Attachment 5-1

Table A2. Thorium Isotopes in 20 Dross Samples + A series

Sample ID	Average Th232+Th228 (pCi/g)	Ratio Th230 -to- (Th232+228)÷2
ka014-1	2.4	2.7
ka024-2	8.1	2.5
ka033(5-10)	4.9	3.6
ka038-5	10.1	3.9
ka052(0-2)	17.2	1.6
ka007-1	16.6	3.2
ka101(4-6)	82.4	2.7
ka102(2-4)	2.5	3.1
ka104(4-6)	29.9	3.1
ka108(2-4)	1.7	3.9
ka109(8-10)	8.0	3.0
ka110(8-10)	9.7	4.5
ka111(6-8)	4.4	5.0
ka113(8-10)	5.1	3.7
ka118top	5.6	5.0
ka119(2-4)	3.7	7.0
ka121(2-4)	6.5	3.2
ka122(blk soil)	10.5	2.8
ka124-68	1.5	3.1
ka125(blk soil)	1.8	2.1
a-19-5	89.6	4.9
a-14	70.3	3.6
a-6	166.5	3.0
a-9	59.0	3.5
	arith. mean	3.5

6.0 Alternatives Considered and Rationale for Chosen Alternative

In arriving at the chosen alternative, Kaiser first considered taking no action to remediate the site. Subsequently, Kaiser considered a number of other possible options before arriving at the chosen alternative. Environmental, technical, and economic factors were considered.

Kaiser has concluded that the selected remedial action to achieve unrestricted release strikes the best overall balance. No adverse impact on low-income/minority groups will result from the proposed action.

The following subsections describe the characteristics of the selected alternative and provide the rationale for its selection versus the no-action alternative.

6.1 Chosen Alternative

This alternative entails removing thorium-bearing materials with concentrations greater than 31.1 pCi/g Th-232 (above-criteria material) and disposal of these materials at a permitted facility. On average, excavated above-criteria material meets the definition of exempt material. Material with concentrations less than 31.1 pCi/g Th-232 will be backfilled in the excavation. Additional clean fill will be used to cover the below-criteria materials to bring the excavation to grade which will require the transport of approximately 135,150 cubic yards (cy) of fill material to the site. Dose analysis for the resident farmer scenario demonstrated that unrestricted release dose criteria could be achieved with a maximum total estimated dose of 0.276 mrem/yr. Due to the industrialized setting and the absence of residences in the immediate vicinity of the site, no impacts are expected for local minority or low-income populations. Local land values and esthetics will not change as a result of implementation of this alternative. Although this alternative will entail significant community relations and multi-agency liaison, it is expected to be favored by the community.

It should be noted that prior to remediation, site preparations will be required, such as dewatering of the site, to facilitate excavation and equipment movement across the site. Sufficient space will be made available to handle material stockpiles for storage and transport preparation.

This alternative was chosen because it achieves the best balance of the evaluation criteria considered. It is protective of human health and the environment, complies with NRC regulatory requirements, affords a permanent remedy without the need for institutional controls, utilizes proven technology, and is economically viable. The total cost estimated for the chosen remediation alternative is $19,840,000.

6.2 No-Action Alternative

This no-action alternative is required as a bench mark against which the other alternatives are reviewed. For this alternative, on-site materials would not be disturbed. Off-site stockpiled materials would be placed in the retention pond and the site regraded to the extent practicable so as to avoid obvious mounds. The area would be reseeded to prevent soil erosion with limited quantities of soil added to improve plant growth. The site would be expected to require annual maintenance for 1,000 years. No additional measures are contemplated under this scenario.

The no-action alternative can easily be implemented, poses a minimum risk of exposure to remediation personnel, and is, by far, the least expensive choice. However, this alternative will not be effective in limiting long-term dose exposure. RESRAD modeling of the residential exposure scenario resulted in calculation of a peak dose of 797 mrem/yr to a resident farmer.

Consequently, the no-action alternative would be considered unacceptable. It would not meet NRC criteria for either unrestricted or restricted release. Restrictions on site use would be required, not allowing for productive use of the site. The no-action alternative would be considerably less expensive than the chosen alternative, but would involve some expense due to the need to place the material that has been stockpiled from the adjacent area remediation project into a permanent configuration. No soil would be transported to an off-site disposal facility under the no-action alternative. The total cost estimated for the no-action alternative is $1,100,000.

7.0 ALARA Analysis

The remediation method that Kaiser selected to achieve the decommissioning goal is described in Chapters 5.0, 6.0, and 8.0 of this plan. As previously discussed, implementation of this plan results in removal and off-site disposal of material with Th-232 concentrations greater than 31.1 pCi/g. As detailed in the subsequent analysis, the cost of removing material in excess of the 31.1 pCi/g cutoff limit far exceeds the value of any benefit that could be realized.

7.1 Quantitative Cost-Benefit Analysis

The purpose of this analysis is to demonstrate that the residual radioactivity resulting from the decommissioning activities has been reduced to a level that is ALARA. In order to accomplish this, the proposed action is compared with removal of additional affected material with Th-232 concentrations below the 31.1 pCi/g criterion.

The ALARA analysis uses a cost-benefit approach to demonstrate that such additional remediation action is not cost effective. In order to compare the benefits and costs of a remediation action, the benefits and costs are assigned a monetary value to the extent practicable. If the desirable beneficial effects (benefits) from the remediation action are greater than the undesirable effects (costs), the remediation action being evaluated is cost effective and should be performed. Conversely, if the benefits are less than the costs, the levels of residual radioactivity are already ALARA without taking the remediation action.

The present-worth equation presented in Draft Regulatory Guide 4006 (DG-4006) takes into consideration the fraction of residual radioactivity physically removed by the remedial action to reduce the dose below the dose that would result from the planned action. Using the widely accepted RESRAD dose model resident farmer scenario, as described in Chapter 5.0, the planned action was found to result in a peak dose to an average member of the critical group (resident farmer) that does not exceed 0.276 mrem/yr. Assuming zero mrem/yr as the lower dose that could be achieved by removal of additional affected material results in a maximum net averted dose of 0.276 mrem/year. This net averted dose is used in the present-worth equation as shown below.

It is recognized that using 0.276 mrem/yr as the net averted dose significantly overstates the potential benefit that could be achieved since the analysis below assumes that this dose would be averted throughout the 1,000-year period considered. Actually, that peak dose would occur only in year 1,000. Estimated doses in earlier years would be lower. In fact, while the site remains dedicated to industrial use, as is expected to be the case for the foreseeable future, there is no exposure due to the pathways that make the greatest contribution to the estimated peak total dose to a resident farmer.

7.1.1 Benefit Calculation

The benefit of remediation in this ALARA analysis is based on the net averted dose achieved from removal of all affected material resulting in a dose of zero mrem/yr rather than the planned action.

From DG-4006:

$$B_{AD} = \$2,000 \text{ x } PW(AD_{Collective})$$

where:

B_{AD} = benefit from averted dose for a remediation action,

\$2,000 = value in dollars of a person-rem averted, and

$PW(AD_{Collective})$ = present worth of future collective averted dose.

$$PW(AD_{Collective}) = P_D \cdot A \cdot (D - C) \cdot \frac{1 - e^{-(r+\lambda)N}}{r + \lambda}$$

where:

P_D	=	population density
	=	4×10^{-3} people/m^2 (Chapter 5.0)
A	=	area being evaluated
	=	37,433m^2 (Chapter 5.0)
C	=	lower dose for ALARA analysis
	=	0 rem/yr
D	=	dose from planned action
	=	0.000276 rem/yr
r	=	monetary discount rate
	=	3% (for doses averted beyond 100 years)
λ	=	radiological decay constant for the radionuclide
	=	0.693/half life of radionuclide
N	=	number of years over which the collective dose will be calculated
	=	1,000 years

Using the worst-case scenario (maximum benefit) in the present-worth equation, the decay constant (λ) would equal zero, and the exponential term will go to zero, giving the following simplified equation:

$$PW(AD_{Collective}) = P_D \times A \times (D\text{-}C) \times \frac{1}{0.03}$$

$$PW(AD_{Collective}) = 4 \times 10^{-3} \text{ people/m}^2 \times 37{,}433\text{m}^2 \times (0.000276 - 0) \times 33.3$$

$$PW(AD_{Collective}) = 1.38$$

$$B_{AD} = \$2{,}000 \times 1.38 B_{AD} = \$2{,}752$$

This is the benefit associated with a reduction in dose to zero mrem/yr rather than implementation of the planned action which would result in a maximum dose of 0.276 mrem/yr.

7.1.2 Cost of Remediation

The cost estimate for the planned action, as presented in Chapter 15.0 of this plan, is $19,840,000. The base unit cost of an incremental removal of 1 cy of material beyond the planned action is $414. This cost represents approximately 15 percent of the above-estimated B_{AD} ($2,752). Removal of approximately 6.6 cy of material will equal the monetary value of the B_{AD} associated with achieving a zero dose. Obviously, much greater quantities of material removal would be required in order to reduce the dose to zero. Moreover, the removal of the 6.6 cy of material would result in a trivial dose reduction--nowhere near zero dose. Therefore, the cost of removal of material beyond the planned action far exceeds the benefit and the planned action is ALARA.

7.1.3 Regulatory Costs

Regulatory costs of both the planned action and dose reduction to zero mrem/yr would be the same since neither would require land use restrictions.

7.1.4 Land Values

Both alternatives result in unrestricted release of the property. The small potential difference in radiation dose is not expected to have any impact on land values. Therefore, no costs or benefits can be attributed to changes in land values.

7.1.5 Esthetics

The two alternatives result in the same site appearance. Therefore, no costs or benefits can be attributed to differences in esthetics.

7.1.6 Reduction in Public Opposition

Decommissioning activities for the two alternatives will be similar, will both provide ample protection of public health and the environment, and will result in a similar site appearance. Consequently, no public opposition is anticipated for either alternative.

7.2 Summary of ALARA Analysis

The results of the ALARA analysis indicate that there is no advantage in removing more material than proposed in the planned action. Removal of only 6.6 cy of affected material would equal the monetary value of the B_{AD} associated with reducing the dose to zero, thus indicating that the cost of incremental dose reduction far exceeds any benefit. Therefore, the planned action is ALARA.

References

1. Nuclear Regulatory Commission, August 1998, Draft Regulatory Guide DG-4006, Demonstrating Compliance with the Radiological Criteria for License Termination.

8.0 Planned Decommissioning Activities

8.1 Predecommissioning Activities

As shown in Figure 8-1, the freshwater pond will be drained, then abandoned by backfilling. Backfilling will be completed by engineering methods so that the finished grade is stable. After backfilling is completed, the southern area may be paved to facilitate soil management, storage, and transportation activities during the decommissioning.

8.2 Remediation Plan

No contaminated structures, systems, or equipment are known to exist on the site. In addition, migration of radionuclides in surface water or groundwater is not occurring. Therefore, this DP has been designed to address remediation of thorium dross and contaminated soil known to be present on the site. As discussed previously, additional site characterization activities are planned to investigate certain areas on the property. If additional contamination is discovered, this plan will be amended to address the newly defined conditions.

8.2.1 Summary of Remediation/Removal Activities

A conceptual engineering plan for site decommissioning activities is presented below. Subsequent to plan approval by NRC, designs and specifications will be developed to better detail approaches to accomplish the objectives set forth in the approved plan. These detailed plans and specifications may differ somewhat from the conceptual engineering approach provided herein.

The planned remediation requires identifying material with concentrations of Th-232 above 31.1 pCi/g, excavating, and segregating it on site. Above-criteria material will be shipped to a facility permitted to receive the material. Below-criteria material will be returned to the excavation. Kaiser will complete the decommissioning with the assistance of contractors, subcontractors, and consultants.

Standard construction equipment will be used to perform decommissioning operations. This equipment will include, but not be limited to, the following:

- Backhoes
- Scrapers
- Excavators
- Bulldozers
- Loaders
- Dump trucks

- Water trucks
- Pickup trucks

In addition, a specialized soil sorting/segregation system may be used. Alternatively, soil segregation may be accomplished via Health Physics Technician (HPT) scanning activities.

The site will be excavated to depths up to 15 to 20 feet and to an average depth estimated at 15 feet across most of the retention and reserve ponds. Excavation activities probably will not be conducted during winter months.

Although closing of the freshwater pond will lower groundwater levels at the site, some dewatering may be required during excavation. A ground improvement technique, such as overexcavation, may be required to facilitate successful excavation and equipment movement across soft portions of the site.

HPT support will be used to monitor the excavated material, the material left in place, workers, equipment, and loaded cars/containers leaving the site. Radiation control procedures and protection methods are described in Chapters 11.0 through 14.0.

Above-criteria material destined for off-site disposal will be transported to the disposal site in intermodal containers on flat cars or trucks. Alternatively, gondola cars may be used. Loading can be accomplished by a front-end loader or a more elaborate conveyer belt system. The material will be dried prior to shipping to the extent needed to prevent development of free water during transportation.

Once the site is remediated to acceptable levels, it will be cleared through a MARSSIM-directed final status survey. Most likely, this will be conducted in stages where certain units will be cleared and backfilled as excavation occurs in other areas.

Below-criteria material will be returned to the excavation. Approximately 4,000,000 ft^3 of clean fill will be added to backfill excavations. The thickness of clean fill will average 10 feet. The site will be graded so that drainage is from east to west, so that surface water discharge from the site is attenuated. The site also will be vegetated to minimize soil erosion. The final site configuration is shown (conceptually) in Figure 8-5.

8.2.2 Site Preparation

As depicted in Figure 8-1, site preparation will include construction of a stockpile and handling/processing/storage area to the west of the site at the former freshwater pond area. Haul roads, culverts, drainage channels, berms, erosion and sedimentation controls, and access controls will be constructed during the site preparation phase. Site preparation activities will be under the direction of an HPT and will be performed to limit personnel exposure and off-site migration.

8.2.3 Excavation

Decommissioning activities likely will proceed in three phases, as described below. However, Kaiser will encourage contractor input regarding work sequence.

8.2.3.1 Phase I

Following site preparation, removal of the existing stockpile generated from the adjacent area remediation will be completed (refer to Figure 8-2). Materials from the existing stockpile will be hauled to the stockpile area, sorted, and above-criteria material will be loaded and shipped to the disposal site. Below-criteria material will be stockpiled until it is needed to backfill Phase II excavations. Approximately 285,000 ft^3 of material is expected to be handled in Phase I operations. During Phase I, a pilot study for a soil sorting/segregation system may be conducted.

8.2.3.2 Phase II

Phase II decommissioning activities will address the reserve pond area as shown in Figure 8-3. Material will be excavated and transported via haul roads to the stockpile area where it will be processed and above-criteria material will be shipped to the disposal site. Below-criteria material will be returned to the excavation. Approximately 783,000 ft^3 of material is expected to be handled during Phase II. Figure 8-6 shows a section through the Phase II excavation.

8.2.3.3 Phase III

Phase III excavation will be completed across the retention pond and former spillway area as shown in Figure 8-4. Material will be excavated, transported via haul roads to the stockpile area, and processed/disposed as in prior phases. Figure 4-1 shows the approximate location of trash piles generated by demolition activities in 1964 and 1967. Trash encountered during excavation will be segregated and radiologically scanned. Details on the scanning of trash are presented in Chapter 14.0. Based on the results of the scanning, the trash will either be disposed at a permitted waste facility or construction/demolition debris landfill.

The former spillway is shown in Figure 8-1. The former spillway will remain intact. It will be radiologically scanned and decontaminated. Details on the scanning of the former spillway are presented in Chapter 14.0.

Approximately 4,900,000 ft^3 of material is expected to be handled during Phase III. Figure 8-6 shows a section through the Phase III excavation.

8.2.3.4 Stockpile Area

The stockpile area will be lined with a 60-mil high-density polyethylene geomembrane liner, or equivalent. Berms or ditches will be constructed at the stockpile perimeter to handle precipitation falling onto the stockpile. The stockpile area will be maintained and managed so that drying of wet materials can be accomplished. During winter months, material in the stockpile will be covered or vegetated.

8.2.3.5 Water Handling

Water will be managed in accordance with applicable federal, state, and local laws, regulations, and permit requirements.

8.2.3.6 Excavation Support

All excavation activities will be conducted in accordance with Occupational Safety and Health Administration (OSHA) safety guidelines. In general, excavation walls will be sloped back. In areas where the excavation abuts the property line, special vertical excavation support, such as sheet piling, may be required to separate the work from the previously completed adjacent land remediation. These areas are shown in Figures 8-2, 8-3, and 8-4.

8.2.4 Material Segregation

An automated system, such as the Segmented Gate System, may be used to segregate above-criteria from below-criteria materials. Excavated material will be transported from the stockpile area to the segregation feed pile located in the processing and storage area. Oversize materials will be removed before the materials are fed into the segregation system. Segregated materials that are below criteria will be stockpiled temporarily and eventually returned to excavations. Alternatively, sorting of material will be completed by scanning with hand-held instruments. However, in either case, hand instruments will be necessary to segregate oversize material.

Material segregation activities will be under the direction of an HPT and will be performed to limit personnel exposure and off-site migration.

8.2.5 Backfilling

Below-criteria soil material will be used to backfill (in part) the excavations. Additional off-site borrow material will be necessary to bring the site to the final grades shown (conceptually) in Figure 8-5.

