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APPENDIX K

100-KR-2 OPERABLE UNIT FOCUSED FEASIBILITY STUDY

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ACRONYMS

CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CFR	*Code of Federal Regulations*
COPC	contaminants of potential concern
D&D	decontamination and decommissioning
FFS	focused feasibility study
HPPS	*Hanford Past-Practice Strategy*
IRM	interim remedial measures
LFI	limited field investigations
NEPA	*National Environmental Policy Act of 1969*
PRG	preliminary remediation goals
RI/FS	remedial investigation/feasibility study
QRA	Qualitative Risk Assessment

1.0 INTRODUCTION

This operable unit-specific focused feasibility study (FFS) provides sufficient information to select interim remedial measures (IRM) for sites associated with the 100-KR-2 Operable Unit. As discussed in the main text, certain inherent assumptions are required to establish "appropriate and timely" IRM. The interim remedial measure candidate waste sites are determined in the limited field investigation (LFI) (Attachment 1), based on analysis of historical and analogous information. Site profiles have been developed for each waste site; these site profiles are used for the plug-in approach in this Appendix. The plug-in approach is based on the same land use and groundwater use scenario as used in the Process Document (Section 1.4 of DOE-RL 1995a). (The Process Document titled *100 Area Source Operable Unit Focused Feasibility Study* is the main umbrella document that this FFS is an Appendix to.) Briefly, the plug-in approach specifies and analyzes remedial alternatives for a group of sites that have similar characteristics, such as contaminants and process history. Then, if it is determined that an individual site is sufficiently compatible with a site group for which the alternatives have already been developed and analyzed, the subject site is said to "plug-in" to the analysis for that group. If the waste site does not plug directly into a waste group, deviations from the developed group of alternatives are described and documented.

The Sensitivity Analysis (Appendix D of DOE-RL 1995a) is then used as a basis to discuss changes to the detailed investigation in Section 5.0 of the Process Document because of new land use and/or groundwater use scenarios (Section 2.0 of Appendix D). Because of the current lack of an identified future land use, remedial alternatives evaluated for near-final selection were constrained by their ability to not limit any future use. Thus, while waste groups in the Process Document were evaluated against containment and in situ treatment alternatives, these alternatives were not carried through to Section 6.0 of this Appendix.

1.1 PURPOSE AND SCOPE

The scope of this document is limited to 100-KR-2 Operable Unit interim remedial measure candidate sites, as determined in the LFI. Impacted groundwater beneath the 100-K Area will be addressed in the 100-KR-4 FFS report (DOE-RL 1995a). In addition, low-priority waste sites and potentially impacted river sediments near the 100 Area are not considered candidates for IRM; they are being addressed under the remedial field investigation/corrective measures study pathway of the *Hanford Past Practice Strategy* (DOE-RL 1991).

This report presents the following:

- The 100-KR-2 Operable Unit individual waste site information (Section 2.0)
- The development of individual site profiles (Section 2.0)

- The identification of representative groups for individual waste sites and a comparison against the applicability criteria and identification of appropriate enhancements for the alternatives (Section 3.0)

- A discussion of the deviations and/or enhancements of an alternative and additional alternative development, as needed (Section 4.0)

- The detailed analyses for waste sites that deviate from the representative group alternatives (Section 5.0)

- A qualitative comparative analysis for all individual waste sites using a revised scenario that does not limit any future use of the sites (Section 6.0).

1.2 INCORPORATION OF NATIONAL ENVIRONMENTAL POLICY ACT VALUES

In accordance with DOE Order 5400.4 and 10 CFR 1021, DOE CERCLA documents are to incorporate *National Environmental Policy Act of 1969* (NEPA) values to the extent practicable. Many NEPA values, such as a statement of purpose and need, description of alternatives for the proposed action (including a no-action alternative), description of the affected environment (including meteorology, hydrology, geology, ecological resources and land-use), applicable laws and guidelines, short-term and long-term impacts on human health and the environment, emissions to air and water, and cost are typically included in a CERCLA FS. Other NEPA values not normally considered in a CERCLA FS, including evaluation of cultural resources, socioeconomic, transportation, indirect and cumulative impacts, irreversible and irretrievable commitment of resources, environmental justice, and mitigation of impacts have been incorporated into the Process Document (Section 3.3 and 5.2).

Several NEPA values common to all of the 100 Area Operable Units, including applicable laws and guidelines, are addressed in the *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1993a) and in the Process Document. Analysis of remedial alternatives is provided in Sections 5.0 and 6.0 of the Process Document.

NEPA values that are specific to the 100-KR-2 Operable Unit, including ecological resources and cultural resources, are discussed in Section 2.2 of this FFS. Other NEPA values relative to meteorology, hydrology, and geology are included in background documents that are referenced in Section 2.2. A detailed evaluation of alternatives, including costs, is presented in Section 5.0 of this 100-KR-2 FFS with discussion in Section 6.0.

2.0 WASTE SITE INFORMATION

2.1 OPERABLE UNIT BACKGROUND

The 100-K Area at the Hanford Site is located in Benton County along the southern banks of the Columbia River, in the north central part of the site (Figure K2-1). The 100-KR-2 Operable Unit comprises the area south of the 100-KR-1 Operable Unit and includes both the 100-KE and 100-KW Reactors and associated facilities. The 100-KR-2 Operable Unit encompasses about 1.17 km^2 (0.45 mi^2) of the 100-K Area. It lies within the southwest quadrant of the Coyote Rapids Quadrangle, Washington, 7.5 Minute Series (U.S. Department of the Interior Geological Survey Topographic map).

