40-2377

KAISER ALUMINUM
CORPORATE ENVIRONMENTAL

December 21, 2001

U. S. Nuclear Regulatory Commission
Washington, DC 20555
Attn: Document Control Desk

Technical Report
Work Plan
Characterization Survey of the Operational Area
Former Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma
Kaiser Aluminum & Chemical Corporation

Dear Sir or Madam:

Kaiser Aluminum & Chemical Corporation (Kaiser) is submitting one copy of the above-referenced technical report which presents a description of the radiological characterization survey efforts to be performed for Kaiser's former Specialty Products facility located in Tulsa, Oklahoma. The work plan focuses on an approximate 3.5-acre land area of the facility known as the former "operational area." Plant processes and operations occurred in this area. A schedule for the implementation of the work plan is also provided. Field activities are scheduled to begin on Thursday, January 3, 2002 and be completed by Friday, February 15, 2002. If you have any questions concerning the enclosure, please do not hesitate to call me at (225) 231-5116.

Sincerely,

J.W. (Bill) Vinzant

J.W. (Bill) Vinzant, P.E.
Manager, Corporate Environmental Affairs

JWV:tls

Enclosure

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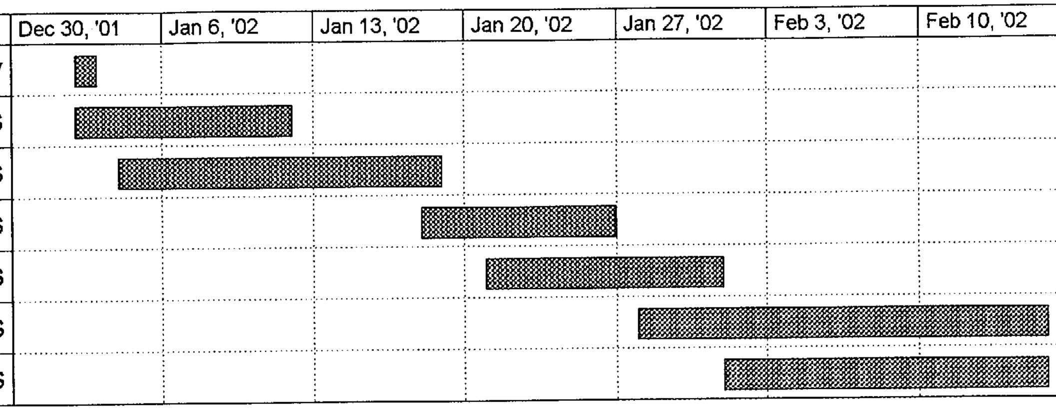
NMSS01 Public

Work Plan Implementation Schedule
Characterization Survey of Operational Area
Former Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma

ID		Task Name	Duration
1		Travel Day	1 day
2		Structure Survey Site Preparation	1.6 wks
3		Structure Survey	2.2 wks
4		Land Area Survey Preparation	1.4 wks
5		Land Area Gross Gamma Survey	2 wks
6		Land Area Soil Core Sampling	3 wks
7		Land Area Soil Core Sample Survey	2.2 wks



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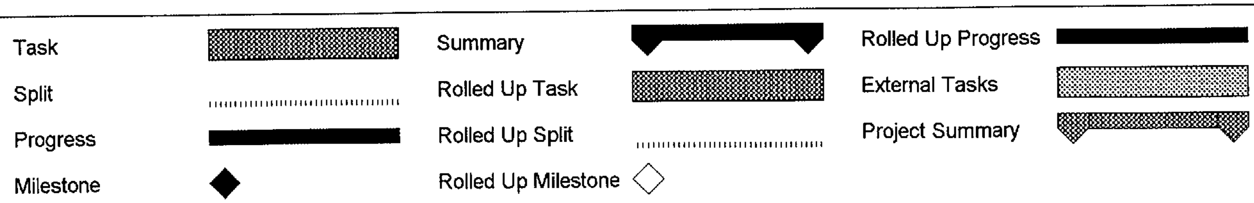
Date: Wed 12/19/01



Work Plan
Characterization Survey of the Operational Area

Former Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma

Kaiser Aluminum & Chemical Corporation
Baton Rouge, Louisiana

Project No. 5427K
December 2001

Earth Sciences Consultants, Inc.

Providing Environmental Consulting Services Since 1979

Work Plan
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December 2001

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Work Plan
Characterization Survey of the Operational Area
Former Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma

1.0 Introduction

This work plan was prepared by Earth Sciences Consultants, Inc. (Earth Sciences) on behalf of Kaiser Aluminum & Chemical Corporation (Kaiser) to present a description of the recommended radiological characterization survey efforts for the former Kaiser Aluminum Specialty Products facility located in Tulsa, Oklahoma (Figure 1). The work plan focuses on an approximate 3.5-acre land area of the facility known as the former "operational area." The former operational area is located to the north of 41st Street and south of the Union Pacific Railroad right-of-way (Figure 2). Plant processes and operations occurred in this area. The former operational area currently houses several structures including the North Extrusion, Office, Maintenance, Warehouse, Crusher, and Crusher Addition buildings. The Flux Building, located to the northeast of the triangular parcel, is also included as part of the former operational area. The "land areas" of the former operational area consist mainly of land beneath concrete pavement.

The primary objectives of the characterization survey are as follows:

(1) Determine the nature and extent of residual radioactive materials within the former operational area,

(2) Collect sufficient data to support evaluation of remedial alternatives and technologies for the former operational area,

(3) Evaluate whether the characterization survey plan for the former operational area can be optimized for use in the final status survey, and

(4) Provide input to the final status survey design for the former operational area.

A Historical Site Assessment (HSA) was recently performed for the facility (Reference 1). The HSA was conducted as the first step toward decommissioning the former operational area. The objective of the HSA was to compile as much historical information as possible for the site and, using Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) guidelines, categorize the land areas and structures of the former operational area of the facility as either impacted or nonimpacted. The results of the HSA were used to design the characterization effort prescribed in this work plan.

1.1 Facility Operational Background

The subject facility, which was built by the Standard Magnesium Corporation (SMC) in the early to mid-1950s, is currently owned by Kaiser. Historical operations at the facility included the smelting of scrap magnesium alloy for the production of magnesium anodes. To facilitate these operations, SMC obtained a source materials license (C-4012) from the Atomic Energy Commission (AEC) in March 1958 to recycle magnesium alloy aircraft scrap with up to 4 percent natural thorium content. This license was renewed and amended several times and was superceded by License No. STB-472 in 1961. In 1968, STB-472 was amended to also authorize possession and processing of uranium-bearing materials, but there is no record that uranium materials ever were received on site. Available site characterization data support this finding. Thorium alloy material comprised only a fraction of the total magnesium refined on site. Kaiser purchased the facility in 1964 and magnesium operations continued to around 1985. However, the radiological license was terminated in 1971 by the AEC at Kaiser's request. Magnesium-thorium alloy reprocessing had been halted at that time for more than a year. Aluminum replaced magnesium in smelting and anode manufacture, and the plant continued operating until the 1997-1998 time frame.

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

1.2 Work Plan Structure

The remainder of this document provides background information relative to the characterization survey, discusses applicable regulatory guidance and acceptance criteria, defines the initial classification of the land areas and structures, and details the radiological characterization survey approach for the former operational area. A survey implementation chapter is included to detail specific activities per survey unit and reference established procedures for completing the activities.

The structure of the work plan is as follows:

- Chapter 2.0 – Characterization Background
- Chapter 3.0 – Regulatory Guidance and Acceptance Criteria
- Chapter 4.0 – Initial Classification and Survey Unit Delineation
- Chapter 5.0 – Characterization Approach/Strategy
- Chapter 6.0 – Survey Implementation

Supporting tables, figures, and appendices are also provided.

2.0 Characterization Background

Extensive site characterization activities have been conducted since 1994 within a 14-acre land area of the facility known as the "pond parcel". These characterization activities have indicated the presence of residual radioactive material within a 10-acre portion of the pond parcel. The radioactive material identified within this portion of land is a thorium-bearing dross containing the isotopes Thorium-232 (Th-232), Thorium-230 (Th-230), and Thorium-228 (Th-228). The affected portion of the parcel contains the retention pond and former reserve pond area. The unaffected portion of the "pond parcel" contains a freshwater pond. A plan was prepared to address the decommissioning of the pond parcel land area. The decommissioning plan (DP) was submitted in June 2001 to the Nuclear Regulatory Commission (NRC) (Reference 2). The work plan focuses on the former operational area of the facility, which was not addressed in the June 2001 DP.

The most recent characterization effort (Additional Site Characterization Activities [ASCA], October 2001 [Reference 3]) investigated parts of the former operational area at the facility. As previously mentioned, the former operational area is defined as the concrete surfaces and structures where plant process and operations occurred. The areas are those that fall in the triangular parcel of land north of 41st Street and south of the railroad right-of-way. The Flux Building is included as part of the former "operational area" (Figure 2), since it is a related structure and will require an appropriate survey according to MARSSIM (Reference 4).

3.0 Regulatory Guidance and Acceptance Criteria

The former Kaiser Aluminum Specialty Products facility is being decommissioned in accordance with Chapter 10 Part 20 of the Code of Federal Regulations (CFR) 10 CFR 20 Subpart E, Radiological Criteria for License Termination and Draft Regulatory Guide 4006, Demonstrating Compliance with the Radiological Criteria for License Termination (DG-4006). In accordance with these documents, this characterization survey was designed based on the guidance of NUREG-1575, MARSSIM. The characterization survey was designed so that data generated could be used in the future to support final surveys for release of the former operational area in accordance with the previously mentioned regulations.

3.1 Classification of Land Areas and Structures

As previously mentioned, the land areas and existing structures located within the former operational area of the facility were initially classified as impacted or nonimpacted based on the results of the HSA. Nonimpacted areas have no reasonable potential for residual contamination and require no further evidence to demonstrate compliance with release criterion. Areas with some potential for residual contamination were classified as impacted. Impacted areas are further divided into one of three classifications:

Land Areas

Class	Definition	Survey Unit Size
1 – Land Areas	Areas known or expected to have radionuclide concentrations above the derived concentration guideline level (DCGL).	Up to 2,000 square meters (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.	2,000 m^2 to 10,000 m^2
3 – Land Areas	Areas that are not expected to have radionuclide concentrations detectable above normal background concentrations.	No Limit

Structures

Class	Definition	Survey Unit Size
1 - Structure	Areas known or expected to have radionuclide concentrations above the DCGL.	Up to 100 m^2 Floor Area
2 - Structure	Areas known or expected to have radionuclide concentrations above normal background concentrations but that are not expected to be above the DCGL.	100 m^2 to 1,000 m^2 Floor Area

Class	Definition	Survey Unit Size
3 - Structure	Areas that are not expected to have radionuclide concentrations detectable above normal background concentrations.	No Limit

A DCGL is a derived radionuclide-specific activity concentration based on the radiological criteria of 10 CFR 20, Subpart E.

3.2 Survey Coverage by Classification

The following table from MARSSIM summarizes the recommended survey coverage for structures and land areas needed to demonstrate compliance.

Recommended Survey Coverage for Structures and Land Areas

Area Classification	Structures		Land Areas	
	Surface Scan	**Surface Activity Measurements**	**Surface Scans**	**Surface Soil Measurements**
Class 1	100 percent	Number of data points from statistical tests (Sections 5.5.2.2 and 5.5.2.3); additional direct measurements and samples may be necessary for small areas of elevated activity (Section 5.5.2.4)	100 percent	Number of data points from statistical tests (Sections 5.5.2.2 and 5.5.2.3); additional direct measurements and samples may be necessary for small areas of elevated activity (Section 5.5.2.4)
Class 2	10 to 100 percent (10 to 50 percent for upper walls and ceilings) Systematic and Judgmental	Number of data points from statistical tests (Sections 5.5.2.2 and 5.5.2.3)	10 to 100 percent Systematic and Judgmental	Number of data points from statistical tests (Sections 5.5.2.2 and 5.5.2.3)
Class 3	Judgmental	Number of data points from statistical test (Sections 5.5.2.2 and 5.5.2.3)	Judgmental	Number of data points from statistical test (Sections 5.5.2.2 and 5.5.2.3)

3.3 Acceptance Criteria

Extensive characterization activities conducted since 1994 have established that Th-228, Th-230, and Th-232 are present in dross/soil residues on the Kaiser property. No elevated uranium has been detected.

Th-228 and Th-232 have been determined to be in secular equilibrium. In addition, a ratio of Th-230 to (Th-228 + Th-232)/2 of 3.5 has been calculated from characterization data.

Acceptance criteria is necessary for final status survey design. In the design of a final status survey, DCGL values are used in the calculation of the minimum number of data points (sample locations) necessary to perform the required statistical tests (MARSSIM). In order to collect the proper number of samples during the characterization surveys so that the data may be used as final survey data, acceptance criteria must be established.

The acceptance criteria for land areas are the average activity concentration in soil (pCi/g) that correspond to the dose-based radiological criteria of 10 CFR 20 Subpart E. The acceptance criteria for structures are the average total surface contamination and the average removable surface contamination levels that correspond to the dose-based radiological criteria of 10 CFR 20 Subpart E. The limits are radionuclide specific and the sum of fractions (unity rule) must be applied to show compliance with the acceptance criteria.

Radionuclide-Specific Acceptance Criteria

Radionuclide	**Land Areas Single Radionuclide $DCGL_W$ (pCi/g)**	**Structures Total Contamination ($dpm/100cm^2$)**	**Structures Removable Contamination ($dpm/100cm^2$)**
Th-228	3.4	41.1	4.11
Th-230	102	36.9	3.69
Th-232	3.4	7.31	0.731

3.3.1 Land Areas

Radionuclide-specific $DCGL_W$ values corresponding to the radiological criteria of 10 CFR 20 Subpart E have been derived for soil using the computer code RESRAD. The derivation is documented in the DP (Reference 2). From the radionuclide specific values and the established activity ratios for the site, a value for Th-232 as a surrogate was also calculated and documented in the DP. The value is 3 pCi/g.

3.3.2 Structures

The radionuclide-specific average total contamination acceptance criteria were derived using the DandD code and default parameters. Values calculated using DandD and default parameters are referred to as screening values by the NRC. The NRC allows use of these screening values in lieu of site-specific DCGL values that must be submitted to the NRC for approval. (Refer to Federal Register Volume 63, Number 222, Page 64132-64134, November 18, 1998). The NRC screening values assume that removable contamination is not more than 10 percent of the total contamination screening value.

From the radionuclide-specific values and the activity ratios of the radionuclides established for the site, a Gross Activity DCGL (GA-DCGL) was calculated using formula Number 4-4 provided in MARSSIM. The calculated GA-DCGL value is 21.5 disintegrations per minute (dpm)/100 cm^2 for average total surface contamination and 2.15 dpm/100cm^2 for removable contamination. Refer to the calculation brief contained in Appendix B for a derivation of these GA-DCGL values.

4.0 Initial Classification and Survey Unit Delineation

This chapter presents an overview of the initial classification (impacted vs. nonimpacted) of the land areas and existing structures located within the former operational area of the facility. A discussion of the subdivision of the impacted land areas and existing structures based on contamination potential (e.g., Class 1, Class 2, or Class 3) and delineation into survey units is also provided. Survey units were delineated based on similarities in contamination potential, operational/construction history, and/or spatial positioning.

4.1 HSA Initial Classification

During the HSA, two separate conceptual models were developed for the initial classification of the former operational area, one for the land areas, and one for the existing structures. Land areas were classified using the following criteria:

- Land area usage related to magnesium-thorium alloy processing.
- Potential for residual radioactive material to have been covered by building expansion.
- Potential for residual radioactive material to have been covered by concrete pavement post-1958.

The areas identified through these screening methods are illustrated in Figure 4. The impacted land areas are as follows:

- Areas covered by concrete post-1958
- Area beneath the former Smelter Building No. 5
- Area beneath the Crusher Addition Building
- Area beneath the Crusher Building
- Area beneath the North Extrusion Building Addition
- Area beneath the Warehouse Building
- Area beneath the Maintenance Building

The second conceptual model focused on the current structures located within the former operational area of the facility. These structures were screened using the following criteria:

- Historical building usage related to magnesium-thorium alloy processing.
- Current building usage related to radioactive materials management.

Current site structures identified through these screening methods are illustrated in Figure 5. The Flux Building was classified as impacted due to the utilization of the building as a sample storage and packing facility during characterization events and the Adjacent Land Remediation Project (ALRP).