Backfill will be placed in 8-inch loose lifts and suitably compacted. Backfilling activities will be under the direction of a qualified technician or engineer and will be performed so as to limit personnel exposure and off-site migration.

8.2.6 Off-Site Disposal

Above-criteria soil distribution to the waste disposal facility will be monitored by an HPT and will be performed to limit personnel exposure and off-site migration. The quantity of material for off-site disposal is estimated to be 1,200,000 ft^3. This estimate assumes approximately 20 percent of the total excavation volume will be above-criteria material.

It has been determined that sufficient disposal capacity currently exists at Resource Conservation and Recovery Act- (RCRA) permitted waste disposal facilities to accommodate the exempt material anticipated to be generated by the planned decommissioning activity. Final determination of the disposal facility will be made during or immediately subsequent to the detailed design phase of the planned project based upon the current market conditions. However, if sufficient capacity at RCRA-permitted waste disposal facilities is no longer available or market conditions change considerably, this proposed remediation plan may become cost prohibitive.

8.2.7 Site Restoration

The site will be restored as each phase is completed so that weathering is minimized. Restoration will include the following:

- Placement of vegetative material
- Seeding and mulching
- Permanent surface water controls
- Permanent erosion and sedimentation controls

8.3 Procedures and Controls

Kaiser is committed to maintaining occupational exposures ALARA during all operations involving the management of radioactive materials. Decommissioning activities will be conducted in accordance with written approved procedures as outlined in this plan. Dust controls and air monitoring will be maintained. HPT support will be used to monitor the material removed, the material left in place, as well as workers, equipment, and loaded cars/containers leaving the site. Radiation control procedures and protection methods are described in Chapters 11.0 through 14.0. There are no safety or removal/remediation issues unique to this site.

8.4 Schedule

Upon approval of this DP by the NRC, Kaiser will undertake preparation of designs and specifications. Subsequently, a construction contractor will be selected. Kaiser may choose to develop performance specifications and require the contractor to develop design details. Alternatively, Kaiser may opt to develop detailed designs/specifications. In either case, preconstruction activities are expected to take approximately 9 months.

Construction activities will not be conducted during the months of December through February. Therefore, remediation is anticipated to begin in March following completion of the design/contractor selection tasks and extend over a period of approximately 3 years. A detailed schedule will be prepared subsequent to NRC approval of the DP. This schedule will be updated as circumstances dictate.

The tentative schedule for decommissioning activities is outlined in Figures 8-7 and 8-8. Figure 8-7 depicts the projected schedule commencing with NRC approval of this plan to complete preparation of detailed engineering plans and specifications, bidding, and contractor selection. Figure 8-8 contains the tentative schedule commencing with field activities in the March following completion of activities shown in Figure 8-7. Conceptual equipment requirements and labor allocations are included in Chapter 15.0.

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

DWG. NO. 5427A413
FIGURE 8-1
CONCEPTUAL SITE PREPARATION PLAN

WITHIN THIS PACKAGE...OR, BY SEARCHING USING THE DOCUMENT/REPORT

DWG. NO. 5427A413

NOTE: Because of this page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.

D-2

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

DWG. NO. 5427A418
FIGURE 8-2
PHASE I - PROCESSING OF ADJACENT LAND REMEDIATION STOCKPILE

WITHIN THIS PACKAGE...OR, BY SEARCHING USING THE DOCUMENT/REPORT

DWG. NO. 5427A418

NOTE: Because of this page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

DWG. NO. 5427500

FIGURE 8-3

PHASE II - RESERVE POND AREA

EXCAVATION PLAN

WITHIN THIS PACKAGE...OR, BY SEARCHING USING THE DOCUMENT/REPORT

DWG. NO. 5427500

NOTE: Because of this page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

DWG. NO. 5427501
FIGURE 8-4
CONCEPTUAL PHASE III - RETENTION POND AREA AND FORMER SPILLWAY EXCAVATION PLAN

WITHIN THIS PACKAGE...OR, BY SEARCHING USING THE DOCUMENT/REPORT

DWG. NO. 5427501

NOTE: Because of this page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

DWG. NO. 5427419A
FIGURE 8-5
CONCEPTUAL FINAL SITE
GRADING PLAN

WITHIN THIS PACKAGE...OR, BY SEARCHING USING THE DOCUMENT/REPORT

DWG. NO. 5427419A

NOTE: Because of this page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

DWG. NO. 5427502
FIGURE 8-6
CONCEPTUAL CROSS SECTIONS THROUGH PHASE II AND III EXCAVATION

WITHIN THIS PACKAGE...OR, BY SEARCHING USING THE DOCUMENT/REPORT

DWG. NO. 5427502

NOTE: Because of this page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.

Figure 8-7
Tentative Gantt Chart Schedule
Design/Contractor Selection Phase

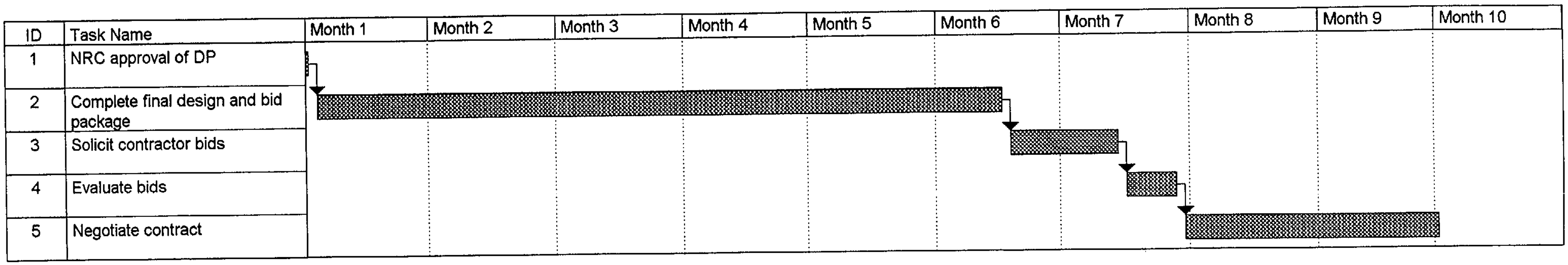
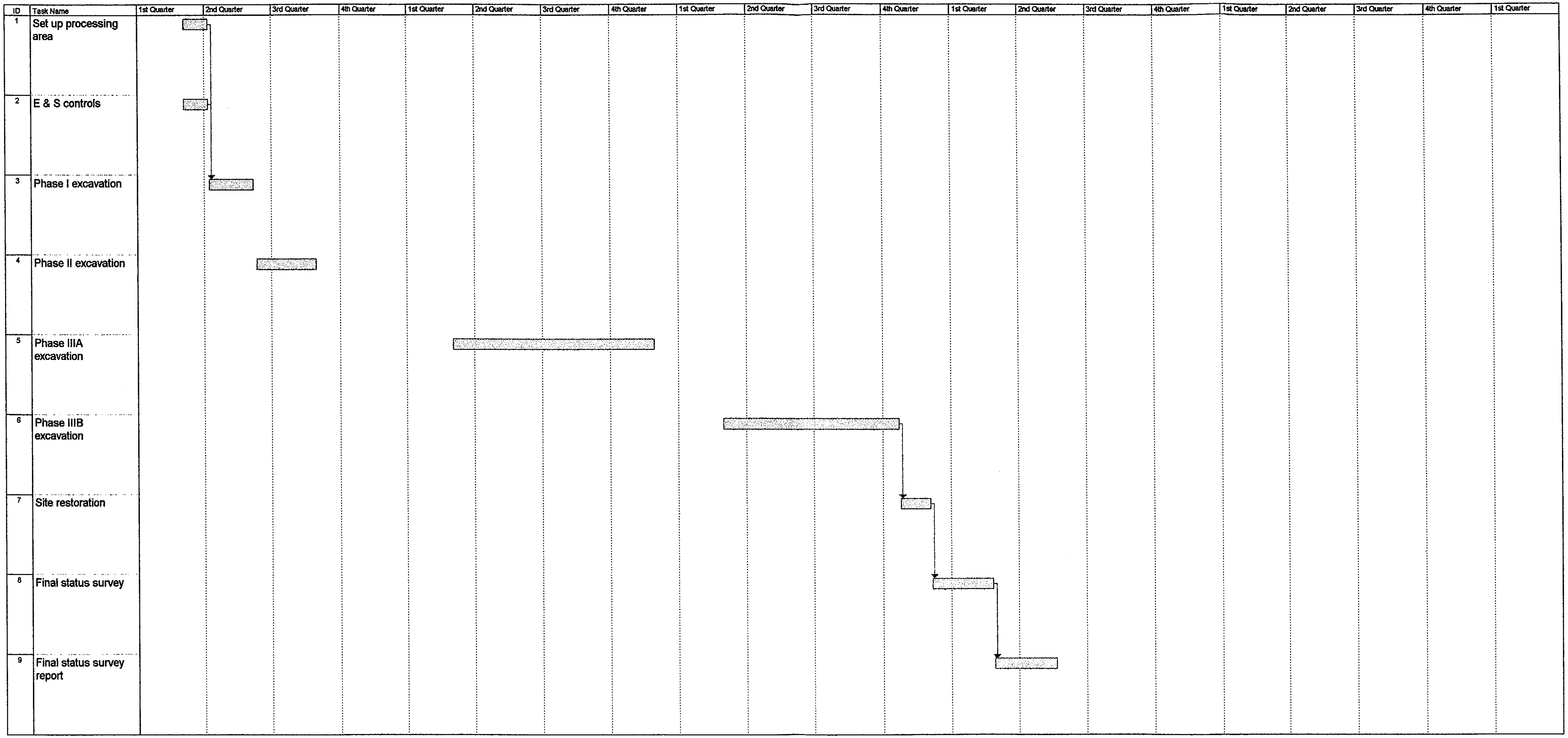


Figure 8-8
Tentative Gantt Chart Schedule
Remediation Phase



p:\crb001\DPSCHED04.MPP P:

9.0 Project Management and Organization

9.1 Decommissioning Management Organization

The following is an outline of the decommissioning organization. This organizational structure may be revised by the Kaiser Project Manager (PM) as deemed appropriate to facilitate execution of the project. Any revisions of the organizational structure will be documented by the Kaiser PM. In addition, any one person may fill multiple positions as long as this does not create an organizational conflict.

9.1.1 Kaiser Project Manager

Kaiser will designate a PM for the decommissioning. The PM has overall responsibility for planning and management of the decommissioning activities. The PM will ensure that remediation activities meet the established environmental, health and safety (H&S), and quality assurance (QA) requirements, and technical performance, in accordance with written procedures. The PM has authority to make necessary changes to the contractor's work and to stop any activity.

9.1.2 Kaiser Site Administrator

Kaiser will designate a Site Administrator (SA) for the decommissioning. This position may be filled either by a Kaiser employee or by a contractor at Kaiser's discretion. The SA has overall responsibility for the on-site planning and management of the decommissioning activities. As an agent for the PM, the SA will observe that remediation activities meet the established environmental, H&S, and QA requirements, and technical performance, in accordance with written procedures. The SA will report to the PM. The SA has authority to make necessary changes to the contractor's work and to stop any activity. The SA will conduct site orientation activities with visitors to the site.

9.1.3 Kaiser Health Physics Advisor/Radiation Safety Officer

Kaiser's PM will utilize a Health Physics Advisor (HPA) to provide guidance on special issues and to review procedures. This position may be filled either by a Kaiser employee or by a contractor at Kaiser's discretion. The HPA may also review qualifications of personnel designated for certain positions in the Decommissioning Management Organization. The HPA will serve as the Radiation Safety Officer (RSO). The RSO will report to the PM. The RSO will be authorized to stop any operation that is unsafe or is in violation of a regulatory requirement.

9.1.4 Kaiser QA Coordinator (Consultant)

Kaiser will employ the services of a third-party QA Coordinator (QAC). The QAC reports to Kaiser's SA for administrative activities and QA guidance. The QAC communicates and coordinates directly with Kaiser's SA and has the delegated responsibility and authority to assure that QA objectives are met. Responsibilities of the QAC include overseeing decommissioning activities to assure that appropriate quality management, policy, training, and verification controls are present. Additional QAC responsibilities include conducting QA audits, surveillance of contractor activities, and correcting conditions which could adversely affect quality. The contractor will allow the QAC to inspect the work at any time and provide every reasonable facility and equipment necessary to inspect the work. The QAC is not authorized to revoke, alter, or waive any requirements of this plan. The QAC has the authority to reject materials or suspend work until any question at issue can be resolved by Kaiser's SA.

9.1.5 Data Manager (Consultant)

The Data Manager will ensure that all required surveys and sampling are performed in accordance with the Final Status Survey Plan and applicable written procedures. Data will be reviewed by the Data Manager to ensure that the requirements stated in the Final Status Survey Plan are implemented as prescribed and that the results of the data collection activities support the objectives of the survey, or permit a determination that these objectives should be modified. The Data Manager will determine if the data are of the right type, quality, and quantity to demonstrate compliance with the plan objective.

9.1.6 Contractor PM

Kaiser will utilize qualified contractor(s) to implement the DP. The contractor(s) will designate a PM (CPM) who will be responsible for planning, managing, and coordinating all contractor activities in accordance with written procedures. The CPM will report to the SA and will ensure that remediation activities meet the established environmental, H&S, QA requirements, technical performance, budgeting, and scheduling criteria. The CPM will be authorized to stop any activity that may be unsafe or is in violation of a regulatory requirement.

9.1.7 Contractor Quality Control Supervisor

The contractor shall designate a Quality Control Supervisor (QCS) who will report to the CPM for administrative activities and QC guidance. The QCS will communicate and coordinate directly with the CPM and will have the delegated responsibility and authority to direct and control contractor QC functions to assure that QC objectives are met. Responsibilities of the QCS include coordination of contractor QC activities and ensuring that appropriate quality management, policy, training, and verification controls are present. The QCS shall provide all necessary QC information to the CPM, Kaiser's SA, and the QAC.

9.1.8 Contractor Lead HPT

The QCS shall designate a Lead HPT (LHPT) who will ensure all necessary sampling and scanning required in the Final Status Survey Plan are performed in accordance with such plan and written procedures. The LHPT is also responsible for sampling of soil stockpiles, off-site borrow material, and transportation containers, and will perform the preliminary review of survey data and analytical results.

9.1.9 Contractor Site Supervisor

The contractor shall designate a Site Supervisor responsible for ensuring that contractor activities are performed in accordance with the plans, the specifications, work plans, and safety work permits. The Site Supervisor reports to the CPM, or may be the CPM. The Site Supervisor has the authority to stop any activity that may be unsafe or is in violation of a regulatory requirement.

9.1.10 Contractor H&S Supervisor

The H&S Supervisor will be responsible for implementing measures that provide safe and healthy work conditions, for assuring radiation exposures are maintained ALARA, and for minimizing release of radioactive material to the environment.

9.1.11 Decommissioning Management Organization Chart

Figure 9-1 depicts the Decommissioning Management Organization and reporting hierarchy.

9.2 Decommissioning Task Management

So that the decommissioning tasks can be effectively managed, written plans and procedures will be established for the decommissioning as discussed in the following subsections.

9.2.1 Design and Construction Specifications

An engineering design will be completed and construction specifications will be developed so that the DP can be implemented. Specifications may be performance specifications or may be based upon detailed engineering designs. The design and specifications will be included in bid documents that will be used in contractor procurement. The design and construction specifications will address the following:

- Site Plan
- Erosion and Sedimentation (E&S) Plan
- Storm Water Control Plan
- Phasing Plans
- Construction Details
- Material Specifications
- Installation Specifications

9.2.2 H&S Plans

The contractor will complete a H&S Plan for its activities. These plans will assure management of H&S at the site and conform with Kaiser's H&S Plan.

9.2.3 E&S Plan

An E&S Plan will be completed for the project. The goal of the E&S Plan is to minimize off-site transport of sediment. Elements of the E&S Plan will be included in the construction specifications.

9.2.4 Contractor Work Plan

The selected contractor will submit a work plan that will outline and describe the sequence of construction activities including the following:

- Mobilization
- Site access
- Haul roads
- Equipment
- Decontamination of personnel and equipment
- Control of water
- Environmental monitoring
- Excavation
- Dust control
- Soil segregation
- Management of intermodal containers or gondola cars
- Backfill
- Site grading
- Site restoration
- Demobilization

The work plan will be reviewed and approved by Kaiser and will be used to manage contractor activities throughout the project.

9.2.5 QA/QC Plan

A QA/QC Plan will be established for the site. The QA/QC Plan will be used in conjunction with the Final Status Survey Plan to ensure that decommissioning goals are achieved. In addition to radiological concerns, the QA/QC Plan will address civil engineering and site restoration issues such as the following:

- Fill material and placement
- Channel and culvert materials and construction
- Seeding
- Construction monitoring
- Site restoration

9.2.6 Final Status Survey Plan

A Final Status Survey Plan will be completed for the decommissioning activities. The purpose of the Final Status Survey Plan will be to demonstrate that remaining thorium levels are at or below the release criteria established in this DP.

9.2.7 Other Plans and Permits

Other plans and permits will likely be required by local and state authorities. These requirements will be addressed as the design proceeds.

9.3 Decommissioning Management Positions and Qualifications

Duties and reporting responsibilities of each person in the management organization are described above. The minimum qualifications for each position are described in the following subsections.