The 100-KR-2 Operable Unit is one of three operable units associated with the 100-K Area at the Hanford Site. The 100-KR-1 and 100-KR-2 are source operable units that address liquid effluent disposal sites and solid waste burial grounds, and the underlying vadose zone. The 100-KR-1 Operable Unit contains waste units associated with the disposal of liquid wastes and cooling water during operation of the two K Area Reactors. The 100-KR-2 Operable Unit contains most of the sites in the 100-K Area that were involved in plutonium production, including the 100-KE and 100-KW Reactors and their cooling systems, associated water treatment, maintenance, management facilities, and solid waste burial grounds. The 100-KR-4 Groundwater Operable Unit addresses contamination that has migrated to the groundwater from both of the 100-K Area source operable units.

The 100-K Reactors were the seventh and eighth Hanford Site reactors built to manufacture plutonium during the Korean Conflict in the Cold War era after World War II. Fuel elements for the reactor were assembled in the 300 Area, and the plutonium-enriched fuel produced by the reactor was processed in the 200 Area. The 100-KE and 100-KW Reactors operated from 1955 to 1971 and 1970, respectively, when they were retired. After the reactors were retired, decontamination and decommissioning (D&D) activities were initiated to minimize the potential spread of radioactive and other contaminants. While this process is ongoing, however, the fuel storage basins at both reactors have been used to store 100-N Reactor fuels since modification in 1975 and continue in that use today. The basins are not covered in this FFS.

Since the preparation of the *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1993a), additional data relevant to this FFS have been collected in both the 100 Area in general, and in the 100-KR-2 Operable Unit specifically. A limited field investigation (LFI) and Qualitative Risk Assessment (QRA) for the 100-KR-2 Operable Unit is Attachment 1 to this appendix. In addition, aggregate area studies have been conducted to evaluate cultural and ecological resources within the 100 Area.

2.2 100 AREA AGGREGATE STUDIES

Hanford Site studies, such as the Hanford Site Background studies, provide integrated analyses of selected issues on a scale larger than the operable unit. Several studies provide information common to the 100 Area, covering topics such as river impacts, shoreline ecology, and cultural resources (e.g., Stegen 1994, Landeen et al. 1993, Fitzner et al. 1994, Chatters et al. 1992, DOE-RL 1994c). The 100-K Area source and groundwater operable unit work plans provide detail on the physical setting within the 100-K Area, such as land form, geology, groundwater, surface water, meteorology, natural resources, and human resources (DOE-RL 1992a and 1992b). Studies that apply to this 100 Area source operable unit FFS are summarized in the Focus Package (DOE-RL 1994b) and in the following subsections.

2.2.1 Hanford Site Background Study

The characterization of the natural chemical composition of Hanford Site soils is presented in *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes* (DOE-RL 1993c). The background values for inorganic constituents in soils, based on the above report, are discussed in Section 2.0 and Appendix A of the Process Document. Background values for radionuclides are currently under evaluation. Many isotopes produced on the Hanford Site are not found in background above levels of detection (see Appendix A of the Process Document).

2.2.2 Ecological Studies

The 100-KR-2 Operable Unit is adjacent to and south of the 100-KR-1 Operable Unit. The boundaries of 100-KR-2 do not encompass any of the shoreline or riparian areas next to the Columbia River.

The plant communities around the 100-K reactor site in general have been described in Landeen et al. (1993) and Stegen (1994). Most of the 100-K Area has been severely disturbed by the original construction and operation of the reactor, and more recently by remedial work on the buildings and waste sites. In areas not treated with herbicide, the vegetation is dominated by cheatgrass and Russian thistle. Other common species include gray rabbitbrush, spring whitlowgrass, jagged chickweed, sand dropseed, and Sandberg's bluegrass.

Very little, if any, land at the 100-KR-2 Operable Unit is good wildlife habitat. The most common animal species is the Great Basin pocket mouse. Mammals that use the area infrequently include mule deer, coyotes, badgers, black-tailed jackrabbits, and some bat species. Birds that inhabit the area include rock doves, western kingbirds, western meadowlarks, horned larks, house sparrows, common ravens, and magpies. Raptors such as red-tailed hawks, Swainson's hawks, and ferruginous hawks have been infrequently observed foraging near the 100-K reactor site. Reptiles that inhabit the area include the side-blotched lizard, gopher snake,

and northern Pacific rattlesnake. Common insect groups include grasshoppers, ants, and darkling beetles.

Sensitive Species

No plant species are listed as sensitive by the state and/or federal governments that are known to occur at the 100-KR-2 Operable Unit. The closest sensitive plant species in the 100-K Area occurs in the riparian zone along the Columbia River, which is part of the 100-KR-1 Operable Unit (Sackschewsky 1992).

Bald eagles, a federal and state listed threatened species, are seasonal residents at the Hanford Site, primarily along the Columbia River during November through March. An eagle roosting area is located northwest of the 100-K Area, on the bank of the Columbia River. Guidance on issues dealing with bald eagles can be found in the Bald Eagle Site Management Plan (Fitzner and Weiss 1994). Peregrine falcons, a federally listed endangered species, have been observed only infrequently at the Hanford Site. They may use the area as a resting or feeding area during spring and fall migrations, but they do not nest at the Hanford Site.

Other species of concern that could occur at or near the 100-KR-2 Operable Unit include the long-billed curlew, burrowing owl, loggerhead shrike, Swainson's hawk, and ferruginous hawk. Ecological surveys should be conducted at waste sites scheduled for remedial actions to document the presence or absence of these species and to determine potential mitigation measures that may be required.

2.2.3 Cultural Resources

Various cultural resource-related investigations have been conducted in the 100-K Area over the last few decades. The investigations include archaeological reconnaissances, systematic surveys, test excavations, and interviews with Native Americans with historical ties to the area (Chatters, Gard, and Minthorn 1992; Relander 1986; Rice 1968 and 1980; Wright 1993). These investigations have helped identify several archaeological and ethnohistoric sites in and around the 100-K Area, which could range in age from 9,000 years ago to the mid-nineteenth century. While these investigations have demonstrated that the 100-K Area is rich in cultural resources, it is unlikely that archaeological sites are located in most of the 100-KR-2 Operable Unit because most of KR-2 is more than 400 m (1,300 ft) from the Columbia River; areas more than 400 m (1,300 ft) at the Hanford Site are generally considered to have low potential for cultural resources (Chatters 1989).

