/05	4	0.227	K-1210	Biased	FSS-020	1	698	3,343	3,147	5	14,875	570	270	1.71	1.04	1.54
9/29/05	4	0.227	K-1057	Biased	FSS-021	1	660	3,269	3,221	5	14,945	570	256	1.71	1.10	1.55
9/29/05	4	0.227	K-1061	Biased	FSS-021	1	627	3,239	3,393	5	14,945	570	327	2.30	1.17	1.55
9/29/05	4	0.227	K-1062	Biased	FSS-021	1	598	3,319	3,340	5	14,945	570	341	2.51	1.23	1.55
9/29/05	4	0.227	K-1063	Biased	FSS-021	1	648	3,389	3,190	5	14,945	570	301	2.05	1.13	1.55
10/20/05	4	0.227	K-1238	Biased	FSS-022	1	623	3,325	3,187	5	15,400	570	176	1.25	1.17	1.57
10/20/05	4	0.227	K-1239	Biased	FSS-022	1	886	3,466	3,723	5	15,400	570	515	2.56	0.862	1.57

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Count Date	Det. #:	Detector Efficiency (cpm / pCi/g)	Sample No.	Sample Type	Survey Unit	Sample Count Time (min)	Net Sample Weight (g)	Gross Count Rate Top (cpm)	Gross Count Rate Bottom (cpm)	BKG Count Time (min)	BKG Counts	BKG Sample Weight (g)	Net Count Rate Average (cpm)	Th-232 (pCi/g)	95% CL Unc. (pCi/g)	MDC (pCi/g)
10/20/05	4	0.227	K-1240	Biased	FSS-022	1	620	3,528	3,304	5	15,400	570	336	2.39	1.20	1.57
10/20/05	4	0.227	K-1241	Biased	FSS-022	1	609	3,402	3,232	5	15,400	570	237	1.72	1.21	1.57
10/20/05	4	0.227	K-1242	Biased	FSS-022	1	562	3,184	3,420	5	15,400	570	222	1.74	1.31	1.57
10/20/05	4	0.227	K-1243	Biased	FSS-022	1	573	3,247	3,413	5	15,035	570	323	2.49	1.29	1.55
10/20/05	4	0.227	K-1244	Biased	FSS-022	1	540	2,952	3,207	5	15,035	570	73	0.592	1.32	1.55
12/1/05	8	0.224	K-1340	Biased	FSS-023	1	726	3,030	2,954	5	13,785	570	235	1.44	0.973	1.50
12/1/05	8	0.224	K-1341	Biased	FSS-023	1	667	2,923	3,122	5	13,785	570	266	1.78	1.06	1.50
12/1/05	8	0.224	K-1342	Biased	FSS-023	1	695	3,099	3,118	5	13,785	570	352	2.26	1.03	1.50
12/1/05	8	0.224	K-1343	Biased	FSS-023	1	601	2,949	3,077	5	13,785	570	256	1.90	1.18	1.50
12/1/05	8	0.224	K-1344	Biased	FSS-023	1	837	3,291	3,231	5	13,785	570	504	2.69	0.878	1.50
12/1/05	8	0.224	K-1345	Biased	FSS-023	1	967	3,148	3,188	5	13,785	570	411	1.90	0.750	1.50
1/24/06	8	0.224	K-1408	Biased	FSS-024	1	833	2,993	3,098	5	13,920	570	262	1.40	0.856	1.51
1/24/06	8	0.224	K-1458	Biased	FSS-024	1	564	2,803	2,885	5	13,920	570	60	0.474	1.22	1.51
1/24/06	8	0.224	K-1459	Biased	FSS-024	1	788	3,094	3,141	5	13,920	570	334	1.89	0.914	1.51
3/28/05	4	0.227	K-565	Biased	FSSB-003	1	645	7,281	6,352	5	15,035	570	3,810	26.0	1.60	1.55
4/1/05	4	0.227	K-566	Biased	FSSB-003	1	645	8,266	6,922	5	15,336	570	4,527	31.0	1.68	1.57
4/13/05	4	0.227	K-568	Biased	FSSB-003	1	645	7,047	6,513	5	14,915	570	3,797	26.0	1.59	1.55