4.2 Impacted Land Areas

Modifications to site facilities (buildings, parking lots, driveways, etc.) may have resulted in the covering of residual radioactive material beneath several currently paved surfaces and building floor areas. These areas of concern include the land areas beneath the Crusher Building, the Crusher Addition Building, the Maintenance Building, the North Extrusion Building, the former Smelter Building No. 5, and the Warehouse Building, as well as concrete paved areas completed post-1958 (Figure 4). Soil quality data obtained during the limited ASCA effort indicated the presence of residual radioactive material beneath several of these structures and concrete paved surfaces. These areas of concern are addressed under the following survey units.

4.2.1 Survey Unit 1

Survey Unit 1 encompasses the land area beneath the North Extrusion Building Addition (Figure 6). This area of concern was classified as a Class 1 Survey Unit due to its potential for containing residual radioactive material based on history (time frame of construction). The surface area of this survey unit is approximately 1,450 m^2.

4.2.2 Survey Unit 2

Survey Unit 2 consists of the land area beneath a paved concrete surface situated northwest of the Maintenance Building, northeast of the North Extrusion Building, and south of the Union Pacific Railroad right-of-way (Figure 6). This area of concern was classified as a Class 1 Survey Unit due to the presence of residual radioactive material (above the DCGL) as identified during the ASCA. The surface area of this survey unit is approximately 450 m^2.

4.2.3 Survey Unit 3

Survey Unit 3 consists of the land area beneath a paved concrete surface situated north of the Office Building, east of the North Extrusion Building, south of Survey Unit 2, and west of the Maintenance Building (Figure 6). This area of concern was classified as a Class 1 Survey Unit due to the presence of residual radioactive material (above the DCGL) as identified during the ASCA. The surface area of this survey unit is approximately 1,750 m^2.

4.2.4 Survey Unit 4

Survey Unit 4 encompasses the land area beneath the Maintenance Building/Scale House Addition (Figure 6). This area of concern was classified as a Class 1 Survey Unit due to its potential for containing residual radioactive material based on history (time frame of construction). The surface area of this survey unit is approximately 850 m^2.

4.2.5 Survey Unit 5

Survey Unit 5 consists of the land area beneath a paved concrete surface situated north of the Warehouse Building, east of the Maintenance Building, south of the Union Pacific Railroad right-of-way, and west of the current Crusher Building (Figure 6). This area of concern was classified as a Class 1 Survey Unit due to its potential for containing residual radioactive material based on operational history (the area of the original Smelter Building). The surface area of this survey unit is approximately 1,850 m^2.

4.2.6 Survey Unit 6

Survey Unit 6 encompasses the land area beneath the floor area of the former Smelter Building No. 5 (Figure 6). The Smelter Building was demolished in October 2000, following completion of survey activities which indicated no contamination within the building. Approximately 2 to 10 feet of clean fill was then placed over the former building's concrete slab floor for site grading purposes. This area of concern was classified as a Class 1 Survey Unit due to its potential for containing residual radioactive material based on history (time frame of construction). The surface area of this survey unit is approximately 650 m^2.

4.2.7 Survey Unit 7

Survey Unit 7 encompasses the land area beneath the Warehouse Building (Figure 6). This area of concern was classified as a Class 1 Survey Unit due to the presence of residual radioactive material (above the DCGL) as identified during the ASCA. The surface area of this survey unit is approximately 1,500 m^2.

4.2.8 Survey Unit 8

Survey Unit 8 consists of the land area beneath a paved concrete surface situated north of 41st Street and the current Crusher Building, east of Survey Unit 5, south of the Union Pacific Railroad right-of-way, and west of areas remediated during the ALRP (Figure 6). This area of concern was classified as a Class 1 Survey Unit due to the presence of residual radioactive material (above the DCGL) as identified during the ASCA. The surface area of this survey unit is approximately 1,350 m^2.

4.2.9 Survey Unit 9

Survey Unit 9 includes the land area beneath the current Crusher and Crusher Addition Buildings (Figure 6). This area of concern was classified as a Class 1 Survey Unit due to the presence of residual radioactive material (above the DCGL) as identified during the ASCA effort. The surface area of this survey unit is approximately 1,200 m^2.

4.3 Structures

Presently, none of the original buildings in which magnesium thorium alloy processing occurred exist on site. With the exception of the Flux Building, there are no buildings in the former operational area of the site classified as impacted in the HSA (Figure 5). The Flux Building was classified as an impacted structure due to the past and current use of the building to house and process soil core and surface samples. Since the Flux Building will continue to be used for these purposes, no characterization surveys will be performed at this time. Upon completion of decommissioning activities at the site, the Flux Building will be addressed as a Class 1 survey unit. Although initially classified as nonimpacted, the remaining six site structures will be evaluated as one Class 3 survey unit for the purpose of documenting final radiological status.

4.3.1 North Extrusion Building

A layout of the North Extrusion Building is presented in Appendix A, Figure A-1. Building dimensions and construction material types are also shown in this figure. The North Extrusion Building consists of the following levels:

- First Floor of Original Building – Approximately 605 m^2 of floor area.
- Loft Area – Approximately 160 m^2 of floor area located above the first floor level office area of the original building.
- Basement of Building Addition – Approximately 945 m^2 of floor area.
- First Floor of Building Addition – Approximately 1,325 m^2 of floor area.

The total floor area for this building inclusive of first floor and loft area of the original building, the basement level of the addition, and the first floor level of the addition, is approximately 3,035 m^2.

4.3.2 Maintenance Building

A layout of the Maintenance Building is presented in Appendix A, Figure A-2. Building dimensions and construction material types are also shown in this figure. The Maintenance Building consists of the following single-story areas:

- Main Building – Approximately 760 m^2 of floor area.
- Building Addition – Approximately 35 m^2 of floor area.

The total floor area for the main building and the building addition is approximately 795 m^2.

4.3.3 Office Building

A layout of the Office Building is presented in Appendix A, Figures A-3 and A-4. Building dimensions and construction material types are also shown in this figure. The Office Building consists of the following levels:

- First Floor – Approximately 310 m^2 of floor area.
- Second Floor – Approximately 310 m^2 of floor area.

The total floor area for this building is approximately 620 m^2.

4.3.4 Warehouse Building

A layout of the Warehouse Building is presented in Appendix A, Figure A-5. Building dimensions and construction material types are also shown in this figure. The Warehouse Building consists of a single-story structure divided into three main sections:

- Western Section – Approximately 695 m^2 of floor area.
- Central Section – Approximately 405 m^2 of floor area.
- Eastern Section – Approximately 215 m^2 of floor area.

The total floor area of the three main building sections is approximately 1,315 m^2.

4.3.5 Crusher Building

A layout of the Crusher Building is presented in Appendix A, Figure A-6. Building dimensions and construction material types are also shown in this figure. The Crusher Building consists of a single-story structure with a main floor area of approximately 500 m^2. This building also contains two aluminum furnaces, a casting pit area, a two-tear stair well, and an exterior concrete pad.

4.3.6 Crusher Addition Building

A layout of the Crusher Addition Building is presented in Appendix A, Figure A-7. Building dimensions and construction material types are also shown in this figure. The Crusher Addition Building consists of a single-story structure with a main floor area of approximately 540 m^2. This building also contains a casting pit, an aluminum tilting furnace, an aluminum smelter, and a preheat furnace.

5.0 Characterization Approach/Strategy

This chapter presents the approach for the radiological characterization survey of the impacted land areas and existing structures located within the former operational area of the facility. Technical procedures defined in the Earth Sciences' Site Health Physics Manual (HPM) (Reference 6) are appropriately referenced in each section. Survey implementation is presented in Chapter 6.0.

5.1 Establishment of Background Radiological Conditions

This section presents the approach for establishing radiological background conditions for the various types of characterization surveys to be performed. Background conditions will be determined prior to the implementation of the defined land area and structure characterization survey activities.

5.1.1 Land Area Characterization Surveys

The background gross gamma count rate will be established for each discrete area (survey unit) to be surveyed and each time (at least daily) that a survey is performed. Refer to Procedure ESC/HPM/M-3-1, Gross Gamma Surveys.

5.1.2 Structure Characterization Surveys

Gross alpha activity background count rates will be determined each day that surveys are performed. Refer to Procedure ESC/HPM/M-3-3, Alpha Surveys. Scan Minimum Detectable Concentration (MDC) values will be calculated each day that surveys are conducted. Refer to Procedure ESC/HPM/M-2-2.

5.1.3 Soil Cores Surveys

The background gross gamma count rate in the standard counting configuration (e.g., inside of the shielded cave) will be determined utilizing a soil core phantom sample for each day that soil cores surveys are conducted. Refer to Procedure ESC/HPM/M-3-6.

5.1.4 Soil Sample Analysis

A background activity concentration for soils has been established for the site based on Th-232 analytical results. Background values for Th-232 ranged from 0.99 to 1.24 pCi/g, with an overall average of 1.1 pCi/g (References 5 and 7).

5.1.5 Smear Sample Analysis

Gross alpha activity background count rates will be determined each day that smear sample analysis is performed. MDC values will be calculated each day that smear sample analysis is conducted. Refer to Procedures ESC/HPM/M-2-7 and ESC/HPM/M-2-2 respectively.

5.2 Characterization Survey of Land Areas

This section presents the approach for conducting characterization surveys of impacted lands areas located within the former operational area of the facility. Characterization survey activities to be performed for each survey unit include gross gamma walk over surveys, surface and subsurface soil sampling, and sample analysis.

5.2.1 Gross Gamma Surveys

Gross gamma walk over surveys will be performed with 2-inch-by-2-inch sodium iodide (NaI) detector-equipped survey meters in accordance with Procedures ESC/HPM/M-2-6 and ESC/HPM/M-3-1. Survey coverage shall be in accordance with the classification of the survey unit as detailed in Section 3.2 of this document. Scan MDCs based on background count rate for each survey unit area will be determined in accordance with Procedure ESC/HPM/M-2-2.

5.2.2 Sampling of Land Areas

This section overviews the strategy for the collection and analysis of surface and subsurface soil samples for each survey unit. As a results of the current site conditions in Survey Unit 6, a separate sampling strategy has been developed for the land area beneath the former Smelter Building No. 5 (refer to Section 5.2.2.5).

5.2.2.1 Minimum Number of Sample Points Determination

The minimum number of samples required based on the scan MDC of the survey instrument will be determined prior to sampling. Refer to Table 1 to look up the minimum number of required samples corresponding to specific background count rates. The calculation brief contained in Appendix B documents the calculation of the minimum number of samples and Table 1.

5.2.2.2 Sample Point Layout

Using a random point generator, the start point of the triangular equal distant sampling grid will be determined for each survey unit. Using an appropriate measuring device, sample locations will be marked in the field and on the appropriate survey unit reference map.

5.2.2.3 Surface and Subsurface Soil Sample Collection and Analysis

Surface soil samples will be collected at each sample point in accordance with Procedure ESC/HPM/M-4-1. A surface soil sample may not be able to be collected at each sampling point due to the presence of concrete pavement. If concrete pavement is present at a desired location, proceed with the collection of subsurface soil samples at such location.

Subsurface soil samples will be collected at each sample point in accordance with Procedure ESC/HPM/M-4-4. If concrete pavement is present at the desired sampling location, a concrete coring device will be used to access the underlying soil material. Subsurface samples (soil cores) will be collected at each sample point from the ground surface to bedrock or until a zone of saturation is encountered. Soil cores representing each sample point will be surveyed for gross gamma activity and sampled for laboratory analysis in accordance with Procedure ESC/HPM/M-3-6.

5.2.2.4 Sampling Strategy for Survey Unit 6

A separate sampling strategy has been developed for the land area beneath the former Smelter Building No. 5. As previously mentioned, approximately 2 to 10 feet of clean fill was placed over the concrete slab of the former structure. The sampling strategy for this survey unit was designed based on its current surface topographical condition and the configuration of the former Smelter Building. Based on the former building's configuration, two areas within the survey unit exist with a maximum potential for containing residual radioactive material. These include the area at ground level to the east (immediately adjacent to areas remediated during the ALRP) and the exterior area immediately abutting the lower walls of the western and southern portions of the former structure. Prior to initiating any surveys or sampling in this survey unit an approximate 10-meter-by-10-meter area in the northeastern most corner of the former building's foot print will be cleared of cover to the concrete floor slab. Once cleared procedures outlined above will be followed. However, the sampling point layout will not be in a triangular grid pattern. Sample points for this survey unit areas will be biased toward instrument readings and generally positioned as shown in Figure 8.

5.3 Characterization Survey of Structures

This section presents the approach for conducting characterization surveys of existing structures located with the former operational area of the facility. Characterization survey activities to be performed include scans and fixed count time measurements of the structural surfaces with the appropriate instrumentation as well as the collection and analysis of removable contamination (smear) samples for each survey unit.

Although initially classified as nonimpacted, the remaining six site structures will be surveyed as one Class 3 survey unit for the purpose of documenting final radiological status. The Class 3 survey unit has been subdivided into 13 subunits consisting of floor surfaces of the structures. The minimum number of sample points (N) and the scan MDC required were calculated using the guidance provided in MARSSIM. The minimum number of sample points per survey unit, based on alpha and beta errors of 0.05 (95 percent confidence level) was 18. Since the calculated scan MDC (425 dpm/100cm^2) exceeds the GA-DCGL value (21.5 dpm/100cm^2), the minimum number of samples (N) was increased to 200 in accordance with MARSSIM. The scan MDC was based on the detection of alpha particles emitted from the established site radionuclide mix. Appendix B contains a calculation brief for the derivation of these key MARSSIM survey parameters.

5.3.1 Gross Alpha Activity Structural Surface Scan Surveys

Gross alpha activity surveys will be performed with gas proportional detector equipped with an appropriate survey meter. Refer to Procedure ESC/HPM/M-3-3, Alpha Surveys. Survey coverage shall be in accordance with the classification of the survey unit as detailed in Section 3.2 of this document. Scan MDCs for each survey unit area will be determined in accordance with Procedure ESC/HPM/M-2-2.

5.3.2 Gross Alpha Activity Structural Surface Fixed Count Measurements and Smear Sample Collection and Analysis

This section overviews the strategy for obtaining structural surface fixed count measurements and the collection and analysis of smear samples for each survey subunit.

5.3.2.1 Sample Point Layout

Using a random point generator, the start point of the triangular equal distant sampling grid will be determined for each survey unit. Using an appropriate measuring device, sample locations will be marked in the field and on the appropriate survey unit reference map.

5.3.2.2 Fixed Count Time Measurements

Fixed count time measurements will be performed at each sample point on the triangular grid. Refer to Procedure ESC/HPM/M-3-3, Alpha Surveys.

The fixed count time based on the background count rate, required to achieve an MDC value equal to a fraction of the acceptance criteria, will be calculated in accordance with Procedure ESC/HPM/M-2-2 and documented.

5.3.2.3 Smear Sample Collection and Analysis

A smear sample representing a surface area of 100 cm^2 will be taken at each sample point on the triangular grid. Refer to Procedure ESC/HPM/M-3-5. Smear samples analysis will be performed in a low background cave. Refer to Procedure ESC/HPM/M-2-7. The MDC of the counter shall be a fraction of the acceptance criteria for removable contamination. A minimum of 5 percent of the collected samples will also be analyzed by an independent analytical laboratory for quality assurance/quality control purposes.

6.0 Survey Implementation

This chapter discusses the implementation of the radiological characterization survey for the impacted land areas and existing structures located within the former operational area of the facility.

6.1 Characterization Survey of Land Areas

This section provides guidance for the implementation of the characterization survey for impacted land areas located within the former operational area of the facility. As presented in Section 4.2 of this work plan, these impacted land areas have been delineated into nine survey units. Characterization survey activities to be performed for each survey unit (with the exception of Survey Unit 6) include gross gamma walk over surveys, surface and subsurface soil sampling, and sample analysis. The characterization survey activities to be performed for Survey Unit 6 are provided in Section 5.2.2.5 of this work plan.

Survey guidelines for each survey unit are provided below.

