40-2377

KAISER ALUMINUM
CORPORATE ENVIRONMENTAL

May 25, 2001

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

Re: Kaiser Tulsa Thorium Site Decommissioning Plan

Dear Sir or Madame:

Enclosed is Kaiser Aluminum & Chemical Corporation's Decommissioning Plan for the Tulsa Thorium Site. If you have any questions concerning the enclosed, call me at 225/231-5116.

Very truly yours,

Bill Vinzant

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

JWV/shh

cc: Mr. John Buckley - United States Nuclear Regulatory Commission
Mr. Louis Carson II – United States Nuclear Regulatory Commission
Ms. Pamela Bishop – Oklahoma Department of Environmental Quality
Mr. Stephen L. Jantzen – State of Oklahoma
Dr. Max Scott – ADA Consultants
John Donnan – Houston
Lamar Nichols – Tulsa
Dave Tourdot – Earth Sciences
Al Gutterman – Morgan, Lewis & Bockius
Turgay Ertugrul – A&M
Paul Handa – Tulsa
Scott Van Loo – City of Tulsa
Mr. Harry Patterson – Union Pacific Railroad

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9141 INTERLINE AVENUE SUITE 1A BATON ROUGE LA 70809-1957

Decommissioning Plan

Tulsa Facility
Tulsa, Oklahoma

Kaiser Aluminum and Chemical Corporation
Baton Rouge, Louisiana

Project No. 5427E
June 2001

Earth Sciences Consultants, Inc.

Providing Environmental Consulting Services Since 1979

Decommissioning Plan

Tulsa Facility
Tulsa, Oklahoma

Kaiser Aluminum and Chemical Corporation
Baton Rouge, Louisiana

Project No. 5427E
June 2001

Earth Sciences Consultants, Inc.
One Triangle Lane
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APPENDIX A

ACCEPTANCE REVIEW CHECKLIST

In the following checklist, all items are applicable to Kaiser Phase 2 DP except those marked with NA (NOT APPLICABLE)

Attachment 2

ACCEPTANCE REVIEW CHECKLIST

LICENSEE NAME: Kaiser Aluminum
LICENSE NUMBER: STB-472 (terminated) DOCKET NUMBER: 040-2377
FACILITY: 7311 East 41st Street, Tulsa, OK
DECOMMISSIONING PLAN DATED/VERSION: Phase 2 DP

Staff will review the decommissioning plan without assessing the technical accuracy or completeness of the information contained therein. The adequacy of this information will be assessed during the detailed technical review.

In most cases, licensees will not be required to submit all of the information in this checklist. Rather, the staff should use this checklist a basis for developing a site specific checklist for the individual facility. Staff should use the checklist first during the initial meetings with licensees to discuss the scope and content of the decommissioning plan for each site. The staff, in conjunction with the licensee, should determine what information should be submitted for the site, based on the uses of radioactive material at the site, the extent and types of radioactive material contamination, the manner in which the licensee intends to decommissioning the facility and other factors affecting the potential for increased risk to the public or workers from the decommissioning operations. This information should be documented by modifying the acceptance review checklist. Copies of the modified checklist should be provided to the licensee and maintained by the Project Manager. When the decommissioning plan is submitted the Project Manager should use the modified checklist to perform the acceptance review.

Staff will review the decommissioning plan table of contents and the individual decommissioning plan chapters or sections to ensure that the licensee or responsible party has included this information in the decommissioning plan. In addition, the staff may use the guidance regarding formatting and suggested length of individual as a guide in determining if the level of detail of the information appears to be adequate for the staff to perform a detailed technical review. Staff should recognize that failure to supply an item included in the checklist does not necessarily constitute grounds for rejecting the decommissioning plan. Rather, the staff should determine if the licensee can supply the information in a timely manner and if so communicate the additional information needs to the licensee in a deficiency letter. Only in those cases where a detailed technical review cannot begin without the required information should the DP be rejected. For example, if the licensee is requesting restricted release and has not obtained the appropriate input from community interests who could be affected by the decommissioning, the decommissioning plan should be rejected during the acceptance review. Questions regarding whether to reject a decommissioning plan based on the results of the acceptance review should be forwarded to the Decommissioning Branch, Division of Waste Management.

EXECUTIVE SUMMARY

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

FACILITY OPERATING HISTORY

LICENSE NUMBER/STATUS/ AUTHORIZED ACTIVITIES

1.0 & 2.2 the radionuclides and maximum activities of radionuclides authorized and used under the former license;
2.2 the chemical forms of the radionuclides authorized and used under the former license;
NA a detailed description of how the radionuclides are currently being used at the site;
1.0 & 2.2 the location(s) of use and storage of the various radionuclides authorized under former licenses; and
NA a scale drawing or map of the site and environs showing the current locations of radionuclide use at the site;
NA a list of amendments to the license since the last license renewal.

LICENSE HISTORY

1.0 & 2.2 the radionuclides and maximum activities of radionuclides authorized and used under all previous licenses;
2.2 the chemical forms of the radionuclides authorized and used under all previous licenses;

2.1 a detailed description of how the radionuclides were used at the site;
2.1 & 4.1 the location(s) of use and storage of the various radionuclides authorized under all previous licenses
Figure 2-1 a scale drawing or map of the site, facilities and environs showing previous locations of radionuclide use at the site

PREVIOUS DECOMMISSIONING ACTIVITIES

1.0 & 2.4 a list or summary of areas at the site that were remediated in the past,
2.4 a summary of the types, forms, activities and concentrations of radionuclides that were present in previously remediated areas;
1.0 the activities that caused the areas to become contaminated;
1.0 & 2.4 the procedures used to remediate the areas and the disposition of radioactive material generated during the remediation;
2.4 a summary of the results of the final radiological evaluation of the previously remediated area
Figure 2-3 a scale drawing or map of the site, facilities and environs showing the locations of previous remedial activity

SPILLS *(Kaiser will provide a summary statement)*

2.5 a summary of areas at the site where spills (or uncontrolled releases) of radioactive material occurred in the past;
2.5 the types, forms, activities and concentrations of radionuclides involved in the spill or uncontrolled release, and;
2.5 a scale drawing or map of the site, facilities and environs showing the locations of spills

PRIOR ON-SITE BURIALS

2.6 a summary of areas at the site where radioactive material has been buried in the past;
2.6 the types, forms, activities and concentrations of waste and radionuclides in the former burial, and;
Figure 2-4 a scale drawing or map of the site, facilities and environs showing the locations of former burials.

FACILITY DESCRIPTION

SITE LOCATION AND DESCRIPTION

3.1 the size of the site in acres or square meters;
3.1 the State and county in which the site is located;
\- the names and distances to nearby communities, towns and cities;
3.1 a description of the contours and features of the site;
3.1 the elevation of the site;

3.3 a description of property surrounding the site; including the location of all off-site wells used by nearby communities or individuals;
3.7 the location of the site relative to prominent features such as rivers and lakes.
Figure 2-1 a map that shows the detailed topography of the site using a contour interval
3.3 the location of the nearest residences and all significant facilities or activities near the site
3.1 a description of the facilities (buildings, parking lots, fixed equipment, etc.) at the site

POPULATION DISTRIBUTION

3.2 a summary of the current population in and around the site, by compass vectors
\- a summary of the projected population in and around the site by compass vectors
\- a list of minority populations by compass vectors
3.2 demographic data by census block group to identify minority or low-income populations

CURRENT/FUTURE LAND USE

3.3 a description of the current land uses in and around the site;
3.3 a summary of anticipated land uses.

METROLOGY AND CLIMATOLOGY

3.4 a description of the general climate of the region
3.4 seasonal and annual frequencies of severe weather phenomena
\- weather-related radionuclide transmission parameters
\- routine weather-related site deterioration parameters
\- extreme weather-related site deterioration parameters
3.4 a description of the local (site) meteorology
3.5 the National Ambient Air Quality Standards Category of the area in which the facility is located and, if the facility is not in a Category 1 zone, the closest and first downwind Category 1 Zone.

GEOLOGY AND SEISMOLOGY

3.6.1 a detailed description of the geologic characteristics of the site and the region around the site
3.6.2 a discussion of the tectonic history of the region, regional geomorphology, physiography, stratigraphy, and geochronology
Figure 3-5 a regional tectonic map showing the site location and its proximity to tectonic structures
3.6.1 a description of the structural geology of the region and its relationship to the site geologic structure
\- a description of any crustal tilting, subsidence, karst terrain, landsliding, and erosion.
3.6.1 a description of the surface and subsurface geologic characteristics of the site and its vicinity
3.6.1 a description of the geomorphology of the site

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

SURFACE WATER HYDROLOGY

3.7 a description of site drainage and surrounding watershed fluvial features
- water resource data including maps, hydrographs, and stream records from other agencies (e.g., U.S. Geological Survey and U.S. Army Corps of Engineers).
Figure 2-1 topographic maps of the site that show natural drainages and man-made features
3.7 a description of the surface water bodies at the site and surrounding areas
3.7 & 8.1 a description of existing and proposed water control structures and diversions (both upstream and downstream that may influence the site).
- flow-duration data that indicate minimum, maximum, and average historical observations for surface water bodies in the site areas
Figure 2-1 maps of the site and adjacent drainage areas identifying features such as drainage areas, surface gradients, and areas of flooding.
- an inventory of all existing and planned surface water users, whose intakes could be adversely affected by migration of radionuclides from the site
Figure 3-6 topographic and/or aerial photographs that delineate the 100-year floodplain at the site
8.1 a description of any man-made changes to the surface water hydrologic system that may influence the potential for flooding at the site

GROUNDWATER HYDROLOGY

3.8 a description of the saturated zone
3.8.1 descriptions of monitoring wells
Tables 4-1 to 4-4 physical parameters
Figures 3-8 & 3-9 a description of groundwater flow directions and velocities
3.8 a description of the unsaturated zone
Table 4-3 information on all monitor stations including location and depth
Tables 4-1 to 4-4 a description of physical parameters
3.8 a description of the numerical analyses techniques used to characterize the unsaturated and saturated zones
4.3 the distribution coefficients of the radionuclides of interest at the site.

NATURAL RESOURCES

3.9 a description of the natural resources occurring at or near the site
3.9 a description of potable, agricultural, or industrial ground or surface waters

3.9 a description of economic, marginally economic, or subeconomic known or identified natural resources as defined in U.S. Geological Survey Circular 831.
3.9 mineral, fuel, and hydrocarbon resources near and surrounding the site which, if exploited, would effect the licensee' or responsible party's dose estimates

ECOLOGY/ENDANGERED SPECIES

3.10 a list of commercially or recreationally important invertebrate species known to occur within 5 km of the site
3.10 a list of all commercially important floral species known to occur within 5 km of the site
3.10 a list of commercially or recreationally important vertebrate animals known to occur within 5 km of the site.
3.10 estimates of the relative abundance of both commercially and recreationally important game and nongame vertebrates
3.10 a list of all endangered species at or within 5 km of the site

RADIOLOGICAL STATUS OF FACILITY

CONTAMINATED STRUCTURES

4.1.1 a list or description of all structures at the facility where licensed activities occurred that contain residual radioactive material in excess of site background levels;
NA a summary of the structures and locations at the facility that the licensee or responsible party has concluded have not been impacted by licensed operations and the rationale for the conclusion;
NA a list or description of each room or work area within each of these structures;
NA a summary of the background levels used during scoping or characterization surveys;
NA a summary of the locations of contamination in each room or work area
NA a summary of the radionuclides present at each location, the maximum and average radionulide activities in dpm/100cm^2, and, if multiple radionuclides are present, the radionuclide ratios;
NA the mode of contamination for each surface (i.e., whether the radioactive material is present only on the surface of the material or if it has penetrated the material);
NA the maximum and average radiation levels in mrem/hr in each room or work area; and
NA a scale drawing or map of the rooms or work areas showing the locations of radionuclide material contamination.

CONTAMINATED SYSTEMS AND EQUIPMENT

4.2 a list or description and the location of all systems or equipment at the facility that contain residual radioactive material in excess of site background levels;
NA a summary of the radionuclides present in each systems or on the equipment at each location, the maximum and average radionulide activities in dpm/100cm^2, and, if multiple radionuclides are present, the radionuclide ratios;

NA the maximum and average radiation levels in mrem/hr at the surface of each piece of equipment;
NA a summary of the background levels used during scoping or characterization surveys; and,
NA a scale drawing or map of the rooms or work areas showing the locations of the contaminated systems or equipment;

SURFACE SOIL CONTAMINATION *(Discussion of surface and subsurface soil Contamination will be combined in one section)*

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

SUBSURFACE SOIL CONTAMINATION

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

SURFACE WATER

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

GROUNDWATER

4.5 a summary of the aquifer(s) at the facility that contain residual radioactive material in excess of site background levels;
4.5 a summary of the background levels used during scoping or characterization surveys

4.5 a summary of the radionuclides present in each aquifer and the maximum and average radionulide activities in pCi/l

DOSE MODELING

UNRESTRICTED RELEASE USING SCREENING CRITERIA

Unrestricted release using screening criteria for building surface residual radioactivity

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

Unrestricted release using screening criteria for surface soil residual radioactivity

(Kaiser will make a statement indicating that site specific information will be used)
5.1 justification on the appropriateness of using the screening approach (for both the source term and the environment) at the site; and,
5.1 a summary of the screening method (i.e., running DandD or using the look-up tables) used in the decommissioning plan.

UNRESTRICTED RELEASE USING SITE-SPECIFIC INFORMATION

5.2.1 source term information including nuclides of interest, configuration of the source, areal variability of the source, etc.
5.2.2 description of the exposure scenario including a description of the critical group.
5.2.1 & 5.2.2 description of the conceptual model of the site including the source term, physical features important to modeling the transport pathways, and the critical group.
5.1 & 5.2.2.1 identification/description of the mathematical model used (e.g., hand calculations, DandD Screen v1.0, RESRAD v5.81, etc.).
Appendix D description of the parameters used in the analysis.
5.2.5 discussion about the effect of uncertainty on the results.
Appendices B,C,D,E input and output files or printouts, if a computer program was used.

RESTRICTED RELEASE USING SITE-SPECIFIC INFORMATION

(This section is applicable if Kaiser decides to a restricted release scenario)

\- source term information including nuclides of interest, configuration of the source, areal variability of the source, and chemical forms;
\- a description of the exposure scenarios including a description of the critical group for each scenario;
\- a description of the conceptual model(s) of the site that includes the source term, physical features important to modeling the transport pathways, and the critical group for each scenario;

- __ identification/description of the mathematical model(s) used (e.g., hand calculations, RESRAD v5.81, etc.);
- __ a summary of parameters used in the analysis;
- __ a discussion about the effect of uncertainty on the results; and
- __ input and output files or printouts, if a computer program was used.

RELEASE INVOLVING ALTERNATE CRITERIA

NA source term information including nuclides of interest, configuration of the source, areal variability of the source; and chemical forms;
NA a description of the exposure scenarios including a description of the critical group for each scenario;
NA a description of the conceptual model(s) of the site that includes the source term, physical features important to modeling the transport pathways, and the critical group for each scenario;
NA identification/description of the mathematical model(s) used (e.g., hand calculations, RESRAD v5.81, etc.);
NA a summary of parameters used in the analysis;
NA a discussion about the effect of uncertainty on the results; and
NA input and output files or printouts, if a computer program was used.

ALTERNATIVES CONSIDERED AND RATIONALE FOR CHOSEN ALTERNATIVE

ALTERNATIVES CONSIDERED

Figure 8-5 &
8.2.7 a description of the facility if the alternative is employed;
5.0 a summary of the health effects to adjacent communities if the alternative is employed;
3.3 a summary of the impacts on community resources such as land use and property values;
5.0 a summary of the impacts on the geology, hydrology, air quality and ecology in and around the site;
6.0 a description of impacts to minority or low-income populations within a 0.6 mile radius of the center of the facility (urban location) or within a 4 mile radius of the center of the facility (rural location);
NA if appropriate, an assessment of the potential for criticality;
8.2.6 a summary of the irreversible and irretrievable commitment of resources.
6.0 an analysis of the proposed alternative and other alternatives as required by 10 CFR 51.45(c);
* a list of the permits, licenses, approvals, and other entitlements and the discussion of the status of compliance with these requirements required in 10 CFR 51.45(d)

RATIONALE FOR CHOSEN ALTERNATIVE

6.1 a description of why the licensee selected the preferred alternative described in the decommissioning plan

*Referenced in various sections throughout the Decommissioning Plan. (Kaiser will obtain necessary permits based on final design considerations.)

_–_ if the licensee has not selected the environmentally preferable alternative, an explanation of why this alternative was not selected.

ALARA ANALYSIS

_7.1_ a description of how the licensee or responsible party will achieve a decommissioning goal below the dose limit;
_7.1_ a quantitative cost benefit analysis;
_7.1_ a description of how costs were estimated; and,
_7.2_ a demonstration that the doses to the average member of the critical group are ALARA

PLANNED DECOMMISSIONING ACTIVITIES

CONTAMINATED STRUCTURES

_NA_ a summary of the remediation tasks planned for each room or area in the contaminated structure in the order in which they will occur;
_NA_ a description of the remediation techniques that will be employed in each room or area of the contaminated structure;
_NA_ a summary of the radiation protection methods and control procedures that will be employed in each room or area;
_NA_ a summary of the procedures already authorized under the existing license and those for which approval is being requested in the decommissioning plan;
_NA_ a commitment to conduct decommissioning activities in accordance with written, approved procedures;
_NA_ a summary of any unique safety or remediation issues associated with remediating the room or area; and,
_NA_ for Part 70 licensees, a summary of how the licensee will ensure that the risks addressed in the facility's Integrated Safety Analysis will be addressed during decommissioning.

CONTAMINATED SYSTEMS AND EQUIPMENT

_NA_ a summary of the remediation tasks planned for each system in the order in which they will occur including which activities will be conducted by licensee staff and which will be performed by a contractor;
_NA_ a description of the techniques that will be employed to remediate each system in the facility or site;
_NA_ a description of the radiation protection methods and control procedures that will be employed while remediating each system;
_NA_ a summary of the equipment will be removed or decontaminated and how the decontamination will be accomplished;
_NA_ a summary of the procedures already authorized under the existing license and those for which approval is being requested in the decommissioning plan;

NA a commitment to conduct decommissioning activities in accordance with written, approved procedures;

NA a summary of any unique safety or remediation issues associated with remediating any system or piece of equipment; and,

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

SOIL

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

8.2.1 a description of the techniques that will be employed to remove or remediate surface and subsurface soil at the site;

8.2.1 a description of the radiation protection methods and control procedures that will be employed during soil removal/remediation;

8.2.1 a summary of the procedures already authorized under the existing license and those for which approval is being requested in the decommissioning plan;

8.3 a commitment to conduct decommissioning activities in accordance with written,
8.2.3.6 approved procedures;
& 8.2.4 a summary of any unique safety or removal/remediation issues associated with remediating the soil; and,

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

SURFACE AND GROUNDWATER

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

NA a description the remediation techniques that will be employed to remediate the ground or surface water;

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

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

NA a commitment to conduct decommissioning activities in accordance with written, approved procedures; and,

NA a summary of any unique safety or remediation issues associated with remediating the ground or surface water.

SCHEDULES

Figure 8-8 a Gantt or PERT chart detailing the proposed remediation tasks in the order in which they will occur

8.4 a statement acknowledging that the dates in the schedule are contingent on NRC approval of the decommissioning plan;

8.4 a statement acknowledging that circumstances can change during decommissioning, and, if the licensee determines that the decommissioning cannot be completed as outlined in the schedule, the licensee or responsible party will provide an updated schedule to NRC; and,

8.4 If the decommissioning is not expected to be completed within the timeframes outlined in NRC regulations, a request for alternative schedule for completing the decommissioning

PROJECT MANAGEMENT AND ORGANIZATION

DECOMMISSIONING MANAGEMENT ORGANIZATION

Figure 9-1 a description of the decommissioning organization

9.1 a description of the responsibilities of each of these decommissioning project units;

Figure 9-1 &9.1 description of the reporting hierarchy within the decommissioning project management organization

9.1 a description of the responsibility and authority of each unit to ensure that decommissioning activities are conducted in a safe manner and in accordance with approved written procedures

DECOMMISSIONING TASK MANAGEMENT

9.2 a description of the manner in which the decommissioning tasks are managed

9.2 a description of how individual decommissioning tasks are evaluated and how the SWPs are developed for each task;

9.2 a description of how the SWPs are reviewed and approved by the decommissioning project management organization;

9.2 a description of how SWPs are managed throughout the decommissioning project

9.2 a description of how individuals performing the decommissioning tasks are informed of the procedures in the SWP

DECOMMISSIONING MANAGEMENT POSITIONS AND QUALIFICATIONS

9.2 & 9.3 a description of the duties and responsibilities of each management position in the decommissioning organization and the reporting responsibility of the position;

9.2 & 9.3 a description of the duties and responsibilities of each chemical, radiological, physical and occupational safety-related position in the decommissioning organization and the reporting responsibility of the position;

9.2 & 9.3 a description of the duties and responsibilities of each engineering, quality assurance, and waste management position in the decommissioning organization and the reporting responsibility of the position

9.3 the minimum qualifications for each of the positions describe above

\- a description of all decommissioning and safety committees, provided Kaiser decides to pursue a restricted release scenario

Radiation Safety Officer

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

9.1.3 a description of the responsibilities and duties of the RSO; and

9.1.3 a description of the specific authority of the RSO to implement and manage the licensee's or responsible party' radiation protection program

TRAINING

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

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

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

CONTRACTOR SUPPORT

8.2.1 a summary of decommissioning tasks that will be performed by contractors

9.1 a description of the management interfaces that will be in place between the licensee or responsible party's management and on-site supervisors and contractor management and on-site supervisors;

9.1 a description of the oversight responsibilities and authority that the licensee or responsible party will exercise over contractor personnel;

9.3 & 9.4 a description of the training that will be provided to contractor personnel by the licensee or responsible party and the training that will be provided by the contractor

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

HEALTH AND SAFETY PROGRAM DURING DECOMMISSIONING

RADIATION SAFETY CONTROLS AND MONITORING FOR WORKERS

Air Sampling Program

10.1 a description which demonstrates that the air sampling program is representative of the workers breathing zones

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

10.1 a description of the conditions under which air monitors will be used

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

10.1.1 a description of the action levels for air sampling results

10.1.1 a description of how minimum detectable activities [MDA] for each specific radionuclide that may be collected in air samples are determined

Respiratory Protection Program

10.1.2 a description of the process controls, engineering controls or procedures to control concentrations of radioactive materials in air;
10.1.2 a description of the evaluation which will be performed when it is not practical to apply engineering controls or procedures
10.1.2 a description of the considerations used which demonstrates respiratory protection equipment is appropriate for a specific task based on the guidance on assigned protection factors;
10.1.2 a description of the medical screening and fit testing required before workers will use any respirator that is assigned a protection factor;
10.1.2 a description of the written procedures maintained to address all the elements of the respiratory protection program;
10.1.2 a description of the use, maintenance, and storage of respiratory protection devices
10.1.2 a description of the respiratory equipment users training program;
10.1.2 a description of the considerations made when selecting respiratory protection equipment

Internal Exposure Determination

10.1.3 a description of the monitoring to be performed to determine worker exposure
10.1.3 a description of how worker intakes are determined using measurements of quantities of radionuclides excreted from, or retained in the human body
10.1 a description of how worker intakes are determined by measurements of the concentrations of airborne radioactive materials in the workplace.
10.1.5 a description of how worker intakes, for an adult, a minor, and a declared pregnant woman are determined using any combination of the measurements above as may be necessary
10.1 a description of how worker intakes are converted into committed effective dose equivalent

External Exposure Determination

10.1.4 a description of the individual-monitoring devices which will be provided to workers
\- a description of the type, range, sensitivity, and accuracy of each individual-monitoring device;
10.1.4 a description of the use of extremity and whole body monitors when the external radiation field is non-uniform
\- a description of when audible-alarm dosimeters and pocket dosimeters will be provided
10.1 a description of how external dose from airborne radioactive material is determined
10.1.4 a description of the procedure to insure that surveys necessary to supplement personnel monitoring are performed

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

Summation of Internal and External Exposures

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

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

\- a description of the monitoring of the intake of a declared, pregnant woman if determined to be necessary;

10.1.8 a description of the program for the preparation, retention and reporting of records for occupational radiation exposures;

Contamination Control Program

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

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

14.2 a description of the surveys which will be performed to determine the baseline of background radiation levels and radioactivity from natural sources for areas where decommissioning activities will take place;

Appendix G a description in matrix or tabular form which describes contamination action limits (that is, actions taken to either decontaminate a person, place or area, or restrict access, or modify the type or frequency of radiological monitoring)

Appendix G a description (included in the matrix or table mentioned above) of proposed radiological contamination guidelines for specifying and modifying the frequency for each type of survey used to assess the reduction of total contamination

\- a description of the procedures used to test sealed sources, and to insure that sealed sources are leaked tested at appropriate intervals

Instrumentation Program

10.1.7 a description of the instruments to be used to support the health and safety program

10.1.7 a description of instrumentation storage, calibration and maintenance facilities for instruments used in field surveys

10.1.1 a description of the method used to estimate the MDC or MDA (at the 95% confidence level) for each type of radiation to be detected;

10.1.7 a description of the instrument calibration and quality assurance procedures;

\- a description of the methods used to estimate uncertainty bounds for each type of instrumental measurement;

10.1.7 a description of air sampling calibration procedures or a statement that the instruments will be calibrated by a qualified service provider.

Nuclear Criticality Safety

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

Health Physics Audits, Inspections and Record-Keeping Program.

10.1.8 a general description of the annual program review conducted by management
10.1.8 a description of the records to be maintained of the annual program review and management audits
10.1.8 a description of the types and frequencies of surveys and audits to be performed by the RSO and RSO staff
10.1.8 a description of the process used in evaluating and dealing with violations of NRC requirements or license commitments identified during audits
10.1.8 a description of the records maintained of RSO audits

ENVIRONMENTAL MONITORING AND CONTROL PROGRAM

ENVIRONMENTAL ALARA EVALUATION PROGRAM

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

EFFLUENT MONITORING PROGRAM

11.1 a demonstration that background and baseline concentrations of radionuclides in environmental media have been established through appropriate sampling and analysis;
11.1 a description of the known or expected concentrations of radionuclides in effluents;
11.1 a description of the physical and chemical characteristics of radionuclides in effluents;
11.2.2.1,Fig.2.1 a summary or diagram of all effluent discharge locations;
11.2.1 & 11.2.4 a demonstration that samples will be representative of actual releases;
11.1, 11.2.1, 11.4 a summary of the sample collection and analysis procedures

11.2.1 a description of the procedures to ensure that releases to sewer systems are controlled and maintained to meet the requirements of 10 CFR 20.2003, and

11.1 a summary of the estimates of doses to the public from effluents and a description of the method used to estimate public dose.

RADIOACTIVE WASTE MANAGEMENT PROGRAM

SOLID RADWASTE

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

12.1.1 a summary of the estimated volume, in cubic feet, of each solid radwaste type summarized under bullet 1 above;

12.1 a summary of the radionuclides (including the estimated activity of each radionuclide) in each estimated solid radwaste type summarized under bullet 1 above;

12.1 & 12.3.1 a summary of the volumes of Class A, B, C and Greater-than-Class-C solid radwaste that will be generated by decommissioning operations;

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

12.1.3 & 12.3.2 a description of how the each of the solid radwastes summarized under bullet 1 above, will be treated and packaged to meet disposal site acceptance criteria prior to shipment for disposal;

12.1.3 & 12.3.2 if appropriate, how the licensee or responsible party intends to manage volumetrically contaminated material;

12.3.2 a description of how the licensee or responsible party will prevent contaminated soil, or other loose solid radwaste, from being re-disbursed after exhumation and collection; and

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

LIQUID RADWASTE

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

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

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

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

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

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

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

MIXED WASTE

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

QUALITY ASSURANCE PROGRAM

ORGANIZATION

- 13.1 a description of the QA program management organization,
- 13.1 a description of the duties responsibilities of each unit within the organization and how delegation of responsibilities is managed within the decommissioning program
- 13.2 a description of how work performance is evaluated;
- 13.1 a description of the authority of each unit within the QA program
- Figure 9-1 an organization chart of the QA program organization

QUALITY ASSURANCE PROGRAM

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

13.2 a description of the authority of each unit within the QA program
Figure 9-1 an organization chart of the QA program organization

QUALITY ASSURANCE PROGRAM

13.2 a commitment that activities affecting the quality of site decommissioning will be subject to the applicable controls of the QA program and activities covered by the QA program are identified on program defining documents;
13.1 a brief summary of the company's corporate QA policies;
13.7 a description of provisions to ensure that technical and quality assurance procedures required to implement the QA program are consistent with regulatory, licensing, and QA program requirements and are properly documented and controlled;
13.7 a description of the management reviews, including the documentation of concurrence in these quality-affecting procedures;
13.7 a description of the quality-affecting procedural controls of the principal contractors
\- a description of how NRC will be notified of changes (a) for review and acceptance in the accepted description of the QA program as presented or referenced in the DP before implementation and (b) in organizational elements within 30 days after the announcement of the changes
13.7 a description is provided of how management regularly assesses the scope, status, adequacy, and compliance of the QA program;
13.7 & 9.4.3 a description of the instruction provided to personnel responsible for performing activities affecting quality
9.4.4 a description of the training and qualifications of personnel verifying activities
9.4 for formal training and qualification programs, documentation includes the objectives and content of the program, attendees, and date of attendance;
13.7 a description of the self-assessment program to confirm that activities affecting quality comply with the QA program;
13.1 a commitment that persons performing self-assessment activities are not to have direct responsibilities in the area they are assessing;
13.7 a description of the organizational responsibilities for ensuring that activities affecting quality are (a) prescribed by documented instructions, procedures, and drawings; and, (b) accomplished through implementation of these documents; and,
13.7 a description of the procedures to ensure that instructions, procedures, and drawings include quantitative acceptance criteria and qualitative acceptance criteria for determining that important activities have been satisfactorily performed.

DOCUMENT CONTROL

13.3 a summary of the types of QA documents that are included in the program
13.3 a description of how the licensee or responsible party develops, issues, revises and retires QA documents

CONTROL OF MEASURING AND TEST EQUIPMENT

13.4 a summary of the test and measurement equipment used in the program
13.4 description of how and at what frequency the equipment will be calibrated;
13.4 a description of the daily calibration checks that will be performed on each piece of test or measurement equipment;
13.4 a description of the documentation that will be maintained to demonstrate that only properly calibrated and maintained equipment was used during the decommissioning

CORRECTIVE ACTION

13.5 a description of the corrective action procedures for the facility, including a description of how the corrective action is determined to be adequate;
13.5 a description of the documentation maintained for each corrective action and any followup activities by the QA organization after the corrective action is implemented;

QUALITY ASSURANCE RECORDS

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

AUDITS AND SURVEILLANCES

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

FACILITY RADIATION SURVEYS

RELEASE CRITERIA

Table 14-1 a summary table or list of the $DCGL_W$ for each radionuclide and impacted media of concern;
Table 14-3 if Class 1 survey units are present, a summary table or list of area factors that will be used for determining a $DCGL_{EMC}$ for each radionuclide and media of concern;
Tables 14-4 & 14-5 if Class 1 survey units are present, the $DCGL_{EMCs}$ for each radionuclide and medium of concern;
Table 14-2 if multiple radionuclides are present, the appropriate $DCGL_W$ for the survey method to be used.

CHARACTERIZATION SURVEYS

14.2.1 to 14.2.3	a description and justification of the survey measurements for impacted media
14.2.1 to 14.2.3	description of the field instruments and methods that were used for measuring concentrations and the sensitivities of those instruments and methods;
14.2.1 to 14.2.3	a description of the laboratory instruments and methods that were used for measuring concentrations and the sensitivities of those instruments and methods;
14.2.1 to 14.2.3	the survey results including tables or charts of the concentrations of residual radioactivity measured;
Figure 2-4 & 14.2.4	maps or drawings of the site, area, or building showing areas classified as non-impacted or impacted
14.7	justification for considering areas to be non-impacted;
14.2.4	a discussion of why the licensee considers the characterization survey to be adequate to demonstrate that it is unlikely that significant quantities of residual radioactivity have gone undetected;
14.2.1 to 14.2.3	for areas and surfaces that are inaccessible or not readily accessible, a discussion of how they were surveyed or why they did not need to be surveyed;
14.2.4 & 14.5	for sites, areas, or buildings with multiple radionuclides, a discussion justifying the ratios of radionuclides that will be assumed in the final status survey or an indication that no fixed ratio exists and each radionuclide will be measured separately.

REMEDIAL ACTION SUPPORT SURVEYS

14.3 & 14.9	a description of field screening methods and instrumentation;
Table 14-6	a demonstration that field screening should be capable of detecting residual radioactivity at the DCGL;

FINAL STATUS SURVEY DESIGN

14.4.2	a brief overview describing the final status survey design.
Figure 2-4 & 14.7	a description and map or drawing of impacted areas of the site, area, or building classified by residual radioactivity levels (Class 1, Class 2, or Class 3) and divided into survey units with an explanation of the basis for division into survey units.
14.6	a description of the background reference areas and materials, if they will be used, and a justification for their selection.
14.4.2.2	a summary of the statistical tests that will be used to evaluate the survey results,
14.9, 14.4.2.3, Table 14-7	a description of scanning instruments, methods, calibration, operational checks, coverage, and sensitivity for each media and radionuclide.
14.9, 14.4.2.3 & Table 14-7	for in-situ sample measurements made by field instruments, a description of the instruments, calibration, operational checks, sensitivity, and sampling methods with a demonstration that the instruments and methods have adequate sensitivity.
14-10	a description of the analytical instruments for measuring samples in the laboratory, calibration, sensitivity, and methods with a demonstration that the instruments and methods have adequate sensitivity;

14.10 a description of how the samples to be analyzed in the laboratory will be collected, controlled, and handled;

14.13.3 a description of the final status survey investigation levels and how they were determined

14.7.2 & 14.7.4 a summary of any significant additional residual radioactivity that was not accounted for during site characterization;

14.13.2 a summary of direct measurement results and/or soil concentration levels in units that are comparable to the DCGL and if data is used to estimate or update the survey unit;

14.12.2 & 14.13.2 a summary of the direct measurements or sample data used to both evaluate the success of remediation and to estimate the survey unit variance.

FINAL STATUS SURVEY REPORT

14.14 an overview of the results of the final status survey.

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

14.14 a description of the method by which the number of samples was determined for each survey unit;

14.14 a summary of the values used to determine the numbers of sample and a justification for these values;

14.14 the survey results for each survey unit include:

- ___ 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 for Class 1 and 2 survey units and random locations shown for Class 3 survey units and reference areas;
- ___ the measured sample concentrations;
- ___ the statistical evaluation of the measured concentrations;
- ___ judgmental and miscellaneous sample data sets reported separately from the 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 $DCGL_w$.
- ___ a statement that a given survey unit satisfied the $DCGL_w$ and the elevated measurement comparison if any sample points exceeded the $DCGL_w$.

14.14 a description of any changes in initial survey unit assumptions relative to the extent of residual radioactivity

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

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

FINANCIAL ASSURANCE

COST ESTIMATE

Table 15-1 a cost estimate that appears to be based on documented and reasonable assumptions;

CERTIFICATION STATEMENT

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

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

FINANCIAL MECHANISM

(Kaiser will prepare and submit financial cost estimates for remediation alternatives considered)

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

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

NA the financial assurance mechanism is an originally signed duplicate.