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Count Date	Det. #:	Detector Efficiency (cpm / pCi/g)	Sample No.	Sample Type	Survey Unit	Sample Count Time (min)	Net Sample Weight (g)	Gross Count Rate Top (cpm)	Gross Count Rate Bottom (cpm)	BKG Count Time (min)	BKG Counts	BKG Sample Weight (g)	Net Count Rate Average (cpm)	Th-232 (pCi/g)	95% CL Unc. (pCi/g)	MDC (pCi/g)
4/13/05	4	0.227	K-569	Biased	FSSB-003	1	645	6,806	6,453	5	14,915	570	3,647	24.9	1.58	1.55
4/15/05	4	0.227	K-573	Biased	FSSB-003	1	645	6,897	6,112	5	14,885	570	3,528	24.1	1.56	1.54
4/20/05	4	0.227	K-577	Biased	FSSB-003	1	645	5,693	5,095	5	14,890	570	2,416	16.5	1.43	1.54
5/10/05	4	0.227	K-635	Biased	FSSB-004	1	593	5,492	5,067	5	14,915	570	2,297	17.1	1.54	1.55
5/10/05	4	0.227	K-636	Biased	FSSB-004	1	737	7,984	6,028	5	14,915	570	4,023	24.1	1.42	1.55
5/11/05	4	0.227	K-637	Biased	FSSB-004	1	682	7,031	5,437	5	15,210	570	3,192	20.6	1.45	1.56
5/17/05	4	0.227	K-662	Biased	FSSB-004	1	520	5,847	5,423	5	15,050	570	2,625	22.3	1.81	1.55
5/17/05	4	0.227	K-663	Biased	FSSB-004	1	576	6,812	6,520	5	15,050	570	3,656	28.0	1.77	1.55
5/19/05	4	0.227	K-664	Biased	FSSB-004	1	564	5,496	5,566	5	15,770	570	2,377	18.6	1.66	1.59
5/19/05	4	0.227	K-665	Biased	FSSB-004	1	594	5,824	5,644	5	15,770	570	2,580	19.2	1.60	1.59
5/19/05	4	0.227	K-666	Biased	FSSB-004	1	590	5,671	5,683	5	15,770	570	2,523	18.9	1.60	1.59
5/19/05	4	0.227	K-667	Biased	FSSB-004	1	738	5,581	4,696	5	15,770	570	1,985	11.9	1.22	1.59
5/19/05	4	0.227	K-668	Biased	FSSB-004	1	606	5,830	5,710	5	15,770	570	2,616	19.0	1.57	1.59
5/19/05	4	0.227	K-669	Biased	FSSB-004	1	531	5,855	5,044	5	15,770	570	2,296	19.1	1.75	1.59
5/19/05	4	0.227	K-670	Biased	FSSB-004	1	549	5,849	5,383	5	15,770	570	2,462	19.8	1.71	1.59
5/19/05	4	0.227	K-671	Biased	FSSB-004	1	564	5,353	5,264	5	15,770	570	2,155	16.8	1.63	1.59
5/20/05	4	0.227	K-672	Biased	FSSB-004	1	598	5,957	5,499	5	14,990	570	2,730	20.1	1.59	1.55

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Count Date	Det. #:	Detector Efficiency (cpm / pCi/g)	Sample No.	Sample Type	Survey Unit	Sample Count Time (min)	Net Sample Weight (g)	Gross Count Rate Top (cpm)	Gross Count Rate Bottom (cpm)	BKG Count Time (min)	BKG Counts	BKG Sample Weight (g)	Net Count Rate Average (cpm)	Th-232 (pCi/g)	95% CL Unc. (pCi/g)	MDC (pCi/g)
5/20/05	4	0.227	K-673	Biased	FSSB-004	1	569	6,395	5,999	5	14,990	570	3,199	24.8	1.73	1.55
5/23/05	4	0.227	K-674	Biased	FSSB-004	1	639	7,146	5,853	5	15,290	570	3,442	23.8	1.58	1.57
5/24/05	4	0.227	K-725	Biased	FSSB-004	1	559	6,576	6,250	5	14,835	570	3,446	27.2	1.79	1.54
5/24/05	4	0.227	K-726	Biased	FSSB-004	1	622	6,256	5,758	5	14,835	570	3,040	21.6	1.56	1.54
5/24/05	4	0.227	K-727	Biased	FSSB-004	1	571	5,873	5,682	5	14,835	570	2,811	21.7	1.67	1.54
7/7/05	4	0.227	K-791	Biased	FSSB-005	1	699	6,794	5,816	5	14,855	570	3,334	21.0	1.42	1.54
7/9/05	4	0.227	K-802	Biased	FSSB-005	1	500	6,520	5,748	5	15,030	570	3,128	27.6	1.96	1.55
7/12/05	4	0.227	K-803	Biased	FSSB-005	1	586	6,663	5,995	5	16,210	570	3,087	23.2	1.70	1.61
7/15/05	4	0.227	K-807	Biased	FSSB-005	1	523	6,251	5,548	5	15,250	570	2,850	24.0	1.84	1.56
7/21/05	4	0.227	K-862	Biased	FSSB-006	1	588	5,638	5,582	5	14,825	570	2,645	19.8	1.60	1.54
8/1/05	4	0.227	K-863	Biased	FSSB-006	1	571	7,193	6,697	5	15,245	570	3,896	30.1	1.82	1.56
8/1/05	4	0.227	K-864	Biased	FSSB-006	1	551	6,243	5,306	5	15,245	570	2,726	21.8	1.73	1.56
8/1/05	4	0.227	K-865	Biased	FSSB-006	1	564	6,251	5,522	5	15,245	570	2,838	22.2	1.71	1.56
8/1/05	4	0.227	K-866	Biased	FSSB-006	1	618	6,936	6,660	5	15,245	570	3,749	26.8	1.67	1.56
8/1/05	4	0.227	K-867	Biased	FSSB-006	1	662	7,303	6,939	5	15,245	570	4,072	27.1	1.59	1.56
8/3/05	4	0.227	K-947	Biased	FSSB-006	1	548	6,614	6,420	5	15,155	570	3,486	28.1	1.84	1.56
8/3/05	4	0.227	K-948	Biased	FSSB-006	1	576	6,910	6,150	5	15,155	570	3,499	26.8	1.75	1.56