Areas to the west, south, and east of the heavily disturbed central portions of the 100-K reactor complex were surface surveyed in the 1990s for evidence of archaeological sites and none were found. It is possible, however, that subsurface archaeological deposits exist at KR-2, especially in those portions that lie within the 400 m (1,300 ft) zone discussed above. Sites in these areas are of moderately high cultural sensitivity (see LFI, Attachment K2). In addition, because discussions with Native American peoples with historical ties to 100-K Area have yet to

be completed, other areas might be considered sacred or to be traditional cultural properties. Such discussions are planned for late 1995.

Cultural resource impact assessments are being conducted for each waste site in the 100-K Area. Assessment scores will be determined and presented in an action plan being prepared for 100-K Reactor Area by ERC cultural resource staff. These assessments will accelerate cultural resource reviews and clearances, which are required of all Hanford Site projects involving ground disturbing activities, as mandated in the Hanford Cultural Resource Management Plan (Chatters 1989).

Based on this existing information, most of the 100-KR-2 Operable Unit is considered to be moderate to low in sensitivity for cultural resources. Sensitive areas include not only those areas where cultural resources have been identified from previous surface investigations (the locations of which cannot be released in public documents), but also those areas where there is high potential for, but no surface indications of, subsurface cultural resources. Future remedial activities at high-priority waste sites in the operable unit are of particular concern. While it appears that these areas were disturbed during construction of the reactor and related structures during the 1940s, the horizontal and vertical extent of this disturbance is not known. Therefore it is possible that intact archaeological deposits exist in the area. Because of Tribal concerns, cleanup activities must incorporate actions to protect cultural resources.

2.2.4 Summary

The potential influence of remedial actions on the resources described in the preceding subsections are considered during the analysis of Remedial Alternatives conducted in Sections 5.0 and 6.0 of the Process Document and Sections 5.0, 6.0, and 7.0 of this 100-KR-2 FFS. Other issues, such as potential transportation and socioeconomic impacts are also discussed in Sections 3.3 and 5.2 of the Process Document. The assessment of potential impacts in the Process Document are consistent with the potential impacts anticipated as a result of remediating the individual waste sites at the 100-KR-2 Operable Unit. Mitigation measures, as discussed in Section 5.2.2 of the Process Document, will be developed during the conceptual and preliminary design of the selected Remedial Alternative to avoid or minimize impacts on physical, biological, and cultural resources.

2.3 LIMITED FIELD INVESTIGATION

The LFI (Attachment K1) is an integral part of the RI/FS process and is based on Hanford Site-specific agreements discussed in the *Hanford Federal Facility Agreement and Consent Order* (Fourth Amendment) (Ecology et al. 1994), the *Hanford Site Risk Assessment Methodology* (DOE-RL 1995), and the *Hanford Past-Practice Strategy (HPPS)* (DOE-RL 1991). The HPPS emphasizes initiating and completing waste site cleanup through interim actions.

The primary purpose of the LFI for the 100-KR-2 Operable Unit was to collect sufficient data to recommend which sites should remain as candidates for IRM. Sites that are not recommended for an IRM will be addressed during the final remedy selection process for the entire 100 Area, or through the D&D program. The data gathered in the LFI are also used to evaluate Remedial Alternatives in this FFS.

A QRA was performed as part of the LFI and determined the principal risk drivers at the 100-KR-2 Operable Unit the 100-KR-2 QRA also qualitatively evaluated human health and environmental exposure scenarios to help determine which waste sites within the 100-KR-2 Operable Unit are candidates for IRM. The QRA evaluated risks for a predefined set of human and environmental exposure scenarios, and is not intended to replace or be a substitute for a baseline risk assessment.

Human health risks were evaluated using a hypothetical future residential scenario, which assumed that exposure could occur through soil ingestion, fugitive dust inhalation, and external exposure to contaminants within the top 4.5 m (15 ft) of soil.

The ecological risk assessment evaluated potential contaminant uptake by the Great Basin pocket mouse. The mouse was used as an indicator receptor because (1) it is common at the Hanford Site, (2) its home range is comparable to the size of most waste sites, and (3) it could live in close proximity to the contaminants in the soil.

Contaminants deeper than 4.5 m (15 ft) in soil are not likely to be associated with potential exposures or risks to humans or ecological receptors. However, these contaminants could potentially migrate to groundwater. Concentrations in soil corresponding to groundwater protection criteria (4 mrem/yr in groundwater, which corresponds to the federal maximum contaminant level) were calculated using the Summers Method.

The results of the LFI/QRA were used to select the sites where an IRM should be evaluated. If an IRM is not decided on, the site will be subject to further investigation and/or remediation under the site-wide RI/FS process. The LFI report for the 100-KR-2 Operable Unit identified the known constituent concentrations at each site, presented the data analysis, and discussed the risk assessment conclusions for the waste sites (Attachment K1).

Based on the LFI/QRA, waste sites at the 100-KR-2 Operable Unit were retained as IRM candidates if the site was considered, using professional judgement, to pose a "medium" or "high" risk. The approach used to develop the risk rankings is discussed in Section 2.8 of the LFI/QRA.

The LFI also assumed that solid waste burial grounds are IRM candidate sites regardless of the above criteria. The IRM candidacy review conducted during the LFI evaluation retained 10 waste sites as IRM candidates (Table K2-1).

The conclusions drawn from the LFI/QRA studies were used to determine IRM candidacy for high-priority waste sites and solid waste burial grounds within the

100-KR-2 Operable Unit. While this FFS report relies on the data presented in the LFI/QRA, the conclusions drawn in this FFS are based on the analyses of the Remedial Alternatives in Sections 5.0 and 6.0 of the Process Document, Sections 4.0 and 5.0 in the Sensitivity Analysis (Appendix D), and Section 6.0 of this FFS.