9.3.1 PM

The PM will be an experienced environmental professional and meet Kaiser's internal requirements.

9.3.2 SA

The SA will be an experienced environmental professional and meet Kaiser's internal requirements.

9.3.3 HPA/RSO

The HPA/RSO will be selected by Kaiser, based on experience, advanced education, and industry reputation.

9.3.4 QAC

The QAC will possess a B.S./B.A. degree in science, or engineering, or have equivalent experience and minimum of 5 years' experience in QA-related activities. The QAC will be a Certified Health Physicist (CHP).

9.3.5 CPM

The CPM will possess a B.S./B.A. degree in science, engineering, or business and have a minimum of 5 years of health, safety, and environmental management experience. Appropriate work experience (for similar radiation remediation projects) may be substituted for the degree requirement.

9.3.6 Contractor QCS

The QCS will possess a B.S./B.A. degree in science, engineering, or business and have a minimum of 3 years' experience in QC-related activities. Appropriate work experience (on similar radiation remediation projects) may be substituted for the degree requirement.

9.3.7 Contractor HPT

The HPT will possess a B.S./B.A. degree in science, or engineering, or have equivalent experience and training and a minimum of 3 years' experience as an HPT.

9.3.8 Contractor Site Supervisor

The Site Supervisor will have appropriate training and experience.

9.3.9 Contractor H&S Supervisor

The H&S Supervisor will possess a B.S. degree in science or engineering, have a minimum of 2 years of experience in health physics/industrial hygiene, and have specific training.

9.4 Training

A training program will be established to meet the following goals:

- Meet or exceed the applicable training requirements specified by NRC, OSHA, and the USEPA.
- Ensure that all personnel are knowledgeable of job requirements and are competent in the operation of the equipment they use, are safe in their work practices, and understand the risks associated with their work environment.

- Ensure that personnel meet the requirements of Kaiser to work at the Tulsa site.
- Indoctrinate new employees to ensure that they understand all requirements they are expected to meet.

The training program will include general radiation safety training/monitoring, site orientation, site-specific training, and training verification and documentation. These aspects of the training program are discussed in the following subsections.

9.4.1 General Radiation Safety Training/Monitoring

At a minimum, all site personnel will be required to have appropriate radiation safety training and to wear radiation-monitoring devices. The contractor will provide thermoluminescent dosimeters (TLD, or equivalent) to personnel who enter and work in radiologically controlled areas. Workspace air monitoring also will be provided by the contractor as well as other environmental monitoring, where appropriate. The contractor will determine if additional personal monitoring is warranted, in accordance with the H&S Plan. At a minimum, exposure will be monitored in accordance with 10 CFR 20. Exposure results will be reviewed by the RSO and provided to Kaiser on a timely basis.

9.4.2 Site Orientation

Prior to entry into any radiological restricted area of the Kaiser site, personnel and visitors will be given a site and radiological orientation. Objectives of this orientation will be to familiarize personnel and visitors to:

- recognize labeled or posted radioactive materials and understand the meaning of radiological warning signs;
- understand that as long as radiological control procedures and limits are followed, harmful effects to personnel and the environment from radioactivity will be minimized; and
- recognize and understand the meaning of, and proper response to, emergency signals.

9.4.3 Site-Specific Training

Site-specific training will be required of all contractor personnel involved in day-to-day operations of the remediation project, project and management personnel who visit the site regularly, and other personnel identified by Kaiser's SA. Prior to being allowed unescorted access to the site and issuance of a TLD, each person shall demonstrate a basic knowledge of radiation worker training.

9.4.4 Training Verification and Documentation

Personnel working on site will present evidence of general radiation safety training as required by 10 CFR 20 and pertinent refresher training (e.g., training certificates, letter of certification) prior to being permitted to perform in a restricted area. All contractor personnel will be required to have OSHA 1910.120 training and the contractor shall meet all the requirements in OSHA 1910.120. The contractor shall provide evidence of this training. In addition, all site personnel shall sign a statement certifying and acknowledging that they have received site-specific training and that they understand the potential site hazards and the necessary control measures to reduce and/or eliminate those hazards. Training documentation, including the content of site-specific training and any other subsequent training (e.g., periodic safety meetings and specific task safety meetings), will be submitted to Kaiser's SA and will be maintained by the contractor for a suitable period to be specified by Kaiser. This information will be available for inspection by Kaiser.

9.5 Contractor Support

As discussed above, Kaiser will utilize qualified contractors and consultants to implement this DP in accordance with the written plans and procedures.

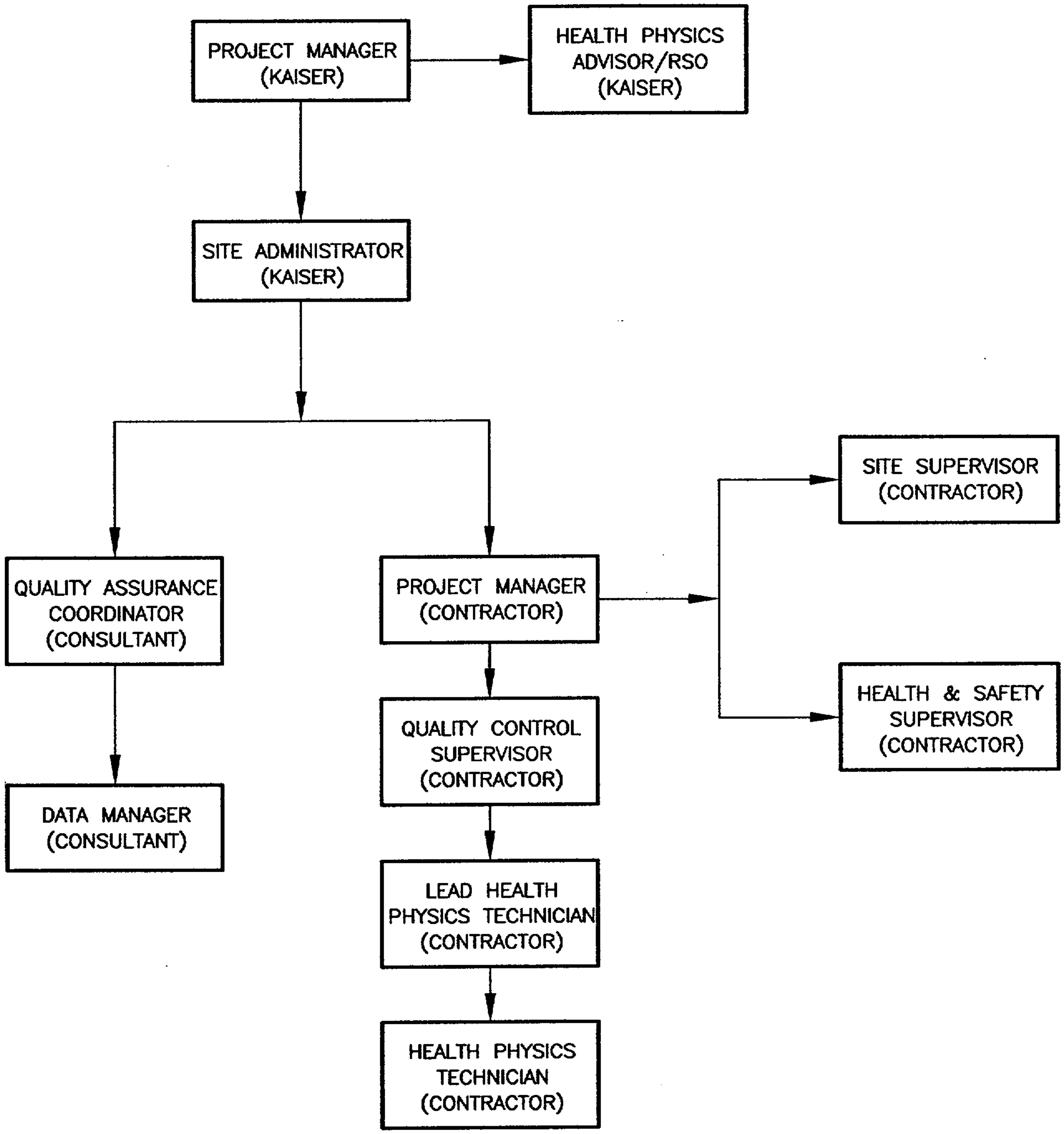


FIGURE 9-1
DECOMMISSIONING MANAGEMENT ORGANIZATION
KAISER ALUMINUM SPECIALTY PRODUCTS
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

APPROVED	5/31/01
CHECKED	5/31/01
DRAWN	GJA 4/16/01

DRAWING NUMBER
5427005

Earth Sciences Consultants, Inc.

10.0 H&S Plan

This section provides the general framework for H&S policies and practices to be followed during decommissioning activities at the Kaiser Tulsa site. Information in this H&S Plan supplements Kaiser's Environmental Health and Safety Plan (June 2000, Revision 2) which is presented in Appendix E and provides the basic policies, objectives, organizational structure, and guidelines governing remediation work at the site. Contractors engaged to perform work related to site remediation will be required to prepare and submit H&S plans of their own that will be specific to activities and services they are to provide.

10.1 Radiation Safety Controls and Monitoring for Workers

Airborne radioactivity monitoring will be conducted to confirm the effectiveness of radioactive material control practices during work activities. A process for assessing compliance that provides at least as much surveillance as Regulatory Guide 8.25 recommends is outlined here.

(1) Examine characterization survey(s) for thorium concentration in soil where work will be performed that will disturb soil or create dust.

(2) If the Th-232 + Th-228 is less than 200 pCi/g soil, perform occasional air sampling near the dust source. If the Th-232 + Th-228 concentration is 200 pCi/g soil or greater, perform continuous, stationary air sampling near the dust source while workers are present.

(3) Collect air samples using portable air samplers with particulate filter medium.

(4) After thoron and daughter decay, measure radioactivity by alpha counting.

(5) Compare with 10 CFR Part 20, Appendix B, Table 1, derived air concentration (DAC) limit, $2 \times 10^{-12} \mu Ci/ml$ = 1 DAC, for Th-228, Th-230, and Th-232 mix.

Having performed extensive soil thorium concentration characterization, Kaiser has a good database to identify where soil exceeds 200 pCi/g Th-232 + Th-228 and thus where airborne dust from nearby soil might reach 0.1 DAC.

10.1.1 Air Sampling Program

If it is determined there is the potential for air concentrations to exceed 10 percent of the DAC, personal and/or area air samples will be collected to evaluate worker exposure. Dust is collected on filters using standard industrial hygiene methods. Personal sampling pumps are attached to a representative number of workers. The pumps used to collect airborne dusts are to be calibrated to a flow between 1.2 and

2.0 liters per minute with cassettes loaded with mixed cellulose ester filters in line. The alpha activity of the dusts captured on the filters will be determined.

Air monitoring instrumentation which requires specific flow rates is to have flow checks performed before and after sampling events. When calibrations are recommended by the manufacturer at different intervals from those described, the H&S Manager and/or the site H&S Officer are to evaluate the calibration frequency. Instruments must be calibrated after major repairs and maintenance. Instrument maintenance and calibration activities are to be recorded and maintained as part of the H&S daily log. These logs are to be maintained at the site during site operations and are to become part of the project permanent record.

If the analytical results for the air samples exceed one tenth of the DAC limit, the RSO will be alerted and respiratory protection such as supplied air or particulate masks may be provided for any workers in the affected area.

MDC values for the radionuclides on site will be calculated using the following equation:

Alpha MDC

$$MDC = \frac{MDCR}{V * E * (1.48 \times 10^6)}$$

Beta MDC

$$MDC = \frac{MDCR}{V * E * (2.22 \times 10^6)}$$

where:

V = volume of air sampled in milliliters (ml),

E = efficiency of the detector,

1.48×10^6 = conversion from disintegrations per minute (dpm) to microcuries (μCi) for alpha,

2.22×10^6 = conversion from dpm to μCi for beta – gamma, and

MDCR = 3.3 ((Background counts/time)+(Sample counts/time))$^{1/2}$.

10.1.2 Respiratory Protection Program

Dust monitoring may be required if operations or conditions at the Kaiser site create or disturb dusts and engineering controls are not available or advisable. Dust levels may be monitored using real-time detectors such as the Mini-RAM Personal Dust Monitor or standard industrial hygiene or environmental methods. The dusts and soils present at the site are anticipated to be significantly disturbed by site activities. Engineering controls such as filtering or misting are to be initiated should dust be visible in the air. Measures to control dust from staged materials may include covering and misting, as necessary. If dust levels are not controlled by these methods, the area is required to be evacuated.

Respiratory protection is not specified under this H&S Plan. Should conditions develop on the site where supplied air would be necessary, the area of concern is required to be evacuated. If personnel are required to work in an area where Level C or Level B protection is necessary, written revisions to this H&S Plan are required to be prepared and in place before work is started in such areas.

All site personnel who may utilize respiratory protection devices are required to be trained in their use and must have received a medical examination to determine their ability to wear a respirator before starting work. Each person who uses a respirator must have been fit tested within the previous year in the size and type of respirator actually in use. Documentation of the fit testing and training provided by subcontractors must be presented to the site H&S Supervisor before work commences.

10.1.3 Internal Exposure Determination

In areas where air monitoring predicts the potential to exceed 10 percent of the DAC, bioassay may be required for workers. Urine, feces, and/or whole body counts for the appropriate isotopes of thorium may be used to evaluate internal exposure of workers. Prior to beginning work in an area where bioassay is required, workers will submit bioassay samples for baseline or prior exposure determinations. Bioassays may be conducted annually following the initial assay and at the end of the project.

10.1.4 External Exposure Determination

External exposure control is accomplished by establishing limits and action levels for personnel occupationally exposed to radiation, and controlling sources of radiation and access to areas containing radioactive material. Areas shall be established and controlled relative to the intensity of existing and potential radiation fields, in accordance with 10 CFR 20 criteria. Radiation surveys will be taken periodically during the course of activities at the work site.

Surveys that will be performed will be Beta-Gamma Surveys. These surveys will be performed in accordance with the approved plans and procedures that will be in place prior to the decommissioning of the site. Procedures for the surveys will be based on generally accepted health physics practices.

Dosimeters are to be provided to site personnel. These are to be used to determine the cumulative gamma radiation exposure to personnel over the period of the dosimetry. Dosimetry is to be analyzed at bimonthly intervals. Written dosimetry reports of exposure are to be issued annually to each person issued a dosimeter. General or area reports may be posted when representative sampling is used.

10.1.5 Summation of Internal and External Exposures

The total measured and/or calculated external and internal doses will be summed and reported as TEDE in accordance with 10 CFR 20.

10.1.6 Contamination Control Program

The Kaiser site is not an operating facility. The work area consists of ponds, a stream, and adjacent lands. The site is located in an urban area developed for commercial and industrial use. Public access to the site is restricted by fencing, gates, and a security guard.

Site operations addressed by this H&S Plan are not expected to occur in areas where facility operations or other activities not related to the project are being conducted. Project-related activities may occur concurrently or may proceed in a consecutive manner. Personnel may be working in different areas of the facility at the same time or several workers may be performing operations in a single area.

The establishment of permanent site zones is not anticipated. Temporary operation zones may be established as part of the site activities. Areas where sampling activities are occurring or contamination is anticipated or known to exist are to have access restrictions.

10.1.6.1 Work Zones

The general requirements for establishing hazardous waste operations work zones are described in this section. They are included here to provide information to site personnel in the event that it becomes necessary to set up work zones.

10.1.6.2 General Description

A description of these work zones is presented below:

- Control Zone - The control zone is defined as the area where contamination is either known or likely to be present, or where the planned activity has the potential to cause harm to personnel. Entry into the control zone requires the use of appropriate personnel protective equipment (PPE). If necessary, a control zone is to be established by determining safe distances around areas of intrusive activity using monitoring results or based on visual observations. Personnel in this area are to wear the appropriate protective clothing as specified by the H&S Plan and the site H&S Officer.

- Contamination Reduction Area - The contamination reduction area is the area where personnel conduct personal and equipment decontamination. It is essentially a buffer zone between contaminated areas and clean areas. Activities to be conducted in this zone may require PPE.

- Support Zone/Clean Area - The support zone/clean area is situated in areas where the chance to encounter hazardous materials or conditions is minimal. PPE is generally not required. Permission to enter the support zone/clean area only is granted to authorized persons, including visitors, after they have received the information listed in this section and have signed the H&S Plan certification.

10.1.6.3 Site Personnel Requirements

No person may enter a designated work area without the complement of PPE specified by the H&S Officer for that area. PPE selections are based on the work to be performed and the hazards present.

Any restricted areas designated by the H&S Supervisor are to be clearly marked in the field. The restrictions and requirements are to be posted and/or verbally communicated to persons on the site. Temporary control zone and contamination reduction areas are to be established for work areas that present a significant risk of exposure to hazards such as high levels of contamination and/or dust-generating operations. A control zone may be established around areas of significant contamination to prevent the spread of contaminated materials. These areas require decontamination procedures for persons or equipment leaving the control zone.

The control zone and contamination reduction area are to be delineated by appropriate physical barriers. Temporary control zone and contamination reduction areas are to be marked in the field using flagging tape or temporary construction fencing with appropriate signage. Temporary control zone or contamination reduction area barriers are to remain in place until the work in the zone is completed or until the potentially hazardous conditions that caused an area to be designated as an control zone are eliminated. The decision to establish or eliminate a control zone or to modify required PPE, environmental monitoring, or other operational requirements are to be made by the H&S Officer.