- Establish a reference coordinate system for the survey unit. This coordinate system will provide a mechanism for referencing a measurement to a specific sampling point location. The reference point (0,0) for the coordinate system should be the southwesternmost corner of the unit. The recommended grid interval spacing for each survey unit is 10 meters.
- Establish background radiological conditions for the survey unit. Determine gross gamma background count rates per minute. Record survey instrument serial number and background count rates on Gross Gamma Scan Survey Data Form ESC/HPM/M-3-1-1.
- Calculate the gross gamma scan MDC. Record on Form ESC/HPM/M-2-2-1.
- Perform 100 percent gamma scan survey of the unit.
- Record the gross gamma scan minimum, maximum, and average count rates per minute for each 100 m^2 grid area per the established reference coordinate system (Grid Coordinates East [E] and North [N]) on Gross Gamma Scan Survey Data Form ESC/HPM/-3-1-1.
- Based on the established background, look up the minimum number of samples (N) required for the survey unit (Table 1).
- Calculate the sampling point spacing interval (L) of the triangular pattern using the following formula:

$$L = \sqrt{\frac{A}{0.866\,N_{EA}}}\ \textit{for a triangular grid}$$

Where:

A = Area of Survey Unit

N = Number of samples

- Utilizing a previously-generated random start point for the survey unit, lay out the triangular grid systematic sample points on the appropriate survey unit reference map and in the field. An example is provided in Figure 7.
- Collect a surface soil sample at each triangular grid sample point as described in Section 5.2.4. Label samples as to survey unit, survey point location, depth of sample, date and time of collection, and initials of sampler.
- Collect subsurface soil core samples at each triangular grid sample point as described in Section 5.2.5. Label samples as to survey unit, survey point location, depth of sample, date and time of collection, and initials of sampler.
- Collect surface and subsurface soil samples at locations of elevated surface activity to assist in the delineation of an impacted area, if appropriate.
- Survey soil core samples for gross gamma activity and sample for laboratory analysis in accordance with Procedure ECS/HPM/M-3-6.

6.2 Characterization Survey of Structures

This section provides guidance for the implementation of the characterization survey for existing structures located within the former operational area of the facility. The remaining structures have been classified as nonimpacted but will be surveyed using MARSSIM guidance. Six site structures including the North Extrusion, Maintenance, Office, Warehouse, Crusher, and Crusher Addition buildings will be surveyed as one Class 3 survey unit for the purpose of documenting final radiological status. The Class 3 survey unit has been subdivided into the following 13 subunits consisting of the floor surfaces of these structures:

Survey Subunit Number	Survey Subunit Description	Floor Surface Area (m^2)
1	North Extrusion Building, First Floor of Original Structure	605
2	North Extrusion Building, Loft Area	160
3	North Extrusion Building, Basement Level of Addition	945
4	North Extrusion Building, First Floor of Addition	1,325
5	Maintenance Building, Main Structure	760
6	Maintenance Building, Scale House Addition	35
7	Office Building, First Floor	310
8	Office Building, Second Floor	310
9	Warehouse Building, Western Section	695
10	Warehouse Building, Central Section	405
11	Warehouse Building, Eastern Section	215
12	Crusher Building	500
13	Crusher Addition Building	540

The total floor surface area for the Class 3 survey unit is 6,805 m^2. Based on the fraction of this total area represented by each subunit, the minimum number of sample points required per survey subunit was determined (Table 2). Accordingly, the triangular grid spacing pattern (L) for the calculated number of sample points was determined to be 6.2 m based on MARSSIM guidance.

Survey guidelines for each survey subunit are provided below.

- Establish a reference coordinate system for the survey subunit. This coordinate system will provide a mechanism for referencing a measurement to a specific sampling point location. The reference point (0,0) for the coordinate system should be the southwestern most interior corner of the subunit.
- Utilizing the established reference coordinate system for the survey subunit, layout the triangular grid systematic sample points as shown in the appropriate figure contained in Appendix A.
- Establish background radiological conditions for the survey subunit. Determine gross alpha activity background count rates per minute. The background count time should be at least 10 minutes to ensure a statistically significant alpha background count rate. Record survey instrument serial number and background count rates on the Decommissioning Survey Data Form ESC/HPM/M-3-2-1.
- Calculate the gross alpha activity scan MDCs. Record on Form ESC/HPM/M-2-2-1.

- Perform gross alpha activity scan surveys of the floor surfaces within the immediate vicinity of subunit access points (man and garage doorways) and each triangular grid sample point (minimum area of 1 m^2). Record the gross alpha activity scan maximum and average count rates per minute for each 1 m^2 grid area per the established reference coordinate system (Grid Coordinates East [E] and North [N]) on Decommissioning Survey Data Form ESC/HPM/M-3-2-1.

- Determine the gross alpha activity fixed count time (t) based on the survey subunit background (B) count rate per minute (refer to Table 3).

- Perform gross alpha activity fixed count time measurements of the following floor surfaces:

  - Locations of elevated direct radiation, as identified by surface scan surveys, if any.
  - Each triangular grid sample point.

- Record the fixed count survey information (Grid Coordinates, Survey Point Number, Count Rates per Minute, and Survey Instrumentation Serial Number) on Decommissioning Survey Data Form ESC/HPM/M-3-2-1. Document floor surface type and condition on the survey sheet.

- Collect a smear sample (representing a surface area of 100 cm^2) at each fixed count sample point location. Label sample as to survey subunit, survey point location, date and time of collection, and initials of sampler. Submit smear samples along with appropriate chain-of-custody for gross alpha activity analysis.

6.2.1 Survey Subunit 1 - North Extrusion Building, First Floor of Original Structure

Survey Subunit 1 consists of floor surface for the first floor level of the North Extrusion Building (Appendix A, Figure A-1). The surface area of this survey subunit is approximately 605 m^2. Specific survey guidelines for this subunit include the following:

- The recommended reference coordinate system grid interval spacing is 4 meters.

- The number of sampling points (N) for this subunit is 18 and the center-to-center spacing interval (L) for the sampling points is 6.2 meters (Appendix A, Figure A-1).

- Gross alpha activity scan surveys should minimally cover the floor surfaces located adjacent (1 m width) to the two garage doors located on the south wall of the subunit as well as a 1 m^2 grid area for each triangular grid sample point.

6.2.2 Survey Subunit 2 - North Extrusion Building, Loft Area

Survey Subunit 2 consists of the floor surface for the loft area of the North Extrusion Building (Appendix A, Figure A-1). The surface area of this survey subunit is approximately 160 m^2. Specific survey guidelines for this subunit include the following:

- The recommended reference coordinate system grid interval spacing is 2 meters.
- The number of sampling points (N) for this subunit is 4 and the center-to-center spacing interval (L) for the sampling points is 6.2 meters (Appendix A, Figure A-1).
- Gross alpha activity scan surveys should minimally cover the floor surface located at the top of the stairs (1 m width) as well as a 1 m^2 grid area for each triangular grid sample point.

6.2.3 Survey Subunit 3 - North Extrusion Building, Basement Level of Addition

Survey Subunit 3 consists of the floor surface of the North Extrusion Building basement level addition (Appendix A, Figure A-1). The surface area of this survey subunit is approximately 945 m^2. Specific survey guidelines for this subunit include the following:

- The recommended reference coordinate system grid interval spacing is 4 meters.
- The number of sampling points (N) for this subunit is 28 and the center-to-center spacing interval (L) for the sampling points is 6.2 meters (Appendix A, Figure A-1).
- Gross alpha activity scan surveys should minimally cover the floor surface located adjacent (1 m width) to the garage door located on the east wall of the subunit as well as a 1 m^2 grid area for each triangular grid sample point.

6.2.4 Survey Subunit 4 - North Extrusion Building, First Floor of Addition

Survey Subunit 4 consists of the floor surface of the North Extrusion Building first floor addition (Appendix A, Figure A-1). The surface area of this survey subunit is approximately 1,325 m^2. Specific survey guidelines for this subunit include the following:

- The recommended reference coordinate system grid interval spacing is 4 meters.
- The number of sampling points (N) for this subunit is 39 and the center-to-center spacing interval (L) for the sampling points is 6.2 meters (Appendix A, Figure A-1).
- Gross alpha activity scan surveys should minimally cover the floor surface located adjacent (1 m width) to the garage doors located on the north, east, and south walls of the subunit as well as a 1 m^2 grid area for each triangular grid sample point.

6.2.5 Survey Subunit 5 - Maintenance Building, Main Structure

Survey Subunit 5 consists of the floor surface of the Maintenance Building (Appendix A, Figure A-2). The surface area of this survey subunit is approximately 760 m^2. Specific survey guidelines for this subunit include the following:

- The recommended reference coordinate system grid interval spacing is 4 meters.
- The number of sampling points (N) for this subunit is 23 and the center-to-center spacing interval (L) for the sampling points is 6.2 meters (Appendix A, Figure A-2).
- Gross alpha activity scan surveys should minimally cover the floor surface located adjacent (1 m width) to the garage doors located on the north, east, and west walls of the subunit as well as a 1 m^2 grid area for each triangular grid sample point.

6.2.6 Survey Subunit 6 - Maintenance Building, Scale House Addition

Survey Subunit 6 consists of the floor surface for the Maintenance Building Scale House Addition (Appendix A, Figure A-2). The surface area of this survey subunit is approximately 35 m^2. Specific survey guidelines for this subunit include the following:

- The recommended reference coordinate system grid interval spacing is 2 meters.
- The number of sampling points (N) for this subunit is 1. Two additional survey points (judgement) as shown in Figure A-2 are recommended for coverage purposes.

6.2.7 Survey Subunit 7 - Office Building, First Floor

Survey Subunit 7 consists of the floor surface for the first floor of the Office Building (Appendix A, Figure A-3). The surface area of this survey subunit is approximately 310 m^2. Specific survey guidelines for this subunit include the following:

- The recommended reference coordinate system grid interval spacing is 2 meters.
- The number of sampling points (N) for this subunit is 9 and the center-to-center spacing interval (L) for the sampling points is 6.2 meters (Appendix A, Figure A-3).

6.2.8 Survey Subunit 8 - Office Building, Second Floor

Survey Subunit 8 consists of the floor surface for the second floor of the Office Building (Appendix A, Figure A-4). The surface area of this survey subunit is approximately 310 m^2. Specific survey guidelines for this subunit include the following:

- The recommended reference coordinate system grid interval spacing is 2 meters.
- The number of sampling points (N) for this subunit is 9 and the center-to-center spacing interval (L) for the sampling points is 6.2 meters (Appendix A, Figure A-4).

6.2.9 Survey Subunit 9 – Warehouse Building, Western Section

Survey Subunit 9 consists of the floor surface for the Warehouse Building, Western Section (Appendix A, Figure A-5). The surface area of this survey subunit is approximately 695 m^2. Specific survey guidelines for this subunit include the following:

- The recommended reference coordinate system grid interval spacing is 4 meters.
- The number of sampling points (N) for this subunit is 20 and the center-to-center spacing interval (L) for the sampling points is 6.2 meters (Appendix A, Figure A-5).
- Gross alpha activity scan surveys should minimally cover the floor surface located adjacent (1 m width) to the garage doors located on the north and east walls of the subunit as well as a 1 m^2 grid area for each triangular grid sample point.

6.2.10 Survey Subunit 10 - Warehouse Building, Central Section

Survey Subunit 10 consists of the floor surface for the Warehouse Building, Central Section (Appendix A, Figure A-5). The surface area of this survey subunit is approximately 405 m^2. Specific survey guidelines for this subunit include the following:

- The recommended reference coordinate system grid interval spacing is 4 meters.
- The number of sampling points (N) for this subunit is 12 and the center-to-center spacing interval (L) for the sampling points is 6.2 meters (Appendix A, Figure A-5).
- Gross alpha activity scan surveys should minimally cover the floor surface located adjacent (1 m width) to the garage doors located on the north, east, and west walls of the subunit as well as a 1 m^2 grid area for each triangular grid sample point.

6.2.11 Survey Subunit 11 - Warehouse Building, Eastern Section

Survey Subunit 11 consists of the floor surface for the Warehouse Building, Eastern Section (Appendix A, Figure A-5). The surface area of this survey subunit is approximately 215 m^2. Specific survey guidelines for this subunit include the following:

- The recommended reference coordinate system grid interval spacing is 4 meters.
- The number of sampling points (N) for this subunit is 6 and the center-to-center spacing interval (L) for the sampling points is 6.2 meters (Appendix A, Figure A-5).
- Gross alpha activity scan surveys should minimally cover the floor surface located adjacent (1 m width) to the garage doors located on the east and west walls of the subunit as well as a 1 m^2 grid area for each triangular grid sample point.

6.2.12 Survey Subunit 12 – Crusher Building

Survey Subunit 12 consists of the floor surface for the Crusher Building (Appendix A, Figure A-6). The surface area of this survey subunit is approximately 500 m^2. Specific survey guidelines for this subunit include the following:

- The recommended reference coordinate system grid interval spacing is 4 meters.
- The number of sampling points (N) for this subunit is 15 and the center-to-center spacing interval (L) for the sampling points is 6.2 meters (Appendix A, Figure A-6).
- Gross alpha activity scan surveys should minimally cover the floor surface located adjacent (1 m width) to the doorways located along the southern and western walls of the subunit as well as a 1 m^2 grid area for each triangular grid sample point.

6.2.13 Survey Subunit 13 – Crusher Addition Building

Survey Subunit 13 consists of the floor surface for the Crusher Addition Building (Appendix A, Figure A-7). The surface area of this survey subunit is approximately 540 m^2. Specific survey guidelines for this subunit include the following:

- The recommended reference coordinate system grid interval spacing is 4 meters.
- The number of sampling points (N) for this subunit is 16 and the center-to-center spacing interval (L) for the sampling points is 6.2 meters (Appendix A, Figure A-7).

- Gross alpha activity scan surveys should minimally cover the floor surface located adjacent (1 m width) to the doorways located on the north, south, and west walls of the subunit as well as a 1 m^2 grid area for each triangular grid sample point.

7.0 References

(1) Earth Sciences, December 2001, Historical Site Assessment, Operational Area, Former Kaiser Aluminum Specialty Products Facility, Tulsa, Oklahoma, Kaiser Aluminum & Chemical Corporation, Baton Rouge, Louisiana.

(2) Earth Sciences, June 2001, Decommissioning Plan, Tulsa Facility, Tulsa, Oklahoma, Kaiser Aluminum & Chemical Corporation, Baton Rouge, Louisiana.

(3) Earth Sciences, October 2001, Additional Site Characterization Activities, Former Kaiser Aluminum Specialty Products Facility, Tulsa, Oklahoma, Kaiser Aluminum & Chemical Corporation, Baton Rouge, Louisiana.

(4) NUREG/CR-1575, August 2000, MARSSIM, Rev. 1.

(5) Earth Sciences, July 2001, ALRP, Final Status Survey Report, Tulsa, Oklahoma Facility, Kaiser Aluminum & Chemical Corporation, Baton Rouge, Louisiana.

(6) Earth Sciences, December 2001, Health Physics Manual, Former Kaiser Aluminum Specialty Products Facility, Tulsa, Oklahoma, Kaiser Aluminum & Chemical Corporation, Baton Rouge, Louisiana.

(7) Scott, L. Max, Ph.D., CHP, March 1999, Adjacent Land Characterization, Kaiser Aluminum Specialty Products, Appendix A, Estimate of Volume of Off-Site Contaminated Soil, Adjacent Land Characterization Report, ADA Consultants, Inc., Baton Rouge, Louisiana

Tables

Table 1

Increasing Minimum Number of Samples (N) Per Increasing Gross Gamma Background Count Rate (B)

Characterization Surveys of Land Areas

Former Kaiser Aluminum Specialty Products Facility

Tulsa, Oklahoma

B BKG (cpm)	I scan time (sec)	p surveyor E (-)	E_i instrument E (cpm / uR/h)	d'	s_i (counts)	MDCR (ncpm)	$MDCR_s$ (cpm)	Scan MDC (uR/h)	CF (pCi/g / uR/h)	Scan MDC (pCi/g)	Area Factor (-)	N Min. # of Samples
7000	1	0.5	830	1.380	15	894	1265	1.52	3	4.6	1.52	9
7500	1	0.5	830	1.380	15	926	1309	1.58	3	4.7	1.58	9
8000	1	0.5	830	1.380	16	956	1352	1.63	3	4.9	1.63	11
8500	1	0.5	830	1.380	16	986	1394	1.68	3	5.0	1.68	13
9000	1	0.5	830	1.380	17	1014	1434	1.73	3	5.2	1.73	15
9500	1	0.5	830	1.380	17	1042	1473	1.78	3	5.3	1.78	19
10000	1	0.5	830	1.380	18	1069	1512	1.82	3	5.5	1.82	21
10500	1	0.5	830	1.380	18	1095	1549	1.87	3	5.6	1.87	24
11000	1	0.5	830	1.380	19	1121	1585	1.91	3	5.7	1.91	26
11500	1	0.5	830	1.380	19	1146	1621	1.95	3	5.9	1.95	29
12000	1	0.5	830	1.380	20	1171	1656	2.00	3	6.0	2.00	32
12500	1	0.5	830	1.380	20	1195	1690	2.04	3	6.1	2.04	35
13000	1	0.5	830	1.380	20	1219	1724	2.08	3	6.2	2.08	39
13500	1	0.5	830	1.380	21	1242	1756	2.12	3	6.3	2.12	43
14000	1	0.5	830	1.380	21	1265	1789	2.16	3	6.5	2.16	48
14500	1	0.5	830	1.380	21	1287	1820	2.19	3	6.6	2.19	51
15000	1	0.5	830	1.380	22	1309	1851	2.23	3	6.7	2.23	56

Notes:

1. The instrument efficiency (E) and the conversion factor (CF) used in the derivation of this table are are based on the detection of Th-232.
2. The CF is based on the detection of Th-232 in soil through a 6-inch layer of concrete.