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Count Date	Det. #:	Detector Efficiency (cpm / pCi/g)	Sample No.	Sample Type	Survey Unit	Sample Count Time (min)	Net Sample Weight (g)	Gross Count Rate Top (cpm)	Gross Count Rate Bottom (cpm)	BKG Count Time (min)	BKG Counts	BKG Sample Weight (g)	Net Count Rate Average (cpm)	Th-232 (pCi/g)	95% CL Unc. (pCi/g)	MDC (pCi/g)
8/3/05	4	0.227	K-949	Biased	FSSB-006	1	553	6,600	5,766	5	15,155	570	3,152	25.1	1.78	1.56
8/3/05	4	0.227	K-950	Biased	FSSB-006	1	588	6,701	6,098	5	15,155	570	3,369	25.3	1.70	1.56
8/5/05	4	0.227	K-951	Biased	FSSB-006	1	547	5,983	5,555	5	15,130	570	2,743	22.1	1.74	1.56
8/5/05	4	0.227	K-952	Biased	FSSB-006	1	630	6,472	5,644	5	15,130	570	3,032	21.2	1.55	1.56
8/10/05	4	0.227	K-953	Biased	FSSB-006	1	597	6,447	6,187	5	15,135	570	3,290	24.3	1.67	1.56
8/10/05	4	0.227	K-954	Biased	FSSB-006	1	581	6,603	6,378	5	15,135	570	3,464	26.3	1.73	1.56
8/10/05	4	0.227	K-955	Biased	FSSB-006	1	516	6,225	6,301	5	15,135	570	3,236	27.7	1.92	1.56
8/10/05	4	0.227	K-956	Biased	FSSB-006	1	562	6,307	5,808	5	15,135	570	3,031	23.8	1.73	1.56
8/10/05	4	0.227	K-957	Biased	FSSB-006	1	551	6,220	5,795	5	15,135	570	2,981	23.9	1.76	1.56
8/10/05	4	0.227	K-958	Biased	FSSB-006	1	593	6,466	6,012	5	15,135	570	3,212	23.9	1.67	1.56
8/31/05	4	0.227	K-1002	Biased	FSSB-007	1	597	6,914	6,104	5	14,775	570	3,554	26.3	1.69	1.54
8/31/05	4	0.227	K-1003	Biased	FSSB-007	1	566	6,316	6,040	5	14,775	570	3,223	25.1	1.74	1.54
8/31/05	4	0.227	K-1004	Biased	FSSB-007	1	542	6,767	5,752	5	14,775	570	3,305	26.9	1.83	1.54
9/6/05	4	0.227	K-1008	Biased	FSSB-007	1	585	6,793	6,152	5	14,775	570	3,518	26.5	1.72	1.54
9/6/05	4	0.227	K-1009	Biased	FSSB-007	1	570	5,941	6,199	5	14,775	570	3,115	24.1	1.71	1.54
9/6/05	4	0.227	K-1010	Biased	FSSB-007	1	591	6,608	6,350	5	14,775	570	3,524	26.3	1.70	1.54
9/6/05	4	0.227	K-1011	Biased	FSSB-007	1	572	6,732	6,295	5	14,775	570	3,559	27.4	1.76	1.54