NA the wording of the financial assurance mechanism is identical to the recommended wording provided in Appendix F,

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

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

<u>RESTRICTED USE/ALTERNATE CRITERIA</u>

(This section not required unless Kaiser proposes a restricted release scenario)

RESTRICTED USE

ELIGIBILITY DEMONSTRATION

___ a demonstration that the benefits of dose reduction are less than the cost of doses, injuries and fatalities; or

___ a demonstration that the proposed residual radioactivity levels at the site are ALARA

INSTITUTIONAL CONTROLS

___ a description of the legally enforceable institutional control(s) and an explanation of how the institutional control is a legally enforceable mechanism;

___ a description of any detriments associated with the maintenance of the institutional control(s);

___ a description of the restrictions on present and future landowners;

___ a description of the entities enforcing, and their authority to enforce, the institutional control(s);

___ a discussion of the durability of the institutional control(s);

___ a description of the activities that the entity with the authority to enforce the institutional controls may undertake to enforce the institutional control(s)

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

___ a description of the duration of the institutional control(s), the basis for the duration, the conditions that will end the institutional control(s) and the activities that will be undertaken to end the institutional control(s);

___ a description of the plans for corrective actions that may be undertaken in the event the institutional control(s) fail; and

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

SITE MAINTENANCE & FINANCIAL ASSURANCE

___ a demonstration that an appropriately qualified entity has been provided to control and maintain the site;

___ a description of the site maintenance and control program and the basis for concluding that the program is adequate to control and maintain the site;

___ a description of the arrangement or contract with the entity charged with carrying out the actions necessary to maintain control at the site;

___ a demonstration that the contract or arrangement will remain in effect for as long as feasible, and include provisions for renewing or replacing the contract;

___ a description of the manner in which independent oversight of the entity charged with maintaining the site will be conducted and what entity will conduct the oversight;

- ___ a demonstration that the entity providing the oversight has the authority to replace the entity charged with maintaining the site;
- ___ a description of the authority granted to the third party to perform, or have performed, any necessary maintenance activities;
- ___ unless the entity is a government entity, a demonstration that the third party is not the entity holding the financial assurance mechanism;
- ___ a demonstration that sufficient records evidencing to official actions and financial payments made by the third party are open to public inspection;
- ___ a description of the periodic site inspections that will be performed by the third party, including the frequency of the inspections.
- ___ a copy of the financial assurance mechanism provided by the licensee or responsible party; and,
- ___ a demonstration that the amount of financial assurance provided is sufficient to allow an independent third party to carry out any necessary control and maintenance activities[2].

OBTAINING PUBLIC ADVICE

- ___ a description of how individuals and institutions that may be affected by the decommissioning were identified and informed of the opportunity to provide advice to the licensee or responsible party;
- ___ a description of the manner in which the licensee obtained advice from these individuals or institutions;
- ___ a description of how the licensee provided for participation by a broad cross-section of community interests in obtaining the advice;
- ___ a description of how the licensee provided for a comprehensive, collective discussion on the issues by the participants represented;
- ___ a copy of the publicly available summary of the results of discussions, including individual viewpoints of the participants on the issues and the extent of agreement and disagreement among the participants;
- ___ a description of how this summary has been made available to the public;
- ___ a description of how the licensee evaluated the advice, and the rationale for incorporating, or not incorporating, the advice from affected members of the community into the decommissioning plan.

DOSE MODELING AND ALARA DEMONSTRATION

- ___ a summary of the dose to the average member of the critical group when radionuclide levels are at the DCGL with institutional controls in place, as well as the estimated doses if they are no longer in place;
- ___ a summary of the evaluation performed pursuant to Section 7 of this SRP demonstrating that these doses are ALARA;
- ___ if the estimated dose to the average member of the critical group could exceed 100 mrem/yr (but would be less than 500 mrem/yr) when the radionuclide levels are at the DCGL, a demonstration that the criteria in 10 CFR 20.1403(e) have been met

ALTERNATE CRITERIA

____ a summary of the dose in TEDE(s) to the average member of the critical group when the radionuclide levels are at the DCGL (considering all man-made sources other than medical);
____ a summary of the evaluation performed pursuant to Section 7 of this SRP demonstrating that these doses are ALARA;
____ an analysis of all possible sources of exposure to radiation at the site and a discussion of why it is unlikely that the doses from all man-made sources, other than medical, will be more than 1 mSv/yr (100 mrem/yr);
____ a description of the legally enforceable institutional control(s) and an explanation of how the institutional control is a legally enforceable mechanism;
____ a description of any detriments associated with the maintenance of the institutional control(s);
____ a description of the restrictions on present and future landowners;
____ a description of the entities enforcing and their authority to enforce the institutional control(s);
____ a discussion of the durability of the institutional control(s);
____ a description of the activities that the party with the authority to enforce the institutional controls will undertake to enforce the institutional control(s)
____ a description of the manner in which the entity with the authority to enforce the institutional control(s) will be replaced if that entity is no longer willing or able to enforce the institutional control(s)
____ a description of the duration of the institutional control(s), the basis for the duration, the conditions that will end the institutional control(s) and the activities that will be undertaken to end the institutional control(s);
____ a description of the corrective actions that will be undertaken in the event the institutional control(s) fail; and
____ a description of the records pertaining to the institutional controls, how and where they will be maintained, and how the public will have access to the records.
____ a description of how individuals and institutions that may be affected by the decommissioning were identified and informed of the opportunity to provide advice to the licensee or responsible party;
____ a description of the manner in which the licensee obtained advice from affected individuals or institutions;
____ a description of how the licensee provided for participation by a broad cross-section of community interests in obtaining the advice;
____ a description of how the licensee provided for a comprehensive, collective discussion on the issues by the participants represented;
____ a copy of the publicly available summary of the results of discussions, including individual viewpoints of the participants on the issues and the extent of agreement and disagreement among the participants;
____ a description of how this summary has been made available to the public; and,

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

1.0 Executive Summary

A Decommissioning Plan (DP) has been prepared to describe remediation activities proposed for implementation at the pond parcel at Kaiser Aluminum & Chemical Corporation's (Kaiser) site located at 7311 East 41st Street in Tulsa, Oklahoma. Implementation of this plan will make the site suitable for unrestricted release. Surveys of potentially affected structures have found no contamination above background levels. 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. Moreover, this plan is based upon available information and existing conditions. Modifications to the DP may be made as new information becomes available and/or as dictated by practical engineering design and construction considerations. For example, additional site characterization activities are planned to investigate certain areas beneath structures on the property. If additional contamination is discovered, this plan will be amended to address the newly identified conditions. This and other possible changes in the DP that do not result in more than a minimal reduction in the protectiveness of the remedy will be documented and/or included in procedures developed to support plan implementation.

The subject facility, which was built by the Standard Magnesium Corporation (SMC) in the early to mid-1950s, currently is owned and operated by Kaiser, whose responsible corporate representative is located at 9141 Interline Avenue, Baton Rouge, Louisiana. Historical operations at the facility included the smelting and manufacture 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 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. 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 1977. Aluminum replaced magnesium (circa 1977) in smelting and anode manufacture, and the plant continued operating until the 1997-1998 time frame. 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.

As a result of smelting and manufacturing operations, a metallic dross generated as a waste product was conveyed to disposal ponds (retention and reserve ponds) located north of the manufacturing complex.

Some of the dross contained thorium. 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. Measured Th-232 concentrations ranged from 1 to 208 picocuries per gram (pCi/g). During the evaluation and screening of possible remediation alternatives, data from past characterization studies were used to develop isoconcentration maps to clarify spatial distribution of thorium levels in soils. Kriging, a geostatistical technique, was utilized to accomplish this purpose and to develop volume estimates.

Having developed an understanding of the spatial distribution of thorium, the RESRAD model was used to calculate a preliminary Derived Concentration Guideline Level ($DCGL_W$). The $DCGL_W$ (3 pCi/g) was calculated to correspond with the basic dose limit criterion of 25 millirem per year (mrem/yr). Derivation of the $DCGL_W$ incorporated the Unity Rule which assures that cumulative doses from Th-232, Th-230, and their daughter products do not result in a total dose that exceeds the basic dose limit. The $DCGL_W$ was used to develop a conservative (high) estimate of the volume of impacted soil potentially requiring remediation. This upper bound estimate did not take into account the presence of natural background or the impact of restoring the site to grade subsequent to remedial excavation. Upper bound estimates were utilized in initial screening evaluations.

The area to be remediated is a large portion of the 14-acre pond parcel located north of the railroad. This parcel is divided into three parts--the unaffected freshwater pond to the west (approximately 4 acres), the affected retention pond/reserve pond area to the east (approximately 9 acres), and the area containing the flux building and paved area (approximately 1 acre) which will be the subject of further investigation. The known affected area covers approximately 9 acres east of the freshwater pond embankment.

The area considered for remediation is bounded by the south fence line, the freshwater pond embankment on the west, Fulton Creek ditch on the north, the east fence line, and the northern and western edges of the flux building and paved area. A central feature of this area is the retention pond and associated embankments. This pond was the primary, but not exclusive, disposal site for dross generated during magnesium-refining operations. Another disposal area is the reserve pond in the northeast corner of the property. Thorium-containing dross was known to exist on land adjacent to the current Kaiser property along the east and south fence lines and represented the margins of the material. In accordance with a Nuclear Regulatory Commission- (NRC) approved remediation plan, Kaiser has remediated this land by excavating and storing the affected soil within the pond parcel. Affected soil generated during remediation of the adjacent land is considered as part of the pond parcel decommissioning.

The purpose of this DP is to decommission the facility safely and meet the NRC requirements for unrestricted use: residual radioactivity distinguishable from background will not result in a total effective dose equivalent (TEDE) to an average member of a critical group that exceeds 25 mrem/yr. In this DP, the critical group for evaluating unrestricted site release is the resident farmer. Additionally, implementation of the DP will reduce residual radioactivity to levels that are as low as reasonable achievable (ALARA).

The remediation alternative chosen for implementation involves excavation of affected material. Material with Th-232 concentrations greater than 31.1 pCi/g will be disposed off site as exempt material. Soil with lower concentrations of Th-232 will be returned to the excavation. The average Th-232 content of below-criteria soil is estimated to be 7 pCi/g. Clean soil obtained from an off-site source will be placed over the below-criteria fill and graded in a manner to direct drainage away from the site, after which the site will be revegetated.

A current version of the RESRAD computer code (Version 6.0) was used to conduct the dose evaluations. Deterministic simulations were performed that required the assignment of single-value inputs to each of the model parameters. Site-specific values were assigned to model input parameters to the extent possible. The primary critical group evaluated was the resident farmer. An alternative residential scenario that assumes gardening rather than farming also was evaluated.

A modified version of NRC's dual simulation approach was utilized for the residential scenarios such that dose contributions from water-independent and water-dependent pathways were modeled separately. Generally, NRC's dual simulation approach assumes that under the residential scenario, a house is constructed atop the cover over the subsurface affected zone. Excavation of the foundation to a depth of 3 meters (m) is assumed to penetrate the affected zone with some of it being brought to the surface, mixed with cover material, and spread over the ground. However, for this DP, engineering designs based on postremediation site regrading and the need for topographic relief results in a layer of clean soil backfill that exceeds the 3-m depth of the foundation; therefore, no intrusion into the affected zone occurs and, therefore, adaptation of the dual simulation approach to better describe expected site conditions was necessary. In accordance with NRC's approach, the modified dual simulation entails modeling of water-independent pathways (Dual Simulation 1) separate from water-dependent pathways (Dual Simulation 2);

however, Dual Simulation 1 is modified to account for gamma exposures both at the ground surface and from inside the basement.

Maximum total dose was used in reporting deterministic results in accordance with NUREG/CR-1727. For the resident farmer and gardener, doses of 0.276 and 0.261 mrem/yr were estimated respectively. Further analysis indicates that water-independent pathways (including both external gamma pathways) contributed negligibly to the total dose which is driven predominantly by drinking water ingestion of Th-230.

The remediation method that Kaiser will use to achieve the decommissioning goal is described in Chapters 5.0, 6.0, and 8.0 of this plan. As previously discussed, implementation results in off-site disposal of all material with Th-232 concentrations greater than 31.1 pCi/g as exempt material. This cutoff concentration was selected because (1) dose evaluations using the resident farmer as the critical group have demonstrated that the remaining average concentrations result in a dose significantly less than the 25 mrem/yr dose criteria established by NRC, and (2) the average concentration of material to be disposed off site will meet the definition of exempt material (less than 0.05 wt% thorium), thereby greatly reducing disposal costs.

An ALARA analysis was conducted which demonstrated that the planned action is ALARA in accordance with NUREG 1727 in that the removal of additional soils/material is not cost beneficial. The ALARA analysis was performed by comparing dose and cost of the planned action with the cost benefits of incremental soil removal to further reduce dose.

Kaiser anticipates completing some site modification activities prior to undertaking the decommis-sioning project described in this plan. Although not decommissioning activities, their completion prior to decommissioning has been assumed in preparation of this plan. The most significant modifications relate to closure of the freshwater pond, construction of an engineered channel to redirect storm water to Fulton Creek, and modification of the existing channel north of the retention pond.

During remediation, the site will be excavated to depths up to 15 to 20 feet and to an average depth estimated at 12 feet across most of the retention and reserve ponds. Excavation activities will not be conducted during winter months. Approximately 4,000,000 cubic feet (ft^3) of off-site soil will be used to backfill excavations. The thickness of clean fill will average 10 feet. The site will be graded and vegetated to minimize soil erosion and promote positive drainage.

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 back-filled as excavation occurs in other areas. Upon completion of all remediation activities, the stock-pile/processing area will be cleared to a 3 pCi/g Th-232 criterion.

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.

Kaiser is seeking approval of this DP to authorize the activities described herein and NRC concurrence that if this plan is implemented as described, it will result in the property being suitable for unrestricted use. However, this remediation plan is premised on current knowledge of site conditions, regulatory guidance, and disposal market factors. If unforeseen circumstances result in significant changes in the economics or feasibility of implementation of the proposed remedial action, Kaiser may find it necessary to reconsider other alternatives.

2.0 Facility Operating History

2.1 Licensing Number/Status/Authorized Activities

No licensed activities are currently conducted at this site, nor have any licensed activities been conducted at the site since 1971.

2.2 License History

The Kaiser plant in Tulsa, Oklahoma was built by the SMC in the early to mid-1950s to manufacture magnesium products. Kaiser purchased the facility in 1964. SMC received a source materials license (C-4012) from the AEC in March 1958 to receive possession and title to magnesium-thorium alloy with up to 4 percent thorium content for processing. The quantity of material SMC and later Kaiser were authorized to possess at one time was amended from time to time, but generally was limited to 30,000 pounds of magnesium-thorium alloy containing no more than 4 percent thorium. Scrap magnesium-thorium alloy was smelted along with other magnesium materials to recover the magnesium. Thorium alloy material comprised a small fraction of the total magnesium refined on site.

License C-4012 was superceded by License STB-472 in November 1961. License STB-472 was amended in June 1968 to add uranium to the list of authorized materials, but there is no record that uranium-bearing materials were ever received on site.

The AEC license was terminated in 1971 by the AEC at Kaiser's request. At the time, Kaiser stated that it had not processed magnesium-thorium alloy in the past year. After it stopped processing magnesium-thorium, Kaiser continued to process magnesium at the site until approximately 1977, when it shifted to fabrication of aluminum products.

Structures known to have been used to process thorium-bearing materials include the crusher and smelter. The smelter was demolished in October 2000, following completion of survey activities which indicated no contamination within the building. From about 1977 until plant shutdown, the crusher building was utilized for smelting aluminum. Instrument surveys indicate the absence of radioactive contamination.

A thoriated metallic "dross" residue material resulted from the smelting of the magnesium-thorium alloy. Dross was ground in the crusher building for a second magnesium recovery step and/or prior to disposal as a waste product. Waste dross was conveyed to disposal ponds (retention and reserve ponds) north of the manufacturing complex, as described below.

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.

2.3 Site Development and Utilization

Kaiser was not able to locate records showing the quantities and location of dross disposal. Aerial photographs documenting site development from the 1940s to 1991 have been presented and discussed elsewhere (A&M Engineering and Environmental Services, Inc. [A&M Engineering], July 1999; Roberts/Schornick & Associates [R/S&A], 1996). These images show prefacility (1940s to early 1950s) features consisting of the freshwater pond plus two smaller ponds immediately downstream in a low marshy area fed by ephemeral streams. Water drained from the freshwater pond through a pipe at the center of the embankment. An overflow spillway was located at the south end of the embankment dam, near the railroad right-of-way.

By 1950, the small downstream ponds had been merged into a single pond by constructing embankments along the east and north sides of the pond area. Water was released from this "east" pond through a ditch at the north side of the pond embankment, although a seepage area was identified at the east side of the pond. A December 1950 image indicates that the freshwater pond's spillway exited to the southeast and approached very close to the railroad right-of-way (within approximately 25 feet) before turning northeast toward the downstream ponds. By 1964, the freshwater pond flow had been diverted to an excavated ditch (now called Fulton Creek) at the north end of the embankment, constructed along the north edge of the pond parcel.

Magnesium-processing facilities constructed by SMC in the early to mid-1950s are shown in a July 1958 aerial photograph. This image shows a small operation that, in a subsequent October 1964 aerial photograph, was considerably changed and expanded. Utilization of the pond parcel is not evident in the July 1958 aerial photograph and there are no indications of construction, roads, or dumping in the pond area. Between the 1958 and 1964 images, a serious fire is reported to have occurred at the old smelter. It is unknown if the fire spread to other structures elsewhere on site. Newer site structures observed in the 1964 photograph may be the result of a rebuilding, plant growth, or a combination.

By October 1964, the pond parcel had been modified with the construction of the flux building and significant adjustments to the pond embankment. A large debris pile was present between the retention pond and the railroad embankment. Changes to the east fence line suggest that approximately 3.5 acres of land along the east property line had been sold and commercial-industrial buildings constructed on what have since become known as the Specific Systems and Red Man Pipe and Supply Co. (Red Man) properties to the east. A 1965 photograph indicates that part of the 3.5 acres was reacquired and the reserve pond constructed on this land. In addition, the eastern property line, shared with Specific Systems, had been moved to the west, and the land paved over into a parking/loading area. This resulted in a westward shift of the retention pond embankment by about 40 to 50 feet.

By September 1965, much of the debris area had been regraded, the retention pond boundaries expanded to the north, the reserve pond constructed, and a paved area established west of the flux building. In addition, a series of new industrial-commercial buildings was being added northeast of the pond parcel. By 1972, the reserve pond was being backfilled. New or modified plant structures appeared at and adjacent to the crusher in the 1979 photograph. Continued development was evident around the site in 1979 with the influx of light industrial and commercial facilities. By 1990, all adjacent land had been developed.

Disposal of dross to the retention and reserve ponds was accomplished by hauling material to the parcel and dumping into the ponds. The ponds also received cooling water from plant operations south of the railroad. It appears that other low spots in this parcel also received waste material including the spillway area adjacent to the railroad right-of-way. Distribution of dross deeper in the subsurface correlates reasonably well with the older pond limits. The thorium concentration for on-site material ranges from approximately 2 pCi/g to 416 pCi/g for Th-232 + Th-228. Figure 2-1, Site Plan, illustrates the historical lay out of the plant as well as the pond areas and adjacent properties.

2.4 Previous Decommissioning Activities

Over time, certain portions of the original SMC property were transferred to other entities. Consequently, some contamination existed on property adjacent to current Kaiser property boundaries. The NRC detected surface contamination around the site in 1993 and subsequently in off-site areas adjacent to the pond parcel. Although no human health risk was reported from either on-site or off-site contamination, the retention pond area was placed on the NRC's Site Decommissioning Management Plan. Characterizations of the pond area and areas adjacent to the south and east property boundaries subsequently were performed in accordance with procedures described in NUREG/CR-5849. Predecommissioning conditions of the adjacent land property are summarized in reports by ADA Consultants, Inc. (ADA), March 1999; ADA, undated; B. Koh & Associates, Inc. (B. Koh), May 1998; and B. Koh, November 1999; and depicted in Figure 2-2.

Kaiser prepared and submitted to the NRC an Adjacent Land Remediation Plan. This plan was approved by the NRC on April 4, 2000. Kaiser conducted off-site remediation activities from October 2000 through May 2001. Contamination of the adjacent properties was found to occur at the ground surface and to reach depths of up to 15 feet. The extent of the contamination was limited to the following properties: Union Pacific Railroad right-of-way, northwest corner of Specific Systems (formerly Unarco) property, along Fulton Creek on the Beejay, Inc. property, north of the north extrusion building, north of the Smalley Equipment property, and adjacent to the Red Man (formerly Premier) property. Contamination also was found along the north side of East 41st Street, between the roadway and the Kaiser building. In addition, contamination was found south of Kaiser's flux building, outside the retention pond property fence, and on Kaiser property between the building and the Union Pacific Railroad property. Remediation was performed in these areas to achieve unrestricted release of the adjacent land areas. Affected material primarily was soil and contaminated dross but included some paving materials, underground pipes, and buried scrap.

During the course of the adjacent land remediation project, a buried spillway structure was uncovered southwest of the retention pond (Figure 2-3). Although this lies primarily on the pond parcel, its southern extremity extends onto the Union Pacific Railroad right-of-way. Decommissioning of the entire buried structure will be included in the current decommissioning effort.

The off-site thorium material ranged from less than minimum detectable activity to 728 pCi/g of Th-232 + Th-228. The average activity computed from the ADA data for adjacent area soil cores with Th-232 + Th-228 content over 2.2 pCi/g (background) was 39.2 pCi/g.

Field surveys were performed to guide remediation activities that, in this case, primarily involved excavating affected soil and moving it onto Kaiser's property. A final status survey was performed following completion of remediation/excavation in each discrete affected survey grid to demonstrate that radiological conditions satisfy criteria for unrestricted release. Following successful remediation, excavations were backfilled.

As of this writing, the Final Status Survey Report is in preparation and, when complete, will be filed with the NRC. The extent of the remediation activities completed on adjacent properties is depicted in Figure 2-4 which is an updated map of the actual areas that were excavated.

2.5 Spills

No spills or uncontrolled releases of chemical or radiological materials are known to have occurred at the site.

2.6 Prior On-Site Burials

The large majority of dross disposed on site is expected to be limited to the retention and reserve ponds. Material was placed in these areas by hauling to the parcel and dumping into the ponds. The ponds also received cooling water from plant operations south of the railroad. It appears that other low spots in this parcel also received waste material including the spillway area adjacent to the railroad right-of-way. Distribution of dross deeper in the subsurface correlates reasonably well with the older pond limits. Concentrations of thorium in the on-site material were calculated using both on-site and off-site data. On-site concentrations have been calculated by kriging, using data generated by Advanced Recovery Systems (ARS) (1995). The thorium concentration for on-site material ranges from approximately 2 pCi/g to 416 pCi/g for Th-232 + Th-228. Figure 2-3 illustrates the boundaries of the two ponds.

Recent aerial photograph interpretations together with observations made during the adjacent land remediations suggest that thorium-bearing material may exist under certain areas of buildings as well as some concrete-covered areas. Such conditions have not been confirmed at this point and the extent of the possible contamination is uncertain. Additional characterization activities are planned to investigate these areas. Upon completion of the additional characterization, the DP will be amended, as appropriate. A complete listing of these areas can be found in Chapter 4.0 of this document.

References

1. ADA Consultants, Inc., March 1999, Adjacent Land Characterization, Kaiser Aluminum Specialty Products, Appendix A, Estimate of Volume of Off-Site Contaminated Soil, Adjacent Land Characterization Report, Baton Rouge, Louisiana.

2. ADA Consultants, Inc., Addendum to Adjacent Land Characterization, Baton Rouge, Louisiana.

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

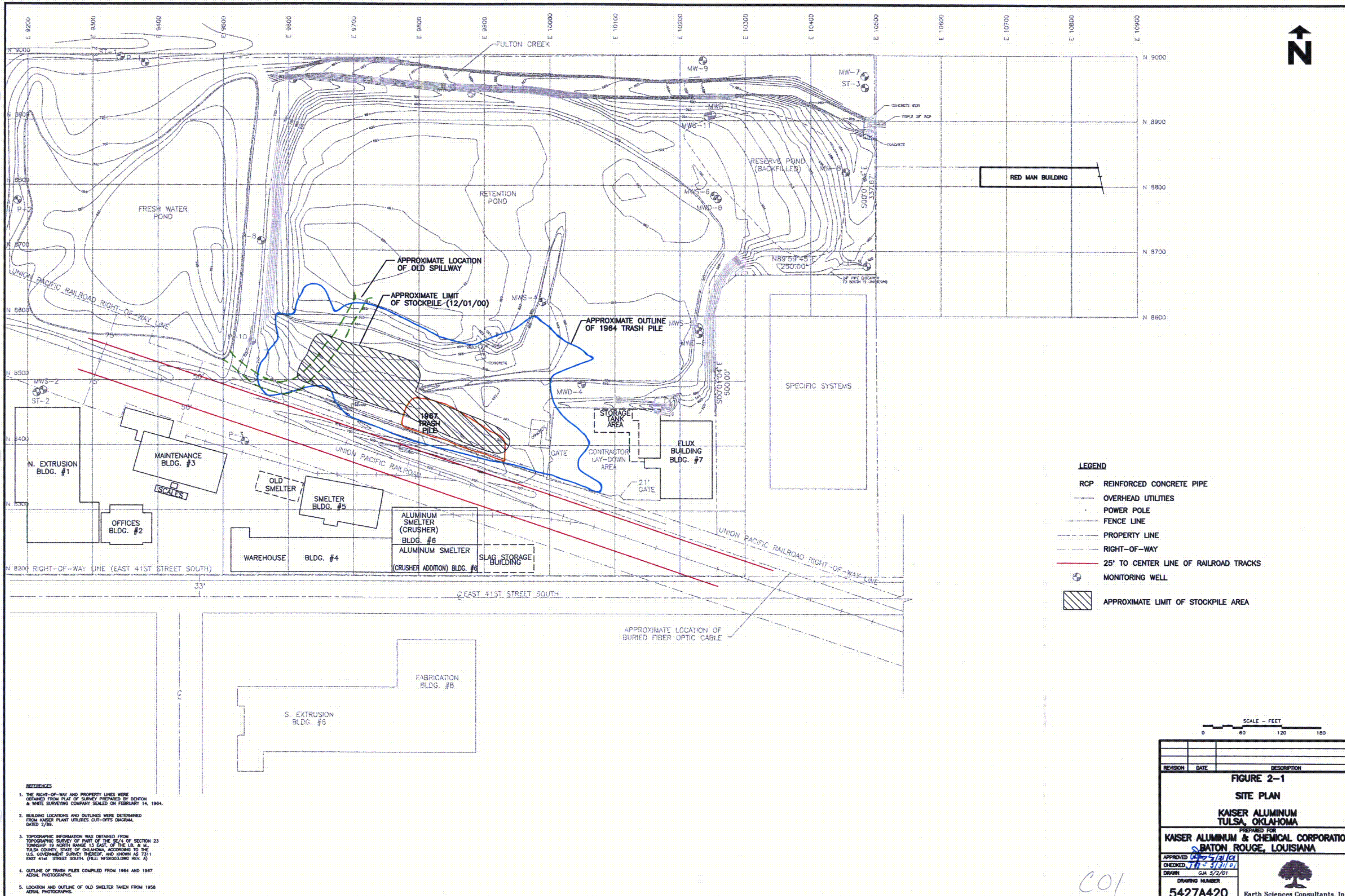
4. A&M Engineering and Environmental Services, Inc., July 1999, Hydrologic and Geologic Investigation, Kaiser Aluminum Specialty Products, Tulsa, Oklahoma.

5. B. Koh & Associates, Inc., May 1998, Characterization Survey, Kaiser Aluminum & Chemical Corporation, Tulsa, Oklahoma, Revision 0.

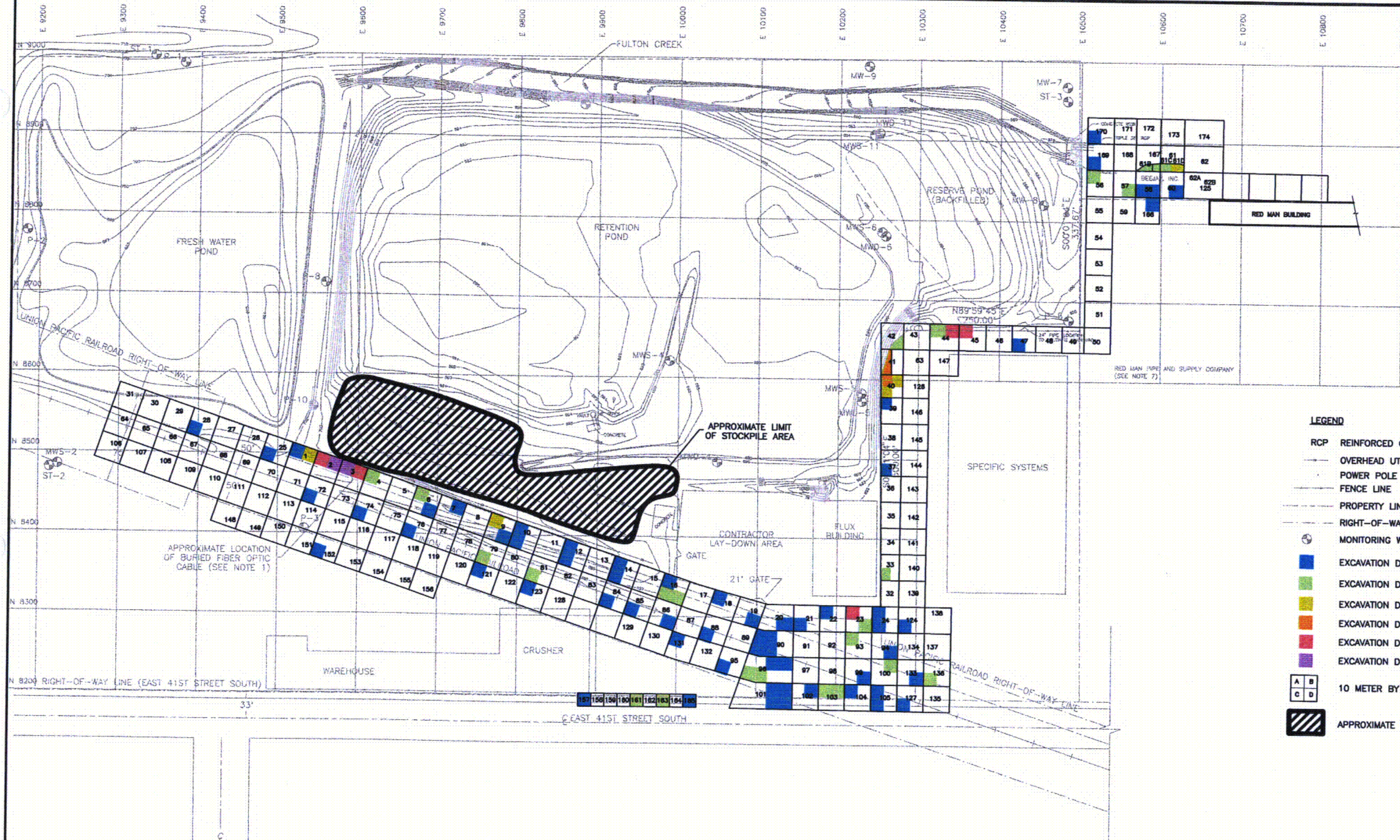
6. B. Koh & Associates, Inc., November 1999, Supplementary Radiological Characterization Survey, Kaiser Aluminum & Chemical Corporation, Tulsa, Oklahoma, Revision 1.

7. NUREG/CR-5849, Manual for Conducting Radiological Surveys in Support of License Termination (June 1992).

8. Roberts/Schornick & Associates, March 20, 1996, Local and Regional Environmental Data Report, Kaiser Aluminum Specialty Products, Tulsa, Oklahoma.



N
FULTON CREEK
MW-9
MW-7
ST-3
MWD-11
MWS-11
RESERVE POND (BACKFILLED)
RED MAN BUILDING
FRESH WATER POND
RETENTION POND
MWS-6
MWD-6
N89°59'45"E 250.00'
S00°00'00"E 337.67'
APPROXIMATE LOCATION OF OLD SPILLWAY
APPROXIMATE LIMIT OF STOCKPILE (12/01/00)
APPROXIMATE OUTLINE OF 1964 TRASH PILE
MWS-4
MWS-2
ST-2
MWD-4
S00°00'04"E 500.00'
SPECIFIC SYSTEMS
UNION PACIFIC RAILROAD RIGHT-OF-WAY LINE
1967 TRASH PILE
STORAGE TANK AREA
CONTRACTOR LAY-DOWN AREA
GATE
21' GATE
FLUX BUILDING BLDG. #7
N. EXTRUSION BLDG. #1
MAINTENANCE BLDG. #3
SCALES
P-3
UNION PACIFIC RAILROAD
OLD SMELTER
SMELTER BLDG. #5
OFFICES BLDG. #2
ALUMINUM SMELTER (CRUSHER) BLDG. #6
ALUMINUM SMELTER (CRUSHER ADDITION) BLDG. #6
WAREHOUSE BLDG. #4
SLAG STORAGE BUILDING
RIGHT-OF-WAY LINE (EAST 41ST STREET SOUTH)
33'
EAST 41ST STREET SOUTH
UNION PACIFIC RAILROAD RIGHT-OF-WAY LINE
APPROXIMATE LOCATION OF BURIED FIBER OPTIC CABLE
FABRICATION BLDG. #8
S. EXTRUSION BLDG. #8
LEGEND
RCP REINFORCED CONCRETE PIPE
OVERHEAD UTILITIES
POWER POLE
FENCE LINE
PROPERTY LINE
RIGHT-OF-WAY
25' TO CENTER LINE OF RAILROAD TRACKS
MONITORING WELL
APPROXIMATE LIMIT OF STOCKPILE AREA
REFERENCES
1. THE RIGHT-OF-WAY AND PROPERTY LINES WERE OBTAINED FROM PLAT OF SURVEY PREPARED BY DENTON & WHITE SURVEYING COMPANY SEALED ON FEBRUARY 14, 1964.
2. BUILDING LOCATIONS AND OUTLINES WERE DETERMINED FROM KAISER PLANT UTILITIES CUT-OFFS DIAGRAM, DATED 2/89.
3. TOPOGRAPHIC INFORMATION WAS OBTAINED FROM TOPOGRAPHIC SURVEY OF PART OF THE SE/4 OF SECTION 23 TOWNSHIP 19 NORTH RANGE 13 EAST, OF THE I.B. & M., TULSA COUNTY, STATE OF OKLAHOMA, ACCORDING TO THE U.S. GOVERNMENT SURVEY THEREOF, AND KNOWN AS 7311 EAST 41st STREET SOUTH. (FILE: NFSK003.DWG REV. A)
4. OUTLINE OF TRASH PILES COMPILED FROM 1964 AND 1967 AERIAL PHOTOGRAPHS.
5. LOCATION AND OUTLINE OF OLD SMELTER TAKEN FROM 1958 AERIAL PHOTOGRAPHS.
SCALE - FEET
0 60 120 180
REVISION DATE DESCRIPTION
FIGURE 2-1
SITE PLAN
KAISER ALUMINUM
TULSA, OKLAHOMA
PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA
APPROVED 5/31/01
CHECKED JH 5/31/01
DRAWN GJA 5/2/01
DRAWING NUMBER
5427A420
Earth Sciences Consultants, Inc.
C01



LEGEND

RCP	REINFORCED CONCRETE PIPE
	OVERHEAD UTILITIES
	POWER POLE
	FENCE LINE
	PROPERTY LINE
	RIGHT-OF-WAY
	MONITORING WELL
	EXCAVATION DEPTH 0 TO 2 FEET (SEE NOTE 6)
	EXCAVATION DEPTH 2 TO 4 FEET (SEE NOTE 6)
	EXCAVATION DEPTH 4 TO 6 FEET (SEE NOTE 6)
	EXCAVATION DEPTH 6 TO 8 FEET (SEE NOTE 6)
	EXCAVATION DEPTH 8 TO 10 FEET (SEE NOTE 6)
	EXCAVATION DEPTH 10 TO 15 FEET (SEE NOTE 6)
A B / C D	10 METER BY 10 METER GRID (SEE NOTE 5)
	APPROXIMATE LIMIT OF STOCKPILE AREA

REFERENCES

1. THE RIGHT-OF-WAY AND PROPERTY LINES WERE OBTAINED FROM PLAT OF SURVEY PREPARED BY DENTON & WHITE SURVEYING COMPANY SEALED ON FEBRUARY 14, 1964.
2. TOPOGRAPHIC INFORMATION WAS OBTAINED FROM TOPOGRAPHIC SURVEY OF PART OF THE SE/4 OF SECTION 23 TOWNSHIP 19 NORTH RANGE 13 EAST, OF THE I.B. & M., TULSA COUNTY, STATE OF OKLAHOMA, ACCORDING TO THE U.S. GOVERNMENT SURVEY THEREOF, AND KNOWN AS 7311 EAST 41st STREET SOUTH. (FILE: NFSK003.DWG REV. A)

NOTES

1. SPRINT FIBER OPTIC CABLE IS LOCATED UNDERGROUND. THE LOCATION HAS BEEN FLAGGED AND SPRAY PAINTED ORANGE. FOR ADDITIONAL INFORMATION CALL 1-800-521-0579.
2. INFORMATION SHOWN MAY NOT BE COMPLETE. THE CONTRACTOR IS RESPONSIBLE FOR VERIFYING THE LOCATION OF ALL UTILITIES (ABOVE GROUND AND BELOW GROUND) AND OTHER INTERFERENCES WHICH MAY AFFECT THE WORK.
3. THE CONTRACTOR SHALL PAY FOR ALL COSTS TO REPAIR OR TO REPLACE MONITORING WELLS DAMAGED DURING REMEDIATION.
4. THE EXCAVATION DEPTHS SHOWN WERE OBTAINED BASED ON INFORMATION PRESENTED IN SECTION 1.3 OF THE PERFORMANCE SPECIFICATIONS.
5. SURVEY DATA FOR 10 METER BY 10 METER GRIDS CAN BE OBTAINED FROM APPENDIX E OF THE PERFORMANCE SPECIFICATIONS. LOCATIONS FOR GRIDS 157-165 ARE APPROXIMATE AND REQUIRE FIELD VERIFICATION.
6. REFER TO TABLE 1 OF THE PERFORMANCE SPECIFICATIONS FOR SPECIFIC QUARTER-GRID CONTAMINATION DEPTHS.
7. THE CONTRACTOR SHALL REFER TO SECTION 6.8 OF THE PERFORMANCE SPECIFICATIONS FOR COMPACTION SPECIFICATIONS FOR THE RED MAN PROPERTY. THE CONTRACTOR SHALL RESTORE DISTURBED SURFACES TO AT LEAST THEIR ORIGINAL LOAD BEARING CAPACITY DUE TO OPERATION OF HEAVY EQUIPMENT BY THE OWNER.