2.4 DEVELOPMENT OF WASTE SITE PROFILES

To facilitate the implementation of the plug-in approach described in Section 1.0, waste site profiles have been developed for each IRM candidate site within the 100-KR-2 Operable Unit. The individual site profiles were developed using radiological data from Dorian and Richards (1978), other historical information, and ground-penetrating radar surveys. When site-specific data were limited or unavailable, data from analogous sites (from the applicable Process groups) were used to describe the conditions at 100-KR-2 sites, and develop waste-site profiles.

2.4.1 Site Descriptions

The first step to develop the individual waste-site profiles was to prepare a basic site description of each IRM candidate site (Table K2-2). This included listing the name of the site, describing its use during the operation of the K Reactors, and describing its physical characteristics (the size and structural material). This information was then used to determine which waste-site group the individual waste site belonged in (see Section 3.0). The waste-site groups are listed in Section 5.0 of this FFS and are described in Section 3.0 of the Process Document.

2.4.2 Refined Contaminants of Potential Concern

To further develop the individual waste site profiles, a determination was made of which contaminants present at each waste site posed a risk to humans, biological receptors (plants and animals), and groundwater quality. These "refined contaminants of potential concern" (COPC) are the risk drivers at the site and represent the contaminants that must be remediated. The refined COPC were identified by starting with the contaminants presented in the LFI (Attachment 1) and screening these contaminants against stringent risk criteria.

The refined COPC for each IRM candidate site at the 100-KR-2 Operable Unit were identified by comparing the concentrations of the COPC to the preliminary remediation goals (PRG) in Table K2-3. If the maximum COPC concentration at the waste site exceeded any of the PRGs, then that contaminant was considered a refined COPC. There can be one to several refined-COPC at each site, and the number and types of refined-COPC are used to help determine which Remedial Alternatives may be appropriate at the site. The derivation of the PRGs is described in Section 2.0 and Appendix A of the Process Document. The PRG represents the maximum concentration of a contaminant that would not exceed an acceptable human health (based on occasional use scenarios) or ecological risk level, or would not exceed

the groundwater protection criteria. These PRGs were set at concentrations above natural background concentrations, to preclude trying to remediate naturally existing constituents in soils. Also, if the risk-based PRG was less that the laboratory required quantification/detection limit for that particular contaminant, then the quantification/detection limit was used as the PRG (for example, the PRG for carbon-14 was set at 50 pCi/g even though the groundwater protection PRG is 18 pCi/g).

To identify the refined COPC at each waste site, several assumptions and protocols were used to compare the COPC to the PRGs. These include the following:

- The soils within the waste site were divided into two depth intervals, corresponding to the depth interval that the human and biological receptors and groundwater could be exposed to. This approach is discussed in Section 2.0 and Appendix A of the Process Document.

- At each waste site, the maximum concentration of each contaminant (COPC) within each interval was identified either from the Dorian and Richards (1978) data set, or assumed from the process group representative (as described in DOE-RL 1995a).

- The historical data set (Dorian and Richards) was modified to account for radioactive decay between 1978 and 1992, so it was consistent with the LFI data from other OUs.

- If a sample was collected at the boundary between two intervals (e.g., at 1 m [3 ft]) or within a wide range, the data from that sample were applied to the shallower interval (i.e., the 0 to 1 m [0 to 3 ft] strata).

- Total uranium concentrations were reported by Dorian and Richards (1978) rather than specific isotopes. For the purpose of this FFS, the total concentrations were considered to be uranium-238 because uranium-238 was determined to be the major risk contributor of the uranium isotopes during the QRA.

The screening process that compares the COPC to PRG, and identifies the refined COPC, results in the identified contaminants to be addressed by remedial action at the given IRM candidate site. Tables K2-4, K2-5, and K2-6 identify the COPC from the 116-KE-1 and 116-KW-1 Condensate Cribs and the 116-KE-2 Crib, the only sites with direct analytical data (Dorian and Richards 1978).

2.4.3 Waste Site Profiles

The waste-site profiles characterizing each individual waste site are presented in Table K2-7. Each profile includes the extent of contamination, the depth of contamination, the media (i.e., soil) or material at the waste site, a list of refined COPCs at the waste site, and the

maximum concentration observed for each refined-COPC. The waste site profiles also state if the contaminant concentrations exceed the reduced infiltration concentration. The reduced infiltration concentration is the soil concentration that is considered protective of groundwater under the assumption that hydraulic infiltration is limited by a surface barrier over the wastes. The reduced infiltration concentrations are presented in Table K2-8; their derivation is discussed in Appendix A of the Process Document; a description of its derivation is presented in Attachment 2, Part 1.

The waste-site profiles serve several purposes. First, they contain information needed to compare each waste site at 100-KR-2 to the Waste Site Groups developed in Section 3.0 of the Process Document. The profile information is also used to compare the site characteristics of each waste site with the applicability criteria developed in Section 4.0 of the Process Document, to help determine which Remedial Alternatives are or are not appropriate for that site. The area, depth, and volume of contamination is used to determine how much soil may have to be excavated, treated, capped, etc.; this has a direct bearing on time and costs for remedial action. The information in the profiles is explained more in the following paragraphs.

- Extent of Contamination - This includes the volume, length, width, area, and thickness of the contaminated media. The volume estimates performed for each site are presented in Attachment 1 of this document. Volume, length, width, and area do not necessarily impact the determination of appropriate Remedial Alternatives, however, they are important considerations to develop costs and estimate the time required for remedial actions. Thickness of the contaminated lens impacts the implementability of In Situ actions, such as vitrification, which has a limited vertical extent of influence.

- Contaminated Media/Material - Contaminated media and material located at the site are determined and described. Structural materials such as steel, concrete, and wooden timbers influence the applicability of Remedial Alternatives, as well as equipment needed for actions such as removal. The presence of solid wastes will influence material handling considerations and may require Remedial Alternatives that are different than alternatives for sites with just contaminated soil.