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Count Date	Det. #:	Detector Efficiency (cpm / pCi/g)	Sample No.	Sample Type	Survey Unit	Sample Count Time (min)	Net Sample Weight (g)	Gross Count Rate Top (cpm)	Gross Count Rate Bottom (cpm)	BKG Count Time (min)	BKG Counts	BKG Sample Weight (g)	Net Count Rate Average (cpm)	Th-232 (pCi/g)	95% CL Unc. (pCi/g)	MDC (pCi/g)
9/8/05	4	0.227	K-1015	Biased	FSSB-007	1	635	5,072	4,990	5	14,875	570	2,056	14.3	1.41	1.54
9/8/05	4	0.227	K-1016	Biased	FSSB-007	1	586	6,268	6,056	5	14,875	570	3,187	24.0	1.68	1.54
9/8/05	4	0.227	K-1017	Biased	FSSB-007	1	596	7,080	6,496	5	14,875	570	3,813	28.2	1.73	1.54
9/8/05	4	0.227	K-1018	Biased	FSSB-007	1	578	6,442	5,912	5	14,875	570	3,202	24.4	1.70	1.54
9/20/05	4	0.227	K-1029	Biased	FSSB-007	1	549	6,664	6,002	5	14,750	570	3,383	27.2	1.81	1.54
9/20/05	4	0.227	K-1030	Biased	FSSB-007	1	509	6,324	5,598	5	14,750	570	3,011	26.1	1.90	1.54
9/20/05	4	0.227	K-1031	Biased	FSSB-007	1	596	6,689	6,294	5	14,750	570	3,542	26.2	1.69	1.54
9/23/05	4	0.227	K-1037	Biased	FSSB-007	1	630	6,771	6,462	5	14,545	570	3,708	26.0	1.61	1.53
9/23/05	4	0.227	K-1038	Biased	FSSB-007	1	601	5,924	6,168	5	14,545	570	3,137	23.0	1.62	1.53
9/23/05	4	0.227	K-1039	Biased	FSSB-007	1	642	6,867	6,601	5	14,545	570	3,825	26.3	1.60	1.53
9/27/05	4	0.227	K-1192	Biased	FSSB-007	1	593	6,512	5,731	5	14,760	570	3,170	23.6	1.65	1.54
9/14/05	4	0.227	K-1193	Biased	FSSB-007	1	659	6,535	5,497	5	15,080	570	3,000	20.1	1.47	1.55
9/12/05	4	0.227	K-1195	Biased	FSSB-007	1	522	6,002	5,622	5	15,095	570	2,793	23.6	1.83	1.56
9/12/05	4	0.227	K-1196	Biased	FSSB-007	1	567	5,885	5,439	5	15,095	570	2,643	20.6	1.66	1.56
11/18/05	8	0.224	K-1291	Biased	FSSB-007	1	612	5,478	5,514	5	14,045	570	2,687	19.6	1.54	1.52
8/31/05	4	0.227	K-1005	Biased	FSSB-008	1	629	6,416	5,645	5	14,775	570	3,076	21.6	1.55	1.54
8/31/05	4	0.227	K-1006	Biased	FSSB-008	1	587	6,628	6,057	5	14,775	570	3,388	25.4	1.70	1.54