SCALE - FEET
0 60 120 180

REVISION	DATE	DESCRIPTION

FIGURE 2-2
REMEDIATION PLAN
ADJACENT LAND AREA REMEDIATION
KAISER ALUMINUM
TULSA, OKLAHOMA

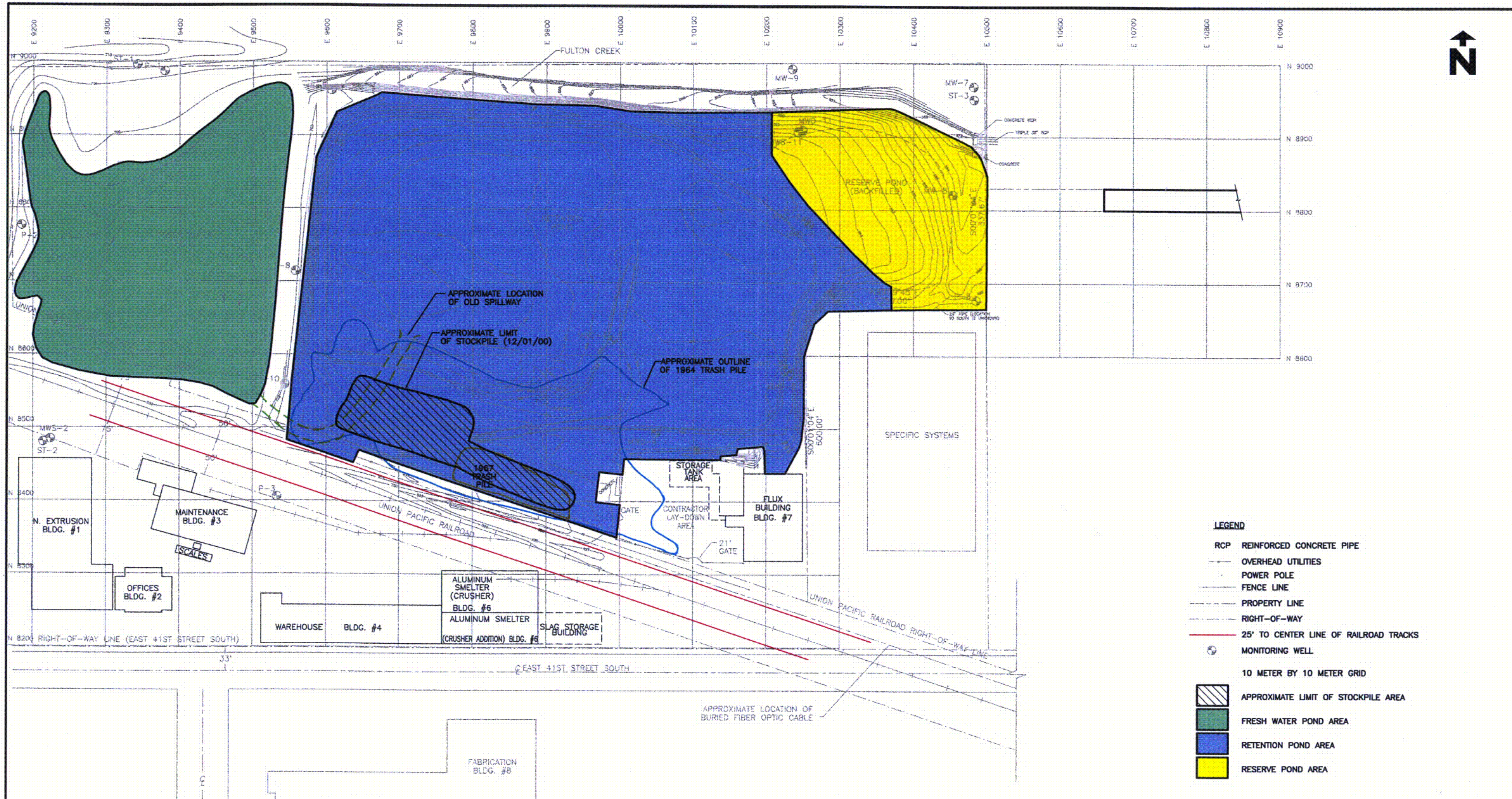
PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

APPROVED 5/21/01
CHECKED 5/31/01
DRAWN

DRAWING NUMBER
5427A402

Earth Sciences Consultants, Inc.

C02



SCALE – FEET
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REFERENCES

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

2. BUILDING LOCATIONS AND OUTLINES WERE DETERMINED FROM KAISER PLANT UTILITIES CUT-OFFS DIAGRAM, DATED 2/89.

3. TOPOGRAPHIC INFORMATION WAS OBTAINED FROM TOPOGRAPHIC SURVEY OF PART OF THE SE/4 OF SECTION 23 TOWNSHIP 19 NORTH RANGE 13 EAST, OF THE I.B. & M., TULSA COUNTY, STATE OF OKLAHOMA, ACCORDING TO THE U.S. GOVERNMENT SURVEY THEREOF, AND KNOWN AS 7311 EAST 41st STREET SOUTH. (FILE: NFSK003.DWG REV. A)

4. OUTLINE OF TRASH PILES COMPILED FROM 1964 AND 1967 AERIAL PHOTOGRAPHS.

5. LOCATION AND OUTLINE OF OLD SMELTER TAKEN FROM 1958 AERIAL PHOTOGRAPHS.

REVISION	DATE	DESCRIPTION

FIGURE 2-3

APPROXIMATE AREA OF POND LOCATIONS

KAISER ALUMINUM
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

APPROVED 5/21/01
CHECKED 5/3/01
DRAWN GJA 5/2/01
DRAWING NUMBER 5427A421

Earth Sciences Consultants, Inc.

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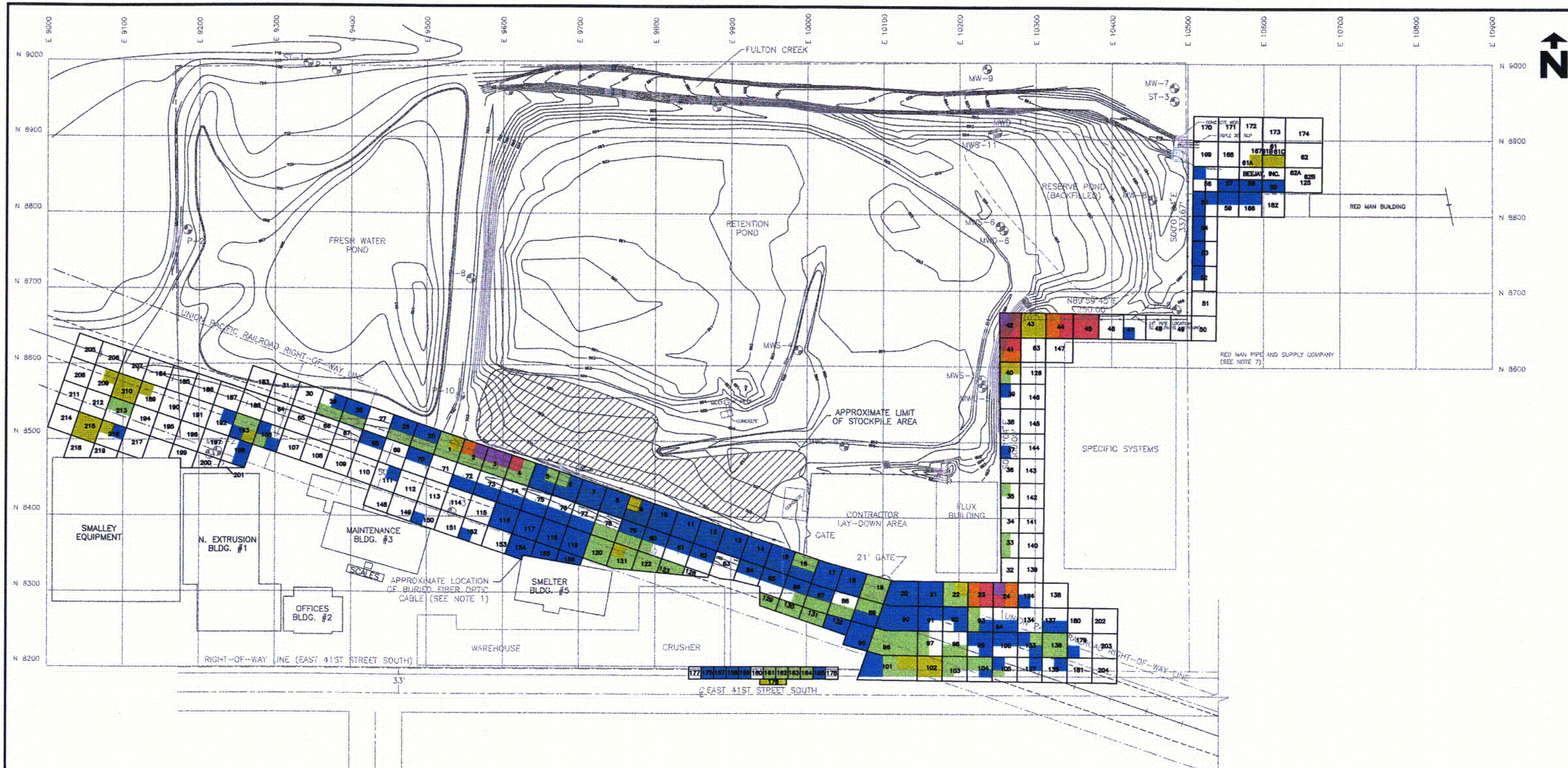


LEGEND

RCP REINFORCED CONCRETE PIPE

OVERHEAD UTILITIES

POWER POLE

MONITORING WELL

FENCE LINE

PROPERTY LINE

RIGHT-OF-WAY

25' OFFSET OF RAILROAD CENTER LINE

SURVEY UNIT BOUNDARY

A B / C D 10 METER BY 10 METER GRID (SEE NOTE 5)

APPROXIMATE LIMIT OF STOCKPILE AREA

EXCAVATION DEPTH 0 TO 2 FEET (SEE NOTE 6)

EXCAVATION DEPTH 2 TO 4 FEET (SEE NOTE 6)

EXCAVATION DEPTH 4 TO 6 FEET (SEE NOTE 6)

EXCAVATION DEPTH 6 TO 8 FEET (SEE NOTE 6)

EXCAVATION DEPTH 8 TO 10 FEET (SEE NOTE 6)

EXCAVATION DEPTH 10 TO 15 FEET (SEE NOTE 6)

REFERENCES

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

2. TOPOGRAPHIC INFORMATION WAS OBTAINED FROM TOPOGRAPHIC SURVEY OF PART OF THE SE/4 OF SECTION 23 TOWNSHIP 19 NORTH RANGE 13 EAST, OF THE I.B. & M., TULSA COUNTY, STATE OF OKLAHOMA, ACCORDING TO THE U.S. GOVERNMENT SURVEY THEREOF, AND KNOWN AS 7311 EAST 41st STREET SOUTH. (FILE: NFSK003.DWG REV. A)

SCALE - FEET
0 60 120 180

REVISION	DATE	DESCRIPTION

FIGURE 2-4
APPROXIMATE EXCAVATION EXTENT
ADJACENT LAND AREA REMEDIATION
KAISER ALUMINUM
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

APPROVED [illegible] 5/31/01
CHECKED TRS 5/31/01
DRAWN GJK 4/13/01
DRAWING NUMBER
5427A417

Earth Sciences Consultants, Inc.

C04

3.0 Facility Description

3.1 Site Location and Description

The Kaiser facility is located at 7311 East 41st Street in Tulsa, Oklahoma. It is situated in Tulsa County, Oklahoma, about 5 miles southeast of the downtown center of the City of Tulsa. The site initially occupied approximately 23 acres of land on both sides of 41st Street (Figure 3-1). Currently, a 3-acre parcel south of 41st Street contains an active extrusion and fabrication facility. North of East 41st Street are several parcels of land previously devoted to refining, processing, and waste disposal functions. This acreage is split by the Union Pacific Railroad right-of-way. An approximate 4-acre parcel south of the railroad houses inactive crusher, smelter, packaging, and warehouse facilities and active office space. An approximate 14-acre pond parcel north of the railroad contains a retention pond, the flux building, a freshwater pond, and a segment of Fulton Creek (Figure 2-1). Some acreage along the east side of the pond parcel was sold to others in the 1960s before Kaiser purchased the facility.

The area to be remediated is a large portion of the 14-acre pond parcel located north of the railroad. This parcel is divided into three parts--the unaffected freshwater pond to the west (approximately 4 acres), the affected retention pond/reserve pond area to the east (approximately 9 acres), and the area containing the flux building and paved area (approximately 1 acre) which current plans do not address (Figure 2-4). The known affected area covers approximately 9 acres east of the freshwater pond embankment.

The area considered for remediation is bounded by the south fence line, the freshwater pond embankment on the west, Fulton Creek ditch on the north, the east fence line, and the northern and western edges of the flux building and paved area. A central feature of this area is the retention pond and associated embankments. This pond was the primary, but not exclusive, disposal site for dross generated during magnesium-refining operations. Another affected area is the reserve pond in the northeast corner of the property. Thorium-bearing dross was present on land adjacent to current Kaiser property along the east and south fence lines and represented the margins of the material. Kaiser has remediated this land by excavation and storing affected soil within the pond parcel. Affected soil generated during remediation of the adjacent land is considered as part of the on-site decommissioning.

The site is located in the Northwest Oklahoma Cherokee Platform Physiographic Province which is a region with low relief. Originally, the site topography ranged from elevations above 710 feet above mean sea level (MSL) south of the tracks to below 690 feet at the retention pond and below 680 feet at the reserve pond. The current topography range of the site has not changed from the original calculations. This is illustrated in Figure 2-1, Site Plan.

3.2 Population Distribution

The Kaiser facility is located within the corporate limits of the City of Tulsa which is the second largest metropolitan area in the State of Oklahoma. In 1993, Tulsa had a population of 384,397. Population within the County of Tulsa was 526,410 in 1993.

In March 1996, demographic and population features were evaluated within an area defined by a square measuring 4 kilometers on each side (Area) with the facility at the center (R/S&A, March 20, 1996). This Area encompasses a radius of approximately 3 kilometers. Population information from the United States Census Bureau for the year 1990 was obtained for the applicable census tracts and block groups within the Area. In 1990, a total of 23,929 persons were living in residential structures within the Area. Additionally, approximately 3,473 business entities were in operation within the Area.

3.3 Current/Future Land Use

Figure 3-2 is a 1995 aerial photograph depicting current land uses within the area. Figure 3-3 provides a current zoning map of the facility and areas of interest. As shown, the facility actually lies within two separate zones--Industrial Moderate District (the area between the railroad and East 41st Street) and Industrial Light District (the area north of the railroad).

Zoning within the vicinity of the plant is not expected to change. Therefore, future use of the site is expected to be restricted to commercial or light industrial use.

3.4 Meteorology and Climatology

Meteorological and climatological data for the facility were obtained from the Oklahoma Climatological Survey and the National Climate Data Center. A general description of Tulsa's climate follows.

The City of Tulsa lies along the Arkansas River at an elevation of about 700 feet above sea level. The surrounding terrain is gently rolling.

Latitude 36°, Tulsa is far enough north to escape long periods of heat in summer, yet far enough south to miss extreme winter cold. The influence of warm moist air from the Gulf of Mexico is often noted, due to the high humidity, but the climate is essentially continental, characterized by rapid changes in temperature. Generally, winter months are mild. Temperatures occasionally fall below 0°F, but last for a very short time. Temperatures of 100°F or higher often are experienced from late July to early September, but usually are accompanied by low relative humidity and a good southerly breeze. The fall season is long with a great number of pleasant sunny days and cool nights.

Rainfall is ample for most agricultural pursuits and is distributed favorably throughout the year. Spring is the wettest season, having an abundance of rain in the form of showers and thunderstorms. The steady rains of fall are a contrast to the spring and summer showers and provide a good supply of moisture and good conditions for growth of winter grains and pastures. The greatest amounts of snow are received in January and early March. Snow usually is light and remains on the ground only for brief periods.

The average date of the last 32°F temperature occurrence is late March and the average date of the first 32°F occurrence is early November. The average growing season is 216 days.

The Tulsa area occasionally is subjected to large hail and violent windstorms that occur mostly during spring and early summer, although occurrences have been noted throughout the year. Prevailing surface winds are southerly during most of the year. Heavy fogs are infrequent. Sunshine is abundant.

3.4.1 Wind

The predominant wind direction is from the south. The prevailing monthly wind speed varies from 9 to 12 knots. The highest 1-minute sustained wind speed was 52 miles per hour (mph). This occurred in April 1982. The highest peak gust was 70 mph recorded in June 1992.

3.4.2 Temperature

Average annual temperature for the years 1948 through 1990 was 61°F. The daily average temperature varies from 83°F in July to 36°F in January. Monthly extremes vary from minus 8°F in December to 112°F in July.

3.4.3 Precipitation

Average annual precipitation is 38.9 inches of rainfall. The wettest year recorded during the period 1948 through 1990 was 69.9 inches of rainfall, while the driest year received 23.2 inches. May is the wettest month with an average of 5.6 inches of precipitation, while January is the driest month with an average of 1.6 inches of precipitation.

Storm events have an average duration of 9.2 hours. There is an average of 48 storm events per year. The average storm produces 0.744 inch of rainfall at an intensity of 0.11 inch per hour.

Annual snowfall averages 10 inches. Monthly snowfall exceeding 0.5 inch occurs in November, December, January, February, and March. Trace amounts (less than 0.5 inch and greater than 0.05 inch) occur in October and April. The remaining months typically are void of snowfall. Figure 3-4 depicts the monthly average snowfall for the years 1948 through 1990.

3.4.4 Relative Humidity

The average annual morning and afternoon relative humidities compiled from readings taken at 0600 hours and 1500 hours for the years 1948 through 1990 are 81 percent and 49 percent respectively. Monthly averages vary from 85 percent in May, June, and September to 46 percent in April, August, and October.

3.4.5 Evapotranspiration

Average monthly potential evapotranspiration varies from 3 millimeters (mm) in January to 188 mm in July. During the months of February through May, the soil is at its maximum water-holding capacity and precipitation exceeds evapotranspiration. Therefore, a water surplus occurs during these 4 months.

During the June through September time frame, potential evapotranspiration exceeds actual evapotranspiration. This is due to the soil moisture content being below its maximum storage capacity, thereby limiting the water uptake of the vegetation. The amount of moisture removed from the soil by the vegetation during this time frame is dependent upon the ratio of the actual soil moisture content to the potential soil moisture content. In other words, actual evapotranspiration equals potential evapotranspiration, multiplied by the ratio of actual soil moisture content to potential soil moisture content. This exceedance of potential evapotranspiration to actual evapotranspiration results in a water deficit during June through September.

3.5 National Ambient Air Quality Standards Category

The U.S. Environmental Protection Agency (USEPA) Office of Air Quality Planning and Standards (OAQPS) is responsible for the development of the National Ambient Air Quality Standards (NAAQS). The NAAQS sets standards for six criteria pollutants: Carbon monoxide, nitrogen dioxide, ozone, lead, particulate (both PM 2.5 and PM 10), and sulfur dioxide. The OAQPS has three classifications of areas as follows:

1. Attainment Areas – Areas in which the concentrations of each of the six criteria pollutants do not exceed the standards established by the OAQPS.

2. Nonattainment Areas – Areas in which the concentrations of each of the six criteria pollutants do exceed the standards established by the OAQPS.

3. Maintenance Areas – Areas which have previously been designated by the OAQPS as Nonattainment, but which have improved and are currently considered Attainment.

No Nonattainment or Maintenance areas are located in the State of Oklahoma. The nearest Nonattainment area to the facility is located in Arcadia, Iron County, Missouri which is approximately 400 miles northeast of the facility.

3.6 Geology and Seismology

3.6.1 Geology

In general, the site is underlain by Quaternary Age alluvial soil deposits. A large portion of the rocks that outcrop in northeastern Oklahoma are Pennsylvanian in age. The Pennsylvanian System is divided into five major series. These series, in descending order, are as follows:

- Virgilian Series (youngest rocks)
- Missourian Series
- Desmoinesian Series
- Atokan Series
- Morrowan Series (oldest rocks)

Figure 3-5 illustrates the general west-to-east cross section for Tulsa County.

Areal geology features a bedrock of mostly flatlying soft shales, interbedded with thin resistant beds of limestone and sandstone. The Kaiser retention pond parcel is located in an area overlying a buried stream valley filled with recently deposited sediments. Borehole data indicate that the pond parcel is situated over a series of stream-deposited clayey silty sands that directly overlie the Nowata Shale bedrock. In turn, the sand units are covered by silty to sandy clays which, together with clayey fill material, form the surface features of the site. The shale bedrock, which underlies much of the area, has been eroded along the original valley axis to average depths of 15 to 20 feet and locally to depths of 25 to 30 feet. Clay and silt sediments have some peat content, and localized thick organic peaty silt (Unit 4, A&M Engineering, July 1999) deposits are known from boreholes across the northern part of the retention pond.

The clay to silt sand unit (Unit 1) is a stream channel fill that ranges from 0 to 10 feet in thickness with the thickest areas under the east end of the retention pond. The silt to sandy clay unit (Unit 2) ranges from 5 to 15 feet in thickness with the thickest section under the freshwater pond. Along the axis of the stream valley, the top of the clayey sand layer is at a near-uniform elevation of 682 feet (ground elevation on the retention pond peninsula is approximately 696 feet) with changes in thickness due to fill in previously existing topography on the eroded shale. The silt clay unit directly overlies the sand and reaches an elevation of 692 feet. Fill (Unit 3) and dross (Unit 5) fill in low spots on this unit. Dross is present in deposits that range in thickness from inches to 10 plus feet. This dross material possesses a characteristic metallic gray color in sand to gravel particle sizes when found in sediments and was described as sludge by ARS (1995) when found in pond-bottom sediments.

Geologic and borehole log descriptions indicate that the dross, clay, and sand units possess little shear strength. The dross, when saturated with groundwater as exists under ponded water conditions, has little mechanical strength. The dross has been observed to run into drilled boreholes within or adjacent to the retention pond. Hammer blow counts for the soil surrounding and underlying the dross generally are low, in single digits, indicating minimal shear strength. Reasonable bearing strength is found in the shale bedrock and, to a lesser degree, in the clayey sands. Particle-size distributions for sand units indicate generally well-sorted sand with 5 to 20 percent fines and less than 10 percent gravel. For the clay units, more than 45 percent of the material passes the No. 200 sieve; the sand fraction composes another 40 to 45 percent of the sediment. Atterberg tests on the fines indicate a low- to medium-plasticity clay. More details on site geotechnical properties are presented in the Geotechnical Brief (Earth Sciences, 2000).

3.6.2 Regional Geologic Structures and Tectonics

The geologic and tectonic history of Oklahoma is basically characterized by marine sedimentation, which periodically was interrupted by episodes of uplift, gentle folding, and erosion, which was followed subsequently by renewed sedimentation.

Tulsa County is located in the eastcentral portion of the northeastern Oklahoma Cherokee Platform. The Oklahoma Cherokee Platform is bounded on the east by the Ozark Uplift, on the west by the Nemaha Uplift, on the south by the Arbuckle Uplift, and on the southeast by the Arkoma Basin and extends north into Arkansas. These physiographic provinces were all created or influenced by Pennsylvanian tectonic activity.

The tectonic activity in this area is associated with the final uplift of the Ozark and Ouachita Mountains. The remnants of this activity across Tulsa County are northeast- to southwest-trending folds, adjustment flexures, and some faults.

Other than these few inactive structural features, the local structural geology of Tulsa County mainly consists of rock formations that gently dip or slope slightly north of west at a rate of 30 to 50 feet per mile.

3.6.3 Seismology

Very little seismic activity has occurred in and around Tulsa County. Historically, there have been five earthquakes in Tulsa County. These earthquakes were of very low intensity and were instrumentally recorded and not felt. These events occurred as follows:

- April 19, 1978 at 1420 hours, rural west Tulsa County
- August 3, 1983 at 0431 hours, rural southwest Tulsa County
- November 13, 1983 at 0527 hours, rural southwest Tulsa County
- November 29 1983 at 0349 hours, rural southcentral Tulsa County
- April 28, 1984 at 2255 hours, rural northcentral Tulsa County

There has never been a recorded earthquake within the corporate boundaries of the City of Tulsa.

3.7 Surface Water Hydrology

The freshwater pond, Fulton Creek, and the retention pond dominate the site surface hydrology. The 274-acre Fulton Creek drainage basin upstream of the retention pond is located to the southwest, west, and northwest of the Kaiser facility. With increasing urbanization, the flow into the pond and creek has changed to receive surface runoff and storm water from an area largely taken over by light industrial and commercial development. Downstream, Fulton Creek connects to Mingo Creek, Bird Creek, and the Verdigris River which ultimately empty into the Arkansas River. Mingo Creek basin waters have been designated by the Oklahoma Water Resources Bureau (OWRB) for beneficial use as emergency water supply, fish and wildlife propagation, agriculture, industrial and municipal process and cooling waters, recreational, and aesthetics. Some flood control is provided within one-half mile downstream from Kaiser's property; however, none of the ponds or structures on Kaiser property are designated as part of this system.

On-site features associated with the Fulton Creek drainage include the embankment that forms the eastern edge of the freshwater pond and the excavated ditch carrying Fulton Creek along the northern edge of

Kaiser's pond parcel. A deteriorating concrete weir at the northeast corner of the freshwater pond controls flow into Fulton Creek. At the east edge of the property line, another deteriorating concrete weir is used to control flow exiting the property. Both weirs are reported to pass water beneath the structures, making measurements of discharge quantities unreliable. In addition, three concrete weirs are present on Kaiser property along Fulton Creek and create small ponds. Discharge varies with season and local precipitation events.

The retention pond covers approximately 5 acres and is bounded on the north and east by embankments and higher ground elsewhere. The pond, permitted by the OWRB (Permit No. CW-72-131) as a nondischarging retention pond, formerly received both industrial process cooling water and solid dross wastes. Liquid wastewater from plant operations was carried to the retention pond through an underground pipe and a pumping station.

Surface runoff from Kaiser's industrial area south of the railroad is directed to the north, beneath the railbed, through three culverts. In addition, surface runoff from the pond parcel is diverted either into the pond or off site through a ditch just north of the flux building and paved area. These structures convey water toward the pond area, toward a ditch along the north edge of the paved area around the flux building, or to an off-site area south of the flux building. Adjacent to the flux building, surface flow is collected in a ditch which enters a pipe at the east fence line. This pipe passes under the northwest corner of Specific Systems' property and enters a concrete-lined ditch, which connects with Fulton Creek, upstream of a weir at the northeast corner of Kaiser property.

The reserve pond was excavated and diked at the northeast corner of the site. It was put into service in 1964, operated to post-1967, and was backfilled circa 1972. This pond was approximately 1 acre in area and reported up to 15 feet deep.

Figure 3-8 is a topographic map of the site. Surface water typically leaves the facility moving north to Fulton Creek. From Fulton Creek, the flow proceeds east.

3.7.1 Flood Plan Data

A copy of the Federal Emergency Management Agency Flood Insurance Rate Map (FIRM) for Mingo Creek and its tributaries in the vicinity of the facility is provided in Figure 3-6. As shown on the FIRM, the facility is outside the 100-year and 500-year flood hazard boundaries. The FIRM for this area was last revised April 16, 1991 to reflect changes in the Base Flood Elevations resulting primarily from completion of major drainage improvement work on Mingo Creek (construction of storm water retention basins).

Figure 3-7 is a portion of a map prepared by the U.S. Army Corps of Engineers (COE) Tulsa District depicting the approximate boundary of areas which experienced significant flooding during the flood of record for Mingo Creek which occurred on May 27, 1984. The facility is not within the flood boundary shown in Figure 3-7. During this flood event, widespread and severe flooding occurred along Mingo Creek and Bird Creek from a flash flood event. As a result of this event, many properties (both residential and commercial) were acquired by the City of Tulsa along the Mingo Creek floodplain. These acquired properties and the existing Mingo Creek channel have been modified significantly since 1984 to prevent the reoccurrence of such flooding.

3.8 Groundwater Hydrology

The hydrogeologic setting was determined for Kaiser by A&M Engineering (July, 1999), based on data from 23 boreholes and piezometers drilled in and adjacent to the pond parcel. Piezometers and monitoring wells were installed to monitor groundwater in shallow fine-grained sediments, in deeper sandy units comprising the basal part of the buried valley fill, and in deep stratigraphic holes drilled into the Nowata Shale Unit. Groundwater elevation monitoring, hydraulic conductivity (slug) tests, and groundwater chemical analyses were performed. A hydrologic budget was estimated for surface and groundwater inflows and outflows of the site.

In general, groundwater flow is from west to the east, along the axis of the buried stream valley. Groundwater was found to lie fairly close (within 3 to 5 feet) to the ground surface but was recognized to vary considerably in response to short- and long-term precipitation patterns. Groundwater is suspected to occur both in shallow perched/mounded conditions and in deeper unconfined to semiconfined conditions. Groundwater elevations in piezometer pairs in deep and shallow aquifers/sediments may differ at locations around the pond by 0.1 foot to 5 feet. Downward vertical groundwater flow through the upper fine-grained units into the lower sandy units was reported. There was little evidence of downward migration between near-surface sediments into the Nowata Shale. See Figures 3-8 and 3-9.

Water level data in wells and ponds were interpreted by A&M Engineering (July, 1999) to indicate that the freshwater pond has a relatively insignificant impact on the groundwater table. This was attributed to the impermeability of the embankment dam and, to a lesser degree, to silting of the pond bottom and controlled outflow through a weir from the pond into Fulton Creek. Retention pond and downstream groundwater elevations were observed to correlate closely during seasonal climate changes. Elevation changes of water in the Fulton Creek ditch were observed to correlate well with both retention pond levels and levels in deeper sand units, suggesting a link between them (A&M Engineering, 1998). However, infiltration through the freshwater pond into the subsurface is suspected of contributing to the locally high groundwater regime beneath the retention pond (Earth Sciences Consultants, Inc. [Earth Sciences], August 2000).

3.8.1 Groundwater Flow Data

Groundwater levels were measured in monitoring wells during each monitoring event. The groundwater levels measured in the field were converted to groundwater elevations based upon surveyed measurement reference point elevations reported in feet above MSL. Three different groundwater-bearing units are monitored at the site: (1) shallow overburden/dross material, (2) deep overburden, and (3) shallow bedrock.

3.8.1.1 Shallow Overburden/Dross Material

Monitoring wells screened in the shallow overburden/dross material are located to the east and northeast of the retention pond and consist of Wells MWS-4, MWS-5, MWS-6, and MWS-11. Groundwater elevations obtained during the March 2000 monitoring event were contoured as shown in Figure 3-8. The piezometric map indicates that shallow groundwater flows toward the northeast (Fulton Creek) away from the retention pond (Figure 3-8). The uppermost water-bearing zone occurs under unconfined conditions, with a direct relation to surface water, and is influenced by topography within the eastern portion of the site. Based on the March 2000 groundwater elevations for Monitoring Wells MWS-4 and MWS-11, the horizontal hydraulic gradient is 0.02 foot per foot. The hydrologic flow data for the September and December 1999 monitoring events are relatively consistent with the March 2000 data. Similarly, groundwater elevations are consistent with past monitoring events (April 1997, September 1998, and March 1999) as reported in the Hydrologic and Geologic Investigation report by A&M Engineering (July 1999).

3.8.1.2 Deep Overburden

Wells used to monitor the aquifer occurring in the deep overburden are P-1, P-2, MWD-2, P-3, P-4, MWD-4, P-5, MWD-5, MWD-6, P-7, MWD-7, P-8, MWD-8, MWD-9, P-10, MWD-10, and MWD-11. Groundwater elevations obtained during the March 2000 monitoring event were used to create a piezometric surface map as shown in Figure 3-9. As indicated in this figure, groundwater in this confined unit flows in an east/northeast direction following the axis of the bedrock valley identified during previous investigations (A&M Engineering, July 1999). Based on the March 2000 groundwater elevation for Monitoring Wells P-2 and MWD-8, the average horizontal hydraulic gradient across the site is 0.01 foot per foot with steeper gradients occurring in the west and south areas along the side of the bedrock valley. The hydrologic flow data for the deep overburden during the September and December 1999 monitoring events are relatively consistent with the March 2000 data. These groundwater elevations also are consistent with past monitoring events (April 1997, September 1998, and March 1999) as reported in the A&M Engineering report (July 1999).