- Refined COPC/Maximum Concentrations - Refined COPC for a site are determined as discussed in Section 2.4.2. The associated maximum concentration for each refined COPC is the highest concentration detected at the site. Refined COPC may influence the applicability of Remedial Alternatives. For example, the presence of certain radioactive contaminants may allow natural decay to be considered in determining appropriate remedial actions. The presence of organic contaminants may require that enhancements, such as thermal desorption, be added to a treatment system.

- Reduced Infiltration Concentration - The reduced infiltration concentration is considered protective of groundwater under a scenario where hydraulic infiltration is limited by the application of a surface barrier. The maximum refined COPC

concentration detected is compared to the allowable reduced infiltration concentration. Exceedance of the reduced infiltration concentrations indicates that containment alternatives using a surface cap may not prevent contaminants from leaching into the groundwater below the site.

The following Section 3.0 (on application of the plug-in approach) describes the use of the site profiles during the feasibility study process.

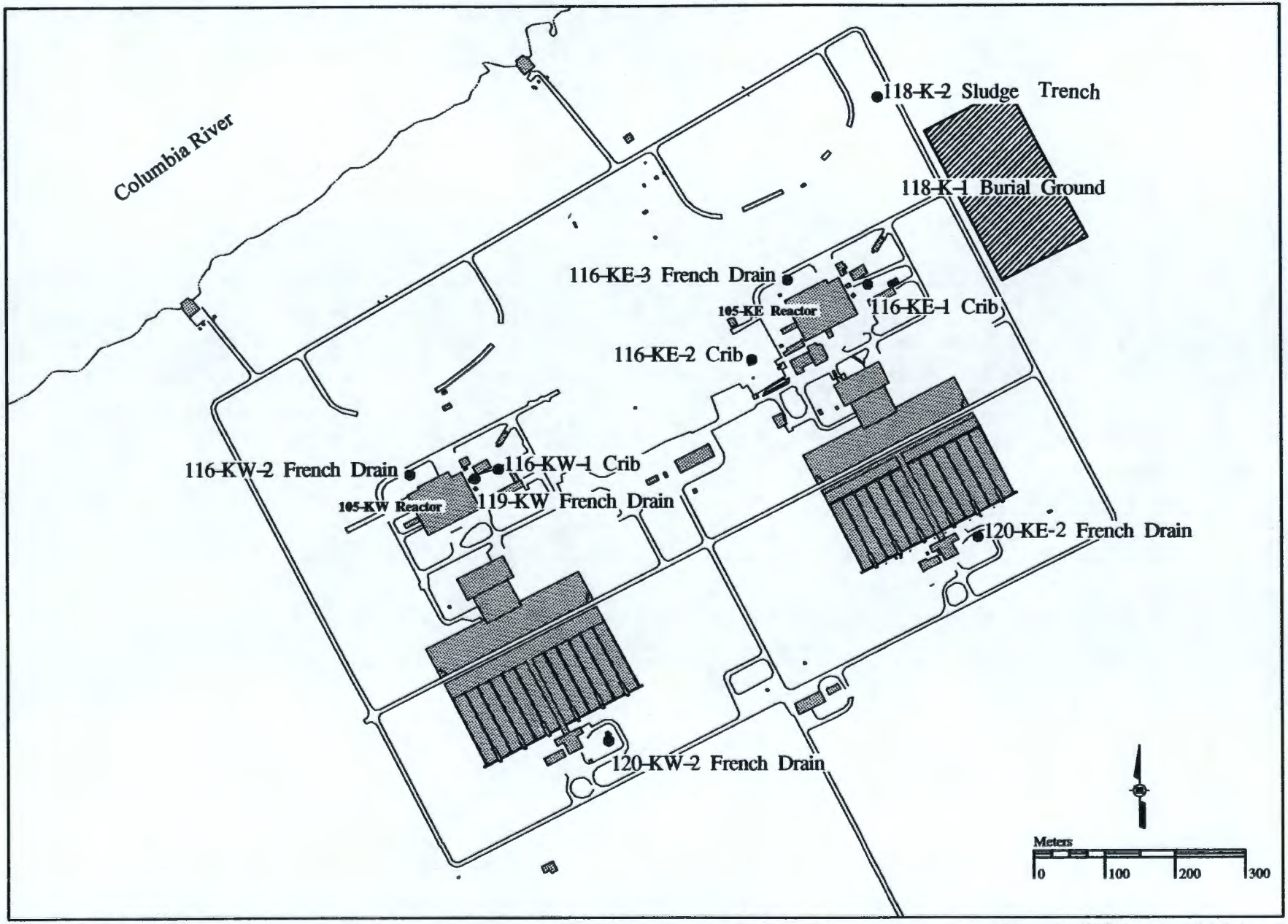

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Figure K2-1. 100-KR-2 Operable Unit Map and IRM Sites.

Table K2-1. Interim Remedial Measures Recommendations from the 100-KR-2 Limited Field Investigation.

Site	Human Health Risk Priority	Eco Risk Priority	Overall Risk[a]	Probable Current Impact on Groundwater	Potential for Natural Attenuation by 2018	IRM Candidate
116-KE-1 Condensate Crib	Low	Low	Medium	High	Low	Yes
116-KE-2 Crib	Low	Low	Low	Medium	Low	Yes
116-KE-3 French Drain	Low	Low	Medium	Low	Unknown	Yes
116-KW-1 Condensate Crib	Low	Low	Medium	High	Low	Yes
116-KW-2 French Drain	Low	Low	Medium	Low	Unknown	Yes
118-K-2 Sludge Trench	Low	Low	Low	Medium	Low (if present)	Yes
French Drain South of 119-KW Building	Low	Low	Medium	Medium	Unknown	Yes
118-K-1 Burial Ground	High	Medium	High	Low	Low	Yes
120-KE-2 French Drain	Low	Low	Medium	Medium	Not applicable	Yes
120-KW-2 French Drain	Low	Low	Medium	Medium	Not applicable	Yes

[a]Includes uncertainties; qualitative evaluation of risk based on previous evaluations of other operable units and professional judgement.