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Count Date	Det. #:	Detector Efficiency (cpm / pCi/g)	Sample No.	Sample Type	Survey Unit	Sample Count Time (min)	Net Sample Weight (g)	Gross Count Rate Top (cpm)	Gross Count Rate Bottom (cpm)	BKG Count Time (min)	BKG Counts	BKG Sample Weight (g)	Net Count Rate Average (cpm)	Th-232 (pCi/g)	95% CL Unc. (pCi/g)	MDC (pCi/g)
8/31/05	4	0.227	K-1007	Biased	FSSB-008	1	559	6,301	5,537	5	14,775	570	2,964	23.4	1.72	1.54
9/6/05	4	0.227	K-1012	Biased	FSSB-008	1	577	6,356	6,335	5	14,775	570	3,391	25.9	1.73	1.54
9/6/05	4	0.227	K-1013	Biased	FSSB-008	1	573	6,308	5,707	5	14,775	570	3,053	23.5	1.69	1.54
9/6/05	4	0.227	K-1014	Biased	FSSB-008	1	602	6,931	5,708	5	14,775	570	3,365	24.6	1.65	1.54
9/20/05	4	0.227	K-1032	Biased	FSSB-008	1	585	6,866	5,991	5	14,750	570	3,479	26.2	1.71	1.54
9/20/05	4	0.227	K-1033	Biased	FSSB-008	1	575	6,571	6,474	5	14,750	570	3,573	27.4	1.76	1.54
9/20/05	4	0.227	K-1034	Biased	FSSB-008	1	586	7,202	6,529	5	14,750	570	3,916	29.5	1.77	1.54
9/20/05	4	0.227	K-1035	Biased	FSSB-008	1	605	7,037	6,364	5	14,750	570	3,751	27.3	1.69	1.54
9/20/05	4	0.227	K-1036	Biased	FSSB-008	1	628	7,040	6,722	5	14,750	570	3,931	27.6	1.65	1.54
9/23/05	4	0.227	K-1040	Biased	FSSB-008	1	604	4,837	4,993	5	14,545	570	2,006	14.6	1.46	1.53
9/23/05	4	0.227	K-1040	Biased	FSSB-008	1	604	4,837	4,993	5	14,545	570	2,006	14.6	1.46	1.53
9/27/05	4	0.227	K-1191	Biased	FSSB-008	1	619	5,226	5,146	5	14,760	570	2,234	15.9	1.46	1.54
9/14/05	4	0.227	K-1194	Biased	FSSB-008	1	778	5,307	5,034	5	15,080	570	2,155	12.2	1.16	1.55
9/12/05	4	0.227	K-1197	Biased	FSSB-008	1	582	5,586	5,308	5	15,095	570	2,428	18.4	1.59	1.56
9/12/05	4	0.227	K-1198	Biased	FSSB-008	1	591	5,389	5,338	5	15,095	570	2,345	17.5	1.56	1.56
9/8/05	4	0.227	K-1199	Biased	FSSB-008	1	591	6,971	6,072	5	14,875	570	3,547	26.5	1.71	1.54
9/8/05	4	0.227	K-1200	Biased	FSSB-008	1	632	6,391	5,772	5	14,875	570	3,107	21.7	1.54	1.54

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9/8/05	4	0.227	K-1201	Biased	FSSB-008	1	602	6,921	6,347	5	14,875	570	3,659	26.8	1.69	1.54
9/8/05	4	0.227	K-1202	Biased	FSSB-008	1	586	6,242	5,702	5	14,875	570	2,997	22.6	1.65	1.54
11/9/05	4	0.227	K-1268	Biased	FSSB-009	1	606	4,706	4,453	5	15,305	570	1,519	11.1	1.41	1.57
11/9/05	4	0.227	K-1269	Biased	FSSB-009	1	570	4,767	4,608	5	15,305	570	1,627	12.6	1.52	1.57
11/18/05	8	0.224	K-1270	Biased	FSSB-009	1	631	5,564	5,431	5	14,045	570	2,689	19.0	1.49	1.52
11/17/05	8	0.224	K-1292	Biased	FSSB-009	1	544	5,864	5,366	5	13,825	570	2,850	23.4	1.74	1.51
11/17/05	8	0.224	K-1292	Biased	FSSB-009	1	544	5,864	5,366	5	13,825	570	2,850	23.4	1.74	1.51
11/17/05	8	0.224	K-1293	Biased	FSSB-009	1	648	5,192	4,691	5	13,825	570	2,177	15.0	1.38	1.51
11/17/05	8	0.224	K-1293	Biased	FSSB-009	1	648	5,192	4,691	5	13,825	570	2,177	15.0	1.38	1.51
11/21/05	8	0.224	K-1333	Biased	FSSB-009	1	664	6,323	6,234	5	14,005	570	3,478	23.4	1.51	1.52
11/21/05	8	0.224	K-1334	Biased	FSSB-009	1	652	5,875	5,648	5	14,005	570	2,961	20.3	1.47	1.52
11/21/05	8	0.224	K-1335	Biased	FSSB-009	1	681	4,150	4,251	5	14,005	570	1,400	9.17	1.22	1.52

Kaiser On-site Cave Counter
Ludlum 2221/44-10 (NaI # 4) Calibration
Serial Number: 172053/PR206815
December 13, 2004

The following documents the calibration of the Kaiser On-site Cave Counter (the counter) located on the Kaiser Aluminum and Chemical Company Tulsa Oklahoma site. The cave counter was equipped with Detector Number 4.