3.9 Natural Resources

There are no known natural resources located at or near the site. Water for industrial, agricultural, and potable uses in the area of the site is supplied by the municipality. There are no known industrial or agricultural users of surface water from the immediate area of the Kaiser facility.

3.10 Ecology/Endangered Species

Information to support this section was obtained from the U.S. Fish & Wildlife Services (USFWS), Oklahoma Wildlife Conservation (OWC), and the Oklahoma Biological Survey and National Heritage Inventory (OBS/NHI) sources. Information gathered leads to the conclusion that while the ecology, endangered species, and threatened species in the Tulsa area are diverse, there are no known species inhabiting or requiring the support of the area encompassed by the Kaiser Tulsa plant or adjacent industrial properties. This is supported by information in Attachment 3-1 which contains a finding by the COE that excavation and/or placement of fill associated with the unnamed tributary of Mingo Creek (Fulton Creek) will have no affect on federally listed endangered or threatened species or habitat critical for the survival of such species.

According to the OBS/NHI, the only known invertebrates, which are commercially or recreationally important in the Tulsa area, are the Fresh Water Mussels. The mussels are collected out of the Grand Lake, which is approximately 60 miles from the site, and Fort Gibson Lake, approximately 40 miles from the site. Neither of these areas will be impacted by the activities required in the DP.

According to the OBS/NHI, the only commercially important floral species in the Tulsa area is the pecan tree. However, the vast majority of the trees are located along the Arkansas River and there is no significant pecan production within 5 kilometers of the site. Activities to be conducted in the DP will not impact the area currently required for the pecan trees and will, therefore, not impact the environmental requirements of this biotic species.

Several animals are commercially and recreationally noted by the OBS/NHI, OWC, and the USFWS to exist within the Tulsa area. These are found in the wild but are not farmed within the immediate area for commercial purposes. None of the remediation activities planned for the Kaiser site are expected to impact the populations of these animals or their required habitat.

Commercially important animals that are within the Tulsa area as well as located on the site are Turtles (six species), Raccoons, Possums, Beavers, and Skunks. Other commercially important animals in the Tulsa area are; Coyote, Bobcats, Minks, Muskrat, and Gray Fox.

Recreationally important animals that are within the Tulsa area as well as located on site are Sunfish (four species), Ducks (four species), Geese (three species), and Morning Doves. Other recreationally important animals in the Tulsa area are; Bass (three species), Catfish (three species), Crappie (two species), Eastern Cotton Tail, Fox Squirrel, White Tailed Deer, Wild Turkey, Northern Bobwhite Quail, Ducks (nine species), Song Birds (30 species), and Hummingbirds.

3.10.1 Relative Abundance

Endangered species that are located within the Tulsa area are the American Burying Beetle and the Interior Least Tern. There are also threatened species of animals, the Bald Eagle and the Piping Plover, that are recorded to inhabit the Tulsa area. The activities, which are scheduled for the decommissioning of the facility, are not expected to impact the existence or the needs of the animals on this list.

References

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

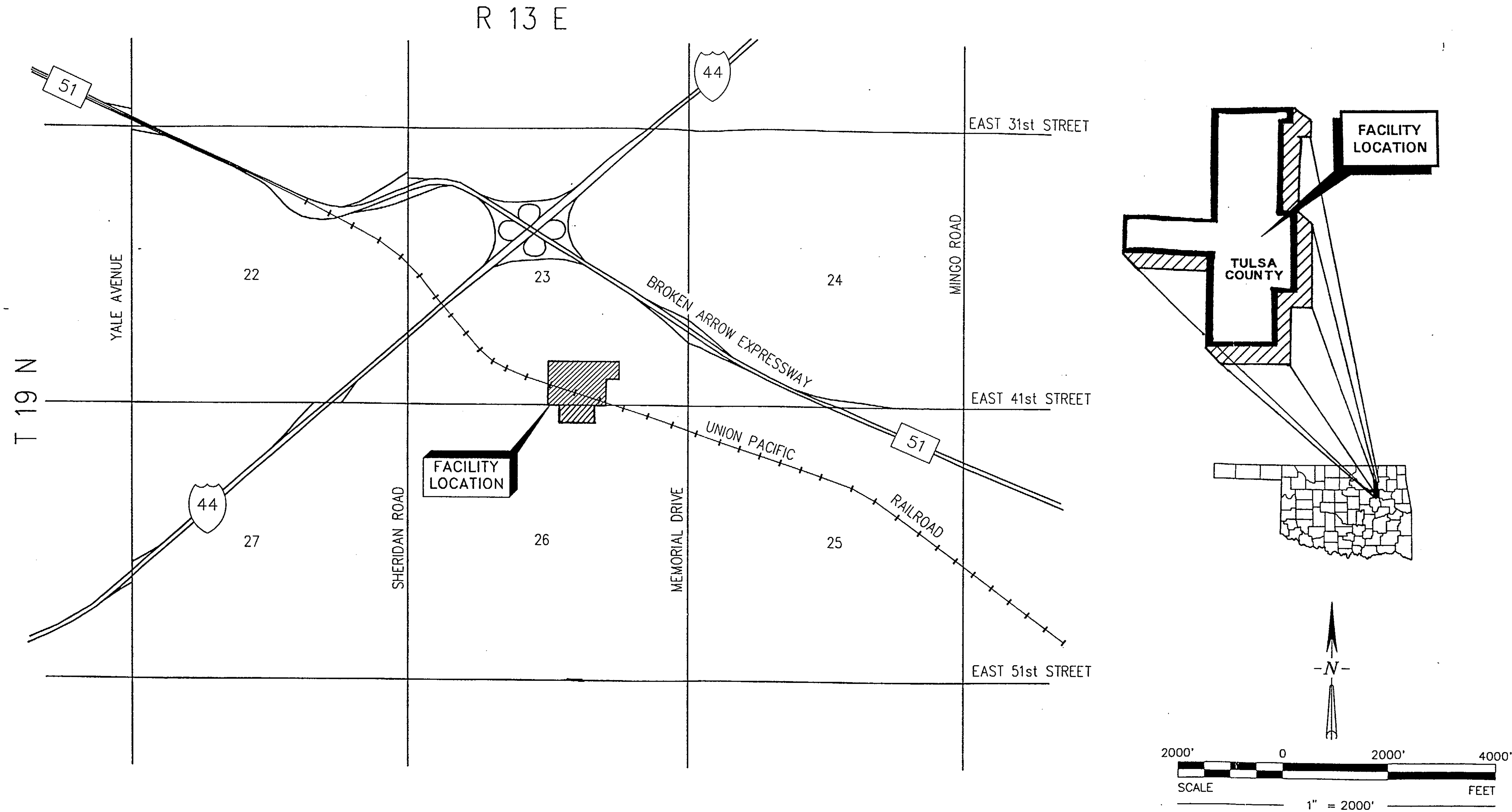
2. A&M Engineering and Environmental Services, Inc., July 1999, Hydrologic and Geologic Investigation, Kaiser Aluminum Specialty Products, Tulsa, Oklahoma.

3. Earth Sciences Consultants, Inc., 2000, Geotechnical Brief, Kaiser Aluminum & Chemical Corporation, Tulsa, Oklahoma.

4. Earth Sciences Consultants, Inc., August 2000, Groundwater Quality Report Retention Pond and Reserve Pond Area, Kaiser Aluminum Specialty Products Facility, Tulsa, Oklahoma.

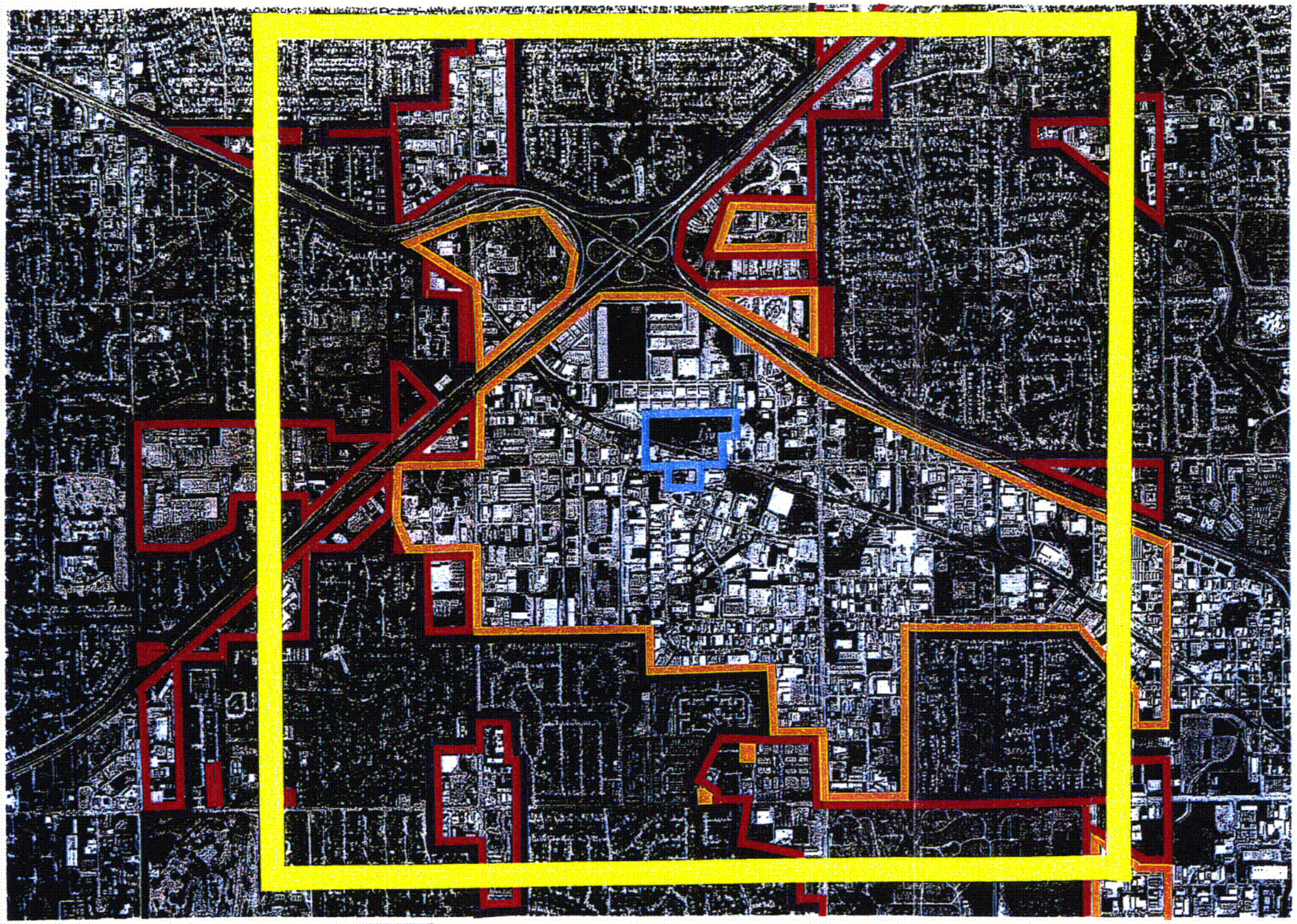
5. Roberts/Schornick & Associates, March 20, 1996, Local and Regional Environmental Data Report, Kaiser Aluminum Specialty Products, Tulsa, Oklahoma.

Figure 3-1



Client: KAISER ALUMINUM EXTRUDED PRODUCTS		Figure Title: FACILITY LOCATION MAP	
Location: 7311 EAST 41ST STREET TULSA, OKLAHOMA		Document Title: LOCAL AND REGIONAL ENVIRONMENTAL DATA REPORT	
ROBERTS/SCHORNICK & ASSOCIATES, INC. Environmental Consultants 6314 South Yale, Suite 1100 Tulsa, Oklahoma 74135 (918) 496-0059	DATE: 11/1/95	PREPARED BY: KE	
	SCALE: 1" = 2000'	CHECKED BY: KE	
		DRAFTED BY: GS	
	PROJECT NO: 9515901 F02	FIGURE NO.: 1	

Figure 3-2



AERIAL DATA SERVICE, INC. ADS
10822 EAST NEWTON PLACE • TULSA, OKLAHOMA 74116 • 918-437-8453

N

LEGEND:

RESIDENTIAL LAND USE

INDUSTRIAL LAND USE

COMMERCIAL LAND USE

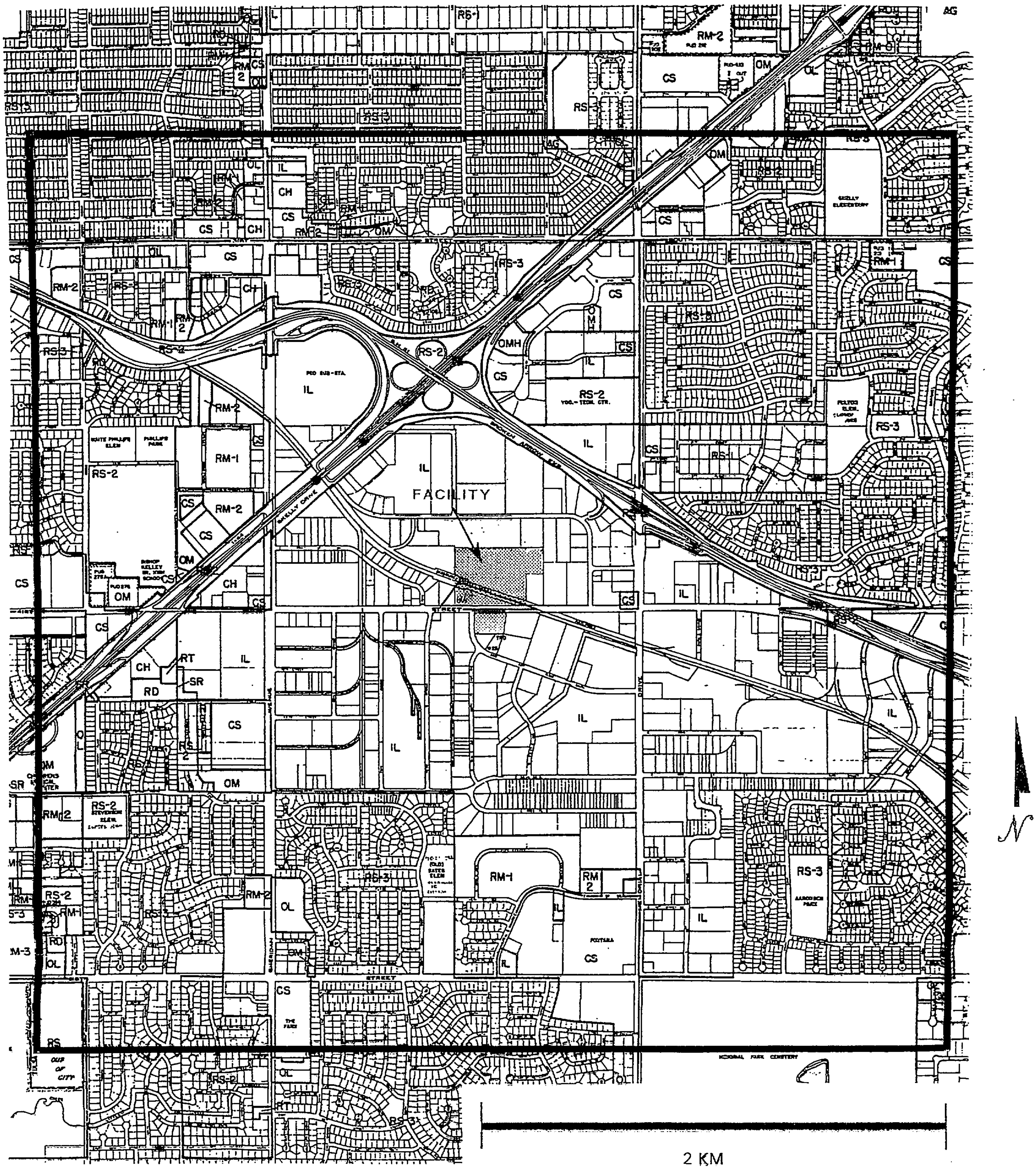
AREA BOUNDARY
(ENCOMPASSES 2 KM RADIUS)

FACILITY BOUNDARY

PHOTOGRAPH TAKEN NOVEMBER 15, 1992

Client: KAISER ALUMINUM EXTRUDED PRODUCTS		Figure Title: LAND USE WITHIN THE AREA, 1995	
Location: 7311 EAST 41ST STREET TULSA, OKLAHOMA		Document Title: LOCAL AND REGIONAL ENVIRONMENTAL DATA REPORT	
ROBERTS/SCHORNICK & ASSOCIATES, INC. Environmental Consultants 6314 South Yale, Suite 1100 Tulsa, Oklahoma 74136 (918) 496-0069	C05	DATE: 11/1/95	PREPARED BY: KE
		SCALE: 1" = 2000'	CHECKED BY: KE
			DRAFTED BY: GS
		PROJECT NO: 9515901 F02	FIGURE NO.: 10

Figure 3-3



TULSA/TULSA COUNTY ZONING CLASSIFICATIONS

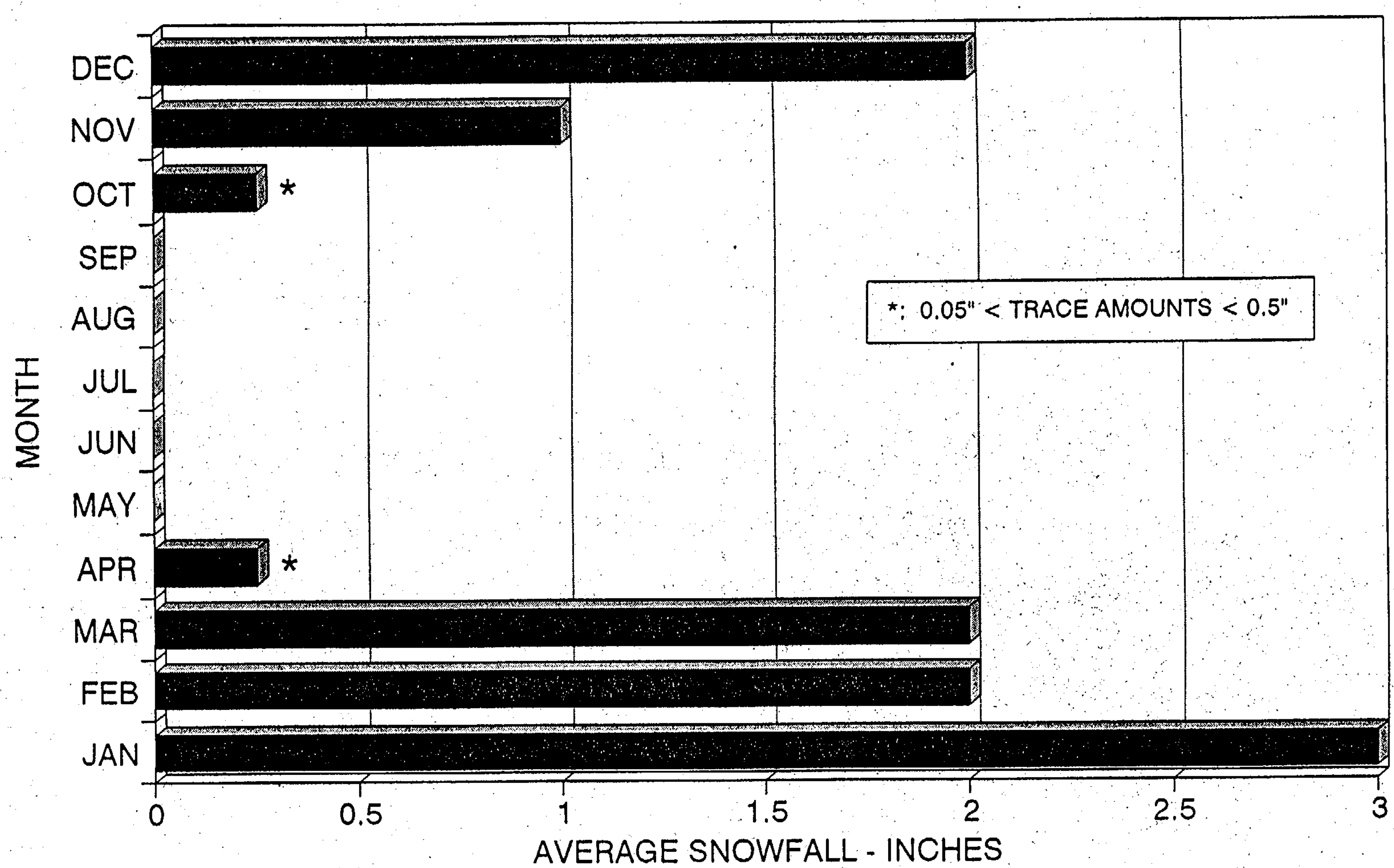
AG	AGRICULTURE GENERAL DISTRICT
AG-R	AGRICULTURE-RESIDENTIAL SINGLE-FAMILY, RURAL DEVELOPMENT
RE	RESIDENTIAL SINGLE-FAMILY, ESTATE DISTRICT
RS	RESIDENTIAL SINGLE-FAMILY DISTRICT
RS-1	RESIDENTIAL SINGLE-FAMILY LOW DENSITY DISTRICT
RS-2	RESIDENTIAL SINGLE-FAMILY MEDIUM DENSITY DISTRICT
RS-3	RESIDENTIAL SINGLE-FAMILY HIGH DENSITY DISTRICT
RS-4	RESIDENTIAL SINGLE-FAMILY HIGHEST DENSITY DISTRICT
RD	RESIDENTIAL DUPLEX DISTRICT
RT/ RM-T	RESIDENTIAL TOWNHOUSE DISTRICT
RM-0	RESIDENTIAL MULTIFAMILY LOWEST DENSITY DISTRICT
RM-1	RESIDENTIAL MULTIFAMILY LOW DENSITY DISTRICT
RM-2	RESIDENTIAL MULTIFAMILY MEDIUM DENSITY DISTRICT
RM-3	RESIDENTIAL MULTIFAMILY HIGH DENSITY DISTRICT
RMH	RESIDENTIAL MANUFACTURED HOME DISTRICT
P/PK	PARKING DISTRICT
OL	OFFICE LOW INTENSITY DISTRICT
OM	OFFICE MEDIUM INTENSITY DISTRICT
OMH	OFFICE MEDIUM-HIGH INTENSITY DISTRICT
OH	OFFICE HIGH INTENSITY DISTRICT
CS	COMMERCIAL SHOPPING CENTER DISTRICT
CG	COMMERCIAL GENERAL DISTRICT
CH	COMMERCIAL HIGH INTENSITY DISTRICT
CBD	CENTRAL BUSINESS DISTRICT
CO	CORRIDOR DISTRICT
SR	SCIENTIFIC RESEARCH AND DEVELOPMENT DISTRICT
IL	INDUSTRIAL LIGHT DISTRICT
IM	INDUSTRIAL MODERATE DISTRICT
IH	INDUSTRIAL HEAVY DISTRICT
IR	INDUSTRIAL RESEARCH AND DEVELOPMENT DISTRICT
FD	FLOODWAY DISTRICT
PUD	PLANNED UNIT DEVELOPMENT (SUPPLEMENTAL ZONING DISTRICT)
HP	HISTORIC PRESERVATION (SUPPLEMENTAL ZONING DISTRICT)

SOURCE: INDIAN NATIONS COUNCIL OF GOVERNMENTS, 07/92

Client: KAISER ALUMINUM EXTRUDED PRODUCTS		Figure Title: COMPREHENSIVE ZONING, CITY OF TULSA	
Location: 7311 EAST 41ST STREET TULSA, OKLAHOMA		Document Title: LOCAL AND REGIONAL ENVIRONMENTAL DATA REPORT	
ROBERTS/SCHORNICK & ASSOCIATES, INC. Environmental Consultants 6314 South Yale, Suite 1100 Tulsa, Oklahoma 74136 (918) 496-0059		DATE: 11/1/95	PREPARED BY: KE
		SCALE: 1" = 1760'	CHECKED BY: KE
			DRAFTED BY: GS
		PROJECT NO: 9515901 F02	FIGURE NO.: 11

3,9

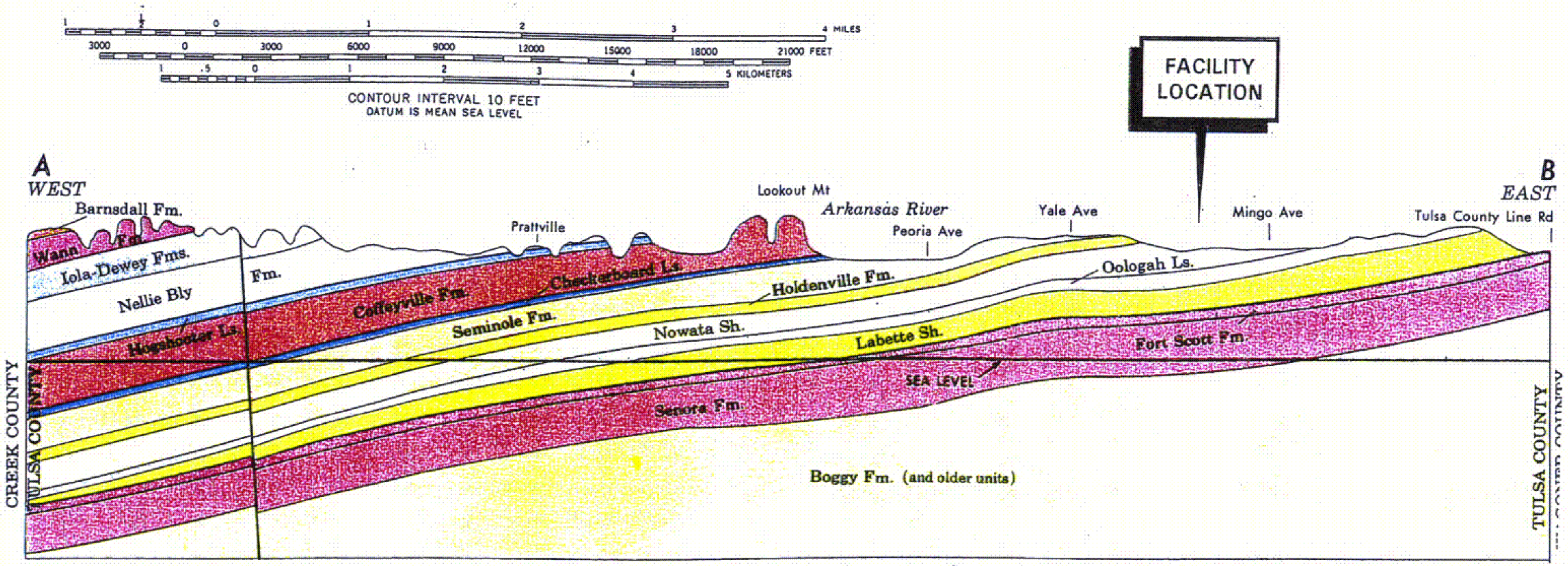
Figure 3-4



NATIONAL CLIMATIC DATA CENTER, 'INTERNATIONAL STATION METEOROLOGICAL CLIMATE SUMMARY', VERSION 2.1, JULY 2, 1992, NWS STATION #723560

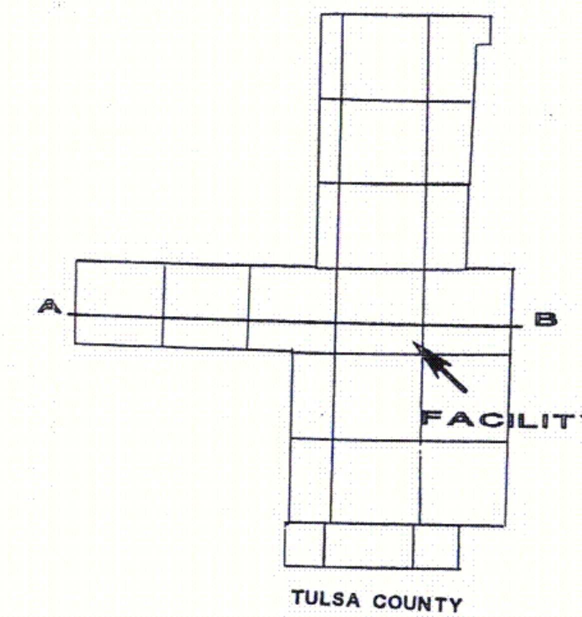
Figure Title: AVERAGE SNOWFALL BY MONTH, TULSA, OKLAHOMA (1948-1990)	Document Title: LOCAL AND REGIONAL ENVIRONMENTAL DATA REPORT		
ROBERTS/SCHORNICK & ASSOCIATES, INC. Environmental Consultants 5314 South Yale, Suite 1100 Tulsa, Oklahoma 74135 (918) 496-0059	Client: KAISER ALUMINUM EXTRUDED PRODUCTS	DATE: 11/1/95	PREPARED BY: CM
		SCALE: NO SCALE	CHECKED BY: CM
	Location: 7311 EAST 41ST STREET TULSA, OKLAHOMA		DRAFTED BY: GS
		PROJECT NO: 9515901 F02	FIGURE NO.: 17

Figure 3-5



West-East Geologic Cross Section Along 31st Street South

SCALE: HORIZONTAL, 1 inch = 3 miles
VERTICAL, 1 inch = 1,000 feet



SOURCE: TULSA'S PHYSICAL ENVIRONMENT, TULSA GEOLOGICAL SOCIETY, 1972

Client: KAISER ALUMINUM EXTRUDED PRODUCTS		Figure Title: GENERALIZED WEST-EAST (A-B) CROSS-SECTION, TULSA COUNTY	
Location: 7311 EAST 41ST STREET TULSA, OKLAHOMA		Document Title: LOCAL AND REGIONAL ENVIRONMENTAL DATA REPORT	
ROBERTS/SCHORNICK & ASSOCIATES, INC. Environmental Consultants 5314 South Yale, Suite 1100 Tulsa, Oklahoma 74135 (918) 496-0059	C06	DATE: 11/1/95	PREPARED BY: KE
		SCALE: NO SCALE	CHECKED BY: KE
			DRAFTED BY: GS
		PROJECT NO: 9515901 F02	FIGURE NO.: 30

Figure 3-6

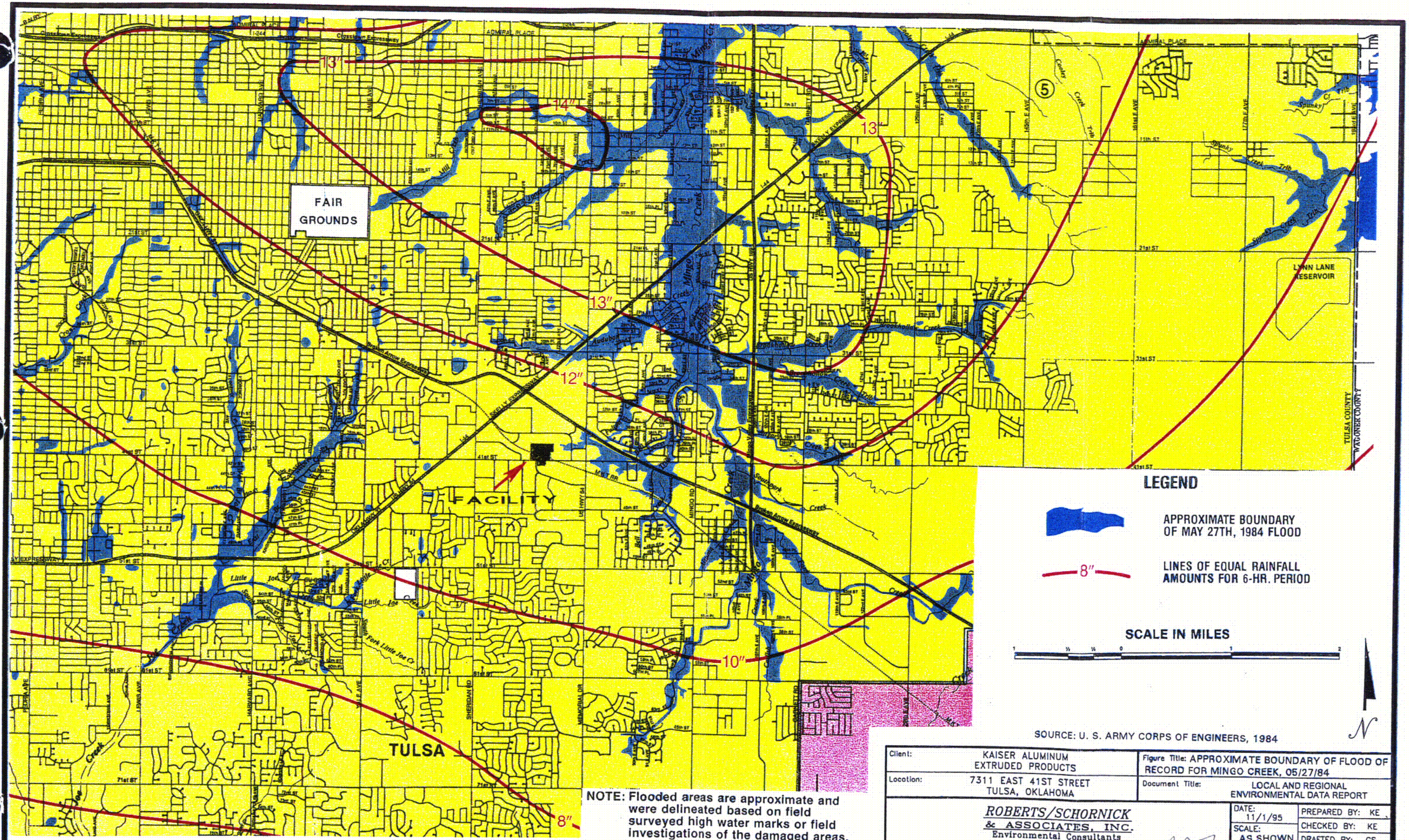
Federal Emergency Management Agency
Flood Insurance Rate Map

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED: FIRM FLOOD INSURANCE RATE MAP PANEL 65 OF 100 WITHIN THIS PACKAGE...OR, BY SEARCHING USING THE DOCUMENT/REPORT DWG. NO. NONE

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 3-7



NOTE: Flooded areas are approximate and were delineated based on field surveyed high water marks or field investigations of the damaged areas.