Table K2-2. 100-KR-2 Interim Remedial Measure Waste Site Description.

Site Number/ Name (Alias)	Previous Use	Physical Description	Data Source
116-KE-1 Condensate Crib	Received condensate effluent from the 115-KE reactor gas purification system.	Constructed of 20.3-cm (8-in.) corrugated, perforated, galvanized steel pipe forming a small drain field located in a cobble-filled pit 7.9 m (26 ft) deep. The bottom is 1.8 m (6 ft) in diameter, the top about 17.3 m (57 ft) in diameter. The perforated pipe is located 5.3 m (17.5 ft) below grade.	Historical
116-KE-2 Waste Crib	Received liquid wastes from test loops, cleanup columns (ion exchange columns), and contaminated cooling water.	Constructed of wooden timbers forming a cobble-filled 4.9 x 4.9 m (16 x 16 ft) crib. The crib structure rests in a (32-ft) deep pit about 1 m (3 ft) above the excavated bottom. The bottom 3 m (10 ft) of the crib is filled with crushed rock. The crib is penetrated by a perforated well that extends 3.6 m (12 ft) below the crib bottom.	Historical
116-KE-3 French Drain	Received liquid effluent from the 105-KE Fuels Storage Basin.	Constructed of an 20.3-cm (8-in.) steel well casing extending to 3 m (10 ft) below groundwater with an overflow drain field distribution located about 8.8 m (29 ft) below grade. It is about 3 m (10 ft) in diameter at the bottom and 18.3 m (60 ft) in diameter at the ground surface.	Historical
116-KW-1 Condensate Crib	Received condensate effluent from the 115-KW reactor gas purification system.	Constructed of 20.3-cm (8-in.) corrugated, perforated, galvanized steel pipe, forming a small drain field located in a cobble-filled pit 7.9 m (26 ft) deep. The bottom is 1.8 m (6 ft) in diameter, the top about 17.3 m (57 ft) in diameter. The perforated pipe is located 5.3 m (17.5 ft) below grade.	Historical
116-KW-2 French Drain	Received liquid effluent from the 105-KW Fuels Storage Basin.	Constructed of a 20.3-cm (8 in.) steel well casing extending to 3 m (10 ft) below groundwater with an overflow drain field distribution located about 8.8 m (29 ft) below grade. It is about 3 m (10 ft) in diameter at the bottom and 18.3 m (60 ft) in diameter at the ground surface.	Historical
118-K-2 Sludge Trench	May have received radioactive sludge removed from the 100-K Area Retention Basins.	Exact location unknown. Construction would have been a shallow (up to 4.5 m [15 ft] deep) trench or pit backfilled immediately after use.	LFI, historical
French Drain South of 119-KW	Received liquid wastes from a floor drain, swamp cooler, and heat exchanger in a detection device for radiological contamination in reactor exhaust air.	Constructed of a concrete pipe 0.3 m (1 ft) in diameter placed vertically in the ground. It extends less than 3 m (10 ft) in the ground and is probably gravel filled. It is fed by a single 5.1-cm (2-in.) drain pipe.	Historical
118-K-1 Burial Ground	Used to dispose of solid wastes generated in the 100-Areas (100-K and 100-N primarily). It also contained an incinerator facility to dispose of combustible low-level radioactive wastes.	The 366- x 183-m (1,200- x 600-ft) burial ground contains many trenches that extend to 6.1 m (20 ft) below grade. The site contains six silos that are 3 m (10 ft) in diameter and 7.6 m (25 ft) deep. The incinerator is located in the southeast corner of the burial ground. The site contains an estimated 10,000 m^3 (353,150 ft^3) of solid wastes.	Historical
120-KE-2 French Drain	Received sulfuric acid sludge, containing mercury, and excess sulfuric acid product from filling and maintenance operations.	Constructed of a 1 m (3 ft) in diameter, 1.8 m (6 ft) long, vitrified clay pipe placed vertically in a gravel-filled excavation about 1.8 m (11 ft) deep.	Historical
120-KW-2 French Drain	Received sulfuric acid sludge, containing mercury, and excess sulfuric acid product from filling and maintenance operations.	Constructed of a 1 m (3 ft) in diameter 1.8 m (6 ft) long vitrified clay pipe placed vertically in a gravel-filled excavation about 3.3 m (11 ft) deep.	Historical

D&D = decontamination and decommissioning
LFI = limited field investigation

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Table K2-3. Preliminary Remediation Goals.