Key:

B = background count rate (cpm).

cpm = counts per minute.

i = scan time interval.

p = surveyor effeciency (ranges from 0.5 to 0.75).

E_i = instrument efficiency (from Table 6.7 of MARSSIM).

d' = value selected from Table 6.5 of MARSSIM.

s_i = minimal number of net source counts.

MDCR = minimum detectable count rate.

$MDCR_s$ = surveyor MDCR.

MDC = minimum detectable concentration.

CF = conversion factor (MARSSIM/Microshield).

ncpm = net counts per minute.

pCi/g = pico curies per gram.

μR/h = micro-Roentgen per hour.

N = Minimum Number of Samples

Table 2
Minimum Number of Sample Points per Survey Subunit
Characterization Survey of Structures
Former Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma

Survey Subunit Number	Survey Subunit Description	Floor Area (m^2)	Fraction of Area	Sample Points per Subunit (N)[1]	L[2] (m)
1	North Extrusion Building, First Floor of Original Structure	605	0.088	18	6.2
2	North Extrusion Building, Loft Area	160	0.022	4	6.2
3	North Extrusion Building, Basement Level of Addition	945	0.140	28	6.2
4	North Extrusion Building, First Floor of Addition	1,325	0.197	39	6.2
5	Maintenance Building, Main Structure	760	0.113	23	6.2
6	Maintenance Building, Scale House Addition	35	0.005	1	6.2
7	Office Building, First Floor	310	0.046	9	6.2
8	Office Building, Second Floor	310	0.046	9	6.2
9	Warehouse Building, Western Section	695	0.099	20	6.2
10	Warehouse Building, Central Section	405	0.060	12	6.2
11	Warehouse Building, Eastern Section	215	0.032	6	6.2
12	Crusher Building	500	0.074	15	6.2
13	Crusher Addition Building	540	0.078	16	6.2
	Total Class 3 Survey Unit Area:	*6,805*		*200*	

Notes:

[1]N represents the minimum number of sample points required per survey subunit. The calculated minimum number of sample points for the survey unit was 200.
[2]L represents the calculated triangular grid spacing interval.

Table 3
Increasing Count Time (t) Per Increasing Alpha Background Count Rate (B) Corresponding to a Fraction of the Gross Activity DCGL Value of 21 dpm/100cm²
(Example Table, Calculation is Detector Efficiency Dependent)

B Background (cpm)	t Count Time (min)	€ Efficiency (cpd)	A Probe Area (cm^2)	k 95% CL (-)	MDC (dpm/100cm^2)
0.1	15	0.028	126	1.645	16
0.2	22	0.028	126	1.645	16
0.3	30	0.028	126	1.645	16
0.4	35	0.028	126	1.645	16
0.5	42	0.028	126	1.645	16
0.6	48	0.028	126	1.645	16
0.7	55	0.028	126	1.645	16
0.8	62	0.028	126	1.645	16
0.9	68	0.028	126	1.645	16
1	75	0.028	126	1.645	16
1.1	81	0.028	126	1.645	16
1.2	88	0.028	126	1.645	16
1.3	94	0.028	126	1.645	16
1.4	101	0.028	126	1.645	16
1.5	107	0.028	126	1.645	16
0.1	11	0.028	126	1.645	20
0.2	16	0.028	126	1.645	20
0.3	20	0.028	126	1.645	20
0.4	25	0.028	126	1.645	20
0.5	29	0.028	126	1.645	20
0.6	33	0.028	126	1.645	20
0.7	37	0.028	126	1.645	20
0.8	41	0.028	126	1.645	20
0.9	46	0.028	126	1.645	20
1	50	0.028	126	1.645	20
1.1	54	0.028	126	1.645	20
1.2	58	0.028	126	1.645	20
1.3	63	0.028	126	1.645	20
1.4	67	0.028	126	1.645	20
1.5	71	0.028	126	1.645	20

Notes:
1. MDC = Minimum Detectable Concentration (dpm/100cm^2).
2. B = Background countrate (cpm) as determined by a background count.
3. t = count time in minutes corresponding to B, required to achieve the MDC value.
4. € = total efficiency including the detector and the surface efficiency, and a correction for the number of alpha emitted per dpm of the site thorium radionuclide mix, estimated at 0.028.
5. A = physical probe area of a Ludlum Model 43-68 gas proportional detector.
6. k = Poisson probability sum for alpha and beta errors of 0.05.

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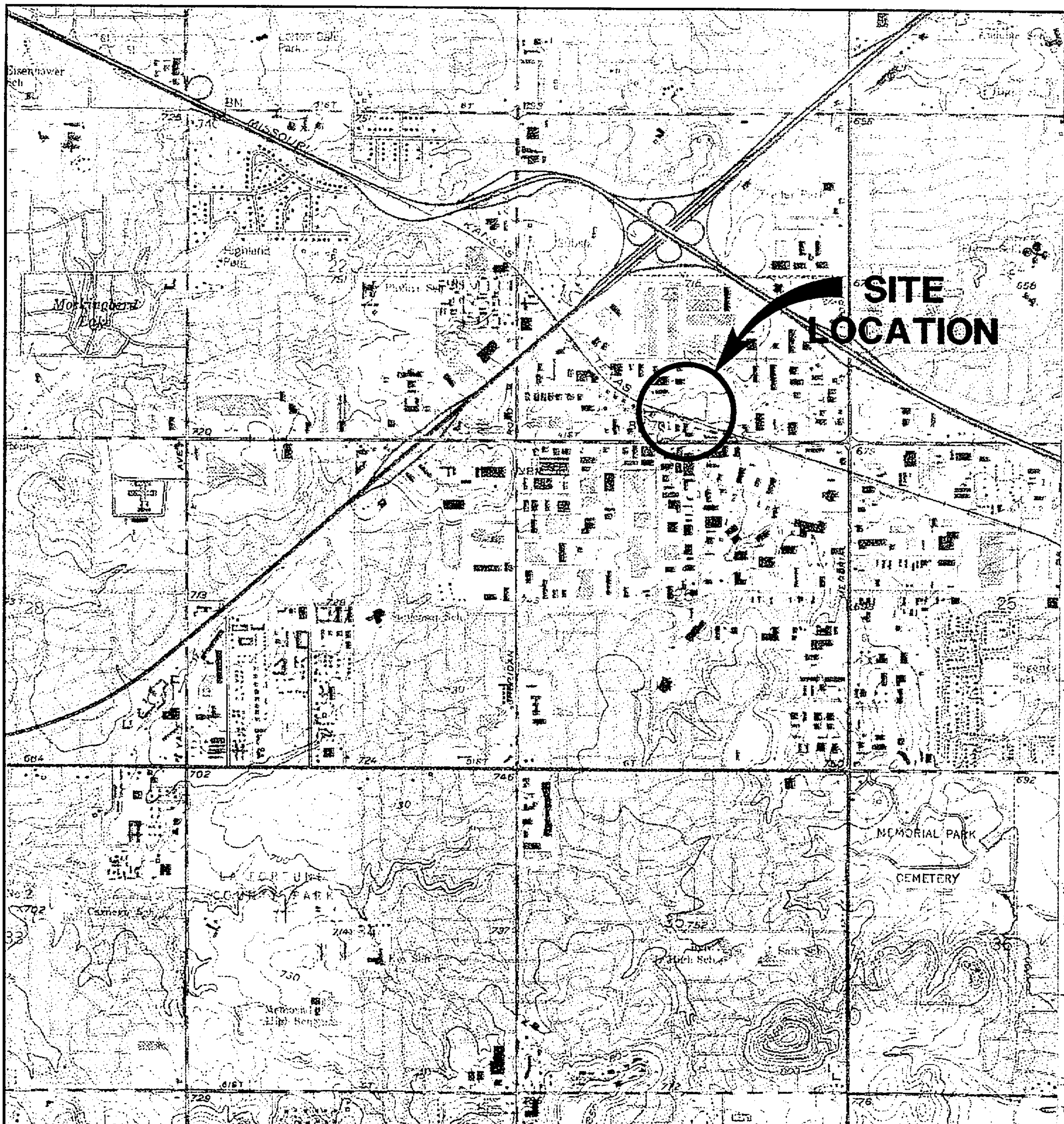
Figures



SCALE – FEET

0 2000

N

REFERENCE
USGS 7.5-MIN TOPOGRAPHIC QUADRANGLE
JENKS, OKLAHOMA
DATED 1952, PHOTOREVISED 1982

FIGURE 1
SITE LOCATION MAP
FORMER KAISER ALUMINUM
SPECIALTY PRODUCTS FACILITY
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

APPROVED	11/2/01
CHECKED	11/2/01
DRAWN	GJA 10/1/01

DRAWING NUMBER
5427039

Earth Sciences Consultants, Inc.

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED: DWG. NO. 5427A442, FIGURE 2 "FORMER OPERATIONAL AREA FORMER KAISER ALUMINUM SPECIALTY PRODUCTS FACILITY TULSA, OKLAHOMA"

WITHIN THIS PACKAGE...OR, BY SEARCHING USING THE DOCUMENT/REPORT NUMBER 5427A442, FIGURE 2

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.

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THAT CAN BE VIEWED AT THE RECORD TITLED:

DWG. NO. 5427A434, FIGURE 3

"SITE MAP, FORMER KAISER ALUMINUM SPECIALTY PRODUCTS FACILITY TULSA, OKLAHOMA"

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

5427A434, FIGURE 3

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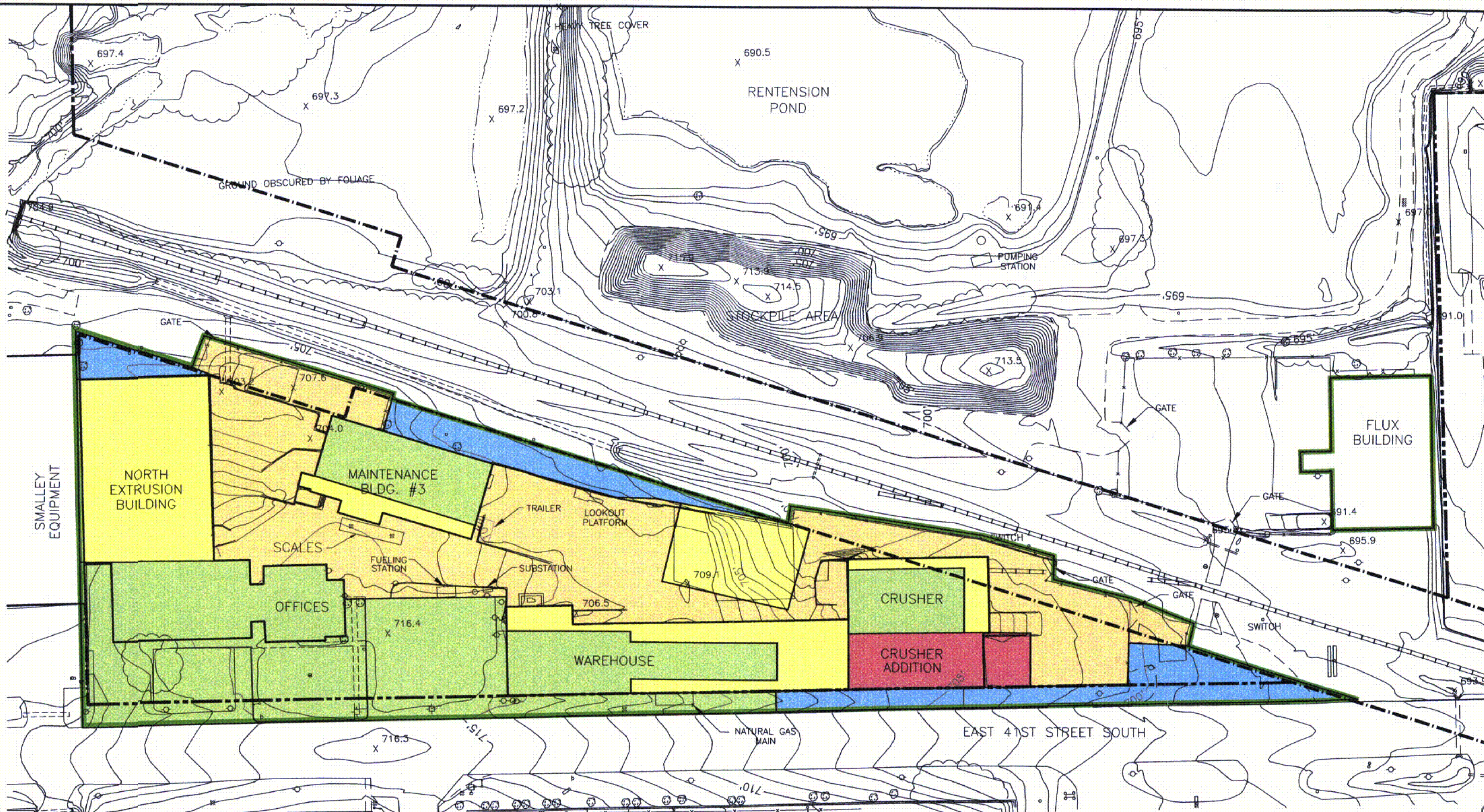

LEGEND

- FORMER OPERATIONAL AREA
- APPROXIMATE PROPERTY LINE
- APPROXIMATE RIGHT-OF-WAY
- AREAS REMEDIATED DURING ALRP
- NON-IMPACTED AREAS
- POTENTIALLY IMPACTED AREAS DUE TO PLANT OPERATIONS
- POTENTIALLY IMPACTED AREAS DUE TO BUILDING RENOVATION BETWEEN 1958-1964
- POTENTIALLY IMPACTED AREAS DUE TO CONCRETE PAVING POST 1958

N

SCALE – FEET
80 0 80
20 0 20
SCALE – METERS

REFERENCES

1. DIGITAL MAPPING ASSOCIATES, INC.; AUG. 16, 2001
2. THE RIGHT-OF-WAY AND PROPERTY LINES WERE OBTAINED FROM A PLAT PREPARED BY DENTON AND WHITE SURVEYING COMPANY ON FEBRUARY 14, 1964.