SOURCE: U. S. ARMY CORPS OF ENGINEERS, 1984

Client: KAISER ALUMINUM EXTRUDED PRODUCTS	Figure Title: APPROXIMATE BOUNDARY OF FLOOD OF RECORD FOR MINGO CREEK, 05/27/84
Location: 7311 EAST 41ST STREET TULSA, OKLAHOMA	Document Title: LOCAL AND REGIONAL ENVIRONMENTAL DATA REPORT

ROBERTS/SCHORNICK & ASSOCIATES, INC.
Environmental Consultants
5314 South Yale, Suite 1100
Tulsa, Oklahoma 74135
(918) 496-0059

C07

DATE: 11/1/95	PREPARED BY: KE
SCALE: AS SHOWN	CHECKED BY: KE
	DRAFTED BY: GS
PROJECT NO: 9515901 F02	FIGURE NO.: 26

3.12

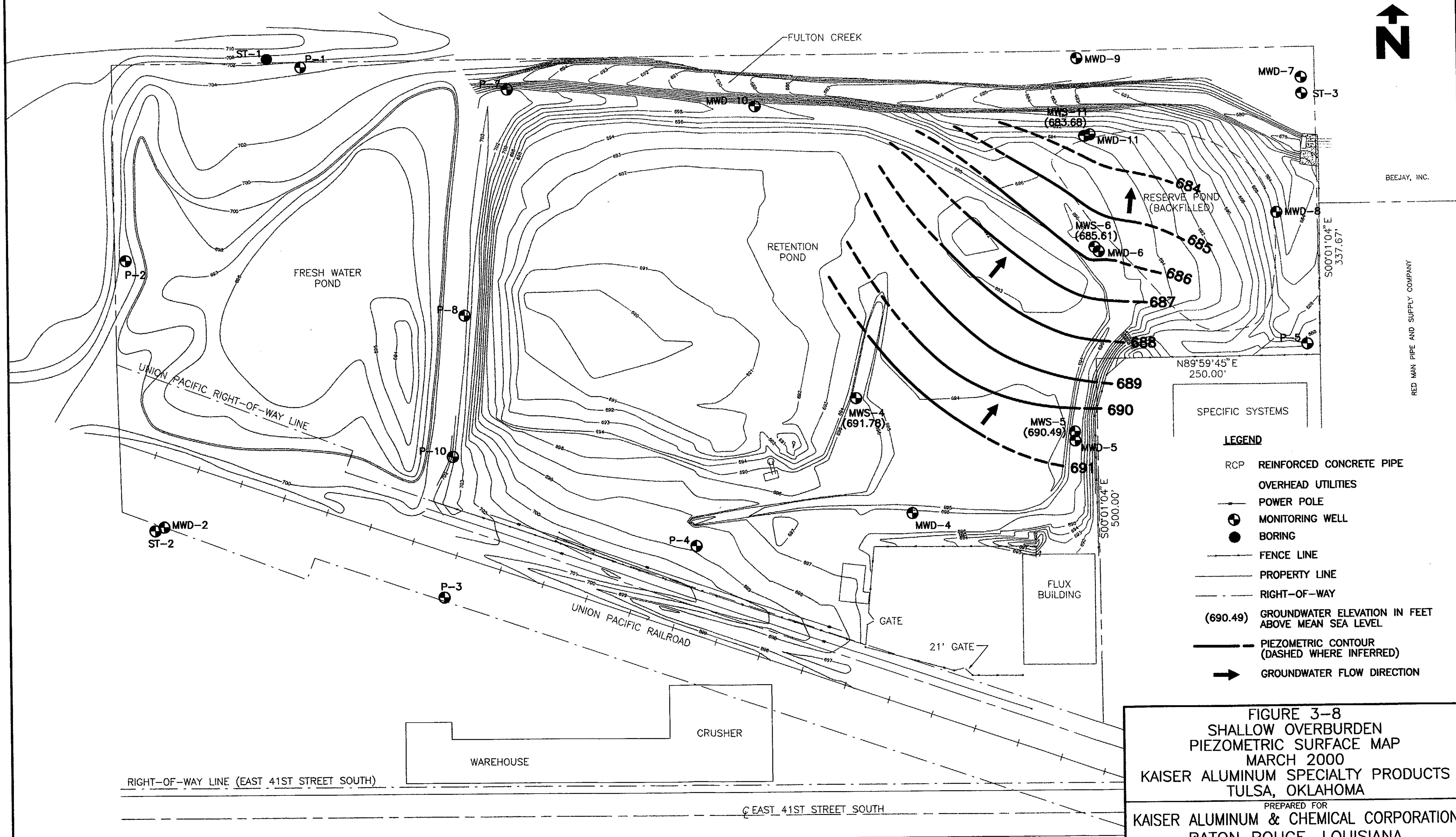


FIGURE 3-8
SHALLOW OVERBURDEN
PIEZOMETRIC SURFACE MAP
MARCH 2000
KAISER ALUMINUM SPECIALTY PRODUCTS
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

APPROVED 5/2/01
CHECKED JHS 5/3/01
DRAWN GJA 5/3/01
DRAWING NUMBER
5427226

Earth Sciences Consultants, Inc.

REFERENCES

1. THE RIGHT-OF-WAY AND PROPERTY LINES WERE OBTAINED FROM PLAT OF SURVEY PREPARED BY DENTON & WHITE SURVEYING COMPANY SEALED ON FEBRUARY 14, 1964.
2. TOPOGRAPHIC INFORMATION WAS OBTAINED FROM TOPOGRAPHIC SURVEY OF PART OF THE SE/4 OF SECTION 23 TOWNSHIP 19 NORTH RANGE 13 EAST, OF THE I.B. & M., TULSA COUNTY, STATE OF OKLAHOMA, ACCORDING TO THE U.S. GOVERNMENT SURVEY THEREOF, AND KNOWN AS 7311 EAST 41st STREET SOUTH. (FILE: NFSK003.DWG REV. A)

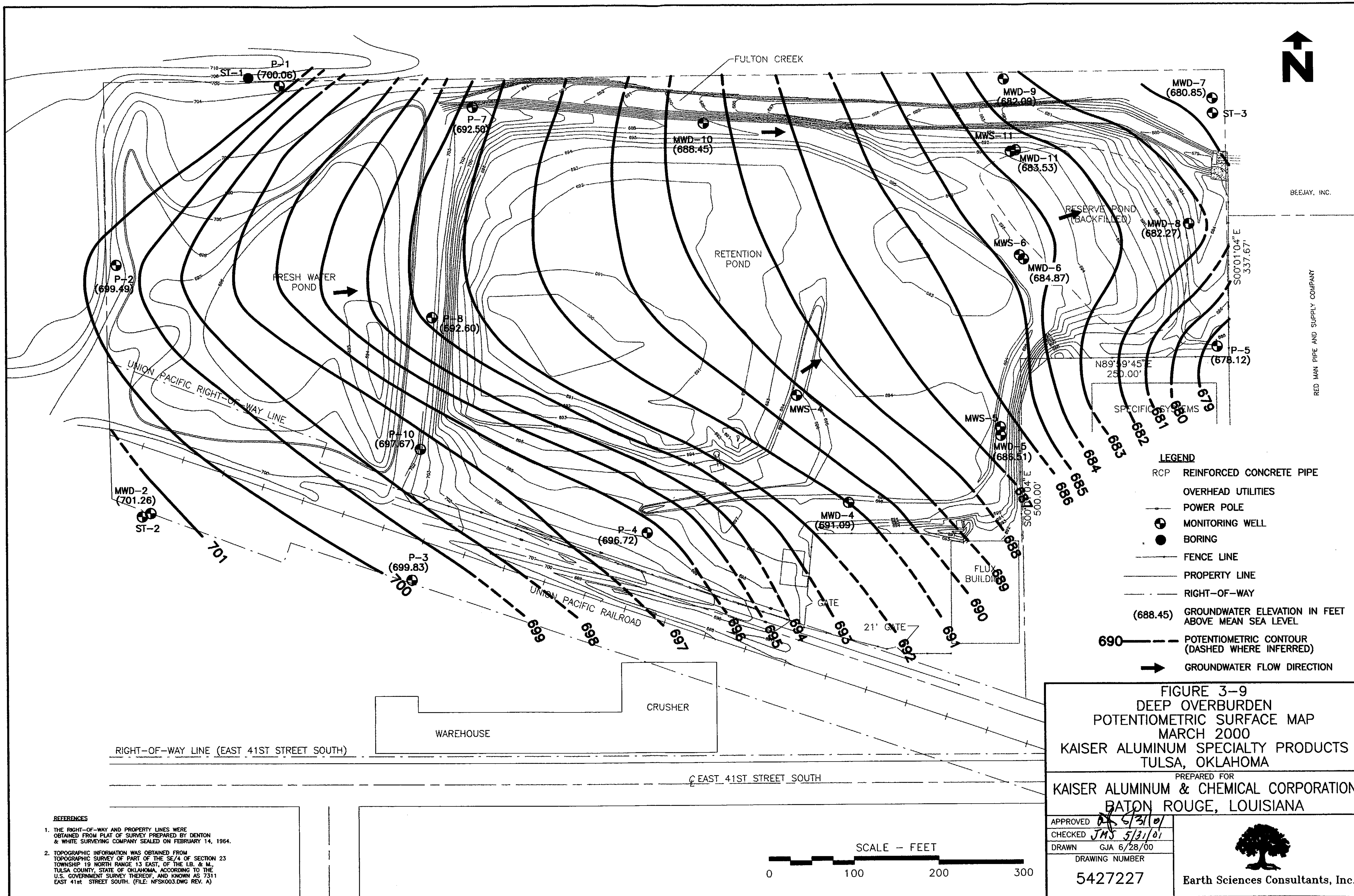


FIGURE 3-9
DEEP OVERBURDEN
POTENTIOMETRIC SURFACE MAP
MARCH 2000
KAISER ALUMINUM SPECIALTY PRODUCTS
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

APPROVED	5/31/01
CHECKED	JMS 5/31/01
DRAWN	GJA 6/28/00
DRAWING NUMBER	5427227

Earth Sciences Consultants, Inc.

REFERENCES

1. THE RIGHT-OF-WAY AND PROPERTY LINES WERE OBTAINED FROM PLAT OF SURVEY PREPARED BY DENTON & WHITE SURVEYING COMPANY SEALED ON FEBRUARY 14, 1964.
2. TOPOGRAPHIC INFORMATION WAS OBTAINED FROM TOPOGRAPHIC SURVEY OF PART OF THE SE/4 OF SECTION 23 TOWNSHIP 19 NORTH RANGE 13 EAST, OF THE I.B. & M., TULSA COUNTY, STATE OF OKLAHOMA, ACCORDING TO THE U.S. GOVERNMENT SURVEY THEREOF, AND KNOWN AS 7311 EAST 41st STREET SOUTH. (FILE: NFSK003.DWG REV. A)

Attachment 3-1

DEPARTMENT OF THE ARMY
U.S. ARMY, CORPS OF ENGINEERS, TULSA DISTRICT
1645 SOUTH 101ST EAST AVENUE
TULSA, OKLAHOMA 74128-4609

May 2, 2001

Planning, Environmental, and Regulatory Division
Regulatory Branch

Mr. Turgay M. Ertugrul
A & M Engineering and Environmental Services, Inc.
10010 East 16th Street
Tulsa, OK 74128-4813

Dear Mr. Ertugrul:

This reply is in reference to your letter of April 18, 2001, concerning your request to extend the verification of previously issued Regulatory Permit No. 7715. This previously authorized project consisted of the placement and/or excavation of fill material in the unnamed tributary of Mingo Creek. The project as proposed is located in the Southwest 1/4 of the Southeast 1/4 of Section 23, Township 19 North, Range 13 East, Tulsa County, Oklahoma.

This project was previously authorized by Nationwide Permit (NWP) 38 for Cleanup of Hazardous and Toxic Waste. According to your office, the project would be conducted in the same manner as originally proposed and would result in the same impacts to the aquatic environment. Consequently, this project would still fall within the scope of NWP 38.

This letter constitutes approval for the extension of the verification for 2 additional years from the date of this letter. Please retain this letter with your copy of the original permit. If we can be of further assistance, contact Mr. Allen Ryan at 918-669-7618.

Sincerely,

for: David A. Manning
Chief, Regulatory Branch

A & M ENGINEERING AND ENVIRONMENTAL SERVICES, INC.
10010 E. 16TH STREET
TULSA, OK 74128-4813
ENGINEERING - ENVIRONMENTAL - CONSTRUCTION
(918) 665-6575 FAX (918) 665-6576

April 18, 2001

Mr. Allen Ryan, Regulatory Specialist
Environmental Biologist
U.S. Army Corps of Engineers
1645 South 101st East Avenue
Tulsa, Oklahoma 74128-4609

RE: U. S. Corps of Engineers Permit No. 7715
Kaiser Aluminum & Chemical Corporation Property, Tulsa, Oklahoma

Dear Mr. Ryan:

In a letter dated March 27, 1997, Mr. Larry D. Hogue, P.E., Chief, Operations Division, issued Permit No. 7715 to A & M Engineering for the placement and/or excavation of fill material in the unnamed tributary to Mingo Creek (see attached copy). The proposed project is located in the Southwest ¼ of the Southeast ¼ of Section 23, Township 19 North, Range 13 East, Tulsa County, Oklahoma. The permit was valid for 2 years.

The referenced activity was never started. However, at this time, A & M Engineering is ready to begin the Privately Funded Public Improvement (PFPI) permitting process with the City of Tulsa and follow with the construction activities. Since our permit has expired, we would like to request an extension of our permit for an additional 2 years from today's date.

Thank you for your cooperation. If you have any questions, please contact Tony Mummolo or me at 665-6575.

Very truly yours,

Turgay M. Ertugrul

Turgay M. Ertugrul, P.E.
Vice President

Attachment

Cc: Bill Vinzant, P.E. - Kaiser Aluminum & Chemical Corporation

DEPARTMENT OF THE ARMY
TULSA DISTRICT, CORPS OF ENGINEERS
P. O. BOX 61
TULSA, OKLAHOMA 74121-0061

REPLY TO
ATTENTION OF:

March 27, 1997

Operations Division
Regulatory Branch

Mr. Turgay M. Ertugrul
A & M Engineering and Environmental Service, Inc.
3840 South 103rd E. Avenue
Tulsa, OK 74146-2419

Dear Mr. Ertugrul:

Please reference your letter of February 20, 1997, regarding the hydrologic investigation of a low-level, radioactive-waste site. The proposed project is located in the Southwest 1/4 of the Southeast 1/4 of Section 23, Township 19 North, Range 13 East, Tulsa County, Oklahoma.

The placement and/or excavation of fill material in the unnamed tributary to Mingo Creek associated with the proposed project falls within the scope of the Nationwide Permit for Cleanup of Hazardous and Toxic Waste, provided the conditions therein are met. This permit was issued pursuant to Section 404 of the Clean Water Act and is enclosed for your reference.

Complete and return the enclosed self-addressed, postage-paid "Permittee Construction Schedule" form. Should construction be initiated prior to 30 days from receipt of this letter, please return the completed form as soon as possible. If you prefer, you may telephone the individual listed below to inform this office regarding the construction start date.

Following completion of your proposed activity, complete and return the enclosed self-addressed, postage-paid "Compliance Certification" form. Submittal of this form is required in accordance with Nationwide Permit General Condition No. 14.

In reviewing this proposed activity, we have determined that the proposed action will have no affect on Federally-listed endangered or threatened species or habitat critical for the survival of such species.

This verification will be valid for 2 years, unless the Nationwide permit authorization is modified, reissued, or revoked. It is incumbent on you to remain informed of changes to the Nationwide permits. The U.S. Army Corps of Engineers will issue a public notice announcing the changes as they occur. Furthermore, if you commence, or are under contract to commence, this activity before the date the Nationwide permit is modified or revoked, you will have 12 months from the date of the modification or revocation to complete the activity under the present terms and conditions of this Nationwide permit.

This authorization is pursuant to Section 404 and does not preclude the need to obtain additional Federal, State, or local authorization which may be required.

Your permit has been assigned Identification Number 7715; please refer to this number during future correspondence. If you cannot comply with the conditions listed in the enclosed permit, contact Ms. Helen J. Williams at 918-669-7009.

Sincerely,

David A. Manning

Larry D. Hogue, P.E.
Chief, Operations Division

Enclosures

NATIONWIDE PERMIT FOR CLEANUP OF HAZARDOUS AND TOXIC WASTE (NWP 38)

- Specific activities required to effect the containment, stabilization, or removal of hazardous or toxic waste materials that are performed, ordered, or sponsored by a Government agency with established legal or regulatory authority provided the permittee notifies the District Engineer (DE) in accordance with the "Notification" general condition. For discharges in special aquatic sites, including wetlands, the notification must also include a delineation of affected special aquatic sites, including wetlands. Court ordered remedial action plans or related settlements are also authorized by this Nationwide permit (NWP). This NWP does not authorize the establishment of new disposal sites or the expansion of existing sites used for the disposal of hazardous or toxic waste. Activities undertaken entirely on a CERCLA site by authority of CERCLA as approved or required by EPA, are not required to obtain permits under Section 404 of the Clean Water Act or Section 10 of the Rivers and Harbors Act.

This NWP is authorized pursuant to Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act. This NWP (33 CFR 330) became effective February 11, 1997, following publication in the Federal Register.

General Conditions: The following general conditions must be followed in order for any authorization by *this* NWP to be valid:

1. Navigation. No activity may cause more than a minimal adverse effect on navigation.

2. Proper Maintenance. Any structure or fill authorized shall be properly maintained, including maintenance to ensure public safety.

3. Erosion and Siltation Controls. Appropriate erosion and siltation controls must be used and maintained in effective operating condition during construction, and all exposed soil and other fills, as well as any work below the ordinary high water mark or high tide line, must be permanently stabilized at the earliest practicable date.

4. Aquatic Life Movements. No activity may substantially disrupt the movement of those species of aquatic life indigenous to the waterbody, including those species which normally migrate through the area, unless the activity's primary purpose is to impound water.

5. Equipment. Heavy equipment working in wetlands must be placed on mats, or other measures must be taken to minimize soil disturbance.

6. Regional and Case-by-Case Conditions. The activity must comply with any regional conditions which may have been added by the Division Engineer (see 33 CFR 330.4(e)) and with any case specific conditions added by the U.S. Army Corps of Engineers (Corps) or by the State or Tribe in its Section 401 water quality certification.

7. Wild and Scenic Rivers. No activity may occur in a component of the National Wild and Scenic River System; or in a river officially designated by Congress as a "study river" for possible inclusion in the system, while the river is in an official study status; unless the appropriate Federal agency, with direct management responsibility for such river, has determined in writing that the proposed activity will not adversely effect the Wild and Scenic River designation, or study status. Information on Wild and Scenic Rivers may be obtained from the appropriate Federal land management agency in the area (e.g., National Park Service, U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service (USFWS)).

8. Tribal Rights. No activity or its operation may impair reserved tribal rights, including, but not limited to, reserved water rights and treaty fishing and hunting rights.

9. Water Quality Certification. The State of Oklahoma has denied NWP wate quality certification for components of the Oklahoma Scenic Rivers includin Illinois River, Flint Creek, Barren Fork Creek, Mountain Fork Creek, Li--le Creek, and Big Lee Creek; waters afforded special protections in Appen B the Oklahoma Water Quality Standards 1994; and those waters designated as Outstanding Resource Waters. For this NWP to be valid in the aforementione waters in Oklahoma, an individual Section 401 water quality certification m obtained or waived from the Oklahoma Department of Environmental Quality.

10. Coastal Zone Management. *Not applicable.*

11. Endangered Species.

a. No activity is authorized under any NWP which is likely to jeopard the continued existence of a threatened or endangered species or a species proposed for such designation, as identified under the Federal Endangered Sp Act (ESA), or which is likely to destroy or adversely modify the critical ha of such species. Non-Federal permittees shall notify the DE if any listed species or critical habitat might be affected or is in the vicinity of the p ect, and shall not begin work on the activity until notified by the DE that requirements of the ESA have been satisfied and that the activity is author

b. Authorization of an activity by a NWP does not authorize the "take" threatened or endangered species as defined under the Federal ESA. In the absence of separate authorization (e.g., an ESA Section 10 Permit, a Biologi Opinion with "incidental take" provisions, etc.) from the USFWS or the Natic Marine Fisheries Service (NMFS), both lethal and nonlethal "takes" of protec species are in violation of the ESA. Information on the location of threate and endangered species and their critical habitat can be obtained directly f the offices of the USFWS and NMFS or their world wide web pages at http:// www.fws.gov/<difference>r9endspp/endspp.html and http:// kingfish.spp.mnfs.gov/tmcintyr/prot_res.html#ES and Recovery, respectively.

12. Historic Properties. No activity which may affect historic proper s listed, or eligible for listing, in the National Register of Historic P ces authorized, until the DE has complied with the provisions of 33 CFR Part 325 Appendix C. The prospective permittee must notify the DE if the authorized activity may affect any historic properties listed, determined to be eligibl which the prospective permittee has reason to believe may be eligible for li on the National Register of Historic Places, and shall not begin the activit until notified by the DE that the requirements of the National Historic Preservation Act have been satisfied and that the activity is authorized. Information on the location and existence of historic resources can be obtai from the State Historic Preservation Office and the National Register of His Places (see 33 CFR 330.4(g)).

13. Notification.

a. Timing: The prospective permittee must notify the DE with a Pre-Construction Notification (PCN) as early as possible and shall not begin the activity:

(1) Until notified by the DE that the activity may proceed under the with any special conditions imposed by the District or Division Engineer; or

(2) If notified by the District or Division Engineer that an individ permit is required; or

(3) Unless 30 days have passed from the DE's receipt of the notifica and the prospective permittee has not received notice from the District or Division Engineer. Subsequently, the permittee's right to proceed under the may be modified, suspended, or revoked only in accordance with the procedure forth in 33 CFR 330.5(d)(2).

b. Contents of Notification: The notification must be in writing and include the following information:

(1) Name, address, and telephone numbers of the prospective permittee;

(2) Location of the proposed project;

(3) Brief description of the proposed project; the project's purpose; direct and indirect adverse environmental effects the project would cause; any other NWP(s), regional general permit(s), or individual permit(s) used or intended to be used to authorize any part of the proposed project or any related activity; and

(4) The PCN must also include a delineation of affected special aquatic sites, including wetlands (see paragraph 13(f)).

c. Form of Notification: The standard individual permit application form (Form ENG 4345) may be used as the notification but must clearly indicate that it is a PCN and must include all of the information required in *Section* (b) of General Condition 13. A letter may also be used.

d. District Engineer's Decision: In reviewing the pre-construction notification for the proposed activity, the DE will determine whether the activity authorized by the NWP will result in more than minimal individual or cumulative adverse environmental effects or may be contrary to the public interest. The prospective permittee may, optionally, submit a proposed mitigation plan with the pre-construction notification to expedite the process and the DE will consider any optional mitigation the applicant has included in the proposal in determining whether the net adverse environmental effects of the proposed work are minimal. If the DE determines that the activity complies with the terms and conditions of the NWP and that the adverse effects are minimal, the DE will notify the permittee and include any conditions the DE deems necessary.

Any mitigation proposal must be approved by the DE prior to commencing work. If the prospective permittee elects to submit a mitigation plan, the DE will expeditiously review the proposed mitigation plan, but will not commence a second 30-day notification procedure. If the net adverse effects of the project (with the mitigation proposal) are determined by the DE to be minimal, the DE will provide a timely written response to the applicant stating that the project can proceed under the terms and conditions of the NWP permit.

If the DE determines that the adverse effects of the proposed work are more than minimal, then he will notify the applicant either: (1) That the project does not qualify for authorization under the NWP and instruct the applicant on the procedures to seek authorization under an individual permit; (2) that the project is authorized under the NWP subject to the applicant's submitting a mitigation proposal that would reduce the adverse effects to the minimal level; or (3) that the project is authorized under the NWP with specific modifications or conditions.

e. Agency Coordination: The DE will consider any comments from Federal and State agencies concerning the proposed activity's compliance with the terms and conditions of the NWPs and the need for mitigation to reduce the project's adverse environmental effects to a minimal level.

The DE will, upon receipt of a notification, provide immediately, e.g., facsimile transmission, overnight mail or other expeditious manner, a copy to the appropriate offices of the USFWS, State natural resource or water quality agency, EPA, State Historic Preservation Officer (SHPO), and, if appropriate, the NMFS. These agencies will then have 5 calendar days from the date the material is transmitted to telephone or fax the DE notice that they intend to provide substantive, site-specific comments. If so contacted by an agency, the DE will wait an additional 10 calendar days before making a decision on the notification. The DE will fully consider agency comments received within the specified time frame, but will provide no response to the resource agency. The DE will indicate in the administrative record associated with each notification that the resource agencies' concerns were considered. Applicants are encouraged to provide the Corps multiple copies of notifications to expedite agency notification.

f. Wetlands Delineations: Wetland delineations must be prepared in accordance with the current method required by the Corps. The permittee may ask the Corps to delineate the special aquatic site. There may be some delay if the Corps does the delineation. Furthermore, the 30-day period will not start until the wetland delineation has been completed and submitted to the Corps, where appropriate.

g. Mitigation: Factors that the DE will consider when determining the acceptability of appropriate and practicable mitigation include, but are not limited to:

(i) To be practicable, the mitigation must be available and capable of being done considering costs, existing technology, and logistics in light of the overall project purposes;

(ii) To the extent appropriate, permittees should consider mitigation banking and other forms of mitigation including contributions to wetland trust funds, "in lieu fees" to organizations such as The Nature Conservancy, state or county natural resource management agencies, where such fees contribute to the restoration, creation, replacement, enhancement, or preservation of wetlands. Furthermore, examples of mitigation that may be appropriate and practicable include but are not limited to: Reducing the size of the project; establishing wetland or upland buffer zones to protect aquatic resource values; and replacing the loss of aquatic resource values by creating, restoring, and enhancing similar functions and values. In addition, mitigation must address wetland impacts, such as functions and values, and cannot be simply used to offset the acreage of wetland losses that would occur in order to meet the acreage limits of some of the NWPs.

14. <u>Compliance Certification</u>. Every permittee who has received a NWP verification from the Corps will submit a signed certification regarding the completed work and any required mitigation. The certification will be forwarded by the Corps with the authorization letter and will include:

a. A statement that the authorized work was done in accordance with the Corps authorization, including any general or specific conditions;

b. A statement that any required mitigation was completed in accordance with the permit conditions;

c. The signature of the permittee certifying the completion of the work and mitigation.

15. <u>Multiple Use of Nationwide Permits</u>. *If this* NWP is combined with any other NWP, as part of a single and complete project, the permittee must notify the DE in accordance with paragraphs a, b, and c on the "Notification" General Condition Number 13. As provided at 33 CFR 330.6(c), two or more different NWPs can be combined to authorize a single and complete project. However, the same NWP cannot be used more than once for a single and complete project.

Section 404 Only Conditions: In addition to the General Conditions, the following conditions apply only to activities that involve the discharge of dredged or fill material into waters of the U.S., and must be followed in order for authorization by the NWPs to be valid:

1. <u>Water Supply Intakes</u>. No discharge of dredged or fill material may occur in the proximity of a public water supply intake except where the discharge is for repair of the public water supply intake structures or adjacent bank stabilization.

2. Shellfish Production. No discharge of dredged or fill material may occur in areas of concentrated shellfish production, unless the discharge is directly related to a shellfish harvesting activity authorized by NWP 4.

3. Suitable Material. No discharge of dredged or fill material may consist of unsuitable material (e.g., trash, debris, car bodies, asphalt, etc.) and material discharged must be free from toxic pollutants in toxic amounts (see Section 307 of the Clean Water Act).

4. Mitigation. Discharges of dredged or fill material into waters of the United States must be minimized or avoided to the maximum extent practicable at the project site (i.e., on-site), unless the DE approves a compensation plan that the DE determines is more beneficial to the environment than on-site minimization or avoidance measures.

5. Spawning Areas. Discharges in spawning areas during spawning seasons must be avoided to the maximum extent practicable.

6. Obstruction of High Flows. To the maximum extent practicable, discharges must not permanently restrict or impede the passage of normal or expected high flows or cause the relocation of the water (unless the primary purpose of the fill is to impound waters).

7. Adverse Effects From Impoundments. If the discharge creates an impoundment of water, adverse effects on the aquatic system caused by the accelerated passage of water and/or the restriction of its flow shall be minimized to the maximum extent practicable.

8. Waterfowl Breeding Areas. Discharges into breeding areas for migratory waterfowl must be avoided to the maximum extent practicable.

9. Removal of Temporary Fills. Any temporary fills must be removed in their entirety and the affected areas returned to their preexisting elevation.

For additional information concerning the NWP, please contact the Regulatory Branch, Tulsa District, U.S. Army Corps of Engineers, Post Office Box 61, Tulsa, OK 74121-0061, or telephone 918-669-7400.

4.0 Radiological Status of Facility

4.1 Contaminated Structures

4.1.1 Radiological Contamination within Structures

Structures that were used to process thorium-bearing materials are the crusher and smelter. Other buildings are not known to have involved operations involving thorium materials.

4.1.1.1 Smelter Building

The smelter building was demolished in October 2000, following completion of a report of survey activities within the structure which indicated no contamination.

4.1.1.2 Crusher Building

From about 1977 until plant shutdown, the crusher building was used for the smelting of aluminum, whereas previously it was used to grind cooled dross masses for a second magnesium recovery step and/or prior to disposal as a waste product. Instrument surveys indicate the absence of radiological contamination in the building.

4.1.2 Radiological Contamination Beneath Structures

Modifications to buildings/structures during the operating life may have resulted in covering thorium-bearing dross beneath several currently paved areas and building floors. There are several such areas where contamination may exist beneath structures based upon interpretation of historical data and/or observations made during adjacent land remediation activities. These areas will be investigated in planned additional site characterization activities. Planned sampling locations are shown in Figure 4-1 and are discussed below.

4.1.2.1 Slag Storage Building

Contamination may be present under the concrete slab of the slag storage building. Remediation activities along 41st Street showed that there is some contamination leading back toward Kaiser property. Contamination also was found at the northern edge of this area. During the excavations of Grids 129-132, thorium-bearing material was found in elevated concentrations and extended south of the dig under the concrete pad. See Figure 4-1, Additional Characterization Sampling Locations, for sample points in the slag storage building.

4.1.2.2 Crusher Addition

Contamination may exist in the area directly south of the original crusher building. This is part of the area in which aluminum billets were manufactured (post-1977). Contamination could be beneath the deck of the building. See Figure 4-1, Additional Characterization Sampling Locations, for sample points in the crusher addition.

4.1.2.3 Crusher

During adjacent land remediation activities, thorium-bearing material was found to exist in Characterization Grids 120-123 and extend south under the concrete driveway surrounding the northern side of the crusher building. Contamination in this area is expected to be relatively close to the surface of the concrete. The full extent of contamination is to be verified during additional characterization of the on-site facilities. See Figure 4-1, Additional Characterization Sampling Locations, for sample points in the crusher building.

4.1.2.4 West of Maintenance Building

There is no historical information suggesting that there is radioactive material beneath the concrete surface of the area west of the maintenance building. However, during off-site remediation activities, there was a small concrete area that evidenced elevated survey meter readings. This area is to be further investigated during additional characterization of the on-site facilities. See Figure 4-1, Additional Characteristic Sampling Locations, for sample points west of the maintenance building.

4.1.2.5 Flux Building

Thorium-contaminated material may exist in some areas beneath the flux building. This condition is suggested by the presence of radioactive material on four sides of the structure, both on site and off site. Contamination has been found along the east fence line in Characterization Grids 33 and 35 and along the south wall of the building during off-site activities. The affected areas that suggested contamination under the building were Characterization Grids 22-24. Contamination found on the north side of the paved area may be limited to the retention pond area. Contamination also has been found west of the paved area. This contamination may be related to the trash pile that once existed here. The exact amount and extent of any contamination under the flux building are unknown. This condition is to be addressed during the additional characterization event. See Figure 4-1, Additional Characterization Sampling Locations, for sample points in and around the flux building.

4.1.2.6 Warehouse

There is no historical information suggesting that there is radioactive material beneath the concrete decking of the warehouse. However, during off-site remediation activities, a small concrete area evidenced elevated survey meter readings. This area is to be further investigated during additional characterization of the on-site facilities. See Figure 4-1, Additional Characterization Sampling Locations, for sample points in the warehouse building.

4.2 Contaminated Systems and Equipment

Smelting of magnesium-thorium alloy was discontinued prior to 1971. Subsequently, nonthoriated magnesium and then aluminum were smelted at the plant. Instrument scans indicate that no contaminated systems or equipment exists at the facility and no further characterization is planned.

4.3 Surface and Subsurface Soil Contamination

4.3.1 Retention Pond and Reserve Pond Area

In accordance with the Radiological Site Characterization Plan provided to the NRC by Kaiser (September 28, 1994), a site characterization investigation was conducted by ARS at the Kaiser facility in Tulsa, Oklahoma. The purpose of the investigation was to characterize soils and sludges containing thorium with respect to criteria used by the NRC for release of sites for unrestricted use, as set forth in the NRC Branch Technical Position, Disposal or On-Site Storage of Residual Thorium or Uranium From Past Operations (1981).

4.3.1.1 Volume Estimates for Retention Pond and Reserve Pond Area

Earth Sciences computed affected material volumes by performing kriging calculations, using data from Appendix I of the 1995 ARS report. These data are included in Appendix A. The estimate from the kriging calculations yielded a total volume of 4,007,909 ft^3 of material greater than 10 pCi/g and a volume of 5,059,614 ft^3 of soil with Th-232 + Th-228 concentrations greater than 6 pCi/g. For off-site stockpiled soils, the 285,000 ft^3 of material that was removed during the Adjacent Land Area Remediation project has been added to the kriging estimate for a total approximate volume of 5,345,000 ft^3.

4.3.1.2 Concentration Estimates for the Retention Pond and Reserve Pond Area

Concentrations of thorium in the on-site material were estimated, using both on-site and off-site data. On-site concentrations were estimated from kriging calculations, using data generated by ARS (1995), Appendix B. The thorium concentration for on-site material ranged from approximately 2 pCi/g to 416 pCi/g for Th-232 + Th-228. The off-site thorium material ranges from less than minimum detectable activity to 728 pCi/g for Th-232 + Th-228. The average computed from the ADA report (1999, 2000) for the adjacent area soil with Th-232 + Th-228 content over 2.2 pCi/g (background) was 39.2 pCi/g.

4.3.2 Additional Areas Where Contamination May Exist at Levels Above Release Criteria

There are several areas where the extent of contamination has not yet been determined. These areas already have been identified in Section 4.1.2, Radiological Contamination Beneath Structures. Before information concerning exact locations, background levels, radionuclides present, depth of contamination, or mrem per hour (mrem/hr) radiation levels can be determined, additional characterization of the facility will need to be performed. Upon the findings of the additional characterization, the radiological status of the facility will be amended, where necessary.

4.4 Surface Water

The freshwater pond, Fulton Creek, and the retention pond dominate the site surface water, as discussed in Section 3.6 of this DP. Radiological contamination in these water bodies is virtually nonexistent. Table 4-1 is a summary of surface water analytical results that helps to illustrate this conclusion.

4.5 Groundwater

Earth Sciences conducted an evaluation of groundwater quality conditions based upon data collected over a period of three consecutive quarters: September 1999, December 1999, and March 2000. Sample points included in the evaluation were P-1, P-2, P-3, P-4, P-5, P-7, P-8, P-10, MWD-2, MWS-4, MWD-4, MWS-5, MWD-5, MWS-6, MWD-6, MWD-7, MWD-8, MWD-9, MWD-10, MWD-11, ST-2, and ST-3. Locations are shown in Figure 4-2. Analytical parameters included both inorganics and radionuclides (Ra-226, Ra-228, Th-228, Th-230, and Th-232).

During the first two events, filtering of samples was delayed until after samples were received at the analytical laboratory. Results from these two events indicated that USEPA drinking water maximum contaminant levels (MCL) (Table 4-5) for both the combined Ra-226 and Ra-228 and gross alpha particle activities were exceeded in the source area only. Exceedances in the source area occur in wells screened in the waste and, therefore, the samples are pore water--not groundwater. Analytical results were compared to the MCLs, as they are a known regulatory standard. However, it should be noted that the site groundwater is not likely to ever be a drinking water source. Only combined Ra-226 and Ra-228 exceeded the MCLs beyond the source area (December 1999). However, during both events, the only significant exceedances of the MCLs were limited to the source area and to one monitoring well in the northeast area for combined Ra-226 and Ra-228.