Support zone/clean areas are to consist of areas of the site which are not contaminated and are not being used for the contamination reduction area. Every effort is to be undertaken to prevent the contamination of clean areas and the support zone/clean area. Personnel and equipment that enter the support zone/clean area after having been in the control zone or contamination reduction area are to be decontaminated.

10.1.6.4 Visitors

Visitors must be authorized by the Kaiser SA or the Kaiser PM and follow the Kaiser Visitor H&S Plan Synopsis.

10.1.6.5 Buddy System

The implementation of a buddy system is mandatory for activities performed in a control zone or contamination reduction area. A buddy system requires teams consisting of at least two people who maintain constant sight or voice contact. The size of the team depends on the level of PPE that is worn by any one team member. The buddy system offers the following:

- Providing the partner with assistance.
- Observing the partner for signs of chemical or thermal exposure.
- Periodically checking the PPE of the partner.
- Summoning emergency assistance when needed.

10.1.6.6 Site Communication

Communication between site personnel is essential. Radios may be required for use to maintain proper communication when a site is large or the work areas are widely spaced. Personnel in the control zone should remain in constant radio communication or within sight of the field team leader/site H&S Officer or his/her designee.

The following standard hand signals are to be used in case of failure of radio communications:

- Hand gripping throat - out of air, cannot breathe
- Grip partners wrist or both hands around waist - leave area immediately
- Hands on top of head - need assistance
- Thumbs up - okay, I am all right, I understand
- Thumbs down - no, negative

In addition, a series of three extended horn blasts are to be the emergency signal to indicate that all personnel should leave the work area.

10.1.6.7 Decontamination

Decontamination of personnel and equipment at the Kaiser site is to be conducted in order to reduce the risk of off-site migration of contaminants and to prevent cross contamination of areas within the site boundaries. Decontamination is one of the primary means used to prevent or reduce the potential for ingestion of radionuclides. Decontamination of equipment may be performed between tasks to reduce the potential for cross contamination of areas and/or samples. Personnel decontamination is to be conducted when workers leave contaminated work areas and enter clean areas. Decontamination activities are to be performed carefully to avoid contamination of workers and the environment

10.1.7 Instrumentation Program

Instrumentation that may be used to aid in the monitoring of the H&S Plan include, but is not limited to, the following: Low Volume, High Volume, lapel samplers, and 0.8-micron cellulose filters or other appropriate filters. The equipment will be calibrated and routine pre-operational checks performed in accordance with approved plans and procedures.

10.1.8 Health Physics Audits, Inspections, and Record Keeping Program

Health Physics Audits, inspections, and record keeping are covered in Chapter 13.0 (QA Program) for the following:

- Section 13.1 addresses the organizational structure.
- Section 13.3 addresses document control.
- Section 13.5 addresses corrective action process.
- Section 13.7 addresses the audits and surveillance methods of the DP.

10.1.9 Air Sampling Plan

Kaiser intends to implement the same Air Sampling Plan that was used for the Adjacent Land Remediation Plan. This plan was found to be effective and is described below.

10.1.9.1 Monitoring of Airborne Radioactivity

Since the thorium concentration range in soil is well characterized, an estimate of the reasonable maximum dust concentration in air caused by work activity enables the maximum potential airborne thorium concentration during work activity to be estimated.

- Ninety percent of soil samples cannot cause potential airborne thorium concentration as high as 0.1 DAC.

- The maximum potential airborne particulate concentration in air on the dross remediation site and adjacent property is about 0.2 DAC.
- Total thorium concentrations greater than 200 pCi/g Th-232 + Th-228 dross or soil that can cause greater than 0.1 DAC is in geographically identifiable areas.
- The maximum thorium concentration measured in any soil sample (on site or in the adjacent areas) was 728 pCi/g Th-232 + Th-228 soil.

Where work will be performed that disturbs soil and creates a substantial amount of dust, the thorium concentration in soil will be estimated. If the Th-232 + Th-228 concentration in soil is less than 200 pCi/g, air will be sampled occasionally to confirm less than 0.1 DAC. But if the Th-232 + Th-228 concentration in soil is greater than 200 pCi/g, air will be sampled continuously near the source of dust during work that creates dust.

10.1.10 Airborne Radioactivity Monitoring Program

Airborne radioactivity monitoring will be conducted to confirm the effectiveness of radioactive material control practices during work activities. A process for assessing compliance that provides as much surveillance as Regulatory Guide 8.25 recommends is outlined in the beginning of Section 10.1.

Kaiser proposes to sample as represented in Section 10.1.1 of this plan by using fixed station, high-flow air samplers. The samples will be alpha counted in a low-background counter.

Considering the proximity of remediation activity to occupied public areas, continuous air sampling near occupied buildings nearby will be initiated if air particulate samples collected near the remediation activity indicate long-term air concentration may exceed 0.5 of the maximum acceptable airborne concentration for members of the public in buildings nearby.

References

1. Nuclear Regulatory Commission, June 1992, Regulatory Guide 8.25, Air Sampling in the Workplace.

w:\5427e\rpt\decomplan\chapter-10.doc

11.0 Environmental Monitoring and Control Program

Kaiser will implement an Environmental Monitoring Program (EMP) during site decommissioning activities for the specific purpose of evaluating whether the decommissioning activities comply with the regulatory requirements in 10 CFR Part 20 and are adequate to protect workers, the public, and the environment from radiation during decommissioning activities.

The following items must be addressed prior to excavation of affected material:

- Management of water encountered in excavations.
- Management of surface water to minimize contact of water with contaminants and minimize erosion.
- Construction of safe stable excavations, particularly deep excavations where water may be encountered.
- Preparation and implementation of a Dust Control Plan to prevent migration of wind-borne contaminants.
- Identification and protection of existing underground and overhead utilities.
- Implementation of site access controls.
- Implementation of internal traffic controls.
- Management of wastewater as a result of remediation activities.

ALARA reviews will be included in regularly scheduled job meetings. The minutes of these meetings will be distributed to the attendees, the PM, and the RSO.

11.1 Environmental ALARA Evaluation Program

Every reasonable effort will be made to limit radiation exposures and releases of radioactive materials in effluents in unrestricted areas. Baseline concentrations have been established for both surface water monitoring and air monitoring. Average water concentrations of Th-232 were 0.146 picocurie per liter (pCi/l). Air concentrations were 4.03×10^{-15} µCi/ml gross alpha. Effluents from the remediation area will be sampled and measured, where applicable. Release of effluents will be restricted to the criteria set forth by the local and regional regulatory bodies. Only effluents which meet the regulatory limits and are approved will be released to the proper environmental channel. Construction management techniques to minimize E&S transport, and E&S control measures to be implemented and maintained during remedial activities are outlined in the later sections of this chapter. In addition, groundwater management methodologies have been outlined in Kaiser's Ground Water Sampling Procedure, KAI–03 in the event groundwater is encountered during soil remediation. Surface water encountered during remediation activities will be monitored and sampled in accordance with the Procedure for General Surface Water Sampling, KAI-06.

The EMP presented below addresses the program that will be conducted during and after remediation, where applicable. In addition, this plan summarizes procedures that will be followed to ensure that samples will be representative of actual conditions as well as methods of environmental record keeping and reporting. Monitoring requirements for airborne particulate addressed in Chapter 10.0, are not included in this EMP.

11.2 Effluent Control Program

Every reasonable effort will be made to limit radiation exposures and releases of radioactive materials in effluents in unrestricted areas. Where applicable, effluent controls will be utilized to prohibit the influx of effluents into restricted areas as well as to prohibit the release of contaminated effluents.

11.2.1 Water Controls

Water inflow is expected in affected soil excavation locations. Engineering solutions, such as excavation dewatering and installation of drawdown wells or sheet pile, will be required. A dry excavation would be beneficial to the persons performing surveys controlling the soil remediation activities. Water inflow also may affect the stability of excavations.

Dewatering requirements for an excavation depend on the rate of intrusion. Minor inflows can be managed using a pump in a sump to drain the excavation. Standing water in the excavation may be pumped into an area where the water can be sampled and measured before it is released. Chapter 12.0, Section 12.2 addresses water management.

11.2.2 Surface Water Management

Surface or storm water must be managed during remediation. Essential aspects of surface water management will be:

- maintenance and restoration of existing drainage ways,
- minimization of water contacting contaminated materials (contact water),
- control and diversion of storm water around remediation areas,

- pumping of contact water into a holding area,
- minimization of soil E&S, and
- protection of water quality in downstream watercourses.

The following sections describe these considerations in detail.

11.2.2.1 Maintenance and Restoration of Existing Drainageways

The contractor's work plan will address the maintenance of existing drainageways (e.g., pipe outlets, ditches, weirs, and Fulton Creek). Any drainageways interrupted by remediation activities will be temporarily rerouted and later restored or improved after the remediation is completed. Damaged items will be repaired or replaced to at least their original condition prior to remediation. Particular attention will need to be given to remediation in and around Fulton Creek. Necessary permits for interruption of existing drainageways will be obtained.

11.2.2.2 Minimization of Contact Water

It will be essential to minimize storm water contact in contaminated areas and soil stockpiles. Contact water will be pumped into a holding area, where applicable.

Minimization techniques may include the following, as necessary:

- Diverting surface water drainage around remediation and stockpile areas,
- Installing covers over stockpiles,
- Minimizing the time of exposure of open areas, and
- Performing work during dry periods.

11.2.2.3 Storm Water Diversion Around Remediation Areas

Diversion channels, berms, or other structures may be installed to divert surface flow around active remediation/excavation areas and stockpiles. Diversion controls will be designed before remediation implementation. Water entering the excavations or the decontamination area, either as surface water or groundwater, may be pumped into holding tanks.

11.2.2.4 E&S Control

E&S controls are required to prevent sediment pollution resulting from excavation activities. The State of Oklahoma has adopted the USEPA's 40 CFR 120 National Pollutant Discharge Elimination System (NPDES) including specifically 40 CFR 122.26(b)(14)(x) which specifies permit requirements for discharge to state rivers and streams. NPDES requires permits for construction sites larger than 5 acres. All necessary E&S permits will be obtained. The contractor's work plan will contain a work-specific E&S Control Plan. The following section outlines the primary issues that need to be addressed in the plan.

11.2.2.4.1 <u>Construction Management for E&S Control</u>

The following techniques will be utilized to minimize E&S transport away from the affected areas and stockpiles.

Interim stabilization measures such as:

- temporary seeding,
- straw mulch application,
- erosion control mat,
- cover barriers (such as plastic sheeting), and
- an erosion control surfactant (Soil Master).

Permanent stabilization measures may include:

- top soil placement and grading,
- seeding and mulching,
- sod matting, and
- gravel or riprap placement.

Erosion control measures must be in place and operational before excavation, backfilling, or grading operations can begin. E&S control measures shall be properly constructed and maintained until the disturbed areas are adequately stabilized. These measures may include:

- diversion channels and berms,
- sediment traps,
- temporary covers (such as plastic sheeting),
- silt fence and/or hay bale barriers,
- riprap linings,
- vegetative strips, and
- surface coatings.

An inspection schedule and reporting protocol shall be prescribed in the contractor's work plan. A record of inspection and all repairs made will be noted and kept on site by the CPM. At a minimum, all E&S control measures will be inspected weekly during soil remediation activities, every 2 weeks during inactive periods, and within 24 hours after each rainfall event exceeding 0.5 inch. During periods when rain is occurring daily, or continuously for days, control measures will be inspected at least daily. Repairs and maintenance will be performed as soon as practical.

11.2.3 Protection of Water Quality in Downstream Watercourses

Adequate controls will be installed and implemented to prevent discharge of contaminated water to downstream watercourses. Contact water will be pumped into holding tanks.

11.2.4 Airborne Radioactivity Monitoring Program

Airborne radioactivity monitoring will be conducted to confirm the effectiveness of radioactive material control practices during work activities. A process for assessing compliance that provides as much surveillance as Regulatory Guide 8.25 recommends is outlined in Chapter 10.0, Section 10.1.

Kaiser proposes to sample as represented in Section 10.1.1 and Section 10.1.2 of the plan by using fixed station, high-flow air samplers. The samples will be alpha counted in a low-background counter.

Considering the proximity of remediation activity to occupied public areas, continuous air sampling near occupied buildings nearby will be initiated if air particulate samples collected near the remediation activity indicate long-term air concentration may exceed 0.5 of the maximum acceptable airborne concentration for members of the public in buildings nearby.

12.0 Radioactive Waste Management

Solid and liquid materials will be generated during the implementation of the planned decommissioning activities. Kaiser will manage the solid and liquid materials generated from the decommissioning effort in a controlled manner in accordance with applicable NRC, Department of Transportation (DOT), and state regulatory requirements. The management approach is based upon minimizing secondary wastes and radiation exposure.

12.1 Solid Material

Two types of solid materials are expected to be generated during the implementation of the planned decommissioning activities at the Kaiser site: Dry Active Waste (DAW) – Thorium-Containing Soil/Dross and Other Incidental DAW.

12.1.1 Volume Estimate of Thorium-Containing Soil/Dross - Retention Pond and Reserve Pond Areas

Volume estimates for the thorium-containing soil/dross in the retention pond and reserve pond areas have been discussed previously. The volume estimates as calculated from krigging and triangulation are presented in Appendix A. In addition, soil/dross material generated in adjacent land remediation excavations will be managed in this decommissioning project. Estimated volumes of solid materials to be handled are as follows:

- Approximately 285,000 ft^3 of soil/dross excavated during adjacent land remediation and stored on site.
- Approximately 5,060,000 ft^3 of solid material with a Th-232 activity concentration of greater than 6 pCi/g.

12.1.2 Thorium Activity Concentrations

Thorium activity concentrations for the soil/dross materials were determined using existing characterization data for both the on-site and adjacent land remediation areas. Based on data generated by ARS in 1995, Th-228 + Th-232 activity concentration for the on-site material ranges from approximately 2 pCi/g to 416 pCi/g. The adjacent land remediation area material exhibited Th-228 + Th-232 activity concentrations ranging from less than minimum detectable activity to 728 pCi/g.

12.1.3 Management of Thorium-Containing Soil/Dross

Thorium-containing soil/dross will be excavated during remediation efforts for the on-site areas. During the site preparation phase of the decommissioning, a controlled stockpile and material handling/processing/storage area will be constructed in the western part of the property (Figure 8-1). Excavated materials will be transported to the stockpile area for segregation into above- and below-criteria materials.

Segregated above-criteria material will be loaded directly into trucks, railcars, or storage containers. Containers awaiting shipment will be placed in a designated Storage Area (Figure 8-1). An off-site disposal facility has not yet been selected. As discussed in Chapter 8.0 of this plan, segregated below-criteria material will be used as backfill in Phase II and Phase III excavation areas. Stockpiled materials will be protected against inclement weather. Storm water runoff will be controlled in the material handling/processing/storage area until the materials are packaged for shipment or determined to be acceptable for use as backfill.

12.1.4 Management of Other Dry Active Waste

Other DAW will consist mainly of compatible paper and plastic (gloves, anticontamination clothing, poly sheeting, etc.). This type of material will be collected in a manner in which it can be easily characterized for radioactivity and shipped to a properly licensed waste processing or disposal facility, if contaminated. DAW of the aforementioned type found to be noncontaminated will be placed in a staged refuse container and disposed as nonradioactive waste at an appropriate facility.

12.2 Liquid Material Management

Liquid materials that may be generated during decommissioning efforts include collected infiltration waters from excavation areas and decontamination process fluids. Minimization of the quantity of liquids requiring disposal as a radioactive waste will be a high priority during the project. Decontamination process activities will be well planned to minimize the generation of secondary waste volumes.

During the excavation activities, infiltrating water may be collected and managed, where practical. Collected waters will be managed in accordance with local, state, and federal laws, regulations, and permits as applicable.

During the adjacent land remediation project, waters infiltrating the excavation areas were collected, temporarily stored for settling, and characterized. Ultimately, the water was discharged to the sanitary sewer system. No collected waters required off-site processing. The average concentration of Th-232 in the collected waters was 1.2 pCi/l (7.7 pCi/l maximum) which is far below the Part 20 Release to Sewers Average Concentration Standard of 300 pCi/l.

12.3 Radioactive Waste Disposal

12.3.1 Waste Classification

All radioactive waste materials are expected to be exempt quantities and will be disposed using procedures that follow the requirements of federal regulations and the receiving disposal facility. Use of procedures will ensure that an accurate profile of the waste is made and that classification is performed in a consistent manner. The following basic methods may be used to ensure materials are exempt:

- Field measurements of gross activity
- Analytical measurements of specific activity

Waste material characterization will be performed based on remediation area or process. Individual waste stream designations will be established for remediation areas or processes that have similar radionuclide profiles and physical properties (e.g., soil/dross, other incidental DAW, or liquids). Waste material characterization will be performed by monitoring with appropriate instrumentation and/or sampling before packaging. The total activity (i.e., curie content) of each waste container will be determined based on the radionuclides present and the activity concentrations of Th-232 (through waste characterization sampling and calculations based on known ratios of thorium isotopes). In addition, characterization data will be utilized to assure that the material meets the exempt waste acceptance criteria of the disposal facility.