FIGURE 4
CONCEPTUAL MODEL OF LAND AREAS
FORMER KAISER ALUMINUM
SPECIALTY PRODUCTS FACILITY
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

APPROVED	RFD 12/01
CHECKED	ASL 12/01
DRAWN	deb 11/20/01
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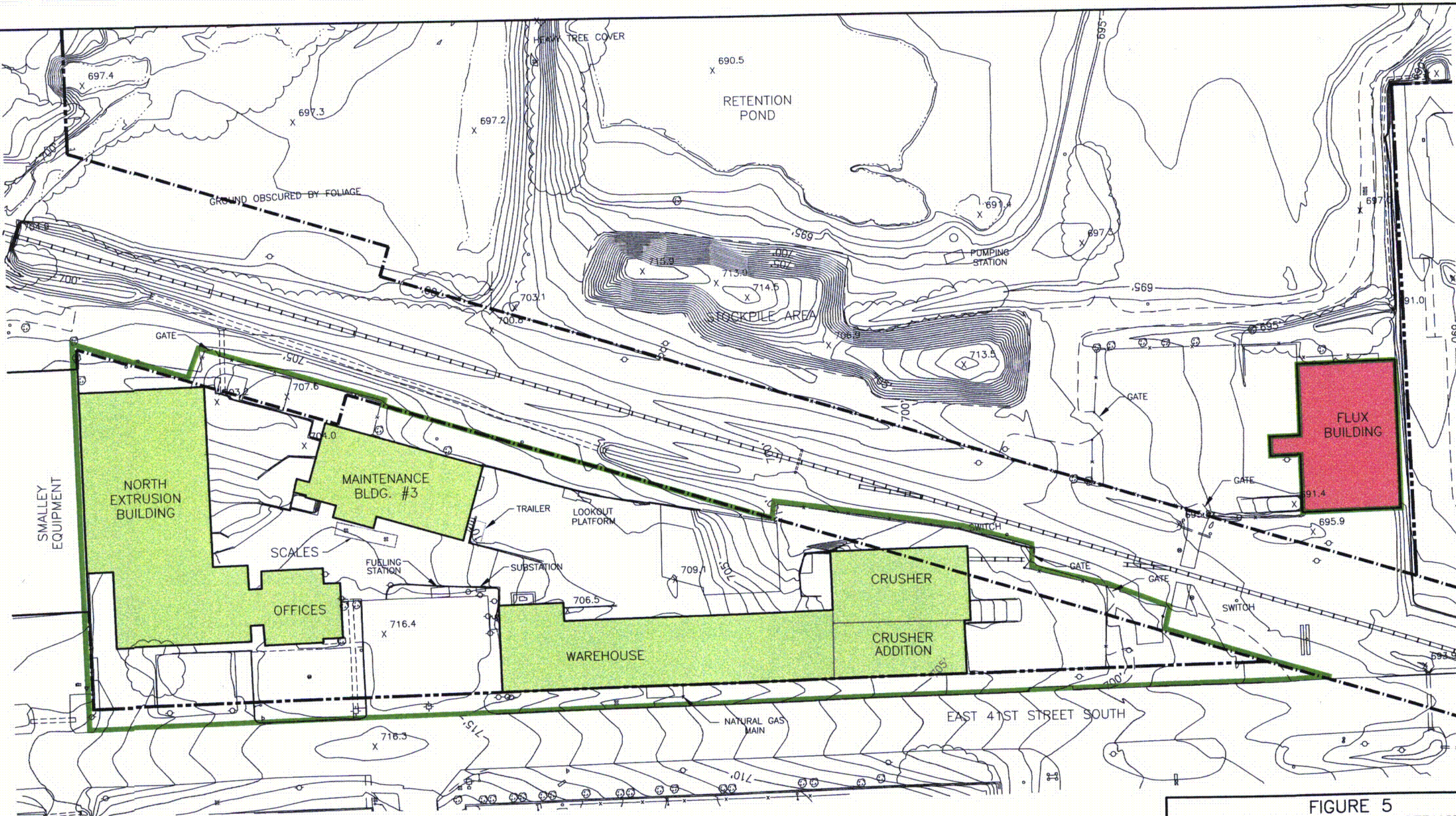

LEGEND

- FORMER OPERATIONAL AREA
- APPROXIMATE PROPERTY LINE
- APPROXIMATE RIGHT-OF-WAY
- NON-IMPACTED STRUCTURES
- STRUCTURES IMPACTED DUE TO CURRENT SITE ACTIVITIES

REFERENCES

1. DIGITAL MAPPING ASSOCIATES, INC.; AUG. 16, 2001
2. THE RIGHT-OF-WAY AND PROPERTY LINES WERE OBTAINED FROM A PLAT PREPARED BY DENTON AND WHITE SURVEYING COMPANY ON FEBRUARY 14, 1964.

FIGURE 5
CONCEPTUAL MODEL OF STRUCTURES
FORMER KAISER ALUMINUM
SPECIALTY PRODUCTS FACILITY
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

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THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

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DWG. NO. 5427A443, FIGURE 6

"PRELIMINARY SURVEY UNIT DELINEATION IMPACTED LAND AREAS FORMER KAISER ALUMINUM SPECIALTY PRODUCTS FACILITY TULSA, OKLAHOMA"

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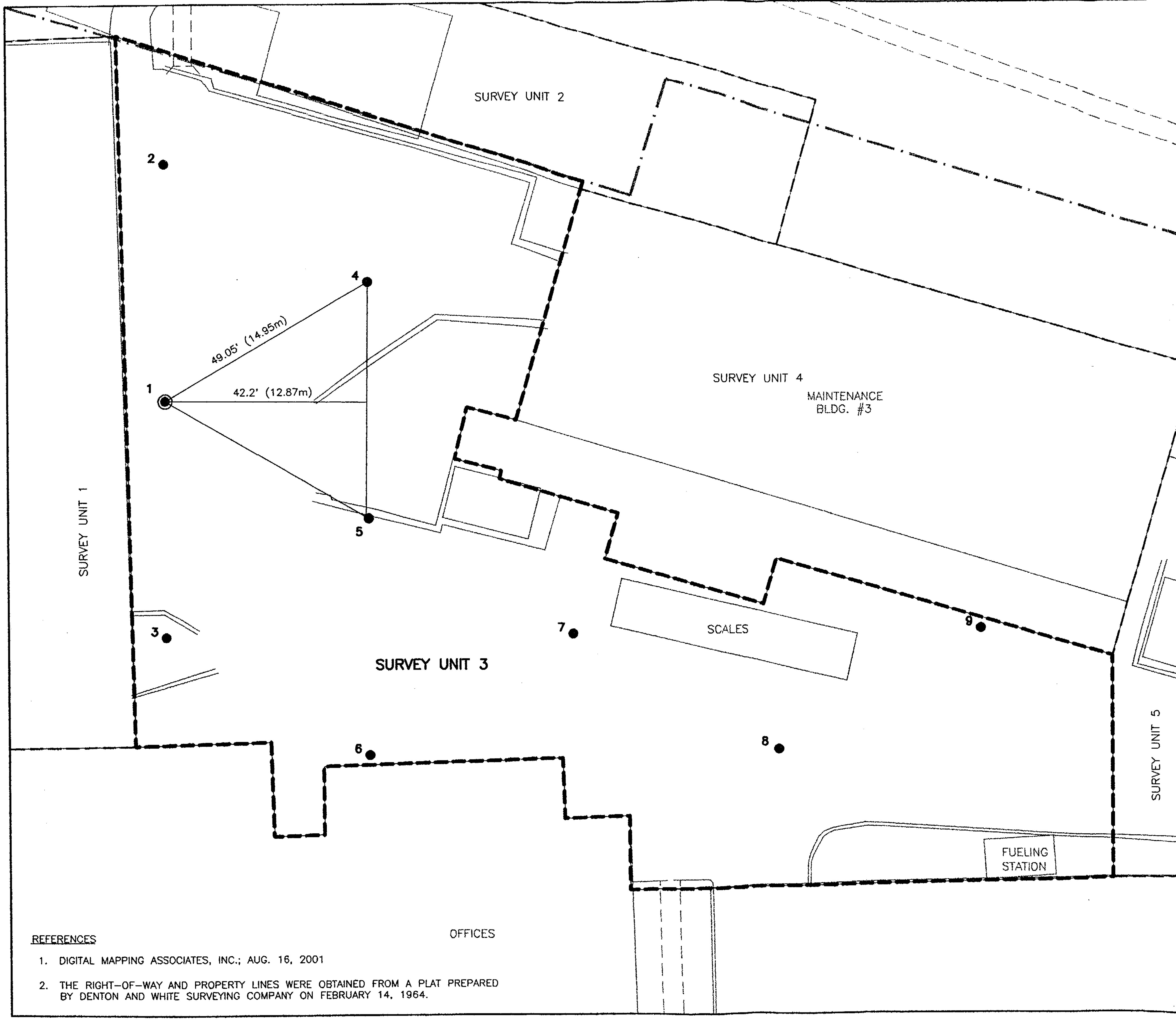
5427A443, FIGURE 6

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.



LEGEND

- RANDOM GENERATED START SAMPLE POINT
- SAMPLE POINT
- SURVEY UNIT BOUNDARY
- APPROXIMATE RIGHT-OF-WAY

L = 14.95m
A = 1750m^2
N = 9

SCALE – FEET: 20 0 20
SCALE – METERS: 5 0 5

REFERENCES

1. DIGITAL MAPPING ASSOCIATES, INC.; AUG. 16, 2001
2. THE RIGHT-OF-WAY AND PROPERTY LINES WERE OBTAINED FROM A PLAT PREPARED BY DENTON AND WHITE SURVEYING COMPANY ON FEBRUARY 14, 1964.

FIGURE 7
EXAMPLE OF LAND AREA SAMPLING STRATEGY
SURVEY UNIT 3
FORMER KAISER ALUMINUM
SPECIALTY PRODUCTS FACILITY
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

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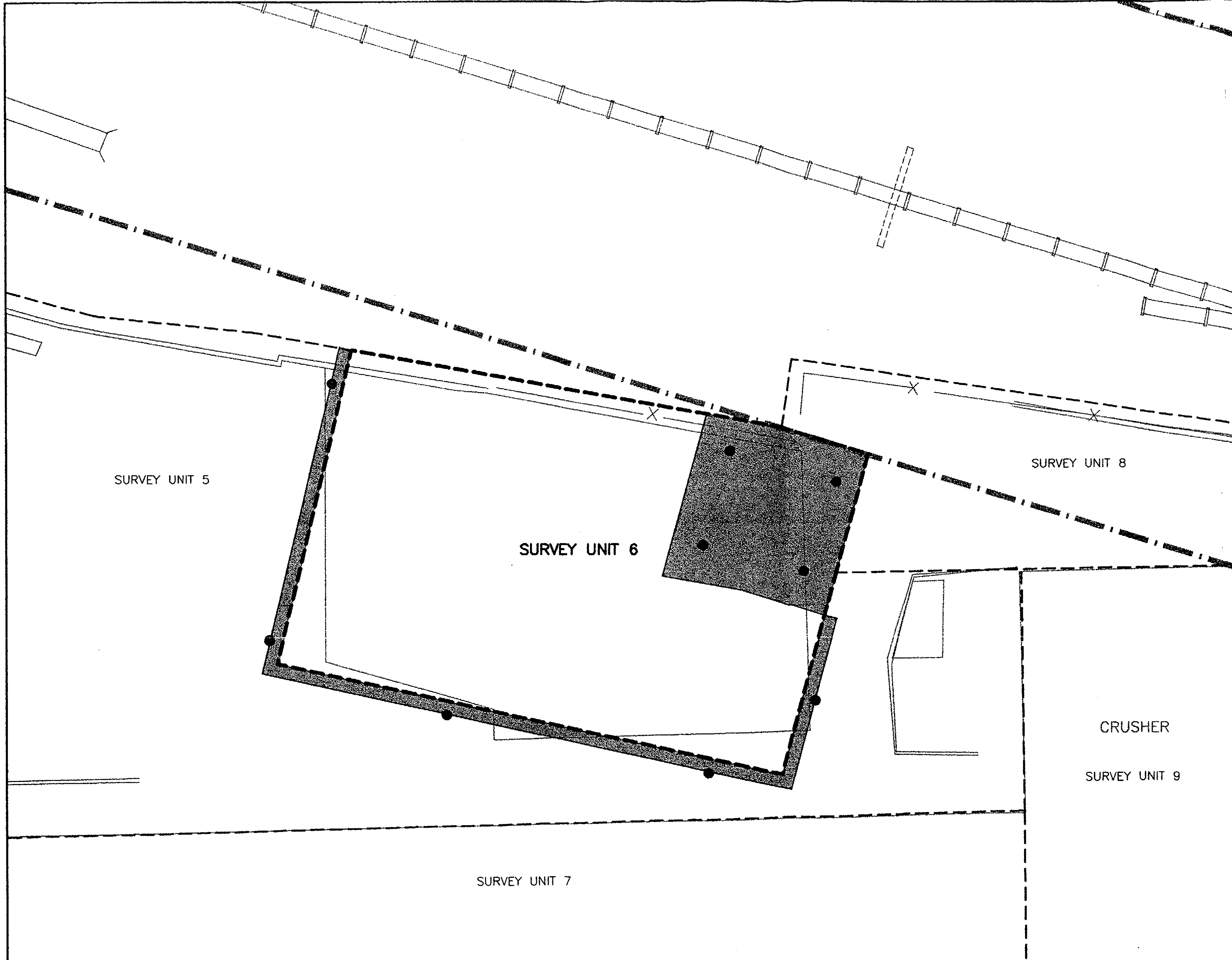

LEGEND

- ● APPROXIMATE SAMPLE POINT LOCATION
- SURVEY UNIT BOUNDARY
- APPROXIMATE RIGHT-OF-WAY
- AREA TO BE SAMPLED AND SURVEYED

SCALE – FEET: 20 0 20

SCALE – METERS: 5 0 5

REFERENCES

DIGITAL MAPPING ASSOCIATES, INC.; AUG. 16, 2001

THE RIGHT-OF-WAY AND PROPERTY LINES WERE OBTAINED FROM A PLAT PREPARED BY DENTON AND WHITE SURVEYING COMPANY ON FEBRUARY 14, 1964.

FIGURE 8
OPEN LAND SAMPLING STRATEGY
SURVEY UNIT 6
FORMER KAISER ALUMINUM
SPECIALTY PRODUCTS FACILITY
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
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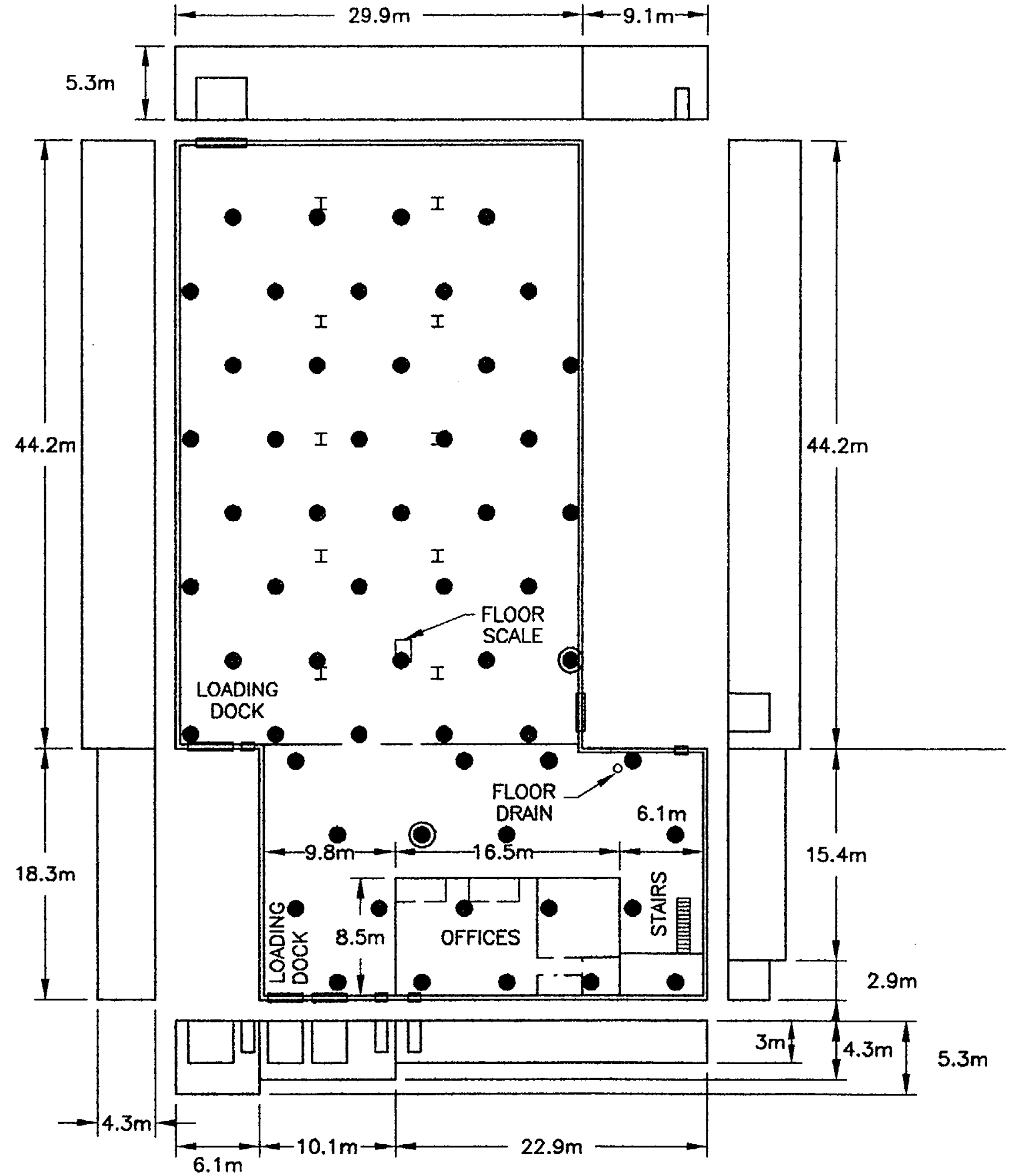
Appendix A