Field filtering was incorporated into the March 2000 sampling event. Analytical results from this event indicated that the MCL was exceeded significantly only for combined Ra-226 and Ra-228 in the source area. Two filtered groundwater samples (P-4 at 7.0 picocuries per liter [pCi/l] and MWD-8 at 5.5 pCi/l) slightly exceeded the MCL for combined Ra-226 and Ra-228 outside the source area. However, both of these wells are located within the limits of the backfilled reserve pond with Well P-4 located within the limits of the dross material.

Incorporation of field filtering (the most widely accepted technical practice) into the sampling program appears to have resulted in analytical results that more accurately reflect actual groundwater conditions by minimizing the potential for chemical change in samples before analysis. These analytical results also indicate that transport of radionuclides beyond the source area does not occur through the groundwater medium. Table 4-2 shows the elevations of the groundwater at each location. Table 4-3 gives specific monitoring well information. Table 4-4 gives a summary of the groundwater analytical results for the two events in December 1999, as well as the event in March 2000. Table 4-5 is a list of MCLs for groundwater.

References

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

2. Earth Sciences Consultants, Inc., August 2000, Groundwater Quality Report Retention Pond and Reserve Pond Area, Kaiser Aluminum Specialty Products Facility, Tulsa, Oklahoma.

Table 4-1
Summary of Surface Water Analytical Results
Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma

PARAMETERS	Units	FRESH WATER POND			RETENTION POND			FULTON CREEK		
		SEPT 99	DEC 99	MAR 2000	SEPT 99	DEC 99	MAR 2000	SEPT 99	DEC 99	MAR 2000
FIELD:										
pH	s.u.	5.90	7.98	-- (1)	8.51	9.25	--	5.90	8.28	--
CONDUCTIVITY	umhos/cm	260	420	--	890	950	--	370	1230	--
TURBIDITY	NTU	16.9	115	--	11.8	7.38	--	11.5	6.7	--
REDOX POTENTIAL	mV	76	215	--	32	130	--	43	179	--
DISSOLVED OXYGEN	mg/l	8.48	13.52	--	13.23	16.00	--	10.18	13.97	--
TEMPERATURE	°C	15.7	10.3	18.1	16.0	10.7	18.4	19.3	9.3	18.0
LABORATORY:										
pH	s.u.	7.83	7.79	7.81	9.27	8.95	9.08	7.85	8.10	7.72
SPECIFIC CONDUCTIVITY	umhos/cm	251	404	675	922	944	1290	304	1260	445
ALKALINITY	mg/l	81	141	217	232	264	366	96	325	133
CHLORIDE	mg/l	1.0	7.4	30.5	129	121	190	14.8	184	32.4
FLUORIDE	mg/l	0.3	0.7	1.0	2.6	2.3	3.1	0.3	1.8	0.4
NITRATE	mg/l	0.5	<0.2	1.0	0.5	1.2	0.5	0.6	1.0	1.0
SILICON DIOXIDE	mg/l	1.3	0.8	2.1	<0.8	<0.8	<0.8	1.5	1.3	1.1
SULFATE	mg/l	29.7	46.4	72.8	67.5	55.4	55.9	32.4	58.7	33.4
BARIUM	mg/l	0.036	0.08	0.11	0.506	0.31	0.519	0.096	2.23	0.188
CALCIUM	mg/l	51.1	68.3	65.3	13.2	16.2	12.8	52.5	88.1	38.0
IRON	mg/l	0.12	0.1	0.076	0.1	0.028	0.012	0.11	0.03	0.053
MAGNESIUM	mg/l	4.54	7.0	13.0	110	108	133	8.06	97.7	11.7
POTASSIUM	mg/l	1.6	2.91	2.7	36	30	38.7	5	49.8	9.14
SODIUM	mg/l	7.65	10.1	38.9	24.5	6.8	23.3	8.43	13.0	17.3
RADIUM - 226	pCi/l	0 +/- 0.139	0.2 +/- 0.194	0.279 +/- 0.145	4.5 +/- 0.775	0.055 +/- 0.208	0.848 +/- 0.215	0.032 +/- 0.102	2.44 +/- 0.488	0.278 +/- 0.176
RADIUM - 228	pCi/l	0 +/- 0.161	0 +/- 0.408	0.742 +/- 0.043	0 +/- 0.337	0.18 +/- 0.447	3.14 +/- 0.053	1.15 +/- 0.183	4.61 +/- 0.497	0 +/- 0.038
THORIUM - 228	pCi/l	0.058 +/- 0.019	0.24 +/- 0.133	0.113 +/- 0.093	0.217 +/- 0.118	0.201 +/- 0.109	0.493 +/- 0.149	0.643 +/- 0.459	0.215 +/- 0.121	1.09 +/- 0.259
THORIUM - 230	pCi/l	0.684 +/- 0.054	1.43 +/- 0.273	0.789 +/- 0.153	0.791 +/- 0.175	0.373 +/- 0.149	1.36 +/- 0.234	2.1 +/- 0.504	0.397 +/- 0.165	0.888 +/- 0.232
THORIUM - 232	pCi/l	0.208 +/- 0.032	0.187 +/- 0.104	0.031 +/- 0.041	0.207 +/- 0.09	0.129 +/- 0.109	0.195 +/- 0.105	0 +/- 0.495	0.149 +/- 0.125	0.205 +/- 0.109

Note:
(1) "--" denotes not analyzed.

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Table 4-2
Groundwater Elevations
Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma

Well I.D.	Groundwater Elevation (feet above MSL) Sep-99	Dec-99	Mar-00
P-1	698.22	699.96	700.06
P-2	698.90	699.39	699.49
P-3	699.09	700.14	699.83
P-4	692.42	694.89	696.72
P-5	679.90	681.20	678.12
P-7	691.88	692.66	692.50
P-8	691.84	692.54	692.60
P-10	696.72	697.28	697.67
MWD-2	700.57	701.23	701.26
MWS-4	691.20	692.23	691.78
MWD-4	690.07	691.30	691.09
MWS-5	690.06	691.96	690.49
MWD-5	686.05	687.34	686.51
MWS-6	684.85	686.67	685.61
MWD-6	684.83	686.59	684.87
MWD-7	678.61	679.47	680.85
MWD-8	680.45	682.15	682.27
MWD-9	681.38	681.74	682.09
MWD-10	688.54	688.74	688.45
MWS-11	683.77	NA (1)	683.68
MWD-11	682.82	683.84	683.53
ST-2	663.74	NA	NA
ST-3	680.20	680.62	680.43

Note:
(1) NA = Not available.

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Table 4-3
Monitoring Well Information
Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma

Well I.D.	Boring Depth (feet, bgs) (1)	Well Screen Interval (feet, bgs)	Dross Material Interval (feet, bgs)
P-1	20	10-20	
P-2	28	18-28	
P-3	13	3-13	
P-4	20	10-20	0-0.083
P-5	20	9-19	
P-7	22	12-22	
P-8	28	16.5-26.5	
P-10	22	12-22	
MWD-2	15	5-15	
MWS-4	10	4-9	0-5
MWD-4	20	10-20	2-2.4
MWS-5	12	7-12	1.5-11
MWD-5	28	16-26	1.5-11
MWS-6	14.5	4.5-14.5	9.5-10 (2)
MWD-6	30	19.5-29.5	9.5-10
MWD-7	20	10-20	
MWD-8	19	9-19	
MWD-9	20.5	9-19	
MWD-10	22	10-20	
MWS-11	10	5-10	4-10
MWD-11	24.5	14-24	4-9.5
ST-2	58	38-48	
ST-3	64	38-48	

Notes:
(1) bgs = Below ground surface.
(2) Well is believed to be screened in dross, but not indicated in the boring log. However, this well is right next to MWD-6 which passes through a dross layer.

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Table 4-4
Summary of Groundwater Analytical Results
Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma

PARAMETERS	Units	P-1 SEPT 99	P-1 DEC 99	P-1 MAR 2000	P-2 SEPT 99	P-2 DEC 99	P-2 MAR 2000
FIELD:							
pH	s.u.	6.81	7.40	6.64	6.73	7.25	6.63
CONDUCTIVITY	umhos/cm	725	875	480	960	1005	950
TURBIDITY	NTU	190.2	116	79	3.74	19.1	2.25
REDOX POTENTIAL	mV	196.3	161	146	115	59	4.07
DISSOLVED OXYGEN	mg/l	3.73	4.65	40.97	1.13	2.00	-- [1]
TEMPERATURE	°C	19.5	14.4	16.1	20.3	16.2	17.3
LABORATORY:							
pH	s.u.	7.33	7.37	7.08	7.19	7.22	7.05
SPECIFIC CONDUCTIVITY	umhos/cm	826	863	869	1020	1270	1040
ALKALINITY	mg/l	391	415	404	537	548	546
CHLORIDE	mg/l	17.2	18.9	19.8	32.5	17.9	16.3
FLUORIDE	mg/l	0.3	0.3	0.4	0.3	0.3	0.3
NITRATE	mg/l	0.2	<0.2	<0.2	1.3	<0.2	<0.2
SILICA DIOXIDE	mg/l	4.9	4.7	4.7	5.7	5.8	5.7
SULFATE	mg/l	14.2	34.3	37.1	6.5	7.5	7.4
BARIUM	mg/l	0.231	0.367	0.282	0.852	0.876	0.931
CALCIUM	mg/l	175	145	160	67.9	187	182
IRON	mg/l	0.24	0.086	0.007	<0.01	0.039	<0.01
MAGNESIUM	mg/l	8.51	8.33	9.11	12.9	14.7	15.3
POTASSIUM	mg/l	<0.2	1.0	0.79	<0.02	0.33	<0.02
SODIUM	mg/l	12.5	16.6	18.5	29.3	24.33	40.8
RADIUM - 226	pCi/l	0.562 +/- 0.313	0.593 +/- 0.156	0.306 +/- 0.123	0 +/- 0.254	0.435 +/- 0.095	0.043
RADIUM - 228	pCi/l	1.59 +/- 0.197	1.83 +/- 1.03	1.78 +/- 0.122	1.07 +/- 0.232	9.68 +/- 1.44	4.37
THORIUM - 228	pCi/l	0.336 +/- 0.169	0.202 +/- 0.081	1.03 +/- 0.406	4.63 +/- 0.505	0.085 +/- 0.051	0.292
THORIUM - 230	pCi/l	1.33 +/- 0.28	0.299 +/- 0.154	1.28 +/- 0.365	1.96 +/- 0.363	0.318 +/- 0.132	0.876
THORIUM - 232	pCi/l	0.551 +/- 0.184	0.118 +/- 0.085	0.363 +/- 0.209	0.864 +/- 0.232	0.102 +/- 0.07	0.689

Note:
(1) "--" denotes not analyzed.

Table 4-4
Summary of Groundwater Analytical Results
Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma

PARAMETERS	Units	P-3 SEPT 99		P-3 DEC 99		P-3 MAR 2000		P-4 SEPT 99		P-4 DEC 99		P-4 MAR 2000	
FIELD:													
pH	s.u.	6.78		7.31		6.64		6.33		6.59		6.63	
CONDUCTIVITY	umhos/cm	2505		2913		2225		14978		17588		>10000	
TURBIDITY	NTU	14.59		179		0.53		667.5		527		1.42	
REDOX POTENTIAL	mV	--		103		155		186.5		144.2		143	
DISSOLVED OXYGEN	mg/l	1.56		7.78		6.27		10.35		88.8		64.1	
TEMPERATURE	°C	21.75		17.6		14.6		17.55		14.5		15.7	
LABORATORY:													
pH	s.u.	7.35		7.24		7.03		6.87		6.84		6.62	
SPECIFIC CONDUCTIVITY	umhos/cm	2740		2910		2540		180000		18400		19400	
ALKALINITY	mg/l	245		263		266		232		233		231	
CHLORIDE	mg/l	688		780		665		6580		6470		6780	
FLUORIDE	mg/l	0.4		0.4		0.4		0.3		0.4		0.5	
NITRATE	mg/l	<0.2		<0.2		<0.2		<0.2		0.5		0.2	
SILICA DIOXIDE	mg/l	4.4		4.6		4.3		5.7		5.3		5.4	
SULFATE	mg/l	54.9		48.8		34.7		208		172		206	
BARIUM	mg/l	0.4		0.449		0.399		0.508		0.533		0.358	
CALCIUM	mg/l	81.2		369		440		3940		2430		2440	
IRON	mg/l	0.11		0.104		0.015		1.12		0.175		0.007	
MAGNESIUM	mg/l	96.8		90.7		69.2		677		606		487	
POTASSIUM	mg/l	11.4		14.1		9.36		47		54.8		44.2	
SODIUM	mg/l	114		66.5		60.1		1020		597		642	
RADIUM - 226	pCi/l	0.676	+/- 0.391	0.817	+/- 0.196	0.42	+/- 0.167	0.649	+/- 0.142	0.037	+/- 0.149	5.55	+/- 0.727
RADIUM - 228	pCi/l	2.19	+/- 0.202	1.77	+/- 0.487	1.8	+/- 0.044	0	+/- 0.337	4.54	+/- 1.84	1.48	+/- 0.05
THORIUM - 228	pCi/l	0.208	+/- 0.099	0.091	+/- 0.052	0.198	+/- 0.148	0.914	+/- 0.442	0.259	+/- 0.19	0.481	+/- 0.236
THORIUM - 230	pCi/l	0.687	+/- 0.158	0.011	+/- 0.103	0.557	+/- 0.183	1.21	+/- 0.501	2.07	+/- 0.524	1.03	+/- 0.301
THORIUM - 232	pCi/l	0.12	+/- 0.09	0.034	+/- 0.059	0.037	+/- 0.54	0.11	+/- 0.312	0.292	+/- 0.211	0.206	+/- 0.202

Note:
(1) "--" denotes not analyzed.

Table 4-4
Summary of Groundwater Analytical Results
Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma

PARAMETERS	Units	P-5 SEPT 99		P-5 DEC 99		P-5 MAR 2000		P-7 SEPT 99		P-7 DEC 99		P-7 MAR 2000	
FIELD:													
pH	s.u.	6.93		7.16		6.66		6.44		6.97		6.64	
CONDUCTIVITY	umhos/cm	3160		3440		2113		700		675		660	
TURBIDITY	NTU	7.91		21.18		0.31		1062.7		715		0.46	
REDOX POTENTIAL	mV	112.3		--		138		158		62		143	
DISSOLVED OXYGEN	mg/l	0.88		1.46		3.23		1.31		1.62		32.4	
TEMPERATURE	°C	19.65		18.5		14.3		20.55		15.7		15.8	
LABORATORY:													
pH	s.u.	7.33		7.29		7.12		7.17		7.08		6.87	
SPECIFIC CONDUCTIVITY	umhos/cm	3470		3410		3470		702		710		685	
ALKALINITY	mg/l	197		209		195		296		311		288	
CHLORIDE	mg/l	916		884		901		18.2		22.7		24.3	
FLUORIDE	mg/l	0.5		0.6		0.5		0.2		0.3		0.3	
NITRATE	mg/l	<0.2		<0.2		<0.2		0.5		<0.2		<0.2	
SILICA DIOXIDE	mg/l	3.8		3.8		3.6		5.2		5		5.2	
SULFATE	mg/l	3.8		7.7		5.4		37		39.6		37.4	
BARIUM	mg/l	10.7		8.5		7.99		0.177		<0.011		0.127	
CALCIUM	mg/l	174		135		127		115		122		88.6	
IRON	mg/l	<0.01		<0.007		<0.007		2.31		0.118		0.008	
MAGNESIUM	mg/l	76.8		82.1		69		16.3		14.8		10.6	
POTASSIUM	mg/l	457		371		380		<0.2		<0.222		0.44	
SODIUM	mg/l	68.7		51.4		57.1		10.6		<47		18	
RADIUM - 226	pCi/l	0.625	+/- 0.192	1.08	+/- 0.192	0.991	+/- 0.218	0	+/- 0.307	0.066	+/- 0.104	0.102	+/- 0.164
RADIUM - 228	pCi/l	74.5	+/- 0.699	2.76	+/- 0.806	1.83	+/- 0.044	0.022	+/- 0.346	0.63	+/- 0.454	1.19	+/- 0.043
THORIUM - 228	pCi/l	0.284	+/- 0.14	0.565	+/- 0.115	1.32	+/- 0.361	1.56	+/- 0.395	0.305	+/- 0.161	0.566	+/- 0.226
THORIUM - 230	pCi/l	1.72	+/- 0.548	0.904	+/- 0.184	0.466	+/- 0.243	0.29	+/- 0.489	0.228	+/- 0.208	0.39	+/- 0.193
THORIUM - 232	pCi/l	0.03	+/- 0.32	0.345	+/- 0.128	0.321	+/- 0.178	0.598	+/- 0.243	0.038	+/- 0.09	0.176	+/- 0.11

Note:
(1) "--" denotes not analyzed.

Table 4-4
Summary of Groundwater Analytical Results
Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma

PARAMETERS	Units	P-8						P-10					
		SEPT 99		DEC 99		MAR 2000		SEPT 99		DEC 99		MAR 2000
FIELD:												
pH	s.u.	6.98		7.38		6.67		6.83		7.07		6.7
CONDUCTIVITY	umhos/cm	1480		1702		1425		730		740		713
TURBIDITY	NTU	9.92		56.06		0.51		11.44		21.52		12.8
REDOX POTENTIAL	mV	-79.75		-114		160.8		149		96		146
DISSOLVED OXYGEN	mg/l	0.79		1.19		2.60		1.93		2.82		18.2
TEMPERATURE	°C	20.55		16.5		18.1		22.5		17.2		17.5
LABORATORY:												
pH	s.u.	7.11		7.15		7.11		7.26		7.32		7.26
SPECIFIC CONDUCTIVITY	umhos/cm	1520		1540		1570		768		761		726
ALKALINITY	mg/l	165		180		189		373		382		364
CHLORIDE	mg/l	359		346		365		22.7		20.7		20.3
FLUORIDE	mg/l	0.5		0.5		0.6		0.5		0.4		0.5
NITRATE	mg/l	0.4		<0.2		0.2		0.4		<0.2		<0.2
SILICA DIOXIDE	mg/l	4.7		4.5		4.8		4.2		4.4		4.0
SULFATE	mg/l	2.0		<1		<1		6.3		7.0		5.2
BARIUM	mg/l	3.68		4.91		4.85		0.103		0.15		0.139
CALCIUM	mg/l	196		201		167		129		182		122
IRON	mg/l	5.34		13.8		16.8		<0.01		0.47		<0.01
MAGNESIUM	mg/l	28.8		29.5		27.1		11.4		16.9		11.3
POTASSIUM	mg/l	1.8		2.32		2.39		<0.2		0.798		4.1
SODIUM	mg/l	10.7		<47		25.7		15.5		11.5		39.8
RADIUM - 226	pCi/l	0.471	+/- 0.171	0.565	+/- 0.326	0.362	+/- 0.251	0.183	+/-0.215	0.375	+/-0.317	0.06
RADIUM - 228	pCi/l	0.9	+/- 0.206	0	+/- 0.433	1.04	+/- 0.042	0.8	+/-0.183	2.33	+/-0.506	3.83
THORIUM - 228	pCi/l	0.284	+/- 0.088	0.115	+/- 0.091	0.493	+/- 0.182	0.241	+/-0.115	0.123	+/-0.064	0.406
THORIUM - 230	pCi/l	1.26	+/- 0.169	1.09	+/- 0.274	1.37	+/- 0.233	0.789	+/-0.183	0.467	+/-0.127	0.432
THORIUM - 232	pCi/l	0.313	+/- 0.09	0.28	+/- 0.141	0	+/- 0.149	0.251	+/-0.122	0.09	+/-0.058	0.131

Note:
(1) "--" denotes not analyzed.

Table 4-4
Summary of Groundwater Analytical Results
Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma

PARAMETERS	Units	MWD-2					MWS-4					
		SEPT 99		DEC 99		MAR 2000	SEPT 99		DEC 99		MAR 2000	
FIELD:												
pH	s.u.	7.01		7.09		6.58	8.8		9.63		6.69	
CONDUCTIVITY	umhos/cm	782.5		840		887	1068		1260		1000	
TURBIDITY	NTU	7.755		3.22		4.5	271.6		17.43		0.74	
REDOX POTENTIAL	mV	207		90.5		148.5	124		--		152	
DISSOLVED OXYGEN	mg/l	3.8		1.82		25.2	2.08		2.33		4.16	
TEMPERATURE	°C	20.03		16.2		17.9	20.63		16.0		17.6	
LABORATORY:												
pH	s.u.	7.46		7.3		7.34	9.5		9.29		9.48	
SPECIFIC CONDUCTIVITY	umhos/cm	852		837		839	1140		1010		1120	
ALKALINITY	mg/l	330		360		336	96		77		64.5	
CHLORIDE	mg/l	48		36		46.4	295		255		291	
FLUORIDE	mg/l	0.6		0.6		0.6	3.1		3.5		2.7	
NITRATE	mg/l	0.3		<0.2		0.3	<0.2		0.2		<0.2	
SILICA DIOXIDE	mg/l	4.5		4.1		3.8	<0.8		<0.8		<0.8	
SULFATE	mg/l	46.7		47.1		47.9	3.9		7.5		5.9	
BARIUM	mg/l	0.092		0.107		<0.11	13.3		16.0		12.7	
CALCIUM	mg/l	105		129		114	30.7		27.1		24.9	
IRON	mg/l	<0.01		0.051		<0.07	0.39		<0.14		0.015	
MAGNESIUM	mg/l	22.1		25.5		24.3	74.1		73.5		66.8	
POTASSIUM	mg/l	7.3		6.1		8.3	105		62.8		60.8	
SODIUM	mg/l	25.2		<47		30.5	12.8		12.9		10	
RADIUM - 226	pCi/l	0	+/-0.265	0.236	+/-0.202	0.087	10.1	+/-0.543	43.6	+/-1.22	3.78	+/-0.287
RADIUM - 228	pCi/l	1.66	+/-0.211	0	+/-0.426	0	429	+/-1.36	481	+/-3.26	325	+/-0.273
THORIUM - 228	pCi/l	0.564	+/-0.252	0.317	+/-0.163	0.37	2.33	+/-0.306	2.84	+/-0.347	1.46	+/-0.213
THORIUM - 230	pCi/l	1.59	+/-0.383	0.406	+/-0.228	0.986	4.01	+/-0.388	1.03	+/-0.213	0.668	+/-0.153
THORIUM - 232	pCi/l	0.261	+/-0.2	0.19	+/-0.124	0.041	0	+/-0.197	0.188	+/-0.094	0.023	+/-0.213

Note:
(1) "--" denotes not analyzed.

Table 4-4
Summary of Groundwater Analytical Results
Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma

PARAMETERS	Units	MWD-4 SEPT 99 filtered	MWD-4 SEPT 99 unfiltered	MWD-4 DEC 99 filtered	MWD-4 DEC 99 unfiltered	MWD-4 MAR 2000 filtered	MWD-4 MAR 2000 unfiltered
FIELD:							
pH	s.u.	6.33	6.33	7.08	7.08	6.69	6.69
CONDUCTIVITY	umhos/cm	1270	1270	1270	1270	1400	1400
TURBIDITY	NTU	667.5	667.5	6.53	6.53	1.08	1.08
REDOX POTENTIAL	mV	186	186.5	--	--	158.25	158.25
DISSOLVED OXYGEN	mg/l	10.35	10.35	1.65	1.65	0.86	0.86
TEMPERATURE	°C	17.55	17.55	17.9	17.9	17.6	17.6
LABORATORY:							
pH	s.u.	7.30	7.06	7.25	6.97	8.14	7.03
SPECIFIC CONDUCTIVITY	umhos/cm	1370	1370	1290	1310	1400	1540
ALKALINITY	mg/l	240	236	242	244	210	257
CHLORIDE	mg/l	253	250	228	225	300	287
FLUORIDE	mg/l	0.5	0.5	0.5	0.4	0.8	0.5
NITRATE	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
SILICA DIOXIDE	mg/l	4.4	4.4	4.2	3.3	4.3	4.4
SULFATE	mg/l	66.9	73.7	66.2	70.3	65.4	59.3
BARIUM	mg/l	0.243	0.64	<0.22	<0.22	0.363	0.085
CALCIUM	mg/l	142	143	129	134	137	119
IRON	mg/l	0.02	<0.01	<0.14	<0.14	<0.105	0.011
MAGNESIUM	mg/l	61.1	54.2	61.6	30.4	61.2	59.7
POTASSIUM	mg/l	35.1	33.6	30.8	30.3	36.8	27.9
SODIUM	mg/l	43.2	39.6	30.6	31.6	45.8	38.9
RADIUM - 226	pCi/l	0.083 +/-0.107	0.024 +/-0.1	0.188 +/-0.107	0.28 +/-0.083	0.275 +/-0.236	0.034 +/-0.119
RADIUM - 228	pCi/l	0 +/-0.269	2 +/-0.331	0 +/-0.446	0 +/-0.867	0 +/-0.105	1.85 +/-0.048
THORIUM - 228	pCi/l	0.343 +/-0.152	0.358 +/-0.152	0.216 +/-0.09	0.065 +/-0.044	0.273 +/-0.263	0.25 +/-0.104
THORIUM - 230	pCi/l	0.996 +/-0.337	2.83 +/-0.505	0.127 +/-0.106	0.237 +/-0.083	3.4 +/-0.551	0.491 +/-0.141
THORIUM - 232	pCi/l	0.057 +/-0.152	0.315 +/-0.217	0.076 +/-0.058	0.079 +/-0.058	0.398 +/-0.229	0 +/-0.04

Note:
(1) "--" denotes not analyzed.

Table 4-4
Summary of Groundwater Analytical Results
Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma

PARAMETERS	Units	MWS-5 SEPT 99	MWS-5 DEC 99	MWS-5 MAR 2000	MWD-5 SEPT 99 filtered	MWD-5 SEPT 99 unfiltered	MWD-5 DEC 99 filtered	MWD-5 DEC 99 unfiltered	MWD-5 MAR 2000 filtered	MWD-5 MAR 2000 unfiltered
FIELD:										
pH	s.u.	9.85	10.21	6.65	7.76	7.86	8.72	8.72	6.65	6.65
CONDUCTIVITY	umhos/cm	772.5	745	778	1395	1395	1320	1320	1213	1213
TURBIDITY	NTU	363.5	164	0.68	2.46	2.46	8.09	8.09	6.17	6.17
REDOX POTENTIAL	mV	-286	-265	145.5	-121	-121	-202	-202	146.8	146.8
DISSOLVED OXYGEN	mg/l	1.48	2.33	19.6	0.75	0.75	3.82	3.82	11.75	11.75
TEMPERATURE	°C	21.15	16.55	15.8	20.53	20.53	15.2	15.2	16.5	16.5
LABORATORY:										
pH	s.u.	9.8	9.84	10.3	7.84	8.00	8.11	8.30	8.05	8.08
SPECIFIC CONDUCTIVITY	umhos/cm	679	777	765	1450	1470	1420	1410	2530	1360
ALKALINITY	mg/l	65	80	83	104	77	109	108	--	109
CHLORIDE	mg/l	143	140	132	345	345	328	323	727	318
FLUORIDE	mg/l	3.5	3.4	2.5	1.4	1.5	1.5	1.6	2.4	1.1
NITRATE	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2
SILICA DIOXIDE	mg/l	<0.8	<0.8	<0.8	2.2	2.1	4.4	2.1	2.3	2.2
SULFATE	mg/l	59.3	113	103	1.2	1.2	1.7	1.9	7.3	1.6
BARIUM	mg/l	0.374	0.317	0.493	5.5	5.74	5.47	5.29	14.1	4.77
CALCIUM	mg/l	24	7.98	8.99	49.6	52	56.6	55.55	63.3	43.4
IRON	mg/l	0.11	0.039	0.012	0.19	0.4	0.013	<0.014	<0.105	0.47
MAGNESIUM	mg/l	73	95.8	76	31.2	32.2	34.7	32.9	138	15.5
POTASSIUM	mg/l	9.9	11.7	12.1	200	210	170	162	184	157
SODIUM	mg/l	15.3	7.39	9.4	27.6	15.7	22.9	22.8	28	25.9
RADIUM - 226	pCi/l	16.1 +/-0.619	11.4 +/-0.492	1.11 +/-0.254	2.29 +/-0.429	1.48 +/- 0.311	2.06 +/-0.269	2.44 +/- 0.297	0 +/-0.660	0.92 +/- 0.241
RADIUM - 228	pCi/l	625 +/-1.58	111 +/-1.8	240 +/-0.232	3.3 +/-0.245	2.41 +/- 0.252	9.42 +/-0.981	15.9 +/- 1.02	0 +/-0.101	2.49 +/- 0.058
THORIUM - 228	pCi/l	3.21 +/-0.657	4.78 +/-0.351	1.48 +/-0.329	0.415 +/-0.171	0.894 +/- 0.318	0.232 +/-0.1	0.108 +/- 0.062	0.139 +/-0.181	0.484 +/- 0.212
THORIUM - 230	pCi/l	1.49 +/-0.457	10.1 +/-0.523	0.389 +/-0.186	1.04 +/-0.229	1.33 +/- 0.356	0.992 +/-0.195	0.192 +/- 0.092	1.23 +/-0.304	0.795 +/- 0.267
THORIUM - 232	pCi/l	0.498 +/-0.311	2.83 +/-0.275	0.031 +/-0.061	0.181 +/-0.158	0.311 +/- 0.305	0.13 +/-0.075	0.008 +/- 0.05	0.251 +/-0.139	0.156 +/- 0.148

Note:
(1) "--" denotes not analyzed.

Table 4-4
Summary of Groundwater Analytical Results
Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma

PARAMETERS	Units	MWS-6						MWD-6											
		SEPT 99		DEC 99		MAR 2000		SEPT 99				DEC 99				MAR 2000			
								filtered		unfiltered		filtered		unfiltered		filtered		unfiltered	
FIELD:																			
pH	s.u.	7.25		7.58		6.69		7.35		7.35		7.37		7.37		6.65		6.65	
CONDUCTIVITY	umhos/cm	1335		2355		1813		2373		2373		1875		1875		2675		2675	
TURBIDITY	NTU	164.5		1.92		3.77		0.4		0.4		71		71		0.95		0.95	
REDOX POTENTIAL	mV	-77.3		--		154		138		138		--		--		144		144	
DISSOLVED OXYGEN	mg/l	3.26		1.45		3.42		0.938		0.938		1.93		1.93		9.13		9.13	
TEMPERATURE	°C	18.03		17.8		13		20.5		20.5		17.9		17.9		--		--	
LABORATORY:																			
pH	s.u.	7.65		7.63		7.40		7.54		7.57		7.64		7.6		7.67		7.67	
SPECIFIC CONDUCTIVITY	umhos/cm	1450		1980		1910		2430		2470		2490		2540		2650		2650	
ALKALINITY	mg/l	362		672		337		122		124		126		126		82.5		89.5	
CHLORIDE	mg/l	235		264		388		634		631		660		691		--		735	
FLUORIDE	mg/l	2.8		3.2		2.6		1.4		1.4		1.4		1.4		1.1		1.1	
NITRATE	mg/l	0.6		<0.2		0.3		<0.2		<0.2		<0.2		<0..2		<0.2		<0.2	
SILICA DIOXIDE	mg/l	2.6		3.0		2.3		2.3		2.3		2.6		2.3		2.3		2.3	
SULFATE	mg/l	34.8		5.8		21.2		11.8		20.3		15.7		14.8		6.5		6.5	
BARIUM	mg/l	3.92		5.65		3.71		3.11		3.65		3.26		2.99		3.64		3.64	
CALCIUM	mg/l	60		68.6		39		77.7		82.8		93.6		84.9		84.4		84.4	
IRON	mg/l	0.79		0.185		1.44		<0.01		0.01		0.016		<0.14		0.018		0.018	
MAGNESIUM	mg/l	145		208		149		140		129		158		139		113		113	
POTASSIUM	mg/l	81.8		101		77.2		221		227		212		187		216		216	
SODIUM	mg/l	24.8		18.1		25.2		13.6		29.9		37.1		28.8		39.4		39.4	
RADIUM - 226	pCi/l	0.535	+/- 0.146	0.722	+/- 0.136	0.486	+/- 0.171	0.768	+/- 0.238	0.044	+/- 0.021	0.816	+/- 0.164	0.657	+/- 0.141	0.611	+/- 0.27	0.87	+/- 0.304
RADIUM - 228	pCi/l	5.25	+/- 0.366	4.13	+/- 0.958	3.21	+/- 0.052	2.46	+/- 0.213	1.05	+/- 0.2	2.17	+/- 0.935	1.08	+/- 0.461	0	+/- 0.195	0.152	+/- 0.04
THORIUM - 228	pCi/l	0.175	+/- 0.115	0.131	+/- 0.066	0.308	+/- 0.18	1.06	+/- 0.396	0.676	+/- 0.345	0.121	+/- 0.076	0.078	+/- 0.052	0	+/- 0.192	1.26	+/- 0.404
THORIUM - 230	pCi/l	0.961	+/- 0.218	0.683	+/- 0.176	0.322	+/- 0.18	0	+/- 0.474	0.349	+/- 0.278	0.121	+/- 0.105	0.296	+/- 0.162	0.416	+/- 0.205	0.868	+/- 0.267
THORIUM - 232	pCi/l	0.055	+/- 0.098	0.072	+/- 0.074	0.182	+/- 0.167	0.087	+/- 0.18	0 +/- 0.278	+/- 0.278	0.076	+/- 0.058	0.085	+/- 0.119	0.072	+/- 0.085	0	+/- 0.111

Note:
(1) "--" denotes not analyzed.

Table 4-4
Summary of Groundwater Analytical Results
Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma

PARAMETERS	Units	MWD-7 SEPT 99	MWD-7 DEC 99	MWD-7 MAR 2000	MWD-8 SEPT 99	MWD-8 DEC 99	MWD-8 MAR 2000	MWD-9 SEPT 99	MWD-9 DEC 99	MWD-9 MAR 2000
FIELD:										
pH	s.u.	6.68	7.09	6.73	7.52	8.19	6.85	6.83	7.21	6.64
CONDUCTIVITY	umhos/cm	1113	1100	1063	1862	2098	2050	695	1002	900
TURBIDITY	NTU	88.25	217.7	0.88	0.413	8.65	1.75	223.5	234.2	1.0
REDOX POTENTIAL	mV	123.8	--	156.3	-167.8	-178	154	143.5	--	163.5
DISSOLVED OXYGEN	mg/l	2.5	1.74	3.95	0.848	1.58	3.19	2.85	4.34	6.37
TEMPERATURE	°C	20.5	16.95	13.2	21.13	16.5	12.9	21.03	17.05	17.6
LABORATORY:										
pH	s.u.	7.25	7.22	6.98	7.68	7.74	7.71	7.36	7.38	7.02
SPECIFIC CONDUCTIVITY	umhos/cm	1190	1240	1180	2050	2180	2350	701	722	764
ALKALINITY	mg/l	313	311	283	160	350	330	277	278	267
CHLORIDE	mg/l	149	167	151	522	503	526	44.3	56.8	68.3
FLUORIDE	mg/l	0.3	0.3	0.3	2	2.4	2.2	0.3	0.3	0.3
NITRATE	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	< 0.2	<0.2	<0.2
SILICA DIOXIDE	mg/l	4.3	4.1	4	2.7	2.5	2.3	4.2	3.6	3.9
SULFATE	mg/l	29.3	18.8	17.2	<1	<1	<1	25.9	26.6	22.4
BARIUM	mg/l	0.967	1.85	1.27	15.7	16.8	15.7	0.187	<0.22	0.206
CALCIUM	mg/l	85.9	65.3	51.7	86.4	66.7	53.1	215	92.2	85
IRON	mg/l	0.13	0.68	0.01	0.73	0.214	1.97	0.33	0.33	0.014
MAGNESIUM	mg/l	30.2	30.6	23.3	124	167	139	30.9	15.9	26.8
POTASSIUM	mg/l	167	209	173	201	180	174	4.5	6.9	5.07
SODIUM	mg/l	29.9	19.6	25.5	48	16.6	23.6	24.1	21.6	25.6
RADIUM - 226	pCi/l	0.08 +/- 0.198	0.572 +/- 0.133	0.947 +/- 0.851	0.479 +/- 0.155	0.778 +/- 0.172	1.34 +/- 0.201	0.119 +/- 0.09	0.158 +/- 0.197	0 +/- 0.124
RADIUM - 228	pCi/l	7.76 +/- 0.38	5.07 +/- 0.558	2.77 +/- 0.047	3.41 +/- 0.219	1.13 +/- 1	4.2 +/- 0.052	1.63 +/- 0.35	1.7 +/- 0.929	0 +/- 0.037
THORIUM - 228	pCi/l	0.619 +/- 0.257	0.221 +/- 0.108	0.188 +/- 0.106	0.536 +/- 0.388	0.155 +/- 0.066	0.294 +/- 0.099	0.397 +/- 0.24	0.137 +/- 0.08	0.389 +/- 1.22
THORIUM - 230	pCi/l	1.33 +/- 0.527	0.717 +/- 0.149	0.556 +/- 0.143	0 +/- 0.223	0.745 +/- 0.129	0.262 +/- 0.11	4.02 +/- 0.515	0.444 +/- 0.143	0.669 +/- 0.169
THORIUM - 232	pCi/l	0.361 +/- 0.238	0.152 +/- 0.076	0.033 +/- 0.039	0 +/- 0.2	0.109 +/- 0.051	0.096 +/- 0.06	0 +/- 0.231	0.125 +/- 0.08	0.037 +/- 0.08

Note:
(1) "--" denotes not analyzed.