An estimate of the volume of above-criteria solid material to be generated during remediation of the site soils has been performed. Approximately 1,200,000 ft^3 of above-criteria soil/dross material may be generated for off-site disposal. Based on existing site characterization data, it is anticipated that this material will be exempt.

12.3.2 Waste Packaging, Transfer, and Storage

Radioactive waste materials will be packaged for disposal in the controlled material handling/processing/storage area (Figure 8-1). Packaging will include DOT and disposal facility-approved containers (minimum of strong tight) such as intermodals, metal drums or boxes, and/or impervious bagging. Containers will be appropriately labeled as they are filled and a control number will be assigned to each container. The control number will be entered in a master log and placed on the container surface. After packaging, the radioactive waste will be transferred to a secured on-site storage area and prepared for shipping or loaded directly for shipping. Solid radioactive waste materials may also be loaded directly into gondola rail cars.

12.3.3 Waste Transportation

Each waste package will be thoroughly inspected prior to shipment to ensure it meets all applicable design and/or certification requirements and is free of damage or impairment. Waste shipments are expected either to be nonradioactive material or low-specific activity material. The waste material will be transported by truck or rail based on volume of material and packaging requirements.

Waste shipments will conform to DOT and other applicable federal regulations as well as the requirements of the receiving waste facilities. Shipping documentation will be maintained in accordance with 49 CFR and 10 CFR Part 71, and the receiving waste facility's requirements.

12.3.4 Waste Disposal

As discussed above, an estimate of the volume of above-criteria solid material to be generated during remediation of the site soils has been performed. Approximately 1,200,000 ft^3 of above-criteria soil/dross material will be generated for off-site disposal.

References

1. Advanced Recovery Systems/Nuclear Fuel Services, Inc., April 25, 1995, Kaiser Aluminum Specialty Products, Field Characterization Report, Tulsa, Oklahoma.

w:\5427e\rpt\decomplan\chapter-12.doc

13.0 QA Program

13.1 Organization

Responsibility for the development, implementation, and revision of the QA Plan for the Kaiser DP is shared by corporate and on-site personnel as delineated below. This organizational structure may be revised by the Kaiser PM as deemed appropriate to facilitate execution of the project. Any revisions will be documented by the Kaiser PM. In addition, any one person may fill multiple positions as long as this does not create an organizational conflict.

13.1.1 Kaiser QAC

Kaiser will employ the services of a third-party QAC. The QAC reports to Kaiser's SA for administrative activities and QA guidance. The QAC communicates and coordinates directly with Kaiser's SA and has the delegated responsibility and authority to assure that QA objectives are met. Responsibilities of the QAC include overseeing that appropriate quality management, policy, training, and verification controls are present. Additional QAC responsibilities include conducting QA audits, surveillance of contractor activities, and correcting conditions which could adversely affect quality. The contractor will allow the QAC to inspect the work at any time and provide every reasonable facility and equipment necessary to inspect the work. The QAC is not authorized to revoke, alter, or waive any requirements of this plan. The QAC has the authority to reject materials or suspend work until any question at issue can be resolved by Kaiser's SA.

13.1.2 Data Manager

The Data Manager will report to the QAC and will ensure that all required surveys and sampling are performed in accordance with the Final Status Survey Plan and applicable written procedures. Data will be reviewed by the Data Manager to ensure that the requirements stated in the Final Status Survey Plan are implemented as prescribed and that the results of the data collection activities support the objectives of the survey, or permit a determination that these objectives should be modified. The Data Manager will determine if the data are of the right type, quality, and quantity to demonstrate compliance with the plan objective.

13.1.3 Contractor LHPT

The QCS shall designate an LHPT who will ensure all necessary sampling and scanning required in the Final Status Survey Plan are performed in accordance with such plan and written procedures. The LHPT is also responsible for sampling of soil stockpiles, off-site borrow material, and transportation containers, and will perform the preliminary review of survey data and analytical results.

13.1.4 Contractor PM

Kaiser will utilize qualified contractor(s) to implement the DP. The contractor(s) will designate a PM who will be responsible for planning, managing, and coordinating all contractor activities in accordance with written procedures. The CPM will report to the SA and will ensure that remediation activities meet the established environmental, H&S, and QC requirements; technical performance; and budgeting and scheduling criteria. The CPM will be authorized to stop any activity that may be unsafe or is in violation of a regulatory requirement.

13.1.5 Contractor QCS

The contractor shall designate a QCS who will report to the CPM for administrative activities and QC guidance. The QCS communicates and coordinates directly with the CPM and will have the delegated responsibility and authority to direct and control contractor QC functions to assure that QC objectives are met. Responsibilities of the QCS include coordination of contractor QC activities and ensuring that appropriate quality management, policy, training, and verification controls are present. The QCS shall provide all necessary QC information to the CPM, Kaiser's SA, and the QAC.

13.2 QA Program

The goal of the QA Program is to identify and implement sampling and analytical methodologies that limit the introduction of error into analytical data. This section establishes the system necessary to ensure that radiation surveys produce results that are of the type and quality needed and expected for their intended use. The QA Program covers all aspects of data collection, including field surveys, soil sampling, and laboratory analyses, through the preparation of the documentation of the results.

13.3 Document Control

Preparation, review, approval, distribution, and revisions of QA, H&S plans, and procedures will be controlled in a manner which will allow for documents to be revised as needed. Superceded copies of revised documents will be voided by written notification. Distribution of approved documents will be controlled to ensure that persons responsible for implementing written project plans and procedures have a current approved copy before work commences.

Aspects of the DP including, but not limited to, training, calibration of the instrumentation, daily checks, surveys, sampling, and results analysis and interpretation will be documented such that all records will stand up to audits. Records related to the DP will be maintained by Kaiser's SA or other persons designated by Kaiser's PM.

13.4 Control of Measuring and Testing Equipment

For all counting systems and instruments used as part of analytical analyses, at a minimum, the following QA/QC principles will be applied.

13.4.1 Procedures

Counting systems and instruments will be used in accordance with approved procedures.

13.4.2 Source and Instrument Checks

Each day that a counting system and instrument are used, the response will be checked using an appropriate source before initial use. Additional response checks may be necessary depending on the counting system used. In addition:

- For laboratory counting systems, source check acceptance criteria (e.g., $\pm 2\ \sigma$ of the average response determined after the most recent calibration or otherwise linking the response to the current calibration) will be established prior to using the counting system. Control charts will be used to evaluate the data.

- For field instrumentation, source check acceptance criteria (e.g., $\pm 2\ \sigma$ for direct [integrated] measurements and ± 20 percent for rate measurements) will be established.

- For field instruments of increased complexity (e.g., single-channel analyzers), additional checks such as energy calibration and efficiency checks will be performed and documented.

- All source check results will be documented.

- Failed source checks will be repeated. Consecutive failure will result in additional testing of the counting system in accordance with the applicable procedure and ultimately removing the counting system from service.

- Survey data acquired prior to an instrument failing a source check will be reviewed by the Data Manager to determine the validity of the data. This review will be documented.

- Instrument failures in the field will be followed by an investigation by the Data Manager of suspect data. Investigations will be documented.

13.4.3 Background Determination

Each day that an analysis is performed, the ambient background will be determined and documented at least once daily, depending on the counting system and instrument used and the variability in the background.

13.4.4 Calibration

Counting systems and instruments will be calibrated with a NIST traceable source at intervals not exceeding 12 months. The source used will be appropriate for the type and the energy of the radiation to be detected. Calibrations will be documented and include the source data.

13.5 Corrective Action

A deficiency or nonconformance that potentially invalidates the quality of measurement subject to this plan or that is an exception to this plan should be reported to the Data Manager, QAC, SA, or PM. Any appropriate person may report a deficiency or nonconformance. Identified exceptions to this plan and the reason for them should be documented and retained with project quality records.

Nonconformances shall be investigated and resolved. The investigation report should identify any substantial undesirable impact caused by the nonconformance, the resolution, and recommended measure(s) to reduce the likelihood or preclude the same of similar nonconformance in the future. An informational copy of the investigation report should be provided to the PM, the SA, and affected contractors.

13.6 QA Records

Records will be maintained to confirm that actions essential to meeting quality objectives were performed. Records, log books, or forms used to document field activities (plans, technical procedures, survey results, analytical data, and survey data) should be retained and managed as quality records. Data of records subject to this plan should be recorded in an orderly and verifiable way. Written instructions will designate documents that must be retained as quality records and maintained on site.

13.7 Audits and Surveillance

13.7.1 Maintenance of the QA Plan

Quality assessments should be preformed to provide added assurance that quality-related activities meet applicable requirements. This QA Plan should be the basis for quality assessments and for necessary response actions. Quality assessments should evaluate whether technical and regulatory requirements are met as well as procedural conformance. Changes in QA policy and procedures should be documented in a timely fashion. Active contractors and affected personnel performing remediation work should be given timely notification of changes to the QA Plan to keep them appraised of the current requirements.

13.7.2 Quality Assessments

The QAC or his/her designee should determine:

- assessment method(s),
- assessment schedule, and
- the planning and implementation process.

Assessment methods may include:

- readiness review,
- data quality evaluation,
- surveillance or performance evaluation,
- management review,
- technical review, and
- periodic audit.

The PM will decide:

- responsibilities, authorities, participants, and roles of persons performing quality assessments;
- how the organization will respond to the need for changes;
- how, when, and by whom actions will be taken in response to assessment findings and recommendations; and
- whether the response has been effective.

Persons conducting quality assessments should have access to managers, documents, and records to:

- identify quality-related problems,
- make recommendations to resolve quality-related problems,
- confirm implementation and effectiveness of corrective responses, and

- report a deficiency or nonconformance to the PM in accordance with the outlined Section 13.5, Corrective Action.

14.0 Facility Radiation Surveys

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 ($ADCL_W$). Based upon dose evaluations, the $ADCL_W$, rounded to 7 pCi/g Th-232, results in a postremediation TEDE well below 1 mrem/yr. This $ADCL_W$ is the release criterion for material returned to the excavation after separation of above-DCCL material.

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
$ADCL_W$	7.0	Average concentration (release criterion) 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 appropriate $DCGL_W$ or $ADCL_W$. The appropriate $DCLG_{EMC}$ and $ADCL_{EMC}$ values are calculated by multiplying the appropriate $DCGL_W$ or $ADCL_W$ by the area factors presented in Table 14-3. $ADCL_{EMC}$ values estimated for the excavation area are presented in Table 14-4. Those for the processing area (area where material will be separated into above- and below-criteria material) were estimated based on the $DCGL_W$ and are presented in Table 14-5.

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

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

Table 14-3
Area Factors

Radio-nuclide	Area Factors								
	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
$ADCL_{EMC}$ Values for Excavation Areas

Radio-nuclide	$ADCL_{EMC}$ (pCi/g)								
	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

Table 14-5
$DCGL_{EMC}$ Values for Processing Area

Radio-nuclide	$DCGL_{EMC}$ (pCi/g)								
	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

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 <u>ARS 1995</u>

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 <u>Adjacent Land Remediation Plan Appendix A</u>

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 "non-impacted." 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 freshwater pond area is nonimpacted. Results of characterization surveys indicate that the remainder of the pond parcel east of the freshwater pond impoundment is impacted. Several of the land areas (as opposed to structures) 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. Results of alpha spectroscopy analysis of composite samples taken during the adjacent land remediation project yielded Th-232 to Th-230 ratios from 1:0.12 to 1:2.95. 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. Based on the results of water samples analyzed, the contaminated material is not soluble.

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. Table 14-6 provides MDC values calculated using the guidance provided in NUREG-1575, MARSSIM, for increasing background values.

Table 14-6 – 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

Background (cpm)	Minimum Detectable Count Rate (ncpm)	Scan Minimum Detectable Concentration (μR/hr)	Scan Minimum Detectable Concentration (pCi/g Th-232)
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. 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 – Soil which requires additional characterization for the determination of whether it is below the $DCGL_W$ or DCCL value.
- Debris – Nonsoil material that is oversized (e.g., concrete fragments, bricks, and construction debris).

Debris will be segregated from soil to the extent practical by visual inspection, surveyed to ensure that removable contamination is absent, dispositioned as structural material, and disposed. The area containing the Characterization Grids 1-4 (Adjacent Land Remediation Project) 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 not expected to be removed. However, it will be surveyed as a Class 1 structure and decontaminated until removable contamination is absent.

Based on survey instrument DCCL, $DCGL_W$, and $ADCL_W$ 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 monitor the effectiveness of the remediation effort and ultimately 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. Since the radionuclides of interest occur naturally in background, the survey unit net radiological conditions will be compared to the specified DCGLs or ADCLs using the Wilcoxon Rank Sum (WRS) Test.

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 ADCL 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.

14.4.2.3 <u>Scanning</u>

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 14-7

Survey Unit Classification	Scanning Coverage
Class 1	100% coverage
Class 2	10 to 100% 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 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.

14.4.2.4 <u>Null Hypothesis</u>

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 <u>Decision Error Rates</u>

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 = $1 - \alpha$)	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 = $1 - \beta$)

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 data quality objective (DQO) selected for α is 0.05. The DQO selected for β is 0.10 or 0.25, depending on the area size.

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

Two sets of 30 samples were taken off site in support of the Adjacent Land Remediation Project. A background value of 1.1 pCi/g Th-232 was established.

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 current 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.

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

Initial Area Classifications

Area	Description	Classification
Processing Area	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, postexcavation 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' survey lifts (≈21 survey units per lift).	1
Spillway/Trash Piles	Areas suspected to contain building materials and or structures located where thoriated material is known to exist.	1

14.7.1 <u>Process for Reassignment of Area Classifications</u>

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 <u>Classification Upgrades</u>

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 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
Eberline E600	Eberline SPA3 2"-x-2" NaI scintillator	Sodium Iodide	Scans for Gamma Emitting Radionuclides
Bubble Technology Microspec-2	Bubble Technology Microspec-2	Sodium Iodide	Portable Gamma Spectroscopy Quantitative
Ludlum 2350-1	Ludlum 44-10 2"-x-2" NaI scintillator	Sodium Iodide	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:

$$\text{MDCR} = s_i \text{ x } (60/i)$$

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

where s_i 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 b_i is the number of background counts in the $interval_i$. 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 MDCs are summarized in Table 14-1 for increasing background count rates.

14.10 Laboratory Analysis

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.

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 14-7, 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.

14.11.2 Discrete Point Measurements

An alternate to scanning is to perform discrete point (fixed) measurements comparable to the scan coverage defined by the class. A fixed gross gamma measurement (or equivalent) and global position system (GPS) reading or alternate marking system may be taken in each grid or a predetermined interval. The fixed reading count time can be determined based on the current background count rate in the area and the required sensitivity as established by the Data Manager.

14.11.3 Soil Sampling

14.11.3.1 Surface Sampling

Surface soil sampling will be conducted in the process area to ensure that the remediation efforts have not contaminated a prior unaffected area. 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 Composite Sampling

Composite sampling may be conducted during remediation activities for soils to be potentially used as backfill. Soil will be randomly collected and uniformly mixed (e.g., a sample from each bucket). A number of samples will be collected to evaluate the radiological composition of that soil.

14.11.3.3 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 m^2. The predetermined number of soil samples will be collected in intervals which encompass the entire backfill layer (prior to placement of clean off-site backfill) plus a minimum of 6 inches of the excavation bottom. Cores that are collected will be analyzed by scanning the entire core with a 2-inch NaI probe (or equivalent) connected to a digital scalar. The coring will be placed in a container and thoroughly mixed to achieve a composite that is representative of the average concentration in that area. A portion of the composite sample of the interval will be submitted for laboratory analysis.

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 $ADCL_{EMC}$.

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.
- 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.

14.13.2 Data Evaluation and Conversion

For comparison of survey data to $DCGL_W$s, ADCLs, or DCCLs, the survey data from field and laboratory measurements will be converted to $DCGL_W$, ADCL, 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.

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. Thus, the total concentration of the radionuclide is compared to the release criterion. The two-sample WRS Test will evaluate whether the median of the data is above or below the $DCGL_W$ or $ADCL_W$.

Summary of Statistical Tests

Survey Result	Conclusion
Difference between maximum survey unit measurement and minimum reference area measurements is less than $DCGL_W/ADCL_W$	Survey unit meets release criterion
Difference of survey unit average and reference area average is greater than $DCGL_W/ADCL_W$	Survey unit does not meet release criterion
Difference between any survey unit measurement and any reference area measurement greater than $DCGL_W/ADCL_W$ or the difference of survey unit average and reference area average is less than $DCGL_W$ / $ADCL_W$	Conduct WRS Test and elevated measurement comparison

Both the measurements at discrete locations and the scans will be subject to the EMC. 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 all or part of 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	$>DCGL_{EMC}$ / $ADCL_{EMC}$ or $> DCGL_W$ / $ADCL_W$ and > statistical parameter-based value	$>DCGL_{EMC}$ or $>ADCL_{EMC}$
Class 2	$> DCGL_W$	$> DCGL_W$ or >MDC
Class 3	> fraction of $DCGL_W$	$> DCGL_W$ 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 $ADCL_W$.
- A statement that a given survey unit satisfied the DCGLW or ADCLW and the elevated measurement comparison, if any sample points exceeded the $DCGL_W$ or $ADCL_W$.
- A description of any changes in initial survey unit assumptions relative to the extent of residual radioactivity.