	HUMAN-HSRAM (a,b)		PROTECTION of GROUNDWATER (a,c)	BACKGROUND (d,e)	CRQL/CRDL or as noted (f)	ZONE SPECIFIC PRG	
	TR = 1E-06	HQ = 0.1				1 (g) 0-15 ft.	2 (h) >15 ft.
RADIONUCLIDES (pCi/g)							
Am-241	76.9	N/A	31	N/C	1	31	31
C-14	44,200	N/A	18	N/C	50	50	50
Cs-134	3,460	N/A	517	N/C	0.1 (d)	517	517
Cs-137	5.68	N/A	775	1.8	0.1 (d)	6	775
Co-60	17.5	N/A	1,292	N/C	0.05 (d)	18	1,292
Eu-152	5.96	N/A	20,667	N/C	0.1	6	20,667
Eu-154	10.6	N/A	20,667	N/C	0.1 (d)	11	20,667
Eu-155	3,080	N/A	103,000	N/C	0.1 (d)	3,080	103,000
H-3	2,900,000	N/A	517	N/C	400	517	517
K-40	12.1	N/A	145	19.7	4 (d)	19.7	145
Na-22	545	N/A	207	N/C	4 (i)	207	207
Ni-63	184,000	N/A	46,500	N/C	30	46,500	46,500
Pu-238	87.9	N/A	5	N/C	1 (d)	5	5
Pu-239/240	72.8	N/A	4	0.035	1 (d)	4	4
Ra-226	1.1	N/A	0.03	0.98	0.1 (d)	1	1
Sr-90	1,930	N/A	129	0.36	1 (d)	129	129
Tc-99	28,900	N/A	26	N/C	15	26	26
Th-228	7,260	N/A	0.1	N/C	1 (j)	1	1
Th-232	162	N/A	0.01	N/C	1	1	1
U-233/234	165	N/A	5	1.1	1 (d)	5	5
U-235	23.6	N/A	6	N/C	1 (d)	6	6
U-238 (k)	58.4	N/A	6	1.04	1 (d)	6	6
INORGANICS (mg/kg)							
Antimony	N/A	167	0.002	N/C	6	6	6
Arsenic	16.2	125	0.013	9	1 (e)	9	9
Barium	N/A	29,200	258	175	20 (e)	258	258
Cadmium	1,360	417	0.775	N/C	0.5	0.8	0.775
Chromium VI	204	2,086	0.026	28	1 (e)	28	28
Lead	N/C	N/C	8	14.9	0.3 (e)	14.9	14.9
Manganese	N/A	2,086	13	583	1.5 (e)	583	583
Mercury	N/A	125	0.31	1.3	0.02 (e)	1.3	1.3
Zinc	N/A	100,000	775	79	2 (e)	775	775
ORGANICS (mg/kg)							
Aroclor 1260 (PCB)	4.34	N/A	1.37	<0.033	0.033 (e)	1	1
Benzo(a)pyrene	5	N/A	5.68	<0.330	0.330 (e)	5	6
Chrysene	N/A	N/A	0.01	<0.330	0.330 (e)	0.330	0.330
Pentachlorophenol	300	N/A	0.27	<0.8	0.8 (e)	0.8	0.8

TR=Target Risk; HQ= Hazard Quotient; N/A=Not Applicable; N/C=Not calculated
(a) Risk-based numbers are expressed to to one significant figure.
(b) Occasional Use Scenario, as described in DOE/RL-94-61.
(c) Based on Summer's Model (EPA 1989b), as described in DOE/RL-94-61.
(d) Hanford Site Background: Evaluation of Existing Soil Radionuclide Data, DOE/RL-94-61
(e) Hanford Site Background: Part 1, Soil Background for Nonradioacitve Analytes, DOE/RL-92-24, Rev. 2.
(f) Based on 100-BC-5 OU Work Plan QAPP (DOE-RL 1992)
(g) PRGs are established to be protective of groundwater, human and ecological receptors. The screening process used to establish PRGs for zone 1 are discussed in section 2.3 of this document.
(h) PRGs are established to be protective of groundwater. The screening process used to establish PRGs for zone 2 are ciscussed in section 2.3 of this document.
(i) Based on gross beta analysis
(j) Detection limit assumed to be same as Th-232
(k) Includes total U if no other data exist
(l) Value calculated exceeds 1,000,000 ppm therefore use 100,000 ppm as default

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Table K2-4. 116-KE-1 Condensate Crib Refined Contaminants of Potential Concern Based on Occasional Land Use Scenario and Protection of Groundwater

	Zone 1 (a)						Zone 2 (b)										Refined
116-DR-9	0 - 3 ft		3 - 6 ft		6 - 10 ft		10 - 15 ft		15 - 20 ft		20 - 25 ft		25 - 30 ft		30 - 35 ft		COPC
	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Summary
RADIONUCLIDES (pCi/g)																	
Am-241		NO		NO		NO		NO		NO		NO		NO		NO	
C-14		NO		NO		NO		NO		NO		NO		NO		NO	
Cs-134		NO		NO		NO		NO		NO		NO		NO		NO	
Cs-137		NO		NO		NO		NO		NO		NO		NO		NO	
Co-60		NO		NO		NO		NO		NO		NO		NO		NO	
Eu-152		NO		NO		NO		NO		NO		NO		NO		NO	
Eu-154		NO		NO		NO		NO		NO		NO		NO		NO	
Eu-155		NO		NO		NO		NO		NO		NO		NO		NO	
H-3		NO		NO		NO		NO		NO		NO	2.13E+03	YES		NO	YES
K-40		NO		NO		NO		NO		NO		NO		NO		NO	
Na-22		NO		NO		NO		NO		NO		NO		NO		NO	
Ni-63		NO		NO		NO		NO		NO		NO		NO		NO	
Pu-238		NO		NO		NO		NO		NO		NO		NO		NO	
Pu-239/240		NO		NO		NO		NO		NO		NO		NO		NO	
Ra-226		NO		NO		NO		NO		NO		NO		NO		NO	
Sr-90		NO		NO		NO		NO		NO		NO		NO		NO	
Tc-99		NO		NO		NO		NO		NO		NO		NO		NO	
Th-228		NO		NO		NO		NO		NO		NO		NO		NO	
Th-232		NO		NO		NO		NO		NO		NO		NO		NO	
U-233/234		NO		NO		NO		NO		NO		NO		NO		NO	
U-235		NO		NO		NO		NO		NO		NO		NO		NO	
U-238 (k)		NO		NO		NO		NO		NO		NO		NO		NO	
INORGANICS (mg/kg)																	
Antimony		NO		NO		NO		NO		NO		NO		NO		NO	
Arsenic		NO		NO		NO		NO		NO		NO		NO		NO	
Barium		NO		NO		NO		NO		NO		NO		NO		NO	
Cadmium		NO		NO		NO		NO		NO		NO		NO		NO	
Chromium VI		NO		NO		NO		NO		NO		NO		NO		NO	
Lead		NO		NO		NO		NO		NO		NO		NO		NO	
Manganese		NO		NO		NO		NO		NO		NO		NO		NO	
Mercury		NO		NO		NO		NO		NO		NO		NO		NO	
Zinc		NO		NO		NO		NO		NO		NO		NO		NO	
ORGANICS (mg/kg)																	
Aroclor 1260 (PCB)		NO		NO		NO		NO		NO		NO		NO		NO	
Benzo(a)pyrene		NO		NO		NO		NO		NO		NO		NO		NO	
Chrysene		NO		NO		NO		NO		NO		NO		NO		NO	
Pentachlorophenol		NO		NO		NO		NO		NO		NO		NO		NO	

* Maximum concentrations (1992 values) are screened against the PRG (preliminary remediation goal). "Yes" if the value exceeds the PRG. "No" if the value is below the PRG.
The COPC (contaminants of potential concern) are refined based on the soil concentration and the PRG.
A blank under "Max" means either no information is available or the constituent was not detected.