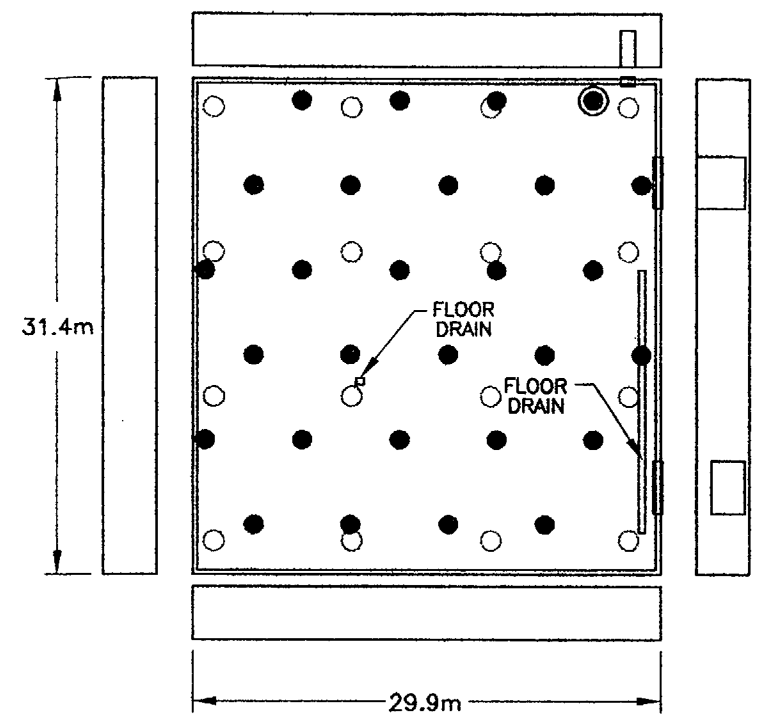
Building Layout Drawings



FIRST FLOOR

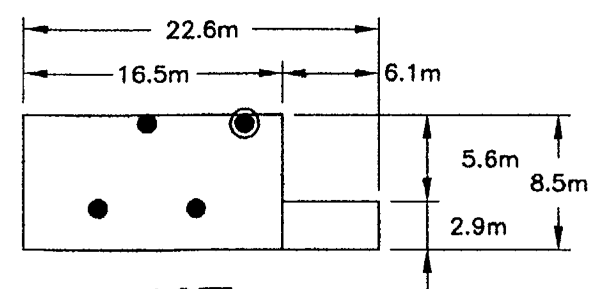
CONSTRUCTION MATERIAL

MAIN FLOOR – CONCRETE
MAIN WALLS – CONCRETE BLOCK
MAIN CEILING – CORRUGATED METAL
I – SUPPORT PILLAR



BASEMENT (1961 ADDITION)

MAIN FLOOR – CONCRETE
MAIN WALLS – CONCRETE BLOCK
MAIN CEILING – CONCRETE
○ – 30" DIA. CONCRETE SUPPORT PILLAR



LOFT

N

LEGEND

◉ RANDOM GENERATED START SAMPLE POINT

● TRIANGULAR GRID SYSTEMATIC SAMPLE POINT

SURVEY SUBUNIT 1
(FIRST FLOOR ORIGINAL)

L = 6.2m
A = 605m²
N = 18 SAMPLES

SURVEY SUBUNIT 2
(LOFT)

L = 6.2m
A = 160m²
N = 4 SAMPLES

SURVEY SUBUNIT 3
(BASEMENT)

L = 6.2m
A = 945m²
N = 28 SAMPLES

SURVEY SUBUNIT 4
(FIIRST FLOOR ADDITION)

L = 6.2m
A = 1325m²
N = 39 SAMPLES

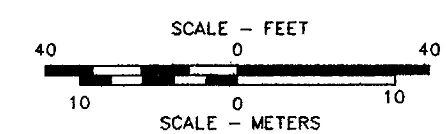


FIGURE A–1
NORTH EXTRUSION BUILDING LAYOUT
FORMER KAISER ALUMINUM
SPECIALTY PRODUCTS FACILITY
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

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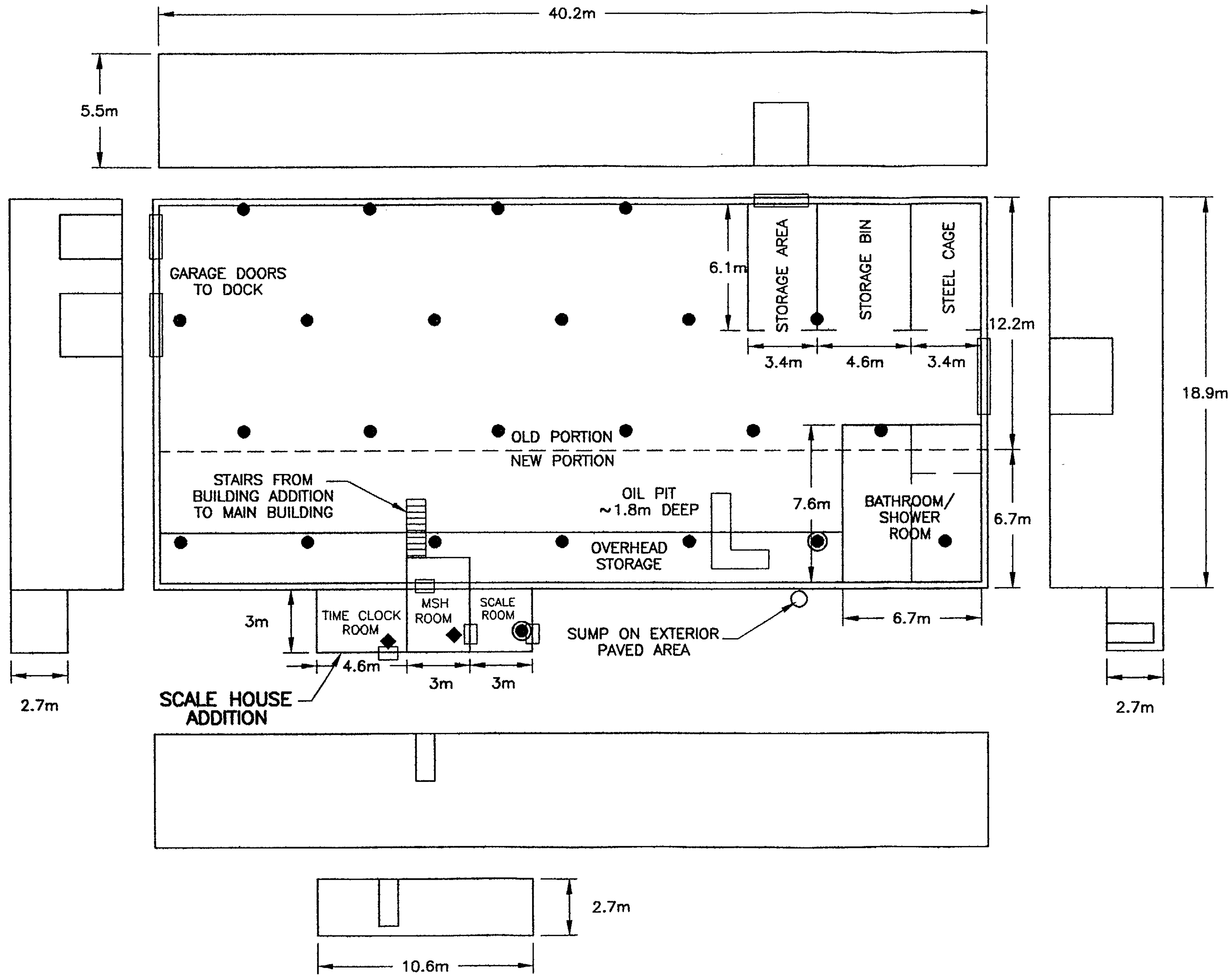

CONSTRUCTION MATERIAL

MAIN FLOOR – CONCRETE
MAIN WALLS – CONCRETE BLOCK
MAIN CEILING – CORRUGATED METAL

LEGEND

◉ RANDOM GENERATED START SAMPLE POINT
● TRIANGULAR GRID SYSTEMATIC SAMPLE POINT
◆ JUDGMENTAL SAMPLE POINT

SURVEY SUBUNIT 5 (MAIN BUILDING)

L = 6.2m
A = 760m^2
N = 23 SAMPLES

SURVEY SUBUNIT 6 (SCALE HOUSE ADDITION)

L = 6.2m
A = 35m^2
N = 1 SAMPLE

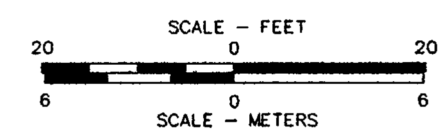

FIGURE A–2
MAINTENANCE BUILDING LAYOUT
FORMER KAISER ALUMINUM
SPECIALTY PRODUCTS FACILITY
TULSA, OKLAHOMA

PREPARED FOR
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BATON ROUGE, LOUISIANA

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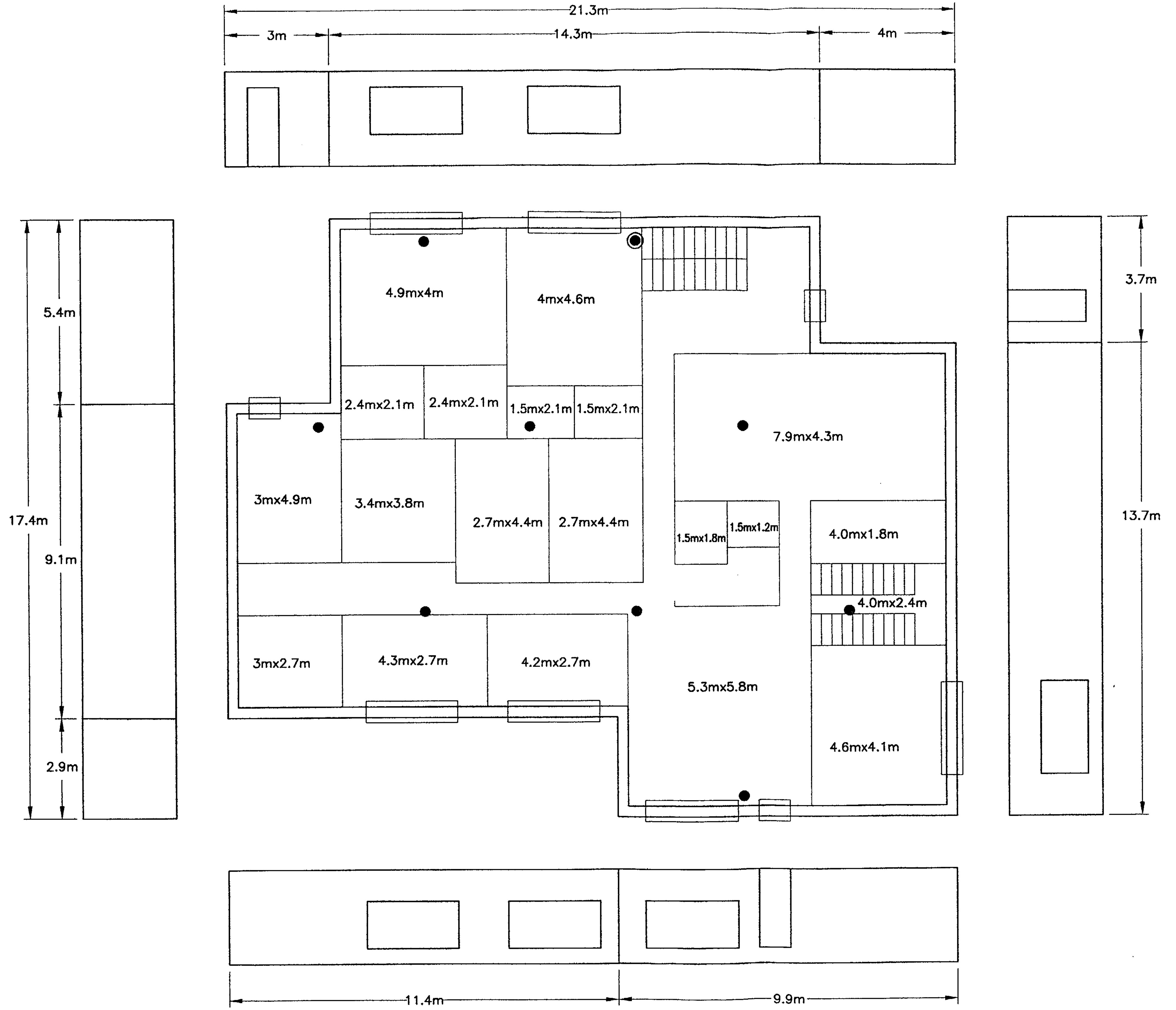

LEGEND

◉ RANDOM GENERATED START SAMPLE POINT

● TRIANGULAR GRID SYSTEMATIC SAMPLE POINT

SURVEY SUBUNIT 7

L = 6.2m
A = 310m^2
N = 9 SAMPLES

SCALE – FEET: 10 0 10

SCALE – METERS: 3 0 3

FIGURE A–3
OFFICE BUILDING–FIRST FLOOR LAYOUT
FORMER KAISER ALUMINUM
SPECIALTY PRODUCTS FACILITY
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
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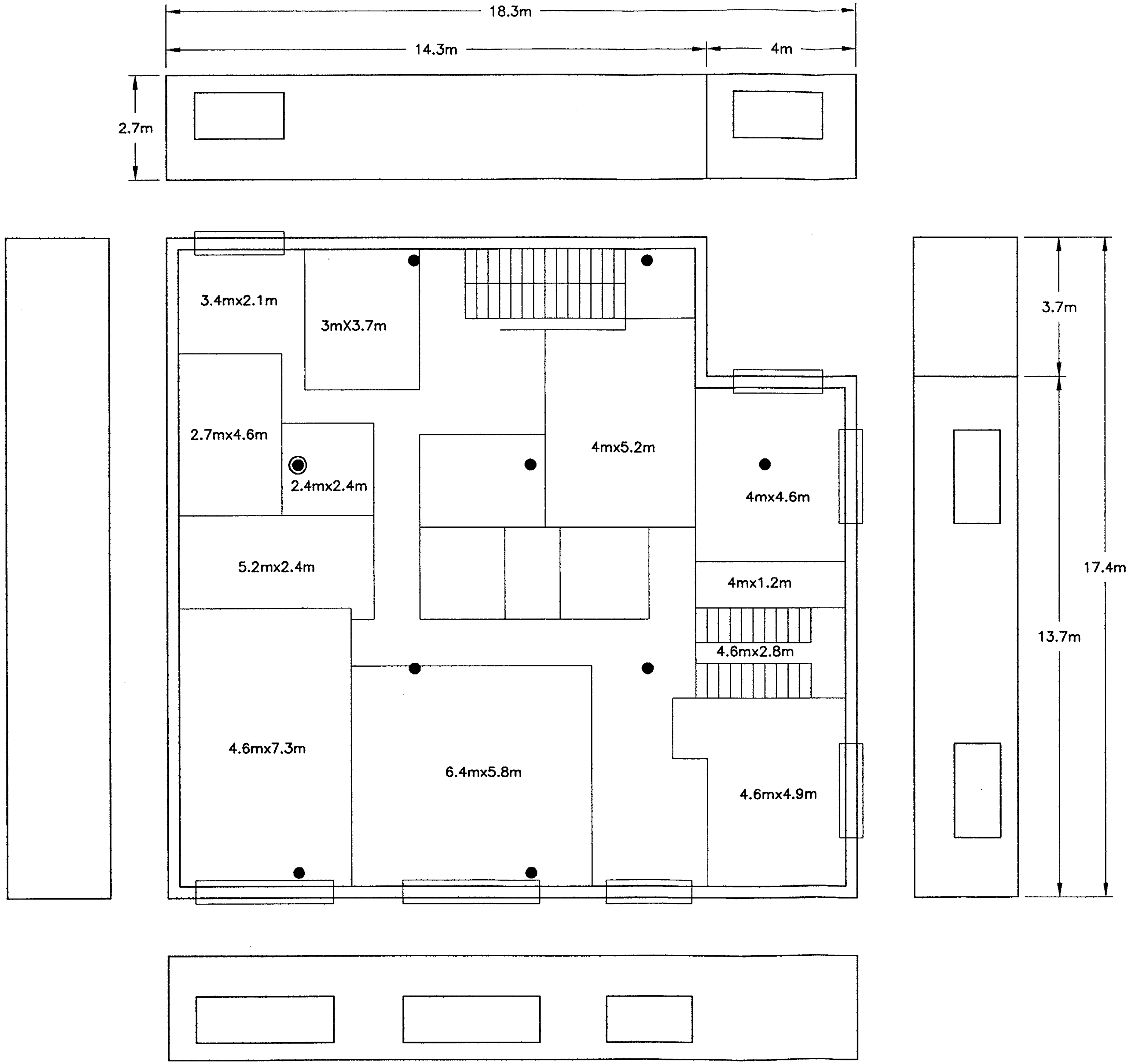