Background

The Kaiser On-site Cave Counter (the counter) consists of a 2-inch by 2-inch sodium iodide Ludlum Model 44-10 detector coupled with a Ludlum Model 2221 Scaler/Ratemeter instrument, mounted inside a shielded box with room for a standard soil sample container to be placed on the face (bottom, non-wire connecting end) of the detector. Four detectors have been used. The four detectors are numbered NaI #1, NaI # 2, NaI # 3 and NaI # 4. The detectors have been calibrated by Ludlum in the past year using a Cs-137 source to verify their response to high energy photons. The detectors, including their use as part of the counter, are used to obtain gross gamma readings from soil samples in units of counts per minute (cpm). Although the response of a NaI detector to gamma is energy dependent, the gamma energy of a Cs-137 source and the average gamma energy of Thorium 232 (Th-232) in equilibrium with progeny are relatively close, so the difference in response is not considered in the calibration of the counter to screen samples for Th-232 activity concentration. This documents the calibration of NaI # 4.

Calibration Standard – Outreach Labs

Samples of material used to calibrate the counter are analyzed by Outreach Labs of Broken Arrow, Oklahoma. Outreach analyzes the samples for Th-232 activity concentration in units of pico-Curies per gram (pCi/g) based on the Ac-228 gamma line. Outreach maintains a National Institute of Technology (NIST) traceable calibration of their gamma spectroscopy systems including daily quality control (QC) checks of the current calibration, and their analyses represent the primary standard for the counter calibration.

Secondary Calibration Standard

Calibration of the counter consisted of 20 counts of the secondary calibration standard, Sample K-430. Sample K-430 is a composite sample of Kaiser Site Pile L-003. Pile L-003 is a homogeneous stockpile of site soil like material of approximately 91 tons. The material has been well mixed and has had two separate sets of equal-distant samples taken and analyzed to properly characterize the material prior to using the material to recalibrate another onsite counting system (SMCM). The pile was characterized on two separate dates by taking a set of equal distant samples and analyzing the samples for Th-232 activity concentration. In addition to the equal-distant samples, a composite sample (K-430) was taken and analyzed by Outreach Labs. The result was 21.5 pCi/g Th-232.

NaI # 4 Calibration

Sample K-430 was used to calibrate the counter (NaI # 4). On December 2 and 3, 2004, counts of background and the top and bottom of Sample K-430 were performed using the cave counter and NaI # 4, a total of twenty times. The sample was also weighted (in grams) each time counted. The results are presented in **Table 4.**

Table 4 – Detector 4 Calibration Count Results

Cave Count #	Weight (grams)	5 min Background (cpm)	1 min Top Screen (cpm)	1 min Bottom Screen (cpm)
1	684	2,995	6,785	5,967
2	684	2,995	6,328	6,363
3	684	2,995	6,685	6,193
4	683	2,995	6,638	6,144
5	684	2,995	6,652	6,111
6	683	2,995	6,450	6,038
7	684	2,995	6,705	5,982
8	684	2,995	6,540	5,983
9	684	2,995	6,726	5,965
10	684	2,995	6,605	5,875
11	684	3,048	6,367	6,221
12	684	3,048	6,644	6,189
13	684	3,048	6,493	6,068
14	684	3,048	6,626	5,977
15	684	3,048	6,758	6,304
16	683	3,048	6,845	6,026
17	684	3,048	6,635	6,111
18	683	3,048	6,638	6,200
19	683	3,048	6,763	5,993
20	683	3,048	6,411	6,249

The following calculations were then performed for each count:

- The net top count rate was calculated (ncpm).
- The net bottom count rate was calculated (ncpm).
- The average (top and bottom) net count rate was calculated (ncpm).

- The total pCi in the sample was calculated by multiplying the Outreach activity concentration result for Sample K-430 (21 pCi/g) by the weight (grams) measured for the sample (pCi).
- The calibration factor in units of pCi/ncpm was calculated by dividing the total pCi for the sample count by the ncpm (average of the top and bottom counts).

The results are presented in **Table 5.**

Table 5 – Calibration Factor Calibration

Cave Count #	1 min Average (ncpm)	Total pCi	Cal Factor (pCi/ncpm)
1	3,381	14,706	4.35
2	3,351	14,706	4.39
3	3,444	14,706	4.27
4	3,396	14,685	4.32
5	3,387	14,706	4.34
6	3,249	14,685	4.52
7	3,349	14,706	4.39
8	3,267	14,706	4.50
9	3,351	14,706	4.39
10	3,245	14,706	4.53
11	3,246	14,706	4.53
12	3,369	14,706	4.37
13	3,233	14,706	4.55
14	3,254	14,706	4.52
15	3,483	14,706	4.22
16	3,388	14,685	4.33
17	3,325	14,706	4.42
18	3,371	14,685	4.36
19	3,330	14,685	4.41
20	3,282	14,685	4.47
Average:	3,335	14,700	4.41
Std. Dev.:	71	10	0.09
Minimum:	3,233	14,685	4.22
Maximum:	3,483	14,706	4.55
Median:	3,350	14,706	4.39
Range:	3.5	2.1	3.5
%CV:	2	0.1	2