References

1. ADA Consultants, Inc., April 1, 1994, Radiological Survey Report, Kaiser Aluminum & Chemical Corporation, Tulsa, Oklahoma.

2. Advanced Recovery Systems/Nuclear Fuel Services, Inc., April 25, 1995, Kaiser Aluminum Specialty Products, Field Characterization Report, Tulsa, Oklahoma.

3. Nuclear Regulatory Commission, July 1998, Draft NUREG-1549: Decision Methods for Dose Assessment to Comply with Radiological Criteria for License Termination.

w:\5427e\rpt\decomplan\chapter-14.doc

15.0 Budgetary Cost Estimate

A budgetary cost estimate of $19,840,000 has been developed for the conceptual design/remediation activity as presented in Chapter 8.0 of this plan. This cost estimate is based on documented and reasonable assumptions. However, the estimate is subject to further refinement as the design details for the project are completed.

Major elements of the cost estimate are provided in Table 15-1. Specific cost items outlined below are identified as the basis for this budgetary cost estimate. Allocation of equipment and labor ultimately will be determined by Kaiser's contractor.

15.1 Mobilization

A $100,000 cost is estimated for mobilization based on experience and includes a $70,000 mobilization/setup cost for a soil segregation system.

15.2 Excavation and Backfill

Based on experience with this type of project, a daily rate has been used in the estimates.

15.2.1 Phase I Contractor Daily Cost

Phase I will involve excavation of the existing stockpile from the adjacent land area remediation. During this time, segregation methods and construction procedures will be fine tuned and, therefore, it is assumed that production will be limited to 300 cy per day (cy/day). For estimating purposes, equipment and labor may consist of:

Phase I				
Equipment and Labor	**Quantity**	**Daily Cost ($)**	**Subtotal ($)**	**Reference**
Foreman	1	305	305	RS Means, 1999
Track hoe, 2 cy bucket, one operator, one oiler	1	1,782	1,782	RS Means, 1999, Crew B-12C
Dozer, 200 hp, one operator, 0.5 laborer	1	1,378	1,378	RS Means, 1999, Crew B-10B
12-ton dump truck, one truck driver	2	681	1,362	RS Means, 1999, Crew B-34A
Vibratory drum roller, one operator, 0.5 laborer	1	900	900	RS Means, 1999, Crew B-10Y
Water truck *(assumes one truck driver from above will be used for water truck)*	1	226	226	RS Means, 1999, Crew B-9A

Phase I				
Equipment and Labor	**Quantity**	**Daily Cost ($)**	**Subtotal ($)**	**Reference**
Front-end loader, 1 cy, one operator, 0.5 laborer	1	747	747	RS Means, 1999, Crew B-10R
Miscellaneous pumps and hose, 0.5 laborer	1	200	200	Estimated
Total Phase I, per day			**6,900**	

15.2.2 Phase II or Phase III Contractor Daily Cost

During Phase II and Phase III segregation, methods and procedures will have been established. Therefore, it is assumed that production will be approximately 600 cy/day. For estimating purposes, equipment and labor may consist of:

Phase II or Phase III				
Equipment and Labor	**Quantity**	**Daily Cost ($)**	**Subtotal ($)**	**Reference**
Foreman	1	305	305	RS Means, 1999
Track hoe, 2 cy bucket, one operator, one oiler	1	1,782	1,782	RS Means, 1999, Crew B-12C
Dozer, 200 hp, one operator, 0.5 laborer	1	1,378	1,378	RS Means, 1999, Crew B-10B
12-ton dump truck, one truck driver	4	681	2,724	RS Means, 1999, Crew B-34A
Vibratory drum roller, one operator, 0.5 laborer	1	900	900	RS Means, 1999, Crew B-10Y
Water truck *(assumes one truck driver from above will be used for water truck)*	1	226	226	RS Means, 1999, Crew B-9A
Front-end loader, 1 cy, one operator, 0.5 laborer	1	747	747	RS Means, 1999, Crew B-10R
Miscellaneous pumps and hose, 1.5 laborer	1	400	400	Estimated
Total Phase II or III, per day			**8,462**	

15.2.3 Sheet Piling

Per RS Means, 2000 Heavy Construction Cost Data (RS Means, 1999), the cost for sheet piling (extracted and salvaged) is $12.35 per square foot.

15.2.4 Soil Segregation Daily Cost

The daily cost for a soil segregation system is approximately $8,000 per day. This cost is based on information provided by a vendor. The labor includes a site manager, control room operator, and three plant operators. Equipment will depend on the segregation system used. A $3,500-per-month cost estimate for downtime during winter months is based on discussions with a vendor. If an automated segregation system is not used, costs for manual screening/separation activities are expected to be of similar magnitude.

15.2.5 Backfill Material

Off-site borrow will be required to bring the site up to final grade. The $6.75-per-cy cost is based on information developed during other similar projects in the area.

15.3 Transportation and Disposal

A $7.00-per-$ft^3$ cost for transportation and disposal is based upon discussion with disposal site operators.

15.4 Vegetative Cover and Seeding

The $5,000-per-acre cost for fine grading, placement of 6 inches vegetative material, and seeding is based on experience.

15.5 Demobilization

The $50,000 cost assumed for demobilization is based on experience and includes dismantling and decontamination of a soil segregation system.

15.6 Engineering Oversight

The $2,000-per-day cost for engineering oversight includes labor, equipment, and expenses for HPT oversight and office support. This cost is based on experience.

15.7 Final Status Survey

The $50,000 estimated cost for the final status survey is based on experience.

15.8 Analytical

Based on experience, $100 per sample has been included for analytical costs. The total number of samples (1,500) is based on 1 per 2,000 m^2 and an additional 500 QC samples.

References

1. R. S. Means Co. Inc., 1999, 2000 Heavy Construction Cost Data (14th Annual Edition).

w:\5427e\rpt\decomplan\chapter-15.doc

Table 15-1
Preliminary Cost Estimate
Decommissioning Plan
Kaiser Aluminum Chemical Corporation
Tulsa, Oklahoma

Contractor Costs

Description	Quantity	Unit		Unit Cost		Subtotal
Mobilization	1	LS	$	100,000.00	$	100,000
Phase I excavation[1]	35	days	$	6,900.00	$	241,500
Sheet piling	-	SF	$	12.35	$	-
Phase I SGS (Segregated Gate System)	35	days	$	8,000.00	$	280,000
Phase I backfill material	-	CY	$	6.75	$	-
Phase I transportation and off-site disposal[2]	57,780	CF	$	7.00	$	404,460
				Total Phase I	*$*	*1,025,960*
Phase II excavation and backfill[3]	48	days	$	8,462.00	$	406,176
Sheet piling	2,500	SF	$	12.35	$	30,875
Phase II SGS	48	days	$	8,000.00	$	384,000
SGS downtime	3	months	$	3,500.00	$	10,500
Phase II backfill material	21,150	CY	$	6.75	$	142,763
Seeding, vegetative cover	2	acres	$	5,000.00	$	10,000
Phase II transportation and off-site disposal[2]	156,000	CF	$	7.00	$	1,092,000
				Total Phase II	*$*	*2,076,314*
Phase III excavation and backfill[3]	302	days	$	8,462.00	$	2,555,524
Sheet piling	10,000	SF	$	12.35	$	123,500
Phase III SGS	302	days	$	8,000.00	$	2,416,000
SGS downtime	3	months	$	3,500.00	$	10,500
Phase III backfill material (including site restoration)	114,000	CY	$	6.75	$	769,500
Phase III transportation and off-site disposal[2]	980,000	CF	$	7.00	$	6,860,000
Seeding, vegetative cover (including freshwater pond area)	12	acres	$	5,000.00	$	60,000
Demobilization	1	LS	$	50,000.00	$	50,000
				Total Phase III	*$*	*12,845,024*
				Contractor Total:	***$***	***15,947,298***

Support Costs

Description	Quantity	Unit		Unit Cost		Subtotal
Design, permitting, NRC interaction (7% of Contractor)	1	estimated	$	1,116,310.83	$	1,116,311
Engineering oversight	385	days	$	2,000.00	$	770,000
Final status survey and report	1	LS	$	50,000.00	$	50,000
Analytical costs	1,500	samples	$	100.00	$	150,000
				Support Total:	***$***	***2,086,311***
10% Contingency						1,803,361
				Total for project:	**$**	**19,840,000**

Notes:
[1]Phase I excavation volume is estimated to be approximately 10,500 cy. The number of workdays is based on a production rate of 300 cy per day.
[2]Assumes that approximately 20% of total excavation volume will be above-criteria material and require off-site disposal. Unit cost is for transportation and disposal at a facility in Texas.
[3]Phase II excavation volume is estimated to be approximately 29,000 cy. The Phase III excavation volume is estimated to be approximately 181,500 cy. The number of work days for Phase II and Phase III is based on a production rate of 600 cy/day.

w:\5427e\rpt\DecomPlan\Cotest2.xls

Appendix A

Volume Estimates

Appendix A

Table of Contents

Appendix A

Volume Estimates

Central to the problem of estimating the volume of contaminated material above a particular cleanup level is understanding the spatial distribution of contamination. Typically, isoconcentration contour maps are used to present this type of information. Several techniques are widely used to produce these types of maps, such as hand contouring, regression analysis, inverse distance, triangulation, and kriging. All of these techniques are predicated on the notion that data values closest to the point or block where the concentration is being estimated contain more information than data further away, and hence get more weight. Hand contouring may only consider the two or three adjacent points without explicit weights. Triangulation considers the three closest points (triangular facets). More sophisticated quantitative techniques consider more points.

The differences in the techniques are how the weights are estimated. Kriging is a weighted, moving-average estimation technique where the weights are determined by using the spatial correlation structure of the contaminant of interest. The difficulty in kriging is estimating the correlation structure. The correlation structure is described by a semivariogram. If there is no spatial correlation, then contour maps are meaningless, and the semivariogram will look like random scatter. The semivariogram presents the spatial structure as a graph with the abscissa the distance between sample locations (lags) and the ordinate the square of the difference in the contaminant concentrations at the sampling locations.

The typical semivariogram is a rising curve showing that points close together (few lags) are more alike (correlated). The semivariogram curve has a horizontal asymptote or maximum variance. This is called the sill. The distance on the abscissa from the origin to the point where the semivariogram curve stops rising and begins to run parallel to the sill is called the range of correlation (or range). This range suggests the size and shape of the ideal sampling grid (i.e., the maximum distance between grid nodes that still allows prediction of contaminant concentrations between grid nodes).

Appendix I of the ARS report (1995) included a summary of the geostatistical analyses (kriging) and the resulting volume estimates. The appendix included a brief description of the geostatistical method, data processing, and modeling results. Modeling results were presented as estimated volumes of contaminated soil above several different thorium concentration levels for four areas (identified as Areas 1, 2, 3, and 4). The total estimated volume above 10 pCi/g was 3,173,200 ft^3). These volume estimates presumably were incorporated into the 3.5-million-cubic-foot estimate cited elsewhere in the report.

The description provided in Appendix I (ARS, 1995) raised several concerns. Most importantly, documentation provided in Appendix I is insufficient to evaluate the credibility of the resulting volume estimates. Furthermore, the description provided suggests some errors in the analyses. Specifically, the following text is erroneous "A pure nugget (Co = 0) effect indicates a complete lack of spatial correlation." In fact, the opposite is true; what the author may have intended to say was that a high nugget (i.e., when the nugget (Co) equals the sill Co = Co + C, and C = 0) indicates a complete lack of spatial correlation. The analyses also include some unconventional data preparation. Results for a given interval, 13 pCi/g for BH-1, 2 to 5 feet, were split into 6-inch intervals, as in 2 to 2.5 feet, 2.5 to 3 feet, and assigned the same result, 13 pCi/g. This treatment of the data would produce an artificial correlation with depth. Consequently, the resulting estimate can be seriously biased.

Although the existing geostatistical analysis is of uncertain value, the technique itself is quite useful. As described earlier, if the semivariogram does not show any structure, it indicates there is no spatial correlation and contouring is meaningless. It also indicates optimum grid spacing for subsequent investigations. Kriging also uses more of the available data than most other techniques; resulting in more reliable estimates particularly when the underlying correlation structure is sound. Kriging also provides a quantitative description of the uncertainty in the estimated value. The technique can be further extended using probability kriging to incorporate specific Type I and II error rates relative to comparisons to a specific cleanup level. Probability kriging also is more robust to extremely high values than ordinary kriging.

The data set provided in Appendix I (ARS, 1995) was evaluated using both kriging and triangulation methods to produce contour maps and volume estimates. Correlation estimation and kriging were done on the log-transformed data. Semivariograms were developed using all the on-site data and just the pond data. Because the distribution of thorium in the pond resulted from a relatively predictable long-term process, it was hypothesized that the resulting semivariogram would have a better correlation structure. As anticipated, the pond-only semivariogram has a larger range (220 vs. 110 feet) and smaller nugget (0.07 vs. 0.10) and sill (0.267 vs. 0.414) than the site-wide semivariogram.

For comparison, the pond-only semivariogram kriging model, the site-wide semivariogram kriging model, and triangulation each were used to estimate the volume of thorium-bearing material in excess of 10 pCi/g total thorium for on site (see Table B-1). Although the contour maps (Figures B-1 to B-8) look somewhat different, the areas below 10 or 15 pCi/g are fairly similar for the 0-2-, 2-5-, and 5-10-foot intervals. The total kriging-estimated volume of material above 10 pCi/g is 4,008,000 cubic feet for the on-site area using the pond semivariogram and 4,559,000 cubic feet using the site-wide semivariogram

(Figures B-1 to B-4). The triangulated volume estimate is approximately 2,644,000 cubic feet, but as stated earlier, this likely to be an underestimate. Triangulated results for the on-site area are biased low by the inability of the method to estimate areas on the periphery of the sampled area (Figure B-5 to B-8). Incorporating the off-site data into the analysis would improve the accuracy of these estimates.

Tables B-2 and B-3 present volumes of material with concentrations (C) above the indicated picocurie/gm value over the indicated intervals and the total thickness under consideration as calculated by kriging and triangulation techniques respectively. The volumes in each interval are added together to get the cumulative value for each concentration. Volumes of material for intervals less than a given concentration or between two concentrations are calculated by subtracting the lesser volume from the greater volume, or total volume. The volumes were required to assist with calculating costs for several alternatives.

It is evident from the contour maps that the volume is fairly constant for cleanup levels between 5 and 15 pCi/g. Significant volume reductions can be achieved at cleanup levels on the order of 40 pCi/g.

Tables

Table A-1
Comparison of Volume Estimates for Natural Thorium Concentrations > 10 pCi/g, by Kriging and Triangulation Techniques

Estimation Method	**Kriging**				**Triangulation**	
Selected Variogram →	Pond	Sitewide	Pond	Sitewide		
Area Considered →	Pond	Pond	Site	Site	Pond	Site
Depth↓	Volume (in ft^3)	Volume (in ft^3)	Volume (in ft^3)	Volume (in ft^3)	Volume (in ft^3)	Volume (in ft^3)
0-2	464,842	468,254	704,316	739,946	430,702	615,786
2-5	653,472	622,155	977,073	942,033	531,519	780,012
5-10	1,045,640	1,150,760	1,578,780	1,690,705	728,225	1,165,965
10-15	499,007	816,170	747,740	1,187,220	82,268	82,268
Sum Total	2,662,961	3,057,339	4,007,909	4,559,904	1,772,714	2,644,031

w:\5427e\rpt\decomplan\tablea-1.doc

Table A-2
Volumes by Kriging, Greater than Concentration (C)

Depth (in ft.)	Total Volume	C* > 6.24 pCi/g	C > 10 pCi/g	C > 12.48 pCi/g	C > 20 pCi/g	C > 30 pCi/g	C > 40 pCi/g	C > 50 pCi/g	C > 60 pCi/g	C > 70 pCi/g	C > 80 pCi/g
0-2	767,299	761,966	704,316	670,676	538,020	384,626	304,132	240,560	188,182	138,187	77,259
2-5	1,178,645	1,091,793	977,073	864,807	683,220	517,320	419,730	364,839	321,021	284,004	248,789
5-10	1,771,688	1,760,275	1,578,780	1,482,025	1,180,130	897,040	691,265	536,815	445,648	377,612	322,541
10-15	1,771,686	1,445,580	747,740	462,612	83,333	11,952	0	0	0	0	0
Sum Total	5,489,318	5,059,614	4,007,909	3,480,120	2,484,703	1,810,938	1,415,127	1,142,214	954,851	799,803	648,589

Depth (in ft.)	C > 90 pCi/g	C > 100 pCi/g	C > 110 pCi/g	C > 120 pCi/g	C > 140 pCi/g	C >160 pCi/g	C >180 pCi/g	C > 200 pCi/g	C > 220 pCi/g	C > 240 pCi/g	C > 260 pCi/g
0-2	32,550	10,600	1,021	0	0	0	0	0	0	0	0
2-5	216,931	188,371	163,184	121,187	63,864	28,954	16,335	8,059	2,285	0	0
5-10	276,462	238,207	201,430	170,326	115,540	58,561	28,294	11,367	0	0	0
10-15	0	0	0	0	0	0	0	0	0	0	0
Sum Total	525,943	437,178	365,635	291,513	179,404	87,515	44,629	19,426	2,285	0	0

* C = Concentration of Natural Thorium (Th-232 + Th-228) in pCi/g.