N

LEGEND

◉ RANDOM GENERATED START SAMPLE POINT

● TRIANGULAR GRID SYSTEMATIC SAMPLE POINT

SURVEY SUBUNIT 8

L = 6.2m
A = 310m²
N = 9 SAMPLES

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

FIGURE A–4
OFFICE BUILDING–SECOND FLOOR LAYOUT
FORMER KAISER ALUMINUM
SPECIALTY PRODUCTS FACILITY
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
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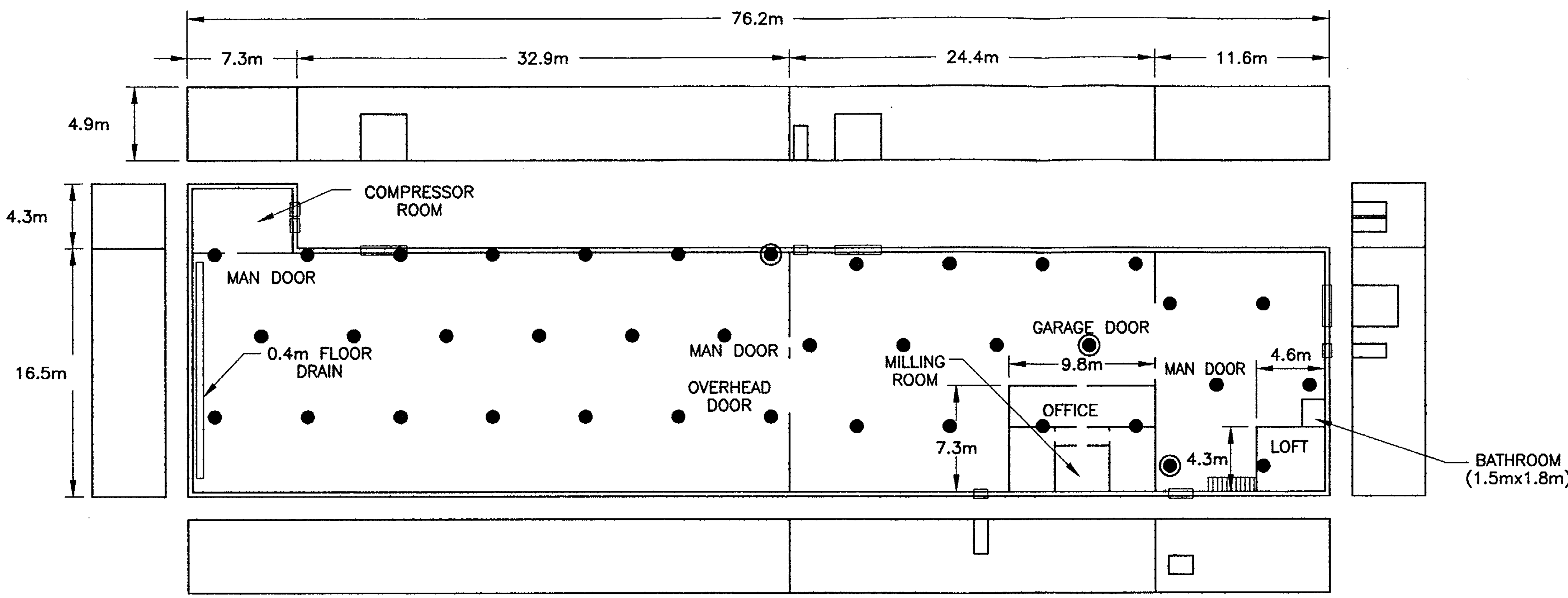

CONSTRUCTION MATERIAL

MAIN FLOOR – CONCRETE
MAIN WALLS – CONCRETE BLOCK
MAIN CEILING – CORRUGATED METAL

LEGEND

◉ RANDOM GENERATED START SAMPLE POINT

● TRIANGULAR GRID SYSTEMATIC SAMPLE POINT

SURVEY SUBUNIT 9 (WESTERN SECTION)

L = 6.2m
A = 695m^2
N = 20 SAMPLES

SURVEY SUBUNIT 10 (CENTRAL SECTION)

L = 6.2m
A = 405m^2
N = 12 SAMPLES

SURVEY SUBUNIT 11 (EASTERN SECTION)

L = 6.2m
A = 215m^2
N = 6 SAMPLES

SCALE – FEET: 30 0 30
SCALE – METERS: 9 0 9

FIGURE A–5
WAREHOUSE BUILDING LAYOUT
FORMER KAISER ALUMINUM
SPECIALTY PRODUCTS FACILITY
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
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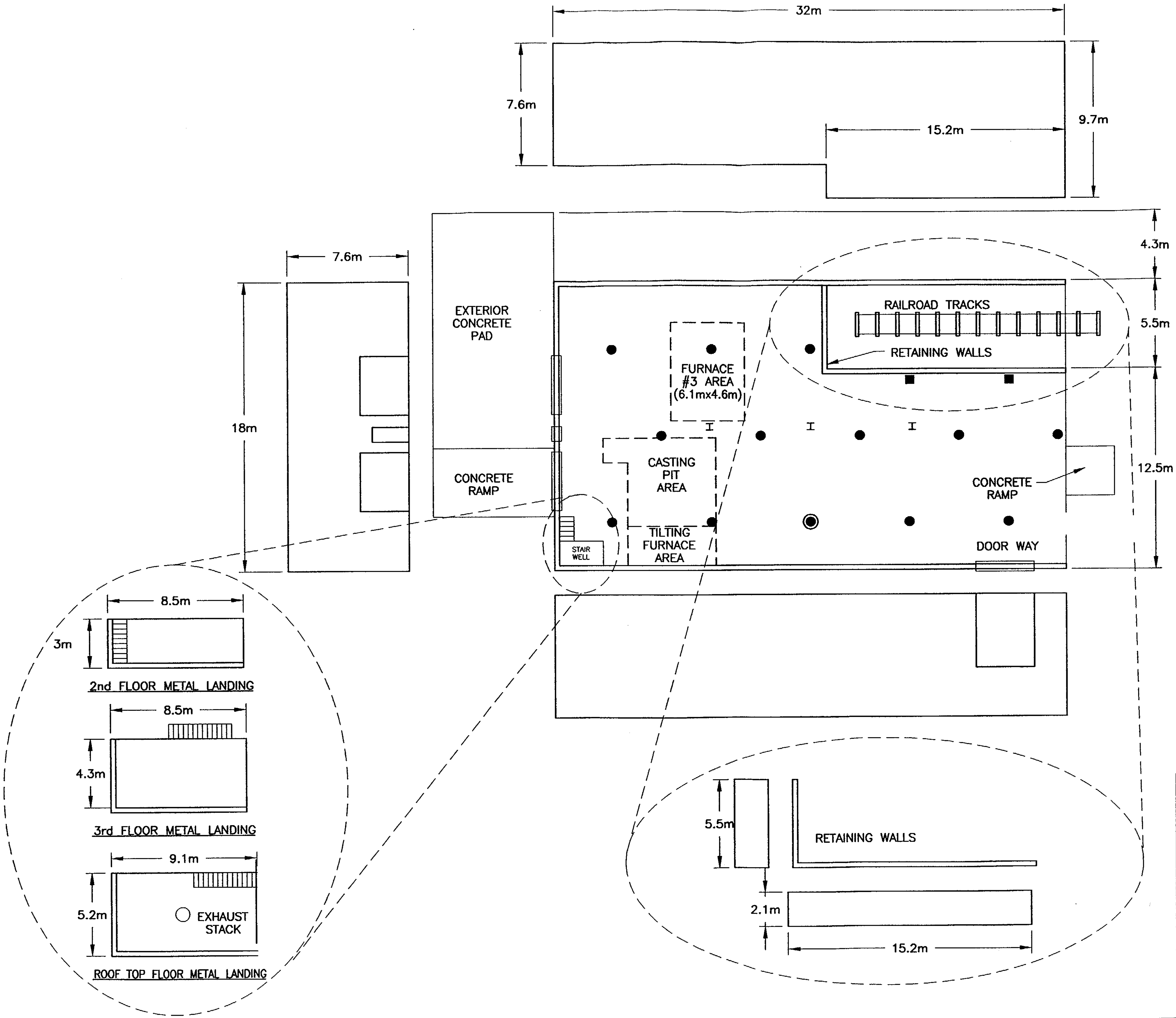

N

CONSTRUCTION MATERIAL

MAIN FLOOR – CONCRETE
MAIN WALLS – SEGMENTED CONCRETE PANELS
MAIN CEILING – CORRUGATED METAL

LEGEND

◉ RANDOM GENERATED START SAMPLE POINT
● TRIANGULAR GRID SYSTEMATIC SAMPLE POINT
I – SUPPORT PILLAR
■ ADJUSTED TRIANGULAR GRID SYSTEMATIC SAMPLE POINT

SURVEY SUBUNIT 12
(MAIN BUILDING)

L = 6.2m
A = $500m^2$
N = 15 SAMPLES

SCALE – FEET
20 0 20
5 0 5
SCALE – METERS

FIGURE A–6
CRUSHER BUILDING LAYOUT
FORMER KAISER ALUMINUM
SPECIALTY PRODUCTS FACILITY
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

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5427251

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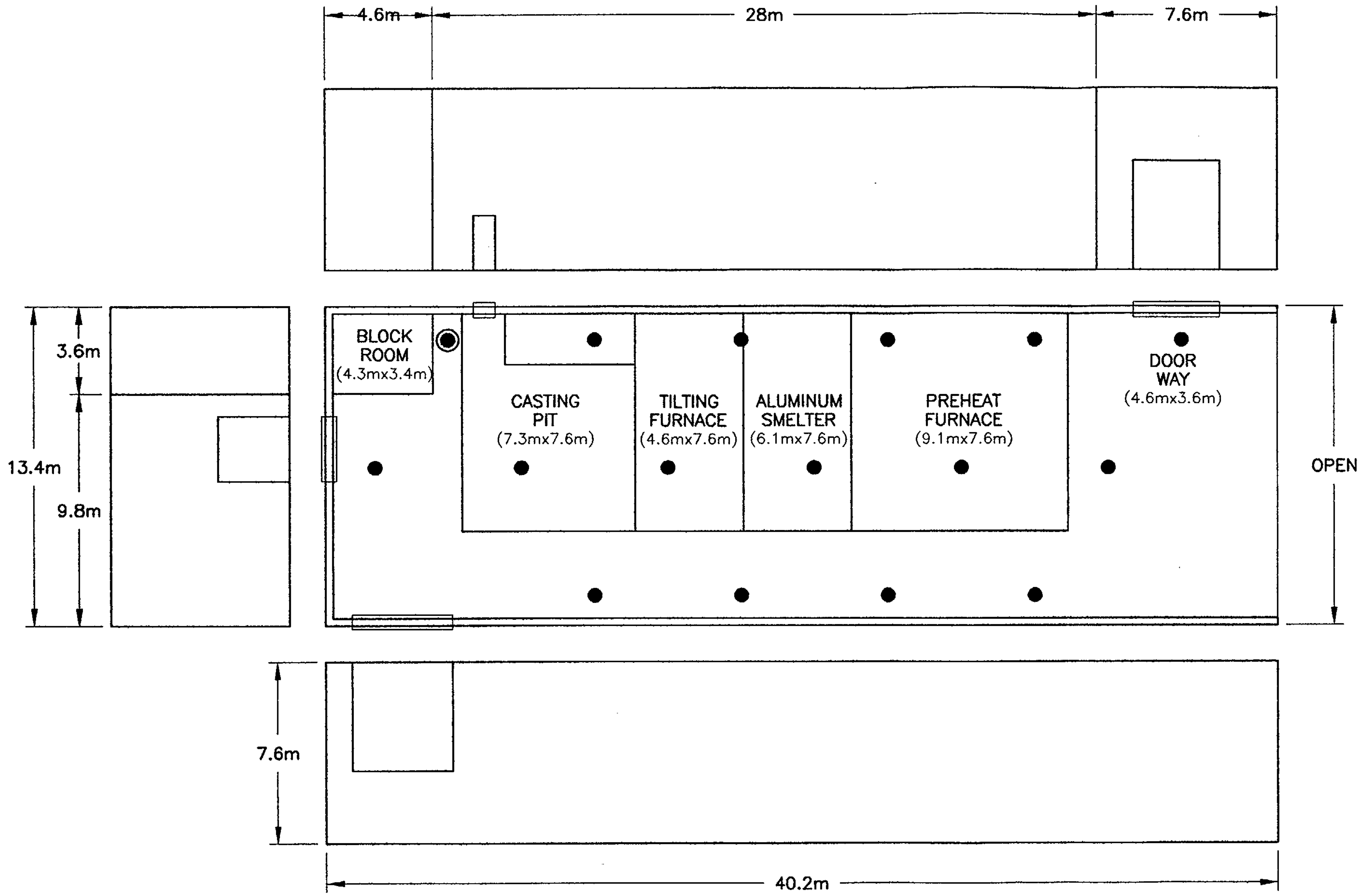

N

CONSTRUCTION MATERIAL

MAIN FLOOR – CONCRETE
MAIN WALLS – CONCRETE BLOCK
MAIN CEILING – CORRUGATED METAL

LEGEND

◉ RANDOM GENERATED START SAMPLE POINT

● TRIANGULAR GRID SYSTEMATIC SAMPLE POINT

SURVEY SUBUNIT 13

L = 6.2m
A = 540m^2
N = 16 SAMPLES

SCALE – FEET: 20 0 20
SCALE – METERS: 5 0 5

FIGURE A–7
CRUSHER ADDITION BUILDING LAYOUT
FORMER KAISER ALUMINUM
SPECIALTY PRODUCTS FACILITY
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

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Appendix B

Derivation of Key MARSSIM Survey Design Parameters

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Export, Pennsylvania 15632

Prepared by: [initials] Date: 12/7/01
Checked by: [initials] Date: 12/14/01
Approved by: RFD Date: 12/20/01
Rev. Prep by: PSB Date: 12/18/01
Rev. Chk by: [initials] Date: 12/20/01
Revision No.: 1

Calculation Brief
Derivation of Key MARSSIM Survey Parameters
Kaiser Aluminum and Chemical Corporation
Tulsa, Oklahoma
Project No. 5427K

Structure Surveys:

1. Calculation of the Gross Activity Concentration Guideline (DCGL) Value
2. Calculation of Minimum Number of Samples (N) for Structure Surveys
3. Calculation of Scan Minimum Detectable Concentration (MDC)
4. Calculation of N Based on Scan MDC
5. Calculation of Fixed Count Time Required to Achieve a Fraction of the Gross Activity DCGL Value

Land Surveys:

6. Calculation of Minimum Number of Samples (N) for Land Area Surveys
7. Calculation of Scan Minimum Detectable Concentration (MDC)
8. Calculation of N Based on Scan MDC

Structure Surveys
Calculation of the Gross Activity Derived Concentration Guideline (DCGL) Value

Gross Activity Derived Concentration Guideline (DCGL) Values for structure surveys are values of the average total surface contamination and the average removable surface contamination levels that correspond to the dose-based radiological criteria of 10 Code of Federal Regulations 20 Subpart E. The limits are radionuclide-specific and the sum of fractions (unity rule) applies. The radionuclide-specific average total surface contamination values were derived using the DandD code and default parameters. Values calculated using DandD and default parameters are referred to as screening values by the Nuclear Regulatory Commission (NRC). The NRC allows use of these screening values in lieu of site-specific DCGL values that must be submitted to the NRC for approval. (Refer to Federal Register Volume 63, Number 222, Page 64132-64134, November 18, 1998). The NRC screening values assume that removable contamination is not more than 10% of the total contamination screening value.

The Activity Fractions for each of the three radionuclides were calculated based on the activity ratios established for the site in the Adjacent Land Remediation Plan. The ratio of Th-232 to Th-228 is 1-to-1 based on secular equilibrium of the natural thorium decay chain and verified by analytical analyses of soil samples. The ratio of Th-230 to Th-232 is 3.5-to-1 based on the results of analytical analyses of soil samples.

Table 1 - Radionuclide-Specific DCGL Values

Radionuclide	Site Mix Activity Fraction	DCGL Total Contamination (dpm/100cm^2)	DCGL Removable Contamination (dpm/100cm^2)
Th-228	0.182	41.1	4.11
Th-230	0.636	36.9	3.69
Th-232	0.182	7.31	0.731

From the radionuclide-specific values and the activity fractions of the radionuclides established for the site, the Gross Activity DCGL value was calculated using formula 4-4 (MARSSIM pg 4-9):

Gross Activity DCGL = $1 / \Sigma (AF_i / DCGL_i)$

Where:
AF_i = Activity Fraction of Radionuclide i.
$DCGL_i$ = Derived Concentration Guideline of Radionuclide i.