The average calibration factor of 4.41 pCi/ncpm can be used to covert the average net count rate of cave counts to activity concentration in units of pCi/g, as follows:

Th-232 (pCi/g) = Average net cpm x CF of 4.41 pCi/ncpm / sample weight (grams)

Use of this calibration factor is good for one calendar year (December 3, 2004 through December 2, 2005). Counts of sample K-430 will be performed as daily QC checks on days when the counter is in service. Acceptance criteria based on the average of at least 10 counts of sample K-430 plus/minus 3 standard deviations will be established. Daily QC counts that fall outside of this range should be repeated. If the repeat count fails, an investigation should be performed and recalibration may be necessary.

ON-SITE CAVE COUNTER NaI # 4 CALIBRATION CERTIFICATE

Calibration Date: December 3 and 4, 2004

Calibration Due: December 3, 2005

Calibration Source: Sample K-430

Source Activity Concentration: Sample K-430 was counted by Outreach Labs of Broken Arrow, Oklahoma and determined to be 21.5 pCi/g of Th-232. Outreach Labs analyzed the sample via gamma spectroscopy using a counting system with National Institute of Technology (NIST) traceable calibration and Quality Control (QC) program.

Cave Counter NaI # 4 Configuration: Detector NaI #4 was positioned in the standard count geometry with in the shield. All calibration counts were performed in the same geometry.

Calibration Factor: 4.41 pCi/ncpm (4.41 pCi of Th-232 per net count per minute)

Calibration Performed By: David Weyant and Daniel Baker

Calibration Approved By: _____ December 13, 2004

Andrew J. Lombardo, CHP

Kaiser On-site Cave Counter
Ludlum 2221/44-10 (NaI # 8) Calibration
Serial Number: 216513/PR230093
November 14, 2005

The following documents the calibration of the Kaiser On-site Cave Counter (the counter) located on the Kaiser Aluminum and Chemical Company Tulsa Oklahoma site. The cave counter was equipped with Detector Number 8.

Background

The Kaiser On-site Cave Counter (the counter) consists of a 2-inch by 2-inch sodium iodide Ludlum Model 44-10 detector coupled with a Ludlum Model 2221 Scaler/Ratemeter instrument, mounted inside a shielded box with room for a standard soil sample container to be placed on the face (bottom, non-wire connecting end) of the detector. Four detectors have been used. The four detectors are numbered NaI #1, NaI # 2, NaI # 3 and NaI # 4. All detectors have been calibrated by Ludlum in the past year and a Cs-137 source has been used to verify their response to high energy photons. The detectors, including their use as part of the counter, are used to obtain gross gamma readings from soil samples in units of counts per minute (cpm). Although the response of a NaI detector to gamma is energy dependent, the gamma energy of a Cs-137 source and the average gamma energy of Thorium 232 (Th-232) in equilibrium with progeny are relatively close, so the difference in response is not considered in the calibration of the counter to screen samples for Th-232 activity concentration. This documents the calibration of NaI # 8.

Calibration Standard – Outreach Labs

Samples of material used to calibrate the counter are analyzed by Outreach Labs of Broken Arrow, Oklahoma. Outreach analyzes the samples for Th-232 activity concentration in units of pico-Curies per gram (pCi/g) based on the Ac-228 gamma line. Outreach maintains a National Institute of Technology (NIST) traceable calibration of their gamma spectroscopy systems including daily quality control (QC) checks of the current calibration, and their analyses represent the primary standard for the counter calibration.

Secondary Calibration Standard

Calibration of the counter consisted of 20 counts of the secondary calibration standard, Sample K-1257. Sample K-1257 is a composite sample of Kaiser Site Pile L-003. Pile L-003 is a homogeneous stockpile of site soil like material of approximately 30 tons. The material has been well mixed and has had a set of nine equal-distant samples taken and analyzed to properly characterize the material prior to using the material to recalibrate another onsite counting system (SMCM). The pile was characterized last year on two separate dates by taking a set of equal distant samples and analyzing the samples for Th-232 activity concentration. In addition to the equal-distant samples, a composite sample (K-1257) was taken and analyzed by Outreach Labs. The result was 19.2 pCi/g Th-232.