Table A-3
Volumes By Triangulation, Greater than Concentration (C)

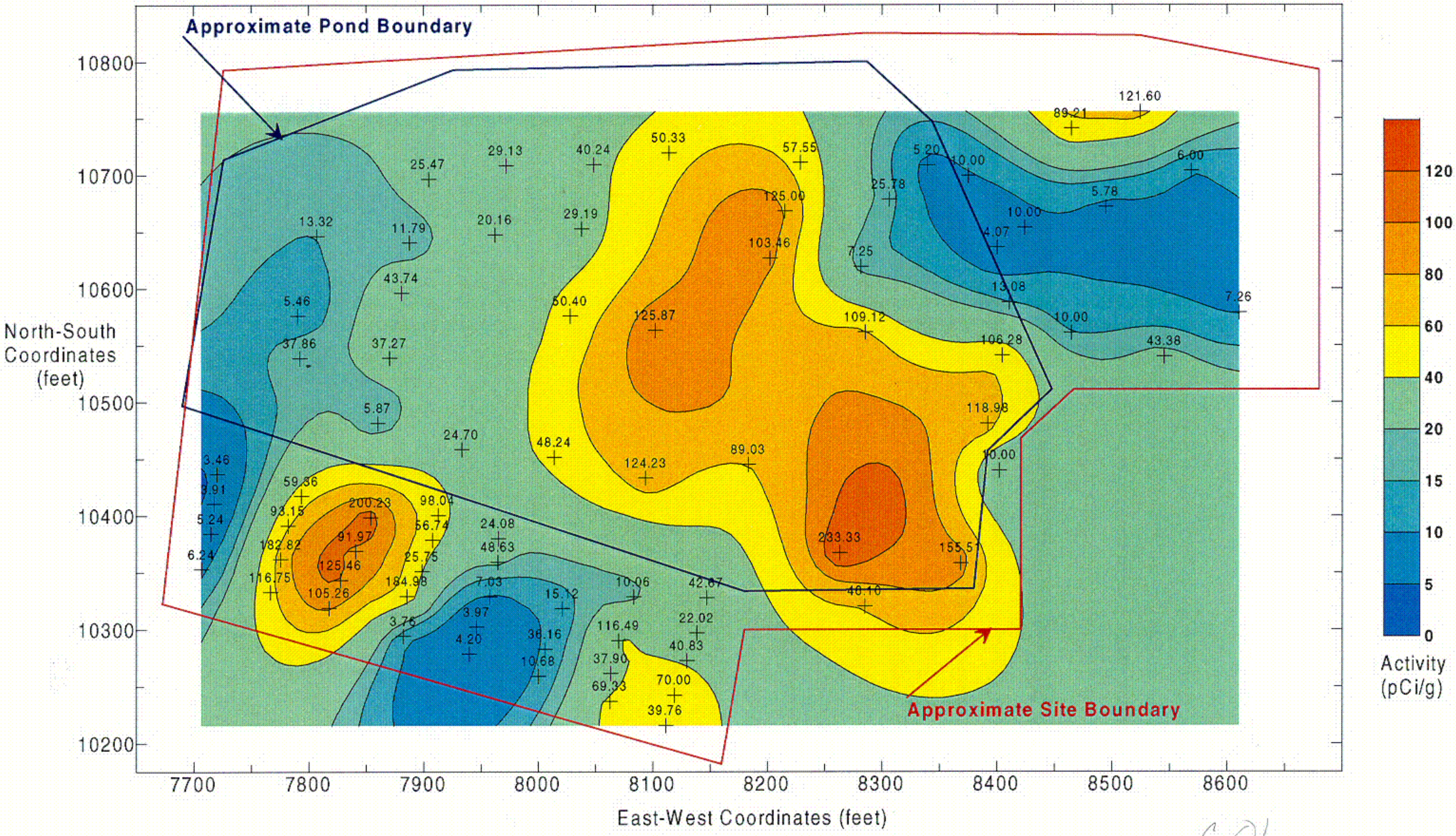
Depth (in ft.)	Total Volume	C* > 6.24 pCi/g	C > 10 pCi/g	C > 12.48 pCi/g	C > 20 pCi/g	C > 30 pCi/g	C > 40 pCi/g	C > 50 pCi/g	C > 60 pCi/g	C > 70 pCi/g	C > 80 pCi/g
0-2	849,725	734,684	615,786	558,742	444,850	339,664	256,980	196,330	160,319	130,827	104,579
2-5	1,274,589	957,099	780,012	715,650	594,096	504,555	442,548	396,261	357,738	322,422	287,979
5-10	2,073,430	1,531,840	1,165,965	1,062,295	865,575	712,705	614,915	542,800	483,618	432,851	390,714
10-15	2,073,425	741,540	82,268	44,281	5,043	0	0	0	0	0	0
Sum Total	6,271,169	3,965,163	2,644,031	2,380,968	1,909,564	1,556,924	1,314,443	1,135,391	1,001,675	886,100	783,272

Depth (in ft.)	C > 90 pCi/g	C > 100 pCi/g	C > 110 pCi/g	C > 120 pCi/g	C > 140 pCi/g	C > 160 pCi/g	C > 180 pCi/g	C > 200 pCi/g	C > 220 pCi/g	C > 240 pCi/g	C > 260 pCi/g
0-2	81,852	60,509	44,309	30,810	17,947	9,603	4,262	296	0	0	0
2-5	261,594	239,126	219,335	198,385	145,839	89,071	61,133	40,005	23,423	11,886	4,271
5-10	352,159	318,219	285,737	260,486	212,002	150,307	94,956	61,195	34,923	17,969	6,531
10-15	0	0	0	0	0	0	0	0	0	0	0
Sum Total	695,605	617,854	549,381	489,681	375,788	248,981	160,351	101,496	58,346	29,855	10,802

* C = Concentration of Natural Thorium (Th-232 + Th-228) in pCi/g.

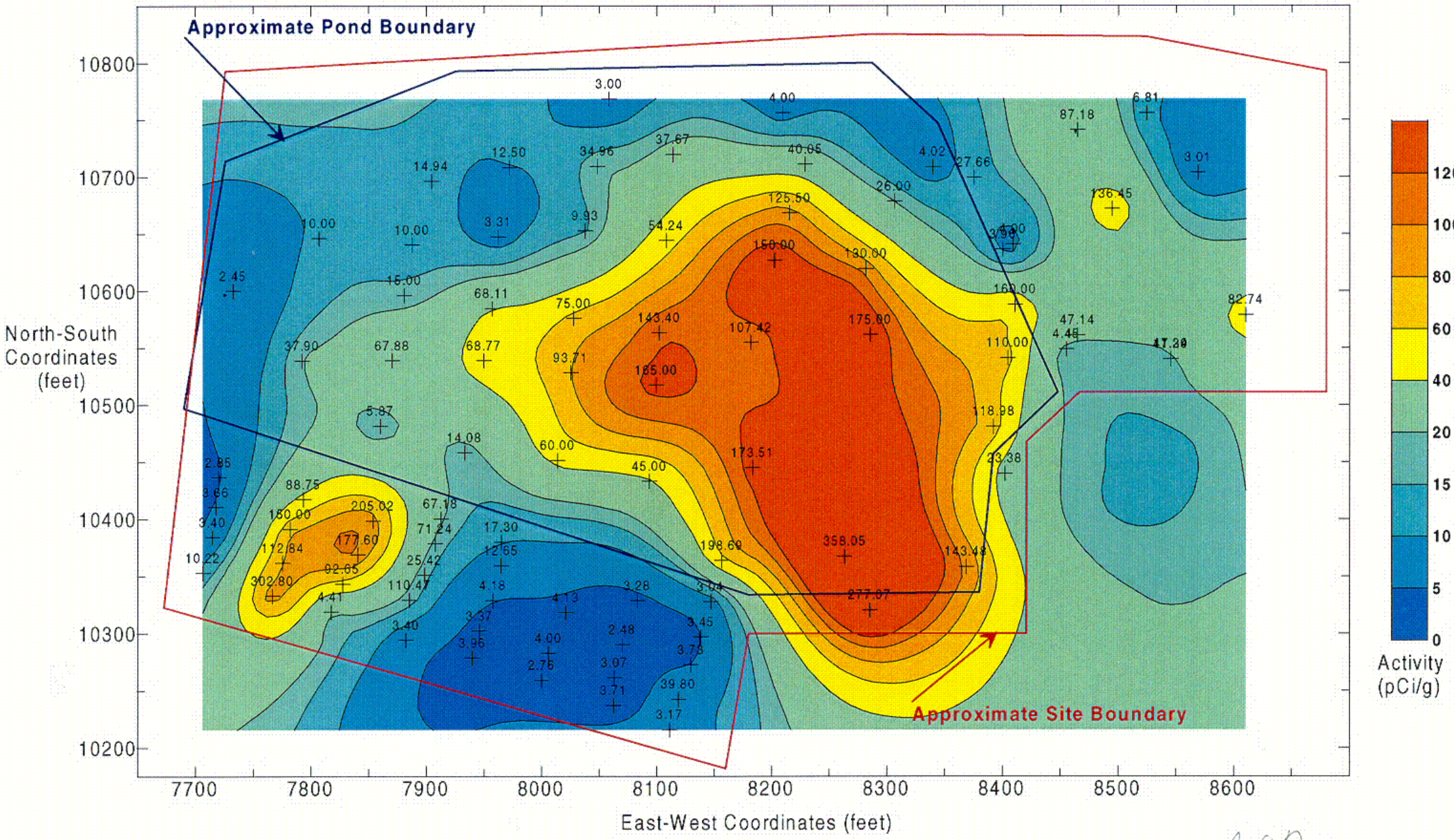
Figures

Figure A-1
Concentration Distributions, Kriging Method,
0 - 2 ft Depth
Kaiser Aluminum, Tulsa, Oklahoma
Kaiser Aluminum & Chemical Corporation
Baton Rouge, Louisiana



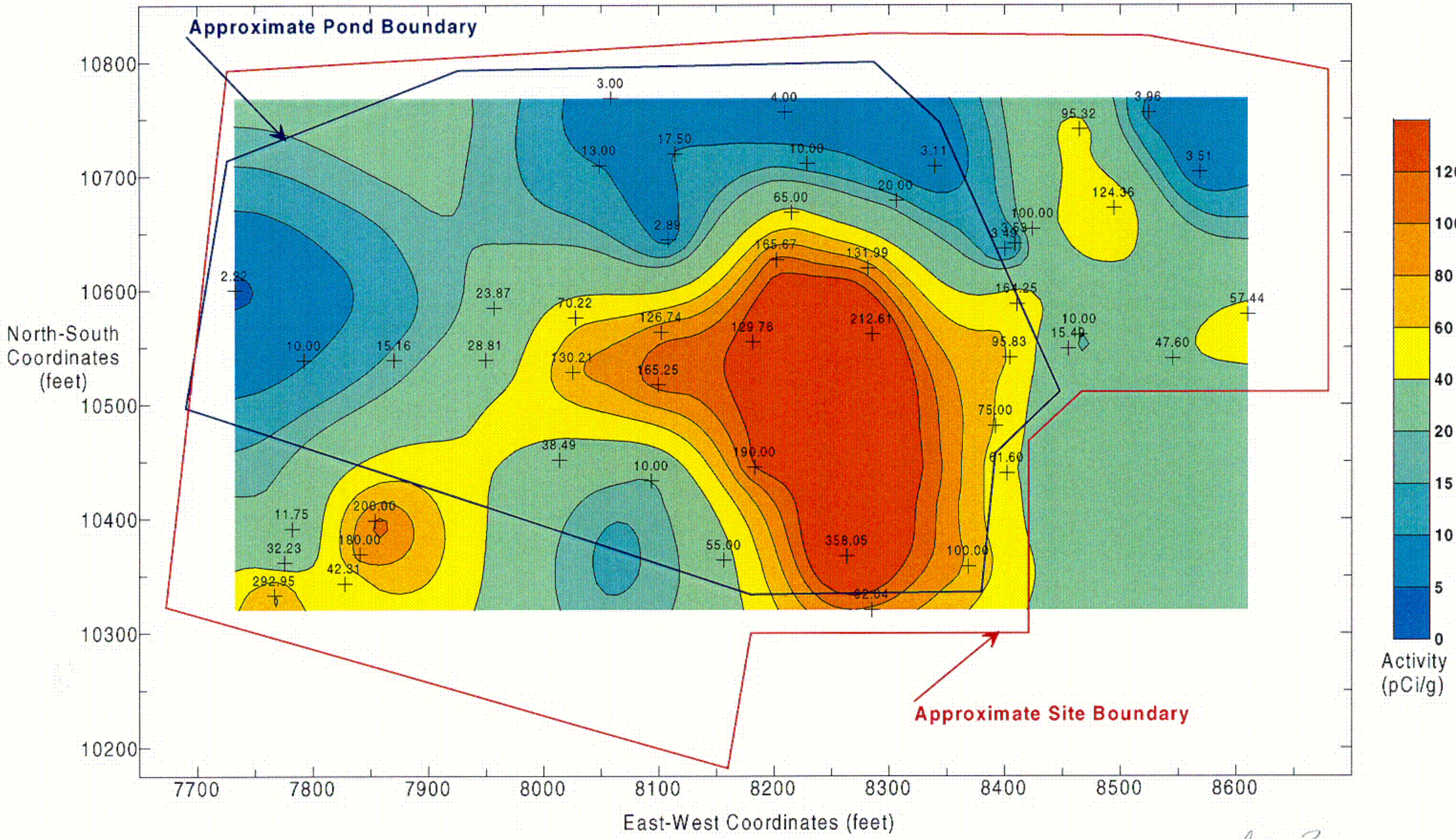
C01

Figure A-2
Concentration Distributions, Kriging Method,
2 - 4 ft Depth
Kaiser Aluminum, Tulsa, Oklahoma
Kaiser Aluminum & Chemical Corporation
Baton Rouge, Louisiana



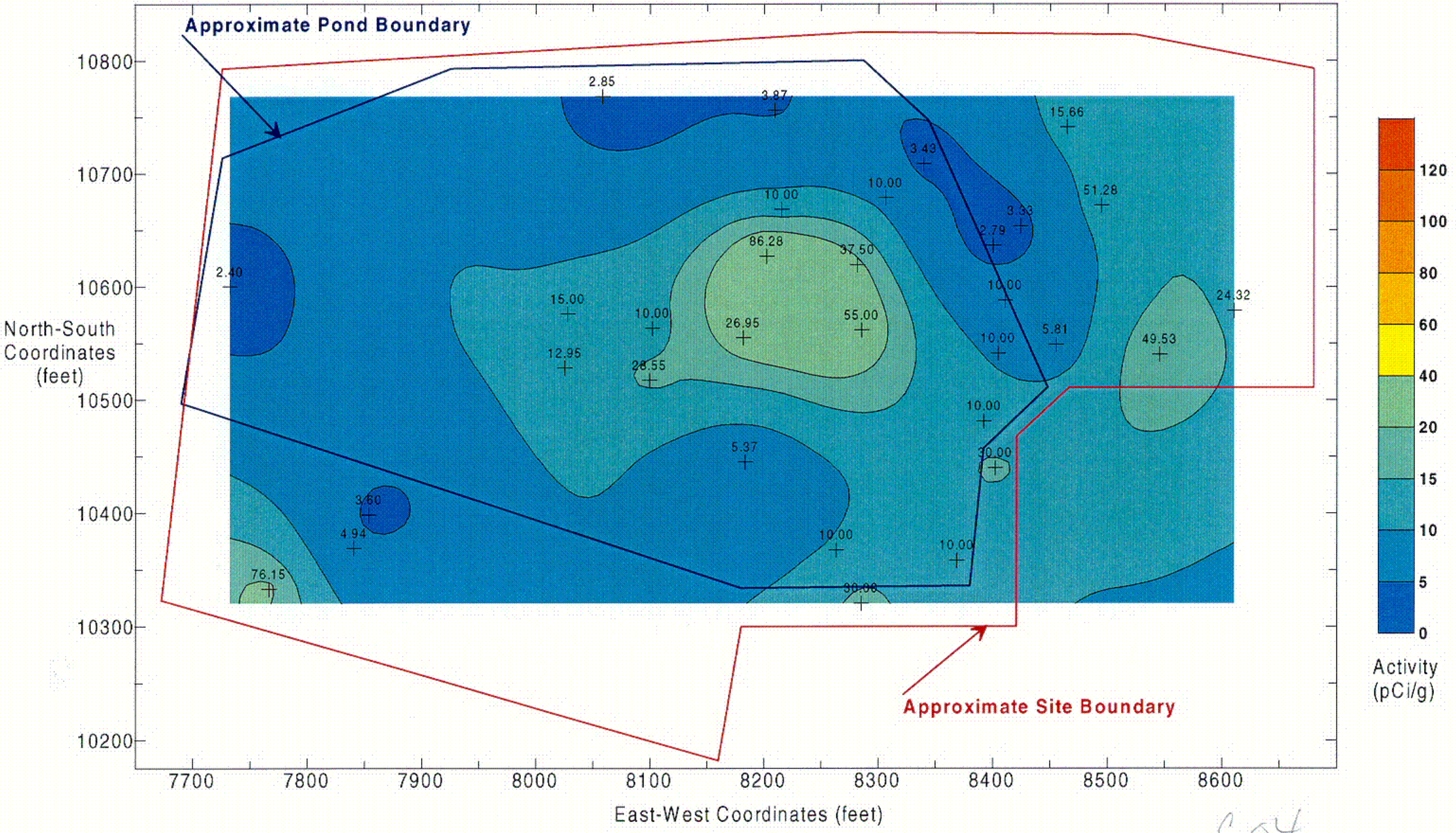
C02

Figure A-3
Concentration Distributions, Kriging Method,
5 - 10 ft Depth
Kaiser Aluminum, Tulsa, Oklahoma
Kaiser Aluminum & Chemical Corporation
Baton Rouge, Louisiana