The Gross Activity DCGL value is 21.5 disintegrations per minute (dpm)/100 cm^2 for average total surface contamination and 2.15 dpm/100cm^2 for removable contamination.

Calculation of Minimum Number of Samples (N) for Structure Surveys

N was calculated for structure survey inputs using the method provided in Section 5 of MARSSIM and the following input parameters:

- Alpha error – 0.05
- Beta error – 0.05
- Gross Activity DCGL – 21.5 dpm/100cm^2 alpha
- Sigma – 7.14 dpm/100cm^2 alpha. Sigma was estimated based on the calculated standard deviation of the results of 20 consecutive 10 minute counts using a gas proportional detector

to measure gross alpha count rates. The results of the 20 consecutive counts are presented in Table 3.

- Lower Bound Gray Region (LBGR) – ½ of the Gross Activity DCGL value (21.5 /2 = 10.75 dpm/100cm^2).

The calculation of the minimum number of samples (N) was done as follows:

- Delta was calculated in accordance with MARRSIM by subtracting the LBGR from the Gross Activity DCGL (21.5 – 10.75 = 10.75).
- Delta/sigma was calculated by dividing delta by sigma (10.75 / 7.14 = 1.5).
- The minimum number of samples (N) corresponding to a delta/sigma of 1.5, an alpha error of 0.05, and a beta error of 0.05 was looked up in MARSSIM Table 5.3. N is equal to 18 samples. Note that in Table 5.3, Values of N/2 for use with the Wilcoxon Rank Sum Test, that N is referred to as N/2 since the minimum number of samples (N) that are taken in the survey unit are also taken in a designated background unit.

Table 3 – Twenty Consecutive 10 Minute Counts for Gross Alpha Measured with a Ludlum Model 43-68 Gas Proportional Detector

Count	Time (min)	Alpha (counts)	Alpha (cpm)	Alpha (dpm/100cm^2)
1	10	9	0.9	25.74
2	10	13	1.3	37.18
3	10	12	1.2	34.32
4	10	8	0.8	22.88
5	10	10	1.0	28.60
6	10	10	1.0	28.60
7	10	9	0.9	25.74
8	10	8	0.8	22.88
9	10	8	0.8	22.88
10	10	9	0.9	25.74
11	10	15	1.5	42.90
12	10	7	0.7	20.02
13	10	7	0.7	20.02
14	10	11	1.1	31.46

Count	Time (min)	Alpha (counts)	Alpha (cpm)	Alpha (dpm/100cm²)
15	10	11	1.1	31.46
16	10	9	0.9	25.74
17	10	6	0.6	17.16
18	10	14	1.4	40.04
19	10	8	0.8	22.88
20	10	13	1.3	37.18
	Average:	10	0.99	28.17
	Stdev.:	2.5	0.25	7.14
	%CV:	25	25	25
	Median:	9	0.9	25.74
	Minimum:	6	0.6	17.16
	Maximum:	15	1.5	42.90

In Table 3, the gross alpha activity concentrations in $dpm/100cm^2$ was calculated using the following formula (MARSSIM 6-2, pg 6-30):

$AC\ (dpm/100cm^2) = CR\ /\ \epsilon_T \times (A / 100)$

Where:

AC = Activity Concentration in $dpm/100cm^2$

CR = Gross Count Rate in counts per minute (cpm)

ϵ_T = Total Efficiency (dpm/cpm),

- For alpha = 2π Instrument Efficiency (0.111 dpm/cpm) x Source Efficiency (0.25 for alpha, MARSSIM pg 6-25)

A = Physical Area of the Probe = 126 cm^2

Calculation of Scan Minimum Detectable Concentration (MDC)

The scan MDC is calculated prior to beginning fixed point measurements and smear sampling of structures. If the scan MDC is equal to or less than the Gross Activity DCGL, the calculated minimum number of samples (18) are required. If the scan MDC is greater than the Gross Activity DCGL, then the minimum number of samples is recalculated. The scan MDC was calculated for alpha detection using the following formula (MARSSIM equation J-5, pg J-2) for anticipated alpha background count rates of <1 to 3 cpm:

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

Where:

$P(n \geq 1)$	= probability of observing one count. P was set at 95%, consistent with alpha and beta errors of 0.05 (95% Confidence Level)
G	= activity (dpm). The equation was solved for G. G represents the activity in dpm that can be detected at the 95% CL.
E	= 4π detector efficiency (0.210 cpm/dpm)
d	= width of detector in direction of scan (11.7 cm), the width of the Ludlum Model 43-68 gas proportional detector.
v	= scan speed (5.85 cm/s), one half Ludlum Model 43-68 detector width per second.

The resulting value of activity (G) was 425 dpm. Since the physical area of the Ludlum Model 43-68 detector is 126 cm^2, it is conservative to assume the scan MDC for alpha is 425 dpm/100cm^2.

Calculation of N Based on Scan MDC

The method provided in Section 5 of MARSSIM was used to calculate the minimum number of samples required based on scan MDC. If the scan MDC is equal to or less than the scan MDC desired, i.e., the Gross Activity DCGL, the calculated minimum number of samples (18) are required. If the scan MDC is greater than the Gross Activity DCGL, then the minimum number of samples is recalculated. The scan MDC is 425 dpm/100cm^2 , greater than the Gross Activity DCGL of 21.5 dpm/100cm^2. Therefore, the minimum number of samples required was calculated as follows:

- The scan MDC was divided by the Gross Activity DCGL (425 / 21.5 = 20). The result, 20, represents the area factor corresponding to the elevated area that can be detected at the scan MDC. (MARSSIM Equation 5-3)

- The elevated area (0.5 m^2) corresponding to an area factor of 20 was taken from Table 4. Table 4 was developed using DandD the same code used to derive the DCGL values in Table 1 for the thorium radionuclides.

- The number of samples required based on the scan MDC is calculated by dividing the maximum area of a Class 1 survey unit (100 m^2) by the area of the elevated area (0.5 m^2) and yields an N of 200.

Table 4 – Default DandD Code Area Factors

Elevated Area Size	10 m^2	5 m^2	2 m^2	1 m^2	0.5 m^2	0.1m^2	100 cm^2
Area Factor	1	2	5	10	20	100	1000

Calculation of Fixed Count Time Required to Achieve a Fraction of the Gross Activity DCGL Value

The fixed count time required to achieve a fraction of the Gross Activity DCGL value (21.5 dpm/100cm^2) was calculated by use of the following derived formula for calculation of fixed time MDC (MARSSIM pg 6-39 – 6-43). The value of 16 and 20 dpm/100cm^2 was substituted for the MDC value and the formula solved for time (t) required in minutes. The parameters used and results are presented in Table 5.

$$MDC = k^2 + 2*k*(2*B*t)^{1/2} \; / \; (t* \epsilon_T *A/100)$$

Where:

MDC = Minimum Detectable Concentration (16 dpm/100cm^2).

B = Background count rate (cpm) as determined by a background count.

t = count time in minutes corresponding to B, required to achieve an MDC of 16 dpm/100cm^2.

ϵ_T = total efficiency including the 2π Instrument Efficiency (0.111 cpm/dpm) times the Surface Efficiency (0.25), 0.0278.

A = physical probe area of a Ludlum Model 43-68 gas proportional detector, 126 cm^2.

k = Poisson probability sum for alpha and beta errors (1.645, for alpha and beta errors equal to 0.05).

Table 5
Increasing Count Time (t) Per Increasing Alpha Background Count Rate (B) Corresponding to a Fraction of the Gross Activity DCGL Value of 21 dpm/100cm²
(Example Table, Calculation is Detector Efficiency Dependent)

B Background (cpm)	t Count Time (min)	€ Efficiency (cpd)	A Probe Area (cm^2)	k 95% CL (-)	MDC ($dpm/100cm^2$)
0.1	15	0.028	126	1.645	16
0.2	22	0.028	126	1.645	16
0.3	30	0.028	126	1.645	16
0.4	35	0.028	126	1.645	16
0.5	42	0.028	126	1.645	16
0.6	48	0.028	126	1.645	16
0.7	55	0.028	126	1.645	16
0.8	62	0.028	126	1.645	16
0.9	68	0.028	126	1.645	16
1	75	0.028	126	1.645	16
1.1	81	0.028	126	1.645	16
1.2	88	0.028	126	1.645	16
1.3	94	0.028	126	1.645	16
1.4	101	0.028	126	1.645	16
1.5	107	0.028	126	1.645	16
0.1	11	0.028	126	1.645	20
0.2	16	0.028	126	1.645	20
0.3	20	0.028	126	1.645	20
0.4	25	0.028	126	1.645	20
0.5	29	0.028	126	1.645	20
0.6	33	0.028	126	1.645	20
0.7	37	0.028	126	1.645	20
0.8	41	0.028	126	1.645	20
0.9	46	0.028	126	1.645	20
1	50	0.028	126	1.645	20
1.1	54	0.028	126	1.645	20
1.2	58	0.028	126	1.645	20
1.3	63	0.028	126	1.645	20
1.4	67	0.028	126	1.645	20
1.5	71	0.028	126	1.645	20

Notes:

1. MDC = Minimum Detectable Concentration ($dpm/100cm^2$).
2. B = Background countrate (cpm) as determined by a background count.
3. t = count time in minutes corresponding to B, required to achieve the MDC value.
4. € = total efficiency including the detector and the surface efficiency.
5. A = physical probe area of a Ludlum Model 43-68 gas proportional detector.
6. k = Poisson probability sum for alpha and beta errors of 0.05.

Land Surveys:
Calculation of Minimum Number of Samples (N) for Land Area Surveys

N was calculated for land area survey inputs using the guidance provided in MARSSIM and the following input parameters:

- Alpha error – 0.05
- Beta error – 0.05
- DCGL – 3 pCi/g Th-232. The DCGL value of 3 pCi/g for Th-232 is a surrogate value for the site mix derived in the Decommissioning Plan (Decommissioning Plan, June 2001).
- Sigma – 0.21 pCi/g Th-232. Sigma was calculated based on the analytical results of 10 randomly selected final status survey samples from the adjacent land remediation survey. The results are presented in Table 6.
- LBGR – ½ of the DCGL value.

The calculation of the minimum number of samples (N) was done as follows:

- Delta was calculated in accordance with MARRSIM by subtracting the LBGR from the DCGL (3 – 1.5 = 1.5).
- Delta/sigma was calculated by dividing delta by sigma (1.5 / 0.21 = 7).
- Delta was calculated in accordance with MARRSIM by subtracting the LBGR from the DCGL (3 – 1.5 = 1.5). Delta/sigma was calculated by dividing delta by sigma (1.5 / 0.21 = 7). The minimum number of samples (N) corresponding to a delta/sigma of 7, an alpha error of 0.05, and a beta error of 0.05 was looked up in MARSSIM Table 5.3. N is equal to 9 samples. Note that in Table 5.3, Values of N/2 for use with the Wilcoxon Rank Sum Test, that N is referred to as N/2 since the minimum number of samples (N) that are taken in the survey unit are also taken in a designated background unit.

Table 6 – Analytical Results for 10 Soil Samples

Sample	Th-232 (pCi/g)
1	0.936
2	1.12
3	1.36
4	0.700
5	0.903
6	0.931
7	0.668
8	1.01
9	1.15
10	1.17
Average:	0.995
Stdev.:	0.214
%CV:	21.6
Maximum:	1.36
Minimum:	0.668
Median:	0.973

Calculation of Scan Minimum Detectable Concentration (MDC)

The scan MDC was calculated for 2-inch-by-2-inch sodium iodide (NaI) detector scanning instruments using the method provided in MARSSIM Section 6.7.2 for calculating MDC that controls 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 = minimum detectable count rate in counts per minute (cpm),

ϵ_i = instrument efficiency (830 cpm/μR/hour for Th-232, MARSSIM Table 6.7).

p = survey efficiency. Based on laboratory studies documented in MARSSIM, the value of p has been estimated to be between 0.5 and 0.75. The value used, 0.5, is conservative.

In addition:

$$MDCR = s_i \times (60/i) \quad \text{and,}$$

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

Where:

s_i = minimal number of net source counts required for a specified level of performance for the interval i (1 second), and:

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

Where 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% false negatives and about 40% false positives. Typical MDC's are summarized in Table 7 for increasing background count rates. The scan MDC value in μR/hr is converted to pCi/g using a Th-232 conversion factor (CF) calculated from the MDC value listed in Table 6.7 of MARSSIM. The scan MDC value in Bq/Kg was converted to pCi/g. The MDC value is pCi/g was then divided by the calculated MDC value in μR/hr, both corresponding to a background of 10,000 cpm. The MDC value in pCi/g was calculated in MARSSIM by converting the MDC value in cpm to pCi/g using a conversion factor developed with the Microshield Code. The calculated Th-232 CF for scanning soil with a 2-inch-by-2-inch NaI detector is 0.99 pCi/g/μR/hr. A value of 3 pCi/g/μR/hr was used to account for the approximate 6-inch layer of concrete covering most land areas on site.

Table 7 – Scan MDCs for Increasing Background

B BKG (cpm)	s_I (counts)	MDCR (ncpm)	$MDCR_s$ (cpm)	Scan MDC (μR/hr)	CF Th-232 (pCi/g/μR/hr)	Scan MDC (pCi/g)
7000	15	894	1265	1.52	3	4.6
7500	15	926	1309	1.58	3	4.7
8000	16	956	1352	1.63	3	4.9
8500	16	986	1394	1.68	3	5.0
9000	17	1014	1434	1.73	3	5.2

B BKG (cpm)	s_I (counts)	MDCR (ncpm)	$MDCR_s$ (cpm)	Scan MDC (µR/hr)	CF Th-232 (pCi/g/µR/hr)	Scan MDC (pCi/g)
9500	17	1042	1473	1.78	3	5.3
10000	18	1069	1512	1.82	3	5.5
10500	18	1095	1549	1.87	3	5.6
11000	19	1121	1585	1.91	3	5.7
11500	19	1146	1621	1.95	3	5.9
12000	20	1171	1656	2.00	3	6.0
12500	20	1195	1690	2.04	3	6.1
13000	20	1219	1724	2.08	3	6.2
13500	21	1242	1756	2.12	3	6.3
14000	21	1265	1789	2.16	3	6.5
14500	21	1287	1820	2.19	3	6.6
15000	22	1309	1851	2.23	3	6.7

Calculation of N Based on Scan MDC

The minimum number of samples required based on the scan MDC was calculated using the method provided in Section 5 of MARSSIM. If the scan MDC is equal to or less than the desired scan MDC, i.e., the DCGL, the calculated minimum number of samples (9) are required. If the scan MDC is greater than the DCGL, then the minimum number of samples is recalculated as follows:

- The scan MDC is calculated based on the background count rate for the survey area. Refer to Table 7.
- The resulting scan MDC is divided by the DCGL (3 pCi/g). The result, represents the area factor of the elevated area that can be detected at the scan MDC.
- The elevated area corresponding to the area factor is looked up in Table 8. If the area factor falls between two of the Table 8 values, non-linear interpolation is used to calculate the corresponding elevated area. The Table 8 area factors for Th-232 were calculated using RESRAD and are part of the Decommissioning Plan, June 2001.
- The number of samples required (N) based on the scan MDC is calculated by dividing the maximum area of a Class 1 survey unit (2000 m^2) by the elevated area (m^2). The results of this calculation are presented in Table 9.

Table 8 – Th-232 Area Factors for Land Surveys

Elevated Area Size	2000 m^2	1000 m^2	300 m^2	100 m^2	30 m^2	10 m^2	3 m^2	1 m^2
Area Factor (-)	1	1.1	1.5	1.8	2.3	3.2	6.2	12.5

Table 9 – Minimum Number of Samples (N) With Increasing Background Count Rate

B BKG (cpm)	Scan MDC (pCi/g)	Area Factor (-)	N Min. # of Samples
7000	4.6	1.52	9
7500	4.7	1.58	9
8000	4.9	1.63	11
8500	5.0	1.68	13
9000	5.2	1.73	15
9500	5.3	1.78	19
10000	5.5	1.82	21
10500	5.6	1.87	24
11000	5.7	1.91	26
11500	5.9	1.95	29
12000	6.0	2.00	32
12500	6.1	2.04	35
13000	6.2	2.08	39
13500	6.3	2.12	43
14000	6.5	2.18	48
14500	6.6	2.19	51
15000	6.7	2.23	56