Table 4-4
Summary of Groundwater Analytical Results
Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma

PARAMETERS	Units	MWD-10				MWD-11											
		SEPT 99		DEC 99	MAR 2000	SEPT 99				DEC 99				MAR 2000			
						filtered		unfiltered		filtered		unfiltered		filtered		unfiltered	
FIELD:																	
pH	s.u.	6.95		7.46	6.73	7.39		7.39		7.63		7.63		6.66		6.66	
CONDUCTIVITY	umhos/cm	1120		1205	1100	985		985		1605		1605		1825		1825	
TURBIDITY	NTU	17.38		24.87	0	3.66		3.66		4.36		4.36		0.36		0.36	
REDOX POTENTIAL	mV	132.5		59	4.14	139.25		139.25		--		--		157		157	
DISSOLVED OXYGEN	mg/l	0.805		1.27	100	0.8		0.8		1.93		1.93		1.02		1.02	
TEMPERATURE	°C	20.8		17.9	17.0	20.73		20.73		17.9		17.9		14.3		14.3	
LABORATORY:																	
pH	s.u.	7.39		7.50	7.33	7.70		7.64		7.65		7.57		7.71		7.48	
SPECIFIC CONDUCTIVITY	umhos/cm	1180		1190	1230	1040		1060		1460		1520		1670		1720	
ALKALINITY	mg/l	272		274	256	252		252		215		217		180		180	
CHLORIDE	mg/l	191		200	219	158		157		318		343		428		404	
FLUORIDE	mg/l	0.9		0.9	0.8	2.5		2.5		2.3		2.4		2.1		2.3	
NITRATE	mg/l	0.2		<0.2	<0.2	<0.2		<0.2		<0.2		<0.2		<0.2		<0.2	
SILICA DIOXIDE	mg/l	3.7		3.5	3.5	2.3		2.3		2.3		2.3		2.3		0.8	
SULFATE	mg/l	17.2		15.7	16	26.8		26.8		20		18.2		17.7		14.7	
BARIUM	mg/l	1.09		1.23	1.17	0.28		0.32		0.995		1.08		0.454		0.474	
CALCIUM	mg/l	75.5		89.1	77.5	23.9		24.6		40.8		41.9		40.4		36.6	
IRON	mg/l	<0.01		0.019	<0.07	<0.01		<0.01		0.015		<0.14		<0.105		0.06	
MAGNESIUM	mg/l	52		59.2	57.8	78.6		79.9		118		116		109		118	
POTASSIUM	mg/l	59.3		64.5	62.3	70.3		72.1.		87.1		78.7		83.1		80.7	
SODIUM	mg/l	23.9		<47	25.8	11.7		23.9		18.8		17.8		--		25	
RADIUM - 226	pCi/l	0.02	+/- 0.246	0.679	0.213	0	+/- 0.347	0	+/- 0.17	0.886	+/- 0.170	1.03	+/- 0.186	0	+/- 0.248	0.33	+/- 0.122
RADIUM - 228	pCi/l	1.17	+/- 0.194	0	0.055	1.1	+/- 0.184	1.61	+/- 0.191	3.71	+/- 0.935	5.4	+/- 5.22	0	+/- 0.095	3.74	+/- 0.058
THORIUM - 228	pCi/l	4.37	+/- 0.659	0.121	0.195	5.09	+/- 0.408	9.99	+/- 1.48	0.424	+/- 0.322	0.11	+/- 0.059	0.219	+/- 0.162	0.106	+/- 0.093
THORIUM - 230	pCi/l	3.03	+/- 0.553	0.615	1.16	0.556	+/- 0.146	2.07	+/- 0.925	1.14	+/- 0.505	0.177	+/- 0.128	1.95	+/- 0.543	0.519	+/- 0.146
THORIUM - 232	pCi/l	0.419	+/- 0.251	0.3	0.251	0.356	+/- 0.117	0.836	+/- 0.554	0.212	+/- 0.322	0.006	+/- 0.058	0.359	+/- 0.176	0.032	+/- 0.084

Note:
(1) "--" denotes not analyzed.

Table 4-4
Summary of Groundwater Analytical Results
Kaiser Aluminum Specialty Products Facility
Tulsa, Oklahoma

PARAMETERS	Units	ST-2 SEPT 99	ST-2 DEC 99	ST-2 MAR 2000	ST-3 SEPT 99	ST-3 DEC 99	ST-3 MAR 2000
FIELD:			Not Sampled	Not Sampled			
pH	s.u.	7.11			7.28	7.54	6.66
CONDUCTIVITY	umhos/cm	7603.3			5735	5760	6175
TURBIDITY	NTU	477			1.68	0.75	1.44
REDOX POTENTIAL	mV	168			-68.25	--	166.25
DISSOLVED OXYGEN	mg/l	3.75			2.7	1.95	2.37
TEMPERATURE	°C	18.37			18.65	16.75	17.2
LABORATORY:							
pH	s.u.	7.96			7.60	7.54	7.39
SPECIFIC CONDUCTIVITY	umhos/cm	8670			6570	6530	6620
ALKALINITY	mg/l	617			135	141	141
CHLORIDE	mg/l	2300			2080	2084	2090
FLUORIDE	mg/l	0.8			0.6	0.6	0.5
NITRATE	mg/l	27.9			<0.2	<0.2	<0.2
SILICA DIOXIDE	mg/l	2.8			3.7	3.5	3.8
SULFATE	mg/l	136			2.6	1.7	3.0
BARIUM	mg/l	0.54			5.6	4.75	4.45
CALCIUM	mg/l	93.6			243	198	179
IRON	mg/l	0.82			0.94	0.51	1.02
MAGNESIUM	mg/l	74.5			77.5	77.4	67.5
POTASSIUM	mg/l	13.6			15.6	10.4	8.54
SODIUM	mg/l	1280			1220	1010	1060
RADIUM - 226	pCi/l	2.12 +/- 0.355			2.99 +/- 0.278	2.69 +/- 0.304	1.88 +/- 0.25
RADIUM - 228	pCi/l	1.68 +/- 0.195			4.87 +/- 0.219	3.91 +/- 1.01	1.68 +/- 0.043
THORIUM - 228	pCi/l	0.392 +/- 0.123			0.205 +/- 0.136	0.118 +/- 0.068	0.157 +/- 0.145
THORIUM - 230	pCi/l	0.925 +/- 0.175			1.54 +/- 0.372	0.076 +/- 0.076	0.321 +/- 0.166
THORIUM - 232	pCi/l	0.257 +/- 0.094			0.11 +/- 0.130	0.025 +/- 0.06	0.027 +/- 0.053

Note:
(1) "--" denotes not analyzed.

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Table 4-5
U.S. Environmental Protection Agency
Maximum Contaminant Level (MCL) for
Drinking Water

PARAMETERS	Units	MCL
pH	s.u.	*6.5-8.5* (1)
SPECIFIC CONDUCTIVITY	umhos/cm	NA
ALKALINITY	mg/l	NA
CHLORIDE	mg/l	*250*
FLUORIDE	mg/l	*2.0*
NITRATE	mg/l	10
SILICA DIOXIDE	mg/l	NA
SULFATE	mg/l	*250*
BARIUM	mg/l	2.0
CALCIUM	mg/l	NA
IRON	mg/l	*0.3*
MAGNESIUM	mg/l	NA
POTASSIUM	mg/l	NA
SODIUM	mg/l	NA
RADIUM - 226	pCi/l	5 (2)
RADIUM - 228	pCi/l	5
THORIUM - 228	pCi/l	15(3)
THORIUM - 230	pCi/l	15(3)
THORIUM - 232	pCi/l	15(3)

__Notes:__
(1) *Italicized* value is a secondary MCL.
(2) MCL for Radium-226 and -228 combined is 5 pCi/l.
(3) Gross alpha particle activity (including Radium-226) is 15 pCi/l.

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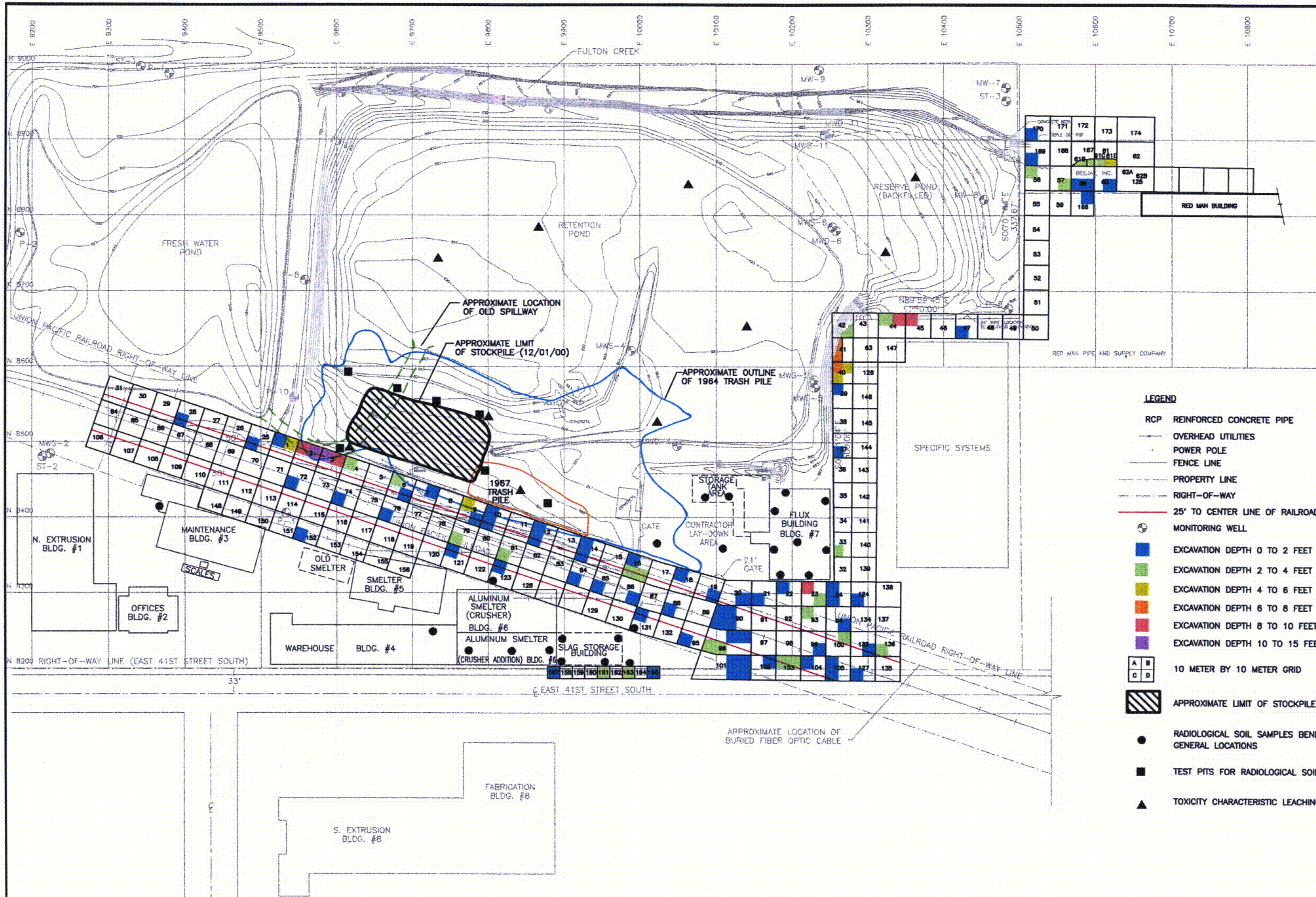

LEGEND

RCP REINFORCED CONCRETE PIPE

OVERHEAD UTILITIES

POWER POLE

FENCE LINE

PROPERTY LINE

RIGHT-OF-WAY

25' TO CENTER LINE OF RAILROAD TRACKS

MONITORING WELL

EXCAVATION DEPTH 0 TO 2 FEET

EXCAVATION DEPTH 2 TO 4 FEET

EXCAVATION DEPTH 4 TO 6 FEET

EXCAVATION DEPTH 6 TO 8 FEET

EXCAVATION DEPTH 8 TO 10 FEET

EXCAVATION DEPTH 10 TO 15 FEET

10 METER BY 10 METER GRID

APPROXIMATE LIMIT OF STOCKPILE AREA

RADIOLOGICAL SOIL SAMPLES BENEATH CONCRETE, GENERAL LOCATIONS

TEST PITS FOR RADIOLOGICAL SOIL SAMPLES

TOXICITY CHARACTERISTIC LEACHING PROCEDURE SAMPLING LOCATIONS

SCALE - FEET
0 60 120 180

REFERENCES

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

2. BUILDING LOCATIONS AND OUTLINES WERE DETERMINED FROM KAISER PLANT UTILITIES CUT-OFFS DIAGRAM, DATED 2/89.

3. TOPOGRAPHIC INFORMATION WAS OBTAINED FROM TOPOGRAPHIC SURVEY OF PART OF THE SE/4 OF SECTION 23 TOWNSHIP 19 NORTH RANGE 13 EAST, OF THE I.B. & M., TULSA COUNTY, STATE OF OKLAHOMA, ACCORDING TO THE U.S. GOVERNMENT SURVEY THEREOF, AND KNOWN AS 7311 EAST 41st STREET SOUTH. (FILE: NFSK003.DWG REV. A)

4. OUTLINE OF TRASH PILES COMPILED FROM 1964 AND 1967 AERIAL PHOTOGRAPHS.

5. LOCATION AND OUTLINE OF OLD SMELTER TAKEN FROM 1958 AERIAL PHOTOGRAPHS.

C08

REVISION	DATE	DESCRIPTION

FIGURE 4-1
ADDITIONAL CHARACTERIZATION SAMPLING LOCATIONS
KAISER ALUMINUM
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

APPROVED RS 5/31/01
CHECKED JHS 5/31/01
DRAWN RAM 12/04/00

DRAWING NUMBER
5427A408

Earth Sciences Consultants, Inc.

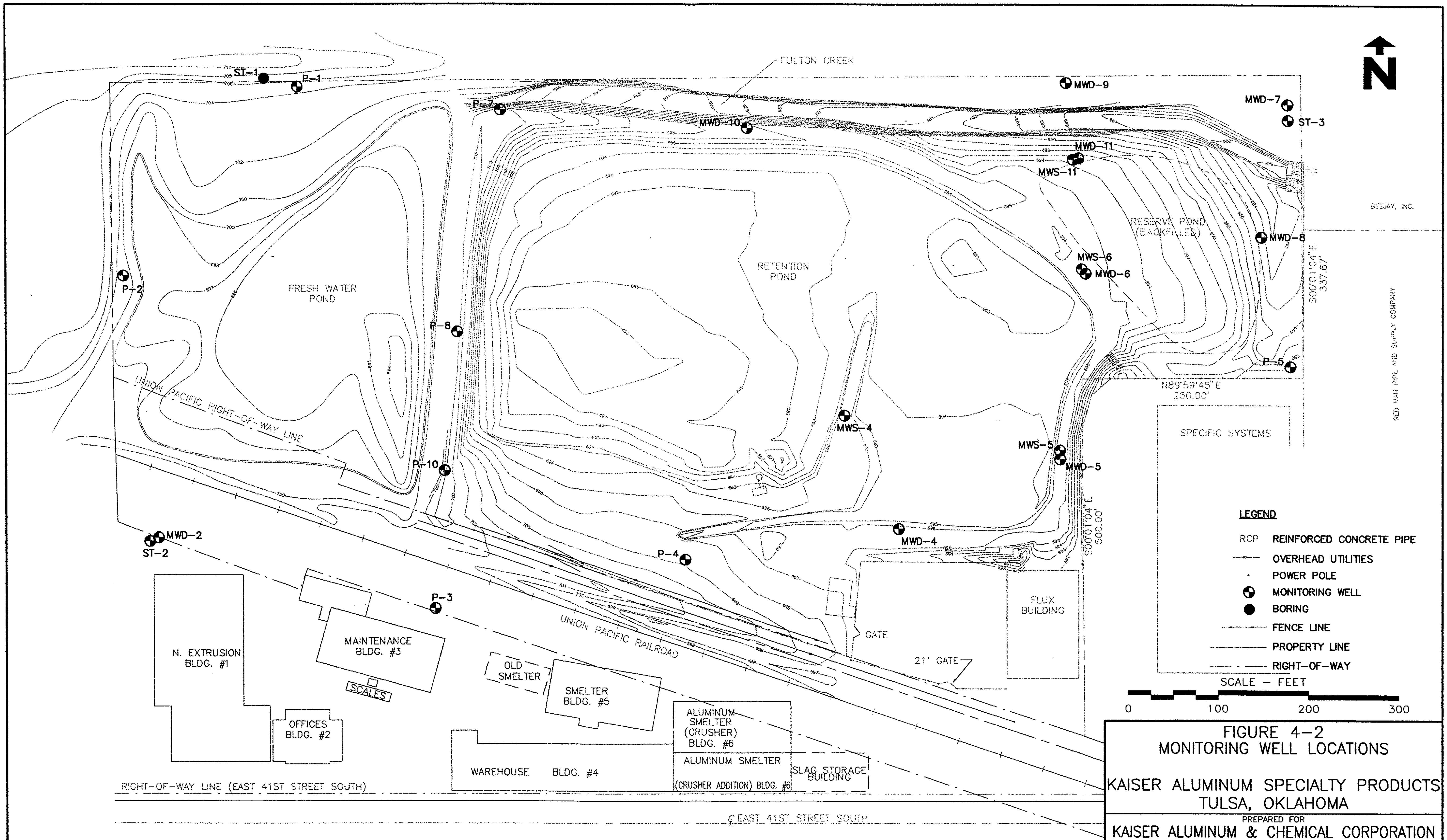

FIGURE 4-2
MONITORING WELL LOCATIONS

KAISER ALUMINUM SPECIALTY PRODUCTS
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

APPROVED	5/31/01
CHECKED	JMS 05/31/01
DRAWN	GJA 5/2/01
DRAWING NUMBER	5427225

Earth Sciences Consultants, Inc.

REFERENCES

1. THE RIGHT-OF-WAY AND PROPERTY LINES WERE OBTAINED FROM PLAT OF SURVEY PREPARED BY DENTON & WHITE SURVEYING COMPANY SEALED ON FEBRUARY 14, 1964.
2. TOPOGRAPHIC INFORMATION WAS OBTAINED FROM TOPOGRAPHIC SURVEY OF PART OF THE SE/4 OF SECTION 23 TOWNSHIP 19 NORTH RANGE 13 EAST, OF THE I.B. & M., TULSA COUNTY, STATE OF OKLAHOMA, ACCORDING TO THE U.S. GOVERNMENT SURVEY THEREOF, AND KNOWN AS 7311 EAST 41st STREET SOUTH. (FILE: NFSK003.DWG REV. A)

5.0 Dose Modeling Evaluations

5.1 Introduction

Dose modeling evaluations (dose assessment) have been performed for development of the DP in the context of the draft NUREG-1549: Decision Methods for Dose Assessment to Comply with Radiological Criteria for License Termination (NRC, July 1998). The process followed is illustrated by the decision framework, as shown in Figure 5-1.

Consistent with NUREG-1549, a phased approach to decision making was used to evaluate a variety of remedial options. Generally, these iterations in the first phase utilize a generic screening process, using predefined models and generic screening parameters, and then proceed to more site-specific evaluations. Site-specific evaluations range in complexity from:

a) use of NRC models with site-specific parameter values;
b) to using both site-specific parameter values and site-specific model assumptions;
c) to combinations of a and b and also remediating the site; and
d) to combinations of a, b, c, and also restricting release of the site.

Generic screening using the DandD model was not appropriate because the volume of waste is relatively large and extends up to 15 feet below grade. Site-specific parameter values were developed from existing characterization data, and $DCGL_W$ were calculated using Residual Radiation (RESRAD) v6.0 (U.S. Department of Energy [USDOE], September 1999). Because a relatively large proportion of the affected soil exceeds the $DCGL_W$s, the analysis proceeded to evaluation of combinations of c and d. Within this more complex framework of analysis, several options were considered that included remediating the site by removal of soil, treatment of soil, and combinations of removal and treatment, as well as restricting the future use of the site under the requirements of 10 Code of Federal Regulations (CFR) 20.1403.

Consistent with the framework presented in Figure 5-1, Step 1, existing data were reviewed to characterize the nature and extent of thorium waste. This included defining the principal radionuclides and their chemical form and physical properties, and characterizing the spatial distribution of thorium waste. Historical characterization documents were used to obtain information regarding site conditions and geological and hydrogeological information.

In Step 2, Scenario Definition/Pathway Identification, exposure scenarios were defined using generic scenarios and critical groups described within NUREG-1549 and the *Preliminary Guidelines for Evaluating Dose Assessments in Support of Decommissioning* (Preliminary Guidelines) (NRC, February 1999);

however, as described in Section 5.2.5, evolution of engineering design concepts for remedial alternatives has necessitated modifications to the NRC's generic scenarios. Step 3 included development of a conceptual site model and selection of an appropriate computer code or model and input parameters for the model. The objective of Step 4, the dose assessment, is to estimate the potential future radiological dose that could be caused by residual radioactivity remaining at the site after decommissioning activities are completed for each of the alternatives selected for evaluation. This is performed by first calculating the dose for the no-action alternative and then calculating the $DCGL_W$s required to meet unrestricted site release dose rates of 25 mrem/yr by removal of contaminated material.

In Step 5, the dose estimates for each alternative were compared to the NRC's license termination requirements in 10 CFR 20, Subpart E for restricted and unrestricted use of facilities after license termination. Dose objectives for both unrestricted and restricted releases require assessments which consider cases in which the average member of the critical group (a hypothetical future land user) is located on the site. Because dose estimates for current site conditions (no-action alternative) exceeded the 25 mrem/yr dose criteria of 10 CFR 20.1402, the analysis proceeded to Step 8.

Step 8 includes defining a range of options, including additional site characterization, remediation, and restricted-use options, to define the most effective and cost-efficient decontamination and decommissioning strategy. Although additional site-specific or regional characterization data, such as physical properties of the affected zone, are likely to lower the estimated dose, the anticipated reduction is modest at best (in absolute terms). Development of additional site-specific exposure scenarios and critical groups in light of reasonable future site uses and surrounding properties could reduce estimated doses. For example, consideration of other site uses consistent with the urban/industrial environs, such as a resident gardener, has been considered.

Based on this assessment, Kaiser selected a decommissioning approach that will achieve unrestricted release. The dose evaluation for the selected approach is discussed below.

5.2 Unrestricted Release Using Site-Specific Information

5.2.1 Source Term

5.2.1.1 Principal Radionuclides

The total thorium concentration present at the site represents concentrations of Th-228, Th-230, and Th-232. As stated in Chapter 2.0, the presence of thorium in soil at the site is the result of historical operations that involved the recycling of magnesium-thorium alloy from aircraft scrap which was used in the smelter and manufacture of magnesium anodes. The waste byproduct of these operations was a thoriated metallic dross that was conveyed to disposal ponds north of the manufacturing complex, often after being ground in the crusher building.

Calculations of model input concentrations for all principal radionuclides are presented in Appendix C. Input concentrations were computed from weighted averages that took into account depth intervals of observed concentrations on site, as well as the combined volumes of on-site and stockpiled adjacent land remediation (approximately 285,000 ft^3) material stored on site. Spreadsheet algorithms take into account naturally occurring background in backfill, the values of which were obtained from literature. Site natural background has been determined to be 1.1 pCi/g.

Ratios of each thorium isotope previously determined by Kaiser were used in this analysis (ADA, March 1999) (see Attachment 5-1). Th-232, Ra-228, and Th-228 are in secular equilibrium. Th-230 concentrations are 3.5 times as much as Th-232 and were estimated using the following equation:

$$[Th\text{-}230] = [Th\text{-}232] \times 3.5 \qquad \text{Equation 5-1}$$

where:

[Th-230] = concentration of Th-230 (pCi/g) and
[Th-232] = concentration of Th-232 (pCi/g).

Concentrations of Ra-226 and Pb-210 were calculated from the Th-230 concentrations considering an elapsed time of 55 years since material production, resulting in Ra-226:Th-230 and Pb-210:Th-230 ratios of 0.0235 and 0.0123 respectively. That is, it is assumed that the age of the original Th-230-containing alloy is 55 years and, therefore, Th-230 is not in secular equilibrium with its daughter products. As a result, concentrations of Th-230 daughter products were estimated by subtracting background from the Th-230 concentration, multiplying that difference by the appropriate ratio, and then adding background to the resulting product because the background Th-230 should be in secular equilibrium with its daughter products. This is exhibited by the following equations:

$$[Ra\text{-}226] = 0.0235 \times ([Th\text{-}230] - [BKGD]_{Th\text{-}230}) + [BKGD]_{Ra\text{-}226} \qquad \text{Equation 5-2}$$

$$[Pb\text{-}210] = 0.0123 \times ([Th\text{-}230] - [BKGD]_{Th\text{-}230}) + [BKGD]_{Pb\text{-}210} \qquad \text{Equation 5-3}$$

where:

$[Ra\text{-}226]$ = concentration of Ra-226 (pCi/g),
$[Th\text{-}230]$ = concentration of Th-230 (pCi/g),
$[BKGD]_{Th\text{-}230}$ = site native background concentration of Th-230,
$[BKGD]_{Ra\text{-}226}$ = site native background concentration of Ra-226,
$[Pb\text{-}210]$ = concentration of Pb-210 (pCi/g), and
$[BKGD]_{Pb\text{-}210}$ = site native background concentration of Pb-210.

The source concentration has been estimated using these calculations for Th-230 and its daughter products, and by knowing that Th-232 and its daughter products are in secular equilibrium.

5.2.1.2 Geochemistry

Several investigations of the chemical form of the radionuclides have been conducted. Pacific Northwest National Laboratory (PNNL) and NRC staff collected a total of 18 sludge, soil, and water samples from the site for chemical and radiological analyses (PNNL, July 1999). GCX, Inc. (GCX) investigated the chemical and mineralogical characteristics of the dross; chemical analysis of the dross pore waters and various groundwater horizons; and measured thorium and radium activity in dross, dross pore waters, and selected groundwaters (GCX, undated).

GCX's geochemical data indicated that the dross is composed primarily of hydrous magnesium (Mg) oxides dominated by the mineral brucite. Thorium is present in the dross material. Surface and upgradient groundwaters are primarily calcium bicarbonate waters with near-neutral pH. Retention pond water and pore waters in dross exhibit elevated pH (9.2 to 9.8) and high Mg/calcium (Mg/Ca) ratios, reflecting interaction with the dross. Filtered pore waters in dross contained little or no detectable thorium.

Concentrations of thorium and radium isotopes measured above and below the dross/clay interface indicate that these constituents have migrated less than 3 inches into the clay. Combined with the dross/clay interface data and known high distribution coefficients (K_d) it can be concluded that vertical transport of thorium and radium through the sediments at the site will be very slow. Although laboratory K_d values were reported by GCX, they are considered qualitative because of concerns that experimental design did not allow for precise determination of the high K_d values characteristic of these elements. Consequently, K_d values for thorium and radium utilized in the dose assessment were obtained from NUREG-5512/Volume III. It is believed that the K_d values selected are conservative and likely to result in an overestimate of dose.

According to the PNNL report (PNNL, July 1999), total chemical analysis of the slag/sludge samples and six core samples shows that the principal constituent is Mg (as high as 36 percent), with lesser amounts of silica, aluminum, manganese, Ca, and iron. High Mg was attributed to disposal of Mg/Th alloy slags. The total chemical analysis also showed significant concentrations of thorium but uranium was undetectable. PNNL concluded that the thorium present on site is most likely very insoluble, either as hydrous thorium oxide or crystalline thoranite. Solubility apparently is controlled by hydrous thorium oxide which accounts for undetectable thorium levels in the retention pond even though significant thorium exists in the solid phase. PNNL calculated a maximum leach rate for thorium of 4.2×10^{-14} grams of thorium per second (gTh/sec) based on an analytical detection limit of $10^{-8.5}$ moles per liter (M). Consequently, a conservative literature solubility constant of 3.16×10^{-9} M was used for thorium isotopes. The solubility limit for radium was not measured and consequently a literature value of 1×10^{-9} M was used (NUREG/CR-6377 PNNL-11408) (NRC, May 1998). Therefore, both measured values and literature values of solubility were utilized in the dose assessment. Both values probably are overestimates of the solubility.

5.2.1.3 Spatial Distribution and Volume Estimates

The volume of material identified as "contaminated" is a function of the cleanup level selected. For the purposes of preliminary dose assessment, "contaminated" was defined as the volume of material greater than $DCGL_W$s. Consistent with draft Regulatory Guide DG-4006, Appendix E of NUREG-1549 and the Standard Review Plan, $DCGL_W$s were calculated assuming that the residual thorium-bearing material is 15 centimeters (cm) thick (which corresponds to the surface plow layer in RESRAD v6.0 and DandD). The dominant exposure pathways in this analysis were direct gamma and plant uptake of Th-232. Consequently, the single-radionuclide $DCGL_W$ for Th-232 (3.45 pCi/g) was adjusted to 3 pCi/g to account for the presence of the other principal radionuclides at the ratios previously discussed. That is, the hypothetical resident farmers dose from 3.45 pCi/g Th-232 is 25 mrem/yr. Therefore, to account for the presence of the other principal radionuclides, this $DCGL_W$ was adjusted to 3 pCi/g Th-232, 3 pCi/g Th-228, 3.5*3 pCi/g Th-230, 1.0*3 pCi/g Ra-228, 0.0235*(3.5*3 pCi/g) Ra-226, and 0.0123*(3.5*3 pCi/g) Pb-210 so that the maximum total dose to the resident farmer from all principal radionuclides and their decay products was 25 mrem/yr. $DCGL_W$s are the concentration above background, so the "contaminated" definition is effectively 3 plus background pCi/g Th-232. $DCGL_W$s for the radionuclides, both as individual contributors and collectively under the Unity Rule, are given below. Current volume estimates do not reflect subtraction of background, but the anticipated effect on the volume estimates of the background adjustment is likely to be a minor lowering of those estimates.

$DCGL_W$s

Radionuclide	Single Radionuclide $DCGL_W$ (pCi/g)	Ratio to Th-232 Assuming Equilibrium	Average Concentration w/Th-232 at Single Rad $DCGL_W$ (pCi/g)	Adjusted $DCGL_W$ to Meet Unity Rule (pCi/g)
Pb-210 pCi/g	1.751	0.043	0.15	0.12
Ra-226 pCi/g	5.9	0.082	0.28	0.24
Ra-228 pCi/g	4.317	1	3.42	2.91
Th-228 pCi/g	3.366	1	3.42	2.91
Th-230 pCi/g	102.3	3.5	11.96	10.19
Th-232 pCi/g	3.418	1	3.42	2.91

Once "contaminated" has been defined, then the proportion of contaminated material can be estimated. Central to the problem of estimating the volume of contaminated material above a particular cleanup level is understanding the spatial distribution of the material in question. Typically, isoconcentration contour maps are used to present this type of information. Several techniques are widely used to produce these types of maps including hand contouring, regression analysis, inverse distance, triangulation, and kriging.

The data set provided in Appendix I of the ARS report (1995) was evaluated using both kriging and triangulation methods to produce contour maps and volume estimates.

For comparison, kriging and triangulation each were used to estimate the volume of affected material in excess of the adjusted Th-232 $DCGL_W$ (3 pCi/g), the 10 pCi/g criteria, and greater than 40 pCi/g Th-232 + Th-228 and greater than 110 pCi/g Th-232 + Th-228. Volume estimates determined by each of the two techniques are provided below (Appendix A).

Estimated Volumes cubic meters (m^3) by Kriging and by Triangulation

	>3 pCi/g Th-232	>10 pCi/g Th-232 + Th-228	>40 pCi/g Th-232 + Th-228	>110 pCi/g Th-232 + Th-228
Triangulation	112,293	74,879	37,225	15,558
Kriging	143,288	113,504	40,076	10,355

The 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. The effect of this bias is more evident at lower concentrations. Therefore, kriging results were utilized in this evaluation.

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

For purposes of dose assessment modeling, the affected zone is assumed to be relatively homogeneous in the distribution of thorium waste. Under the no-action scenario, this assumption may result in an underestimate of risk, because significant large volumes of relatively higher level thorium wastes remain. For the other alternatives considered, the affected zone will be relatively homogeneous due to material handling and/or removal of more affected areas.

5.2.1.4 Chosen Remedial Action: Off-Site Disposal/Site Restoration

Based on evaluations, off-site disposal in a facility authorized to accept unimportant quantities (exempt) of source material was selected for implementation to achieve unrestricted release of the site. This remediation approach requires excavation and identification of thorium-bearing soil/dross containing concentrations of Th-232 greater than 31.1 pCi/g, and separating it from the remainder of the material. It will be necessary to excavate below-criteria thorium-bearing material to access deeper wastes. Some stockpiling and redistribution of material on site will be required after the more concentrated material has been removed. Above-criteria material, the volume of which is estimated to be approximately 970,000 ft^3, will be shipped to an off-site disposal facility.

This approach achieves the goal of reducing the residual dose to less than 25 mrem/yr. In addition, it minimizes the quantity of material requiring off-site disposal and maintains the exempt classification of exported material. The excavation would be backfilled with approximately 4,000,000 ft^3 of clean soil. The resulting generalized configuration includes an area of approximately 9.25 acres (comprising the retention pond area) that would consist of about a 10.9-foot-thick layer of below-criteria soil covered with clean backfill at an average depth of 10 feet. The remaining average Th-232 concentration in the below-criteria soil would be 6.35 pCi/g above background. The upper 10 feet would contain only background concentrations.

5.2.2 Critical Groups Scenarios and Pathway Identification and Selection

Critical groups, pathway identification, and exposure scenarios were selected consistent with the Preliminary Guidelines, Regulatory Guide DG-4006, and NUREG-5512/Volume 1.