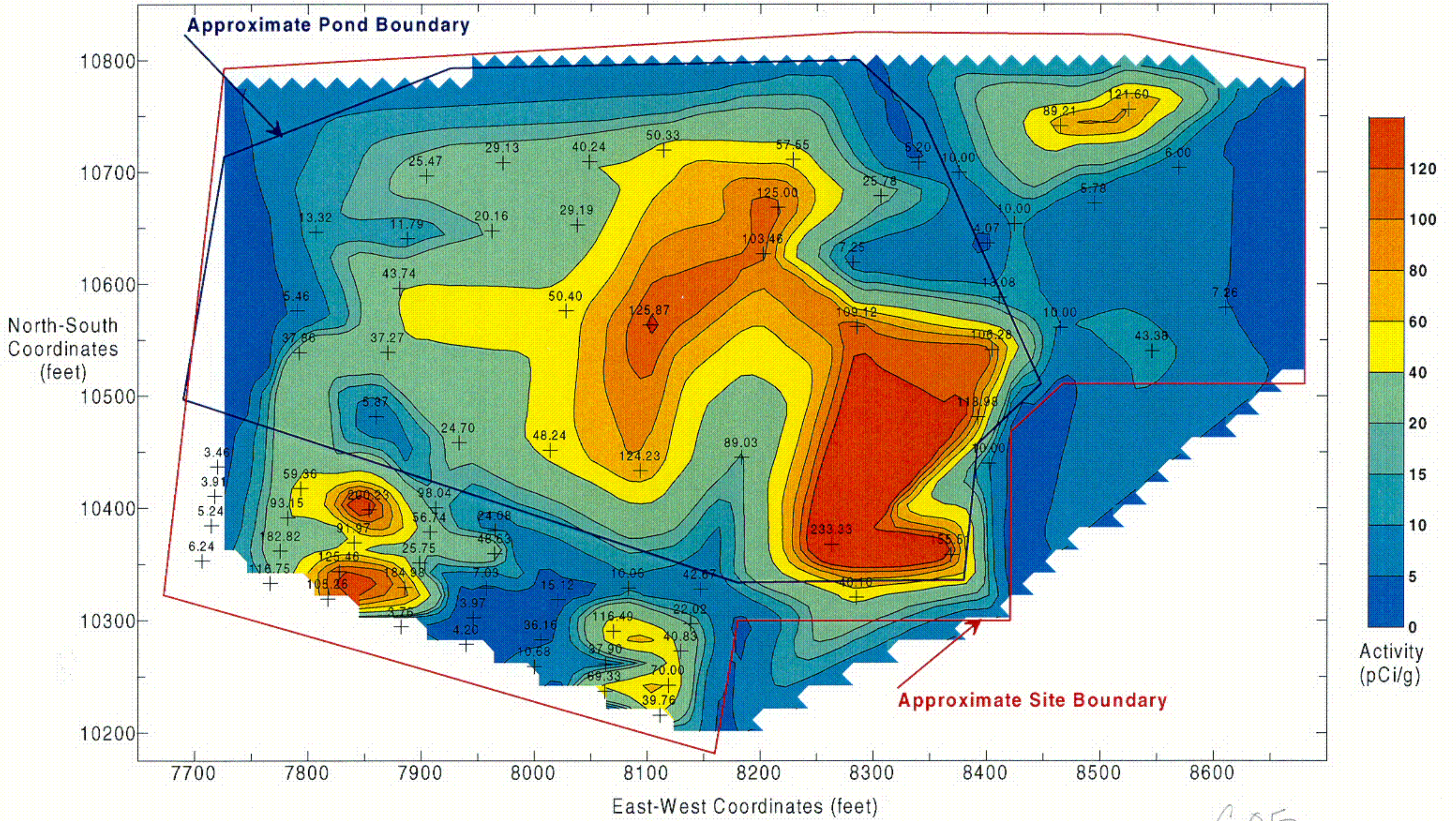
C03

Figure A-4
Concentration Distributions, Kriging Method,
10 - 15 ft Depth
Kaiser Aluminum, Tulsa, Oklahoma
Kaiser Aluminum & Chemical Corporation
Baton Rouge, Louisiana



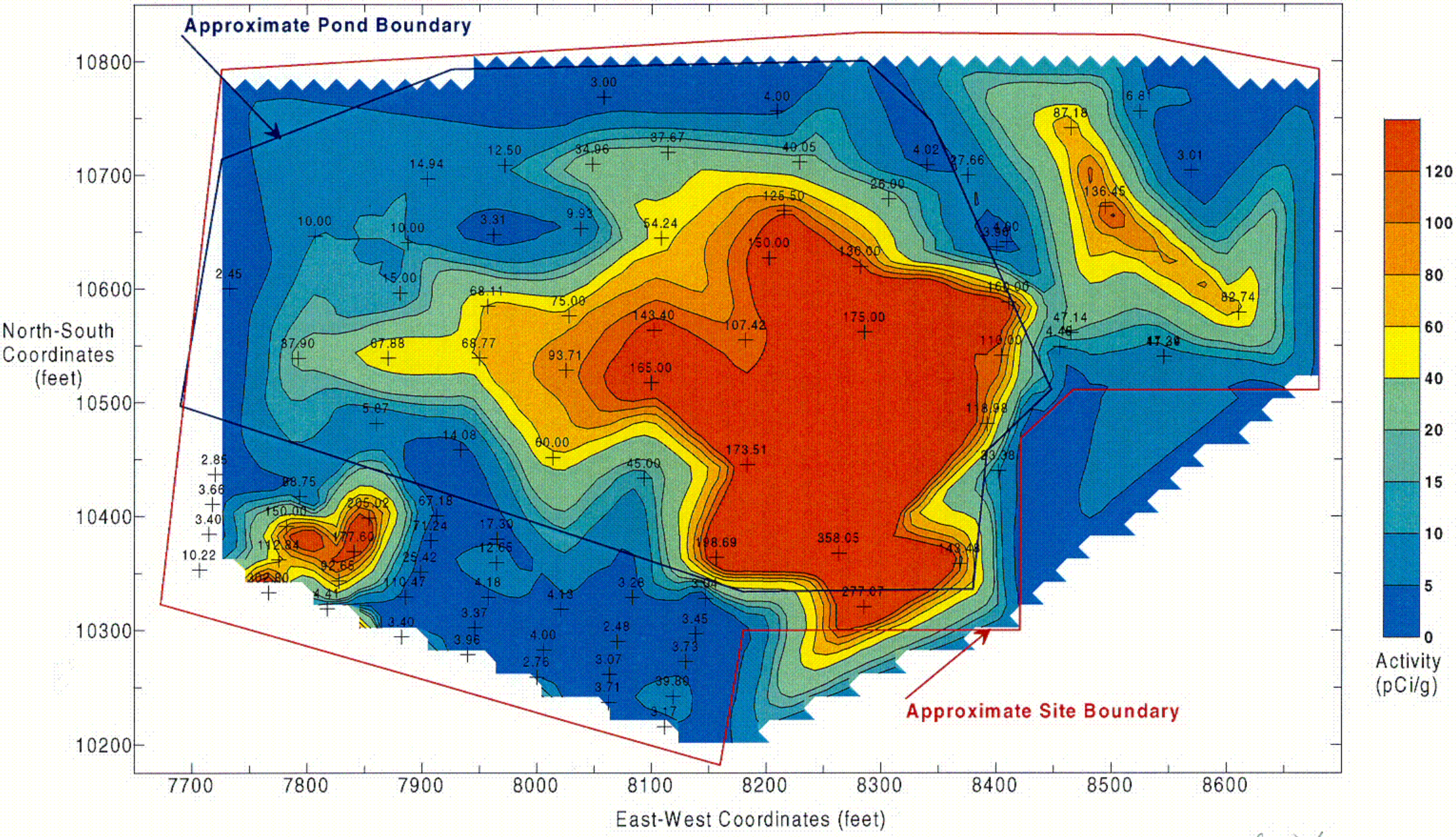
C04

Figure A-5
Concentration Distributions, Triangulation Method, 0 - 2 ft Depth
Kaiser Aluminum, Tulsa, Oklahoma
Kaiser Aluminum & Chemical Corporation
Baton Rouge, Louisiana



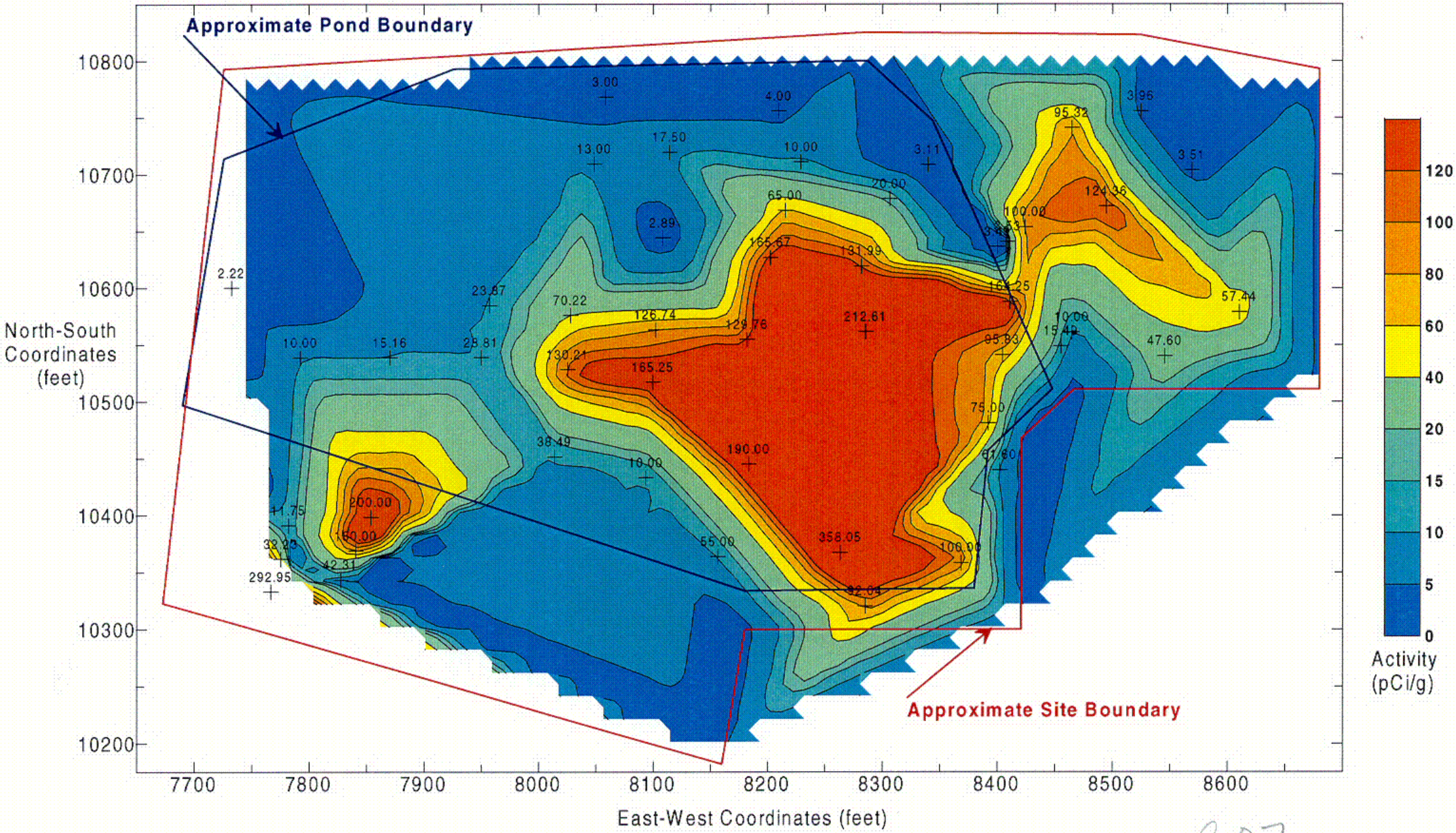
C05

Figure A-6
Concentration Distributions, Triangulation Method,
2 - 4 ft Depth
Kaiser Aluminum, Tulsa, Oklahoma
Kaiser Aluminum & Chemical Corporation
Baton Rouge, Louisiana



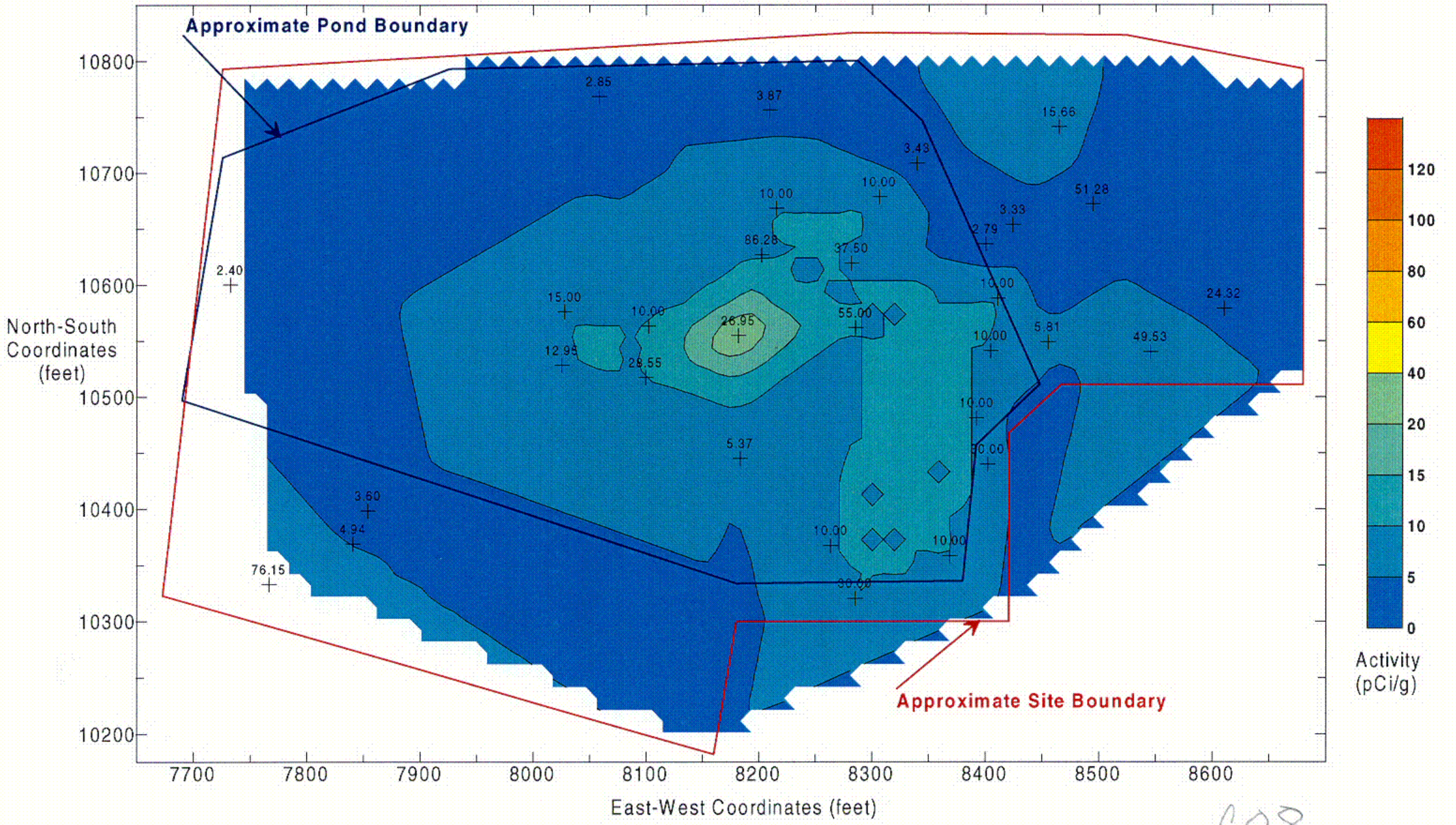
C06

Figure A-7
Concentration Distributions, Triangulation Method,
5 - 10 ft Depth
Kaiser Aluminum, Tulsa, Oklahoma
Kaiser Aluminum & Chemical Corporation
Baton Rouge, Louisiana



C07

Figure A-8
Concentration Distributions, Triangulation Method,
10 - 15 ft Depth
Kaiser Aluminum, Tulsa, Oklahoma
Kaiser Aluminum & Chemical Corporation
Baton Rouge, Louisiana



C08