NaI # 8 Calibration

Sample K-1257 was used to calibrate the counter (NaI # 8). On November 3, 2005, counts of background and the top and bottom of Sample K-1257 were performed using the cave counter and NaI # 8, a total of twenty times. The sample was also weighted (in grams) each time counted. The results are presented in **Table 4.**

Table 4 – Detector 8 Calibration Count Results

Cave Count #	Weight (grams)	5 min Background (cpm)	1 min Top Screen (cpm)	1 min Bottom Screen (cpm)
1	672	2,760	5,985	5,152
2	672	2,760	6,038	5,122
3	672	2,760	5,925	5,272
4	672	2,760	5,790	5,365
5	672	2,760	5,713	5,287
6	673	2,762	6,008	5,512
7	673	2,762	5,844	5,488
8	673	2,762	6,107	5,516
9	673	2,762	5,885	5,399
10	673	2,762	5,897	5,418
11	673	2,759	5,977	5,340
12	673	2,759	6,000	5,443
13	673	2,759	5,854	5,333
14	673	2,759	5,890	5,347
15	673	2,759	5,844	5,412
16	673	2,745	5,963	5,525
17	673	2,745	5,993	5,266
18	673	2,745	6,026	5,408
19	673	2,745	6,026	5,413
20	673	2,745	6,031	5,394

The following calculations were then performed for each count:

- The net top count rate was calculated (ncpm).
- The net bottom count rate was calculated (ncpm).

- The average (top and bottom) net count rate was calculated (ncpm).
- The total pCi in the sample was calculated by multiplying the Outreach activity concentration result for Sample K-1257 (19.2 pCi/g) by the weight (grams) measured for the sample (pCi).
- The calibration factor in units of pCi/ncpm was calculated by dividing the total pCi for the sample count by the ncpm (average of the top and bottom counts).

The results are presented in **Table 5.**

Table 5 – Calibration Factor Calibration

Cave Count #	1 min Average (ncpm)	Total pCi	Cal Factor (pCi/ncpm)
1	2,808	12,902	4.59
2	2,820	12,902	4.58
3	2,838	12,902	4.55
4	2,817	12,902	4.58
5	2,740	12,902	4.71
6	2,998	12,922	4.31
7	2,904	12,922	4.45
8	3,050	12,922	4.24
9	2,880	12,922	4.49
10	2,896	12,922	4.46
11	2,900	12,922	4.46
12	2,963	12,922	4.36
13	2,835	12,922	4.56
14	2,860	12,922	4.52
15	2,869	12,922	4.50
16	2,999	12,922	4.31
17	2,885	12,922	4.48
18	2,972	12,922	4.35
19	2,975	12,922	4.34
20	2,968	12,922	4.35
Average:	2898.6	12,917	4.46
Stdev.:	79.38	8.53	0.12
Minimum:	2739.7	12,902	4.24
Maximum:	3049.5	12,922	4.71
Median:	2890.0	12,922	4.47
Range:	3.90	2.25	3.93
%CV:	2.74	0.07	2.69

The average calibration factor of 4.46 pCi/ncpm can be used to covert the average net count rate of cave counts to activity concentration in units of pCi/g, as follows:

Th-232 (pCi/g) = Average net cpm x CF of 4.46 pCi/ncpm / sample weight (grams)

Use of this calibration factor is good for one calendar year (November 3, 2005 through November 3, 2006). Counts of sample K-1257 will be performed as daily QC checks on days when the counter is in service. Acceptance criteria based on the average of at least 10 counts of sample K-1257 plus/minus 3 standard deviations will be established. Daily QC counts that fall outside of this range should be repeated. If the repeat count fails, an investigation should be performed and recalibration may be necessary.

ON-SITE CAVE COUNTER NaI # 4 CALIBRATION CERTIFICATE

Calibration Date: November 3, 2005

Calibration Due: November 3, 2005

Calibration Source: Sample K-1257

Source Activity Concentration: Sample K-1257 was counted by Outreach Labs of Broken Arrow, Oklahoma and determined to be 19.2 pCi/g of Th-232. Outreach Labs analyzed the sample via gamma spectroscopy using a counting system with National Institute of Technology (NIST) traceable calibration and Quality Control (QC) program.

Cave Counter NaI # 8 Configuration: Detector NaI #8 was positioned in the standard count geometry with in the shield. All calibration counts were performed in the same geometry.

Calibration Factor: 4.46 pCi/ncpm (4.46 pCi of Th-232 per net count per minute)

Calibration Performed By: David Weyant

Calibration Approved By: November 14, 2005

Andrew J. Lombardo, CHP