5.2.2.1 Scenario Identification

Two residential land use scenarios were evaluated using the RESRAD program: residential farming and residential gardening. These residential scenarios evaluate residents inhabiting the site and cultivating the land for farming (i.e., residential farming) or gardening (i.e., residential gardening) purposes. The residential farming scenario considers the raising of crops and livestock for subsistence purposes, and use of potable water from on site. The residential gardening scenario evaluates an urban/ suburban/rural setting where subsistence farming is not practiced; however, a small portion of land is used for gardening. The residential gardening scenario assumes no raising of livestock.

Dose assessment results derived for the most conservative scenario (i.e., residential farming), have been utilized for analysis, planning, design, and implementation of decommissioning activities at the site. Consideration of residential farming accounts for uncertainties in actual land use activities that could occur on site over the next 1,000 years. Analysis of the residential gardening scenario is presented together with analysis of the residential farming scenario.

5.2.2.2 Critical Group Determination

The dose objective for unrestricted use requires an assessment considering no land use restrictions which means that the average member of the critical group is located on the site. A resident farmer scenario is described in NUREG-1549 as the presumptive screening group for the default scenarios of NUREG/CR-5512 and the Standard Review Plan. Consequently, and as previously stated, the resident farmer was selected as the critical group. The resident gardener was evaluated as a less conservative critical group under an alternative residential land use scenario, the analyses of which was carried along with the residential farmer. Behavioral and metabolic parameters for the resident farmer were obtained from recommended RESRAD defaults in the Preliminary Guidelines and NUREG/CR-5512. Those for the resident gardener are not as well defined as for the farmer; therefore, behavioral and metabolic parameters for the farmer, with minimal modifications, were used in the analyses of the resident gardener. These modifications are discussed in Section 5.2.4.

5.2.2.3 Exposure Pathways

External gamma, inhalation, plant, meat, milk, aquatic, drinking water, and soil ingestion are the transport pathways that were considered for evaluation in this dose assessment. External gamma is applicable to all scenarios since it takes into account the radiation emanating from the radionuclides found in the affected zone regardless of the future use of the site or possible situations that may occur. The ingestion pathways of plant, meat, milk, water, and soil are considered applicable to the model when the site is used to obtain food and water for living or farming purposes.

Evaluation of the resident gardening scenario considers subsistence farming as not necessary for survival; therefore, meat and milk ingestion pathways are not considered. Additionally, under the resident gardener scenario, the annual consumption of homegrown vegetables, fruits, and grains occurs at a 75 percent lower rate than that evaluated for the farmer. This assumption is utilized through application of a diet factor (equivalent to a value of 0.25) to the farmer consumption rates (NUREG/CR-5512).

Under both residential scenarios, the soil ingestion pathway is complete when the affected zone is exposed from lack of cover or excavation activities. The inhalation pathway is evaluated when there is potential to expose an individual to airborne radionuclides from the affected zone. In other words, similar to soil ingestion, inhalation can occur if the affected zone is exposed by either excavation from farming activities or construction, or through lack of a cover. However, application of site-specific and NRC default assumptions regarding a dual simulation modeling approach (i.e., per the Preliminary Guidelines) to postdecommissioning site conditions results in elimination of the soil ingestion and inhalation pathways from evaluations of both residential scenarios.

The consumption of aquatic foods (from Fulton Creek) pathway was considered not to be a viable ingestion pathway for a future resident farmer or resident gardener living on the site for several reasons as follows:

- No edible species currently inhabit or are expected to inhabit that portion of the stream proximate to the site.
- Monitoring at the site has indicated that no radionuclide migration to Fulton Creek is occurring or is expected to occur in the future.

- The possibility of contaminated soil runoff into the creek will be eliminated as a result of soil/dross remediation.

The following items summarize the pathways applicable for each of the residential critical groups:

Resident Farmer

- External Gamma
- Water- Dependent and Independent Plant Ingestion
- Water- Dependent and Independent Meat Ingestion
- Water- Dependent and Independent Milk Ingestion
- Drinking Water

Resident Gardener

- External Gamma
- Water- Dependent and Independent Plant Ingestion
- Drinking Water

5.2.3 Conceptual Model

The conceptual model generically represents the actual site configuration. Layers of material that make up the site in the model are the affected zone and the saturated zone overlain by a zone of clean backfill utilized in site restoration.

5.2.3.1 Affected Zone

Physical characteristics of the site are described in the Geotechnical Brief by lithologic unit. Boring logs through the affected material, which includes the dross (Unit 5), describe the material as silty clay. Hydraulic conductivity measurements of the dross were not possible due to poor sample recoveries. Slug test results of Unit 5 were between 3.41 x 10^{-4} to 3.06 x 10^{-4} cm per second (cm/sec). Therefore, the existing soil/dross material was considered to have physical properties similar to silty clay. Draft attachments to NUREG/CR-5512 include average estimates for silty clay of 0.35 total porosity, 2.19 x 10^{-6} cm/sec (0.691 meter per year [m/yr]) hydraulic conductivity, and 1.696 grams per cubic cm (g/cm^3) by density (as calculated from particle density). Effective porosity and field capacity were calculated proportionate to total porosity for similar soil (No. 27 SC moderate density, USEPA, September 1994). Physical properties for the affected zone are shown in Appendix C.

5.2.3.2 Saturated Zone

Generally, the saturated zone is made up of Unit 2 and Unit 3 soils (described as silty clay) with some Unit 4 soils (peaty silty clay) mixed in (A&M Engineering, 1999). Subsequent grain-size analysis and plasticity indices indicated the Unit 2 material would be classified by Unified Soil Classification System Classifications as CL. For the purposes of this dose assessment, the unsaturated zone was conservatively assumed to be absent. (When the freshwater pond is removed and closed, the water table could drop to create an unsaturated zone beneath the affected material.)

Laboratory measurements of Unit 2 soil hydraulic conductivity ranged from 2.3×10^{-9} to 3.2×10^{-8} cm/sec (average of 5.32×10^{-3} m/yr) (Earth Sciences, 2000). For the purposes of the dose modeling, the hydraulic conductivity of the saturated zone used in the modeling was to be 1×10^{-8} cm/sec (3.16×10^{-2} m/yr) because horizontal hydraulic conductivity typically is an order of magnitude less than laboratory measurements of vertical hydraulic conductivity. Average measured dry density of Unit 2 soils was 107.5 pound per ft^3 (lb/ft^3) or 1.72 g/cm^3 (Earth Sciences, 2000). The total porosity of the saturated zone was calculated to be 0.35 (considering a particle density of 2.65 g/cm^3 [draft attachments to NUREG/CR-5512]) and the effective porosity was estimated as one tenth of the total porosity which is typical of moderate density CL soils (USEPA, 1994).

5.2.3.3 Conceptual Model for a Dual Simulation Approach to Dose Modeling

As described previously, the critical group being evaluated for unrestricted release is the resident farmer and gardener, with the former driving the decision process in the DP. Upon implementation of remediation, residual, below-criteria material (concentration less than 31.1 pCi/g Th-232) will be allowed to remain beneath a clean layer of soil backfill. In addressing potential residential exposures to buried subsurface contamination, NRC has established a generic scenario under which it is assumed that the residential farmer constructs a house over subsurface contamination.

The NRC's Generic Dual Simulation Approach

In evaluating the above-described scenario, assumptions must be made about how much affected material will be brought to the surface and how it will be mixed with uncontaminated soil. Excavation of affected material to the surface creates two zones of contamination, one surface and the other subsurface, from which exposures could occur to the hypothetical resident farmer. This excavation results in exposures to the farmer via all pathways from the surface material; however, exposure to the deeper subsurface zone occurs from groundwater impacted by the overlying soil contamination. Groundwater exposures to the resident farmer are considered from drinking water, crops used for human and animal consumption (i.e., fodder) that are affected by irrigation, and livestock affected by contaminated drinking water and fodder. Consequently, buried material requires two simulations.

In the first simulation (referred to in this dose assessment as "Dual Simulation 1"), it is assumed that a small volume of affected material (600 m^3) is excavated and spread out over the ground surface to a depth of 0.9 m (NRC default value for plant root depth) to accommodate construction of a basement. The foundation is assumed to encompass an area of 200 m^2 and is excavated to a depth of 3 m. Spreading of the excavated material over the ground surface to a depth of 0.9 m results in an areal coverage of 667 m^2, within which it is assumed that farming occurs. It also is assumed that the source concentration is the average of the radionuclide-affected material after mixing with clean soil from the cover. Dose from exposures to the material brought to the surface is estimated by evaluation of direct gamma radiation, inhalation, soil ingestion, and plant ingestion (excluding irrigation with thorium-bearing water).

Water-dependent pathways are evaluated separately in the second simulation (referred to in this assessment as "Dual Simulation 2"). These include exposure from ingestion of groundwater and irrigation (with subsequent uptake into plants, and transfer to meat and milk). In the second simulation, the source concentration is the average concentration of the radionuclide-bearing soil.

In summary the following items present the pathways generically associated with each simulation for evaluation of the resident farmer scenario:

<u>Dual Simulation 1 (Water-Independent Pathways)</u>

- External Gamma
- Soil Ingestion
- Inhalation
- Plant Ingestion
- Meat Ingestion
- Milk Ingestion

<u>Dual Simulation 2 (Water-Dependent Pathways)</u>

- Water Ingestion
- Meat Ingestion
- Milk Ingestion
- Aquatic Food Ingestion

However, as discussed above, the aquatic food pathway would be eliminated from the dual simulation modeling for both the resident farmer and gardener, and all meat and milk pathways would be eliminated from the resident gardener evaluation.

Modified Dual Simulation Approach

During the site restoration phase of the planned decommissioning activities, clean backfill will be placed to achieve the planned final grade of the site, resulting in an average thickness to a depth of about 10 feet (3.05 m). The hypothetical excavation of the foundation is still evaluated; however, due to the backfill thickness, intrusion into the affected zone does not occur. Only clean backfill is excavated and spread out over the surface, effectively eliminating the likelihood of direct contact exposures (via soil ingestion and inhalation) to affected material. However, the assessment considers exposures via the external gamma pathway (both outside of the house, as well as in the basement) and via water-dependent pathways (e.g., drinking water, meat, and milk pathways).

Based on conditions expected to exist on the restored site, the major pathways of concern are basement gamma exposures and the water-dependent pathways. In order to accommodate a complete evaluation of this scenario, a modified dual simulation scenario has been developed which considers all of the water-independent pathways (corresponding to Dual Simulation 1) that include gamma exposures both outside of the house and in the basement, and the water-dependent pathways (corresponding to Dual Simulation 2). Evaluation of outdoor and basement gamma exposures requires that two different thicknesses of backfill be input into RESRAD (i.e., as "cover thickness" in the model), as well as two different shielding factors to account for shielding with and without the presence of a cement foundation slab (for basement and outdoor exposures respectively). Since the RESRAD code can accommodate input of only one value each for cover thickness and shielding factor, separate model simulations must be performed in order to estimate dose rates attributed to basement and outdoor gamma exposures.

Therefore, for dose evaluations in this DP, the NRC's dual simulation approach has been modified to include an additional water-independent simulation which assesses basement gamma dose. As such, dose evaluations of the resident farmer have been conducted per the following (minus the pathways of soil ingestion, inhalation, and aquatic food ingestion which are not applicable):

Dual Simulation 1A (Water-Independent Pathways)

- External Gamma (Outdoors)
- Plant Ingestion
- Meat Ingestion
- Milk Ingestion

Dual Simulation 1B (Water-Independent Pathways)

- External Gamma (Basement)

Dual Simulation 2 (Water-Dependent Pathways)

- Water Ingestion
- Meat Ingestion
- Milk Ingestion
- Aquatic Food Ingestion

Figure 5-2 presents a schematic of the restored site and the model used in the above-described modified dual simulation approach for the resident farmer. Alternative evaluations of the resident gardener using this approach, as with the generic approach, consider the consumption of homegrown meat and milk to be not applicable.

5.2.4 Calculations and Input Parameters

5.2.4.1 Selection of Computer Model

Two computer codes have been widely used to evaluate exposure to radionuclides in soil, RESRAD and DandD. The DandD code is based upon methodology described in NUREG/CR-5512. RESRAD has been widely used for dose assessment in support of decommissioning. The two codes use somewhat different site conceptual models, and both are limited to on-site exposures (that is, they do not cover off-site land uses which may need to be considered for restricted release). RESRAD Version 6.0 was selected because it could best analyze the conceptual site model. Unlike DandD, RESRAD is able to incorporate industrial and other land use scenarios.

5.2.4.2 Input Parameters

Deterministic simulations were performed to evaluate dose resulting to the critical group following remediation. The following subsection describes the methods employed in this dose evaluation, and generically discuss input parameters and sources of parameter input values for each model type. The second subsection discusses values for key input parameters important in the modified dual simulation approach. Finally, the third subsection discusses inputs for the dose evaluations of the resident gardener.

Deterministic Dose Modeling

Dose is determined from a combination of variables including concentrations of radionuclides, exposure duration, and frequency of exposure. These variables can be dependent upon human activity patterns and time spent at each activity and/or location. RESRAD is equipped with modules that can calculate both deterministic and probabilistic estimates of the TEDE to an average member of the critical group. Deterministic simulations were performed for this dose assessment which require the assignment of a single input value for each model variable. Conservative default parameters and site-specific parameters, where available, were input into the program to characterize the site for different circumstances and conditions. As described previously, site-specific physical properties were used, where available. Where literature values were required, the principal references used were the NUREG/CR-5512 draft revised Volume 3, the RESRAD Manual, and the Data Collection Handbook. Behavioral and metabolic parameters were obtained from NUREG/CR-5512 Volume I, supplemented by suggested initial parameters for RESRAD as presented in the Preliminary Guidelines. Specific deterministic inputs are documented in Appendix D.

Key Input Parameters under the Modified Dual Simulation Approach

Dual Simulation 1A

Dual Simulation 1A of the chosen remediation alternative (5B-3) evaluates exposures occurring to the farmer during cultivation of the 667 square meter (m^2) area, the top 0.9 m of soil of which was excavated from the subsurface backfill material. This assumption was made to correspond with the same area of surface contamination that would be evaluated using the generic dual simulation approach. However, unlike the generic dual simulation approach discussed in Section 5.2.3.3, excavation which results in this surface layer does not include mixing with subsurface material in the affected zone, because there is no intrusion into the affected zone. Therefore, only radiation from the subsurface can result in exposures to the farmer, the area of which under Dual Simulation 1A corresponds to the cultivation area of 667 m^2. This area, in conjunction with the thickness of the affected material zone being 3.31m, results in a volume of contamination of 2,211 m^3 beneath the area of cultivation. The total thickness of the backfill in this area is the sum of the previously mentioned 3.05 m and the 0.9 m of excavated soil that was spread over the ground surface, or 3.95 m. The NRC default shielding factor of 0.5512 was used (Preliminary Guidelines).

Dual Simulation 1B

Dual Simulation 1B evaluates gamma exposure to the farmer in a 200 m^2 basement; therefore, the area of subsurface contamination contributing to basement gamma exposure is 200 m^2. This area, in conjunction with the affected zone thickness (3.31 m), results in a volume of 663 m^3. The total thickness of backfill between the bottom of the foundation slab and the top of the contaminated zone represents the difference between the total backfill thickness from Dual Simulation 1A (3.95 m) and the depth of the foundation (3 m), or 0.95 m. A value of 7 inches was assumed for thickness of the cement slab. According to NUREG/CR-5512 (Volume 3), the most conservative shielding factor for a 7–inch-thick slab of cement is 0.479. This shielding factor was applied to dose evaluations .

Dual Simulation 2

Dual Simulation 2 estimates dose from exposures via water-dependent pathways. In RESRAD, the non-dispersion model was used which assumes that a well is placed at the downgradient toe of the contaminated zone. The entire footprint of the affected zone, 37,432 m^2, is evaluated as a potential source for impacting underlying groundwater. This area, in conjunction with the thickness of material remaining (3.31 m and 3.04 m respectively), results in a volume of 124,072 m^3. Calculation of the total backfill thickness under Dual Simulation 2 excludes the additional 0.9 m of excavated subsurface material that is spread over the ground surface. This was done for the following two reasons:

(1) All simulations (1A, 1B, and 2) are additive and the additional 0.9 m layer of soil is already considered in Dual Simulation 1A.

(2) The area assumed to be covered by the additional layer of soil (667 m^2) would constitute less than 2 percent of the entire area evaluated under Dual Simulation 2 (37,432 m^2); therefore, entering the thickness of the cover plus the additional soil layer into the RESRAD model would overcompensate for cover thickness for over 98 percent of the evaluated area.

Inputs for Dose Evaluations of the Resident Gardener

As discussed previously, subsistence farming is not practiced in the resident gardening scenario. Therefore, meat and milk ingestion pathways are considered not applicable to the resident gardener. Additionally, the annual consumption of homegrown vegetables, fruits, and grains occurs at a 75 percent lower rate than that evaluated for the farmer. This assumption is utilized through application of a diet factor (equivalent to a value of 0.25) to the farmer consumption rates (NUREG/CR-5512).

Application of the diet factor to NUREG/CR-5512 (Volume 3) farmer consumption rates given for leafy vegetables (11 kilograms per year [kg/yr]), other vegetables (51 kg/yr), fruit (46 kg/yr), and grain (69 kg/yr) results in consumption rates of 2.75 kg/yr, 12.75 kg/yr, 11.5 kg/yr, and 17.25 kg/yr respectively. The dietary ingestion module of RESRAD requires an input for each of the following categories: (1) fruits, vegetables, and grains; and (2) leafy vegetables. Therefore, resident gardener model inputs for the former and latter were 41.5 kg/yr and 2.75 kg/yr respectively.

5.2.5 Uncertainty Analysis

This dose assessment employed the deterministic approach to modeling using RESRAD Version 6.0. Deterministic analysis involves calculation of a single value of the dose using single values for input parameter values. Consequently, sensitivity analysis was performed on several variables.

Of the several hundred input parameters for the RESRAD model, only a handful describe the physical characteristics of the backfill (when present), contaminated zone, unsaturated zone (when present), and the saturated zone. Other parameters describe the partitioning and transport of radionuclides within and between zones. Remedial action can alter the physical properties of the contaminated zone, as well as partitioning and transport. Most of the behavioral and metabolic parameters are default values provided in guidance documents. Consequently for this dose assessment, sensitivity analysis was performed on those parameters used to describe the physical properties of the contaminated zone, saturated zone, and contaminant transport.

In general, those parameters that impact the drinking water and external (gamma) pathways have the largest effect on dose. For the modified dual simulation approach, the water-dependent pathways, driven by drinking water ingestion, result in the largest contribution to the total dose. In the nondispersion model which was employed in RESRAD, dose resulting from drinking water ingestion is sensitive to changes in the ingestion rate, Kd values, and saturated zone parameters (e.g., hydraulic conductivity and porosity). External gamma exposures, though insignificant in comparison with drinking water exposures, produced the second highest dose estimates for basement exposures evaluated under Dual Simulation 1B. Differences in dose estimates between Dual Simulations 1A and 1B demonstrate that the density and thickness of a cover have significant impact on dose from external (gamma) exposure. Outdoor gamma exposure was evaluated under Dual Simulation 1A which assumed a backfill thickness of 3.95 m. Basement gamma exposures evaluated under Dual Simulation 1B assume a basement floor thickness of 0.18 m (i.e., 7 inches) layer which is underlain by 0.95 m of soil backfill above the affected material zone. Indoor and outdoor shielding factors used in the model to describe attenuation of gamma radiation by the clean soil cover evaluated in Dual Simulation 1A and by the cement foundation slab evaluated in Dual

Simulation 1B represent conservative estimates as obtained from NRC guidance documentation (i.e., as cited in Section 5.2.4.2).

As discussed in Section 5.2.3.3, dose modeling was performed using a modification to NRC's dual simulation approach in which water-independent pathways and water-dependent pathways were evaluated separately. NRC states in the Preliminary Guidelines that doses estimated from dual simulations are assumed to be additive at each time period evaluated. The output result reported for the deterministic model is the maximum dose that occurs over 1,000 years, as presented later in Section 5.2.6. For all resident farmer/gardener scenarios evaluated, the maximum doses for Dual Simulations 1A, 1B, and 2 each occur at 1,000 years, as opposed to occurring at different times (e.g., at hundreds of years apart from each other). Therefore, the maximum doses for the individual simulations were summed and the total doses for the resident farmer and gardener are presented in Section 5.2.6.

5.2.6 Compliance with Radiological Criteria for License Termination

The NRC has established criteria for releasing a site for unrestricted use in 10 CFR Part 20 Subpart E. The objective of this dose assessment is to assess compliance with the dose criteria of these regulations.

	Unrestricted Release
Dose Criterion	25 mrem TEDE per year peak annual dose to the average member of the critical group
Time Frame	1,000 years
Other Requirements	As Low As Reasonably Achievable (ALARA)

Dose modeling results for unrestricted release are presented in Table 5-1. As previously stated, all dose estimates represent postremedial doses above background to the average members of the critical groups evaluated (i.e., the resident farmer and the resident gardener). A modified dual simulation approach was applied to account for potential exposures to contamination from the surface, basement, and subsurface zones. Appendix D contains all RESRAD summary report outputs for the deterministic models. All dose estimates for unrestricted release scenarios were compared to the dose limit criterion of 25 mrem/year. Additionally, in accordance with NRC's Standard Review Plan, the results of the dose modeling for unrestricted release were compared to those obtained from the evaluation of consequences should no remedial actions ever be taken at the site (i.e., the no-action alternative). Dose resulting from implementation of the no-action alternative was estimated for an average member of the critical group during separate evaluations conducted prior to the preparation of this DP.

Table 5-1 shows that the evaluations for both the resident farmer and gardener result in TEDEs of 0.276 mrem/year and 0.261 mrem/year respectively. Both TEDEs estimated for the residential critical groups occur at 1,000 years and are well below the 25 mrem/year dose limit. The dose estimated for the resident farmer for the chosen action (0.276 mrem/yr) is much less than that estimated for the no-action alternative (797 mrem/yr). Table 5-1, as well as RESRAD plots in Appendix D, show that for both residential groups, water-dependent pathways (Dual Simulation 2), more specifically, water ingestion, of Th-230 (and to a much lesser extent Ra-226) was the predominant dose-contributing pathway.

The difference between the total dose estimates for the resident farmer and resident gardener are minute (0.01 mrem/year). Since Dual Simulation 1A dose estimates for water-independent pathways (outdoor gamma, plant ingestion, meat ingestion, and milk ingestion) are negligible, and there are no differences in the assumptions regarding basement gamma and drinking water exposures between the farmer and gardener, the minute differences in dose between the farmer and the gardener scenarios are attributed to water-dependent meat and milk pathways evaluated for the farmer, but not the gardener.

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Table 5-1
Summary of Deterministic Dose Estimates for Unrestricted Site Release
Retention Pond Area
Kaiser Aluminum & Chemical Corporation

Simulation (Description)	Pathways Evaluated	Resident Farmer		Resident Gardener	
		Total Maximum Pathway Dose (mrem/yr)	Predominant Radionuclide	Total Maximum Pathway Dose (mrem/yr)	Predominant Radionuclide
Dual Simulation 1A (Water-Independent Pathways)	External Gamma	1.23E-18	Th-232	1.23E-18	Th-232
	Plant Ingestion	0.00E+00	NA	0.00E+00	NA
	Meat Ingestion	0.00E+00	NA	NE	NE
	Milk Ingestion	0.00E+00	NA	NE	NE
	Subtotal Dose	1.23E-18	Th-232	1.23E-18	Th-232
Dual Simulation 1B (Basement Gamma)	External Gamma	1.50E-02	Th-232	1.50E-02	Th-232
Dual Simulation 2 (Water-Dependent Pathways)	Drinking Water	2.46E-01	Th-230	2.46E-01	Th-230
	Meat Ingestion	4.04E-03	Th-230	NE	NE
	Milk Ingestion	1.08E-02	Th-230	NE	NE
	Subtotal Dose	2.61E-01	Th-230	2.46E-01	Th-230
TOTAL DOSE	--	***2.76E-01***	Th-230	***2.61E-01***	Th-230

Notes:
NA = Not applicable.
NE = Pathway was not evaluated.

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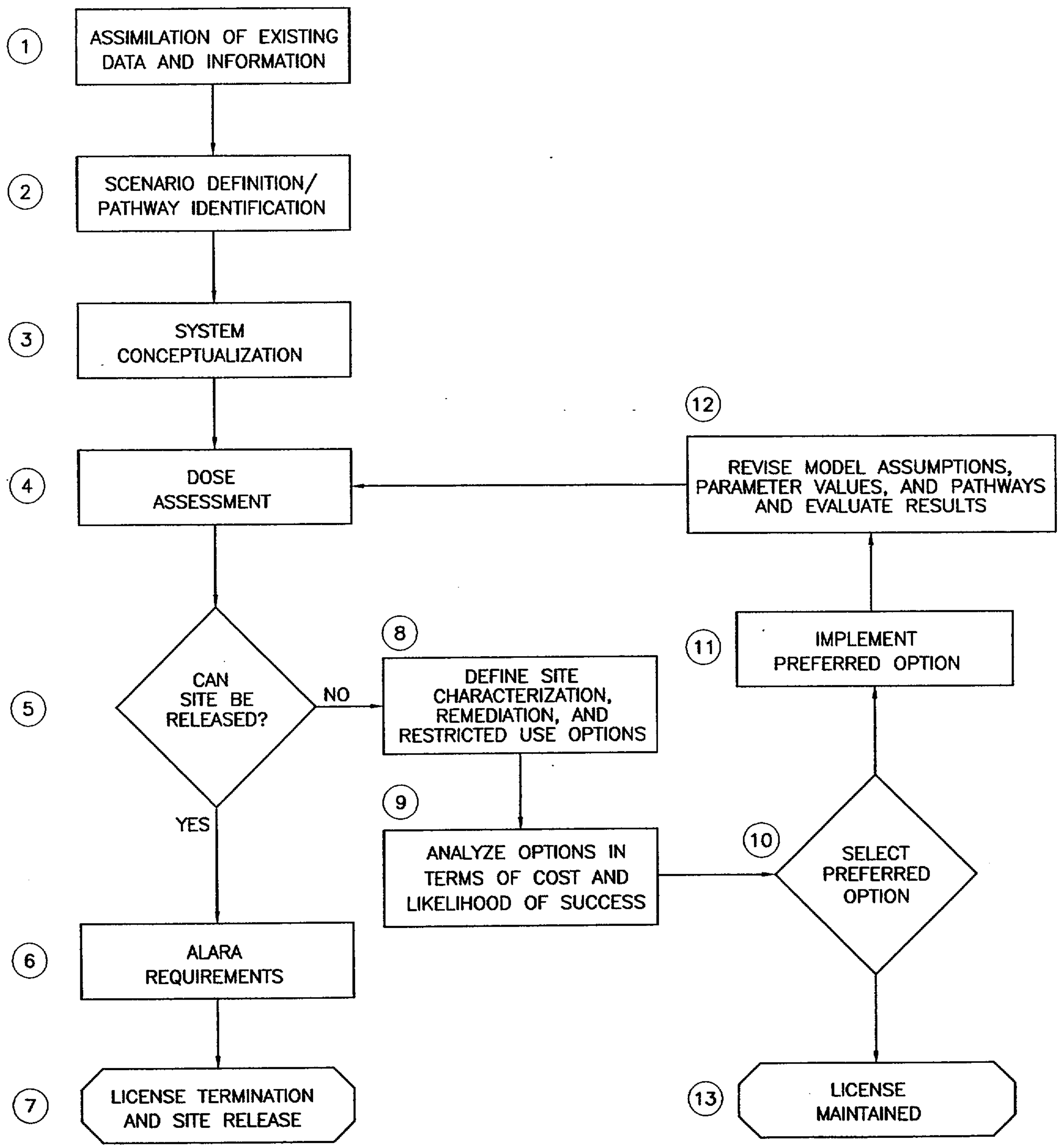


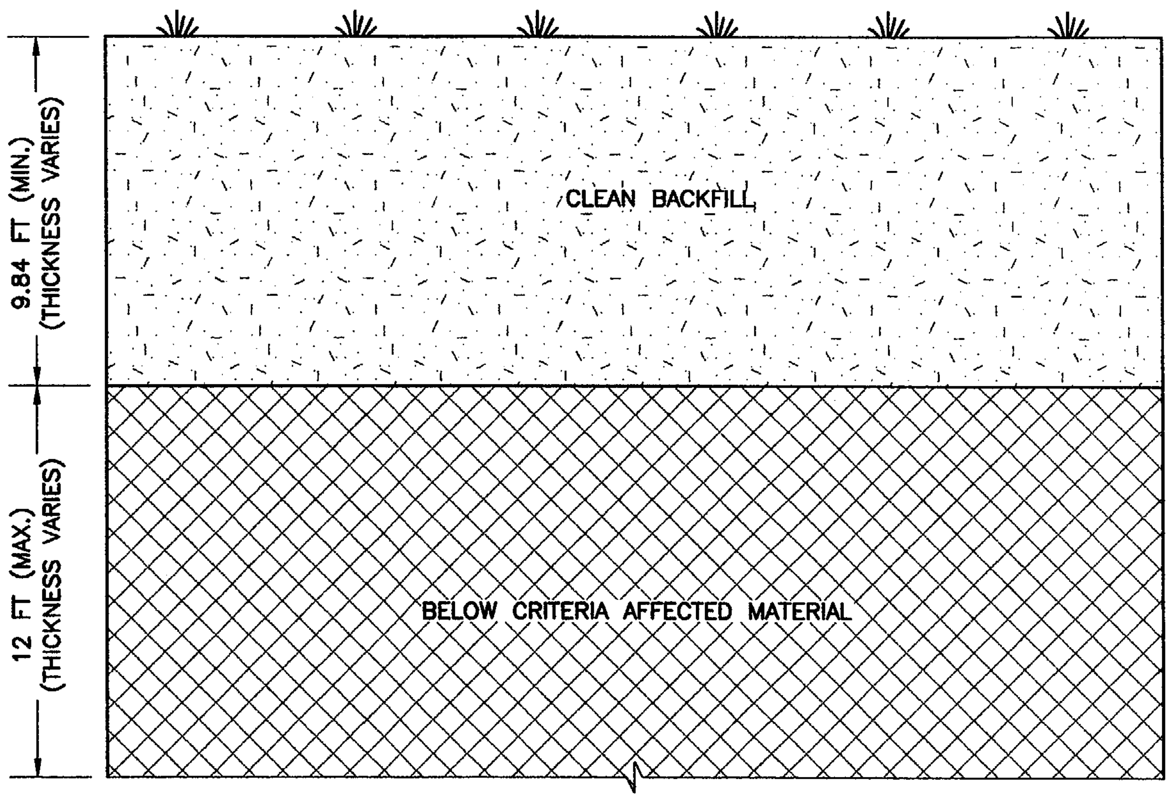
FIGURE 5-1
FRAMEWORK FOR
DECOMMISSIONING AND LICENSE TERMINATION
KAISER ALUMINUM SPECIALTY PRODUCTS
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

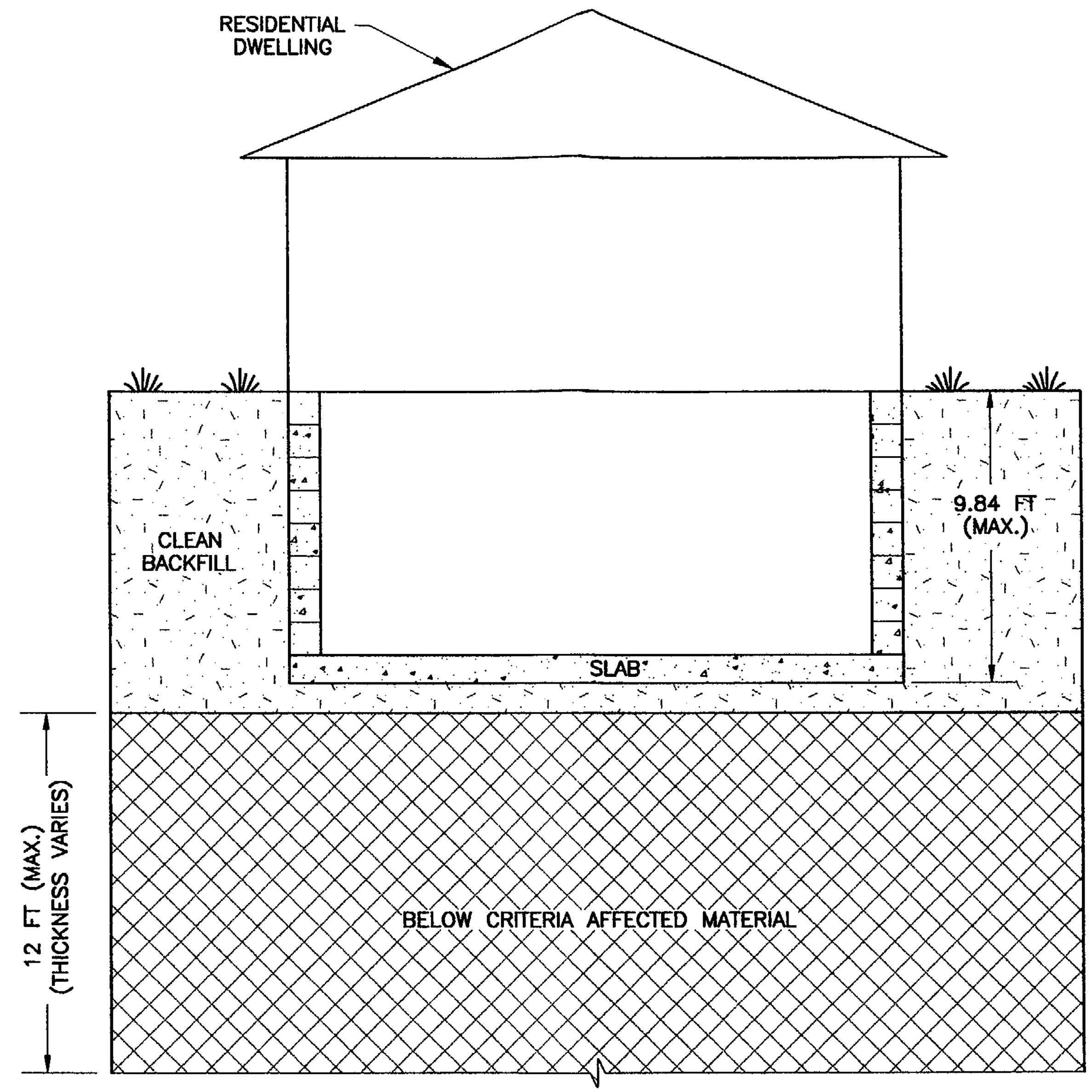
APPROVED
CHECKED
DRAWN RAM 10/09/00

DRAWING NUMBER
5427002

Earth Sciences Consultants, Inc.



TYPICAL CROSS SECTION
THROUGH RESTORED SITE



TYPICAL CROSS SECTION THROUGH RESTORED SITE
WITH RESIDENTIAL DUAL SIMULATION SCENARIO
FOR DOSE MODELING

DRAWING NOT TO SCALE

FIGURE 5-2
CONCEPTUAL MODEL FOR MODIFIED
DUAL SIMULATION EVALUATIONS
DECOMMISSIONING PLAN
KAISER ALUMINUM
TULSA, OKLAHOMA

PREPARED FOR
KAISER ALUMINUM & CHEMICAL CORPORATION
BATON ROUGE, LOUISIANA

APPROVED
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