(a) PRGs are established to be protective of groundwater, human and ecological receptors.
(b) PRGs are established to be protective of groundwater.
Source:
Dorian and Richards (Table 3.4-10,1978) data as decayed in the LFI (Attachment K1)

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Table K2-4. 116-KE-1 Condensate Crib Refined Contaminants of Potential Concern Based on Occasional Land Use Scenario and Protection of Groundwater

	Zone 1 (a)						Zone 2 (b)										Refined
116-DR-9	0 - 3 ft		3 - 6 ft		6 - 10 ft		10 - 15 ft		15 - 20 ft		20 - 25 ft		25 - 30 ft		30 - 35 ft		COPC
	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Summary
RADIONUCLIDES (pCi/g)																	
Am-241		NO		NO		NO		NO		NO		NO		NO		NO	
C-14		NO		NO		NO		NO		NO		NO		NO		NO	
Cs-134		NO		NO		NO		NO		NO		NO		NO		NO	
Cs-137		NO		NO		NO		NO		NO		NO		NO		NO	
Co-60		NO		NO		NO		NO		NO		NO		NO		NO	
Eu-152		NO		NO		NO		NO		NO		NO		NO		NO	
Eu-154		NO		NO		NO		NO		NO		NO		NO		NO	
Eu-155		NO		NO		NO		NO		NO		NO		NO		NO	
H-3		NO		NO		NO		NO		NO		NO	2.13E+03	YES		NO	YES
K-40		NO		NO		NO		NO		NO		NO		NO		NO	
Na-22		NO		NO		NO		NO		NO		NO		NO		NO	
Ni-63		NO		NO		NO		NO		NO		NO		NO		NO	
Pu-238		NO		NO		NO		NO		NO		NO		NO		NO	
Pu-239/240		NO		NO		NO		NO		NO		NO		NO		NO	
Ra-226		NO		NO		NO		NO		NO		NO		NO		NO	
Sr-90		NO		NO		NO		NO		NO		NO		NO		NO	
Tc-99		NO		NO		NO		NO		NO		NO		NO		NO	
Th-228		NO		NO		NO		NO		NO		NO		NO		NO	
Th-232		NO		NO		NO		NO		NO		NO		NO		NO	
U-233/234		NO		NO		NO		NO		NO		NO		NO		NO	
U-235		NO		NO		NO		NO		NO		NO		NO		NO	
U-238 (k)		NO		NO		NO		NO		NO		NO		NO		NO	
INORGANICS (mg/kg)																	
Antimony		NO		NO		NO		NO		NO		NO		NO		NO	
Arsenic		NO		NO		NO		NO		NO		NO		NO		NO	
Barium		NO		NO		NO		NO		NO		NO		NO		NO	
Cadmium		NO		NO		NO		NO		NO		NO		NO		NO	
Chromium VI		NO		NO		NO		NO		NO		NO		NO		NO	
Lead		NO		NO		NO		NO		NO		NO		NO		NO	
Manganese		NO		NO		NO		NO		NO		NO		NO		NO	
Mercury		NO		NO		NO		NO		NO		NO		NO		NO	
Zinc		NO		NO		NO		NO		NO		NO		NO		NO	
ORGANICS (mg/kg)																	
Aroclor 1260 (PCB)		NO		NO		NO		NO		NO		NO		NO		NO	
Benzo(a)pyrene		NO		NO		NO		NO		NO		NO		NO		NO	
Chrysene		NO		NO		NO		NO		NO		NO		NO		NO	
Pentachlorophenol		NO		NO		NO		NO		NO		NO		NO		NO	

* Maximum concentrations (1992 values) are screened against the PRG (preliminary remediation goal). "Yes" if the value exceeds the PRG. "No" if the value is below the PRG.
The COPC (contaminants of potential concern) are refined based on the soil concentration and the PRG.
A blank under "Max" means either no information is available or the constituent was not detected.

(a) PRGs are established to be protective of groundwater, human and ecological receptors.
(b) PRGs are established to be protective of groundwater.
Source:
Dorian and Richards (Table 3.4-10,1978) data as decayed in the LFI (Attachment K1)

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Table K2-5. 116-KW-1 Condensate Crib Refined Contaminants of Potential Concern Based on Occasional Land Use Scenario and Protection of Groundwater

	Zone 1 (a)						Zone 2 (b)										Refined
116-DR-9	0 - 3 ft		3 - 6 ft		6 - 10 ft		10 - 15 ft		15 - 20 ft		20 - 25 ft		25 - 30 ft		30 - 35 ft		COPC
	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Summary
RADIONUCLIDES (pCi/g)																	
Am-241		NO		NO		NO		NO		NO		NO		NO		NO	
C-14		NO		NO		NO		NO		NO		NO	3.90E+05	YES	3.60E+04	YES	YES
Cs-134		NO		NO		NO		NO		NO		NO	2.20E-02	NO	4.70E-04	NO	
Cs-137		NO		NO		NO		NO		NO		NO	2.20E-02	NO	7.10E+00	NO	
Co-60		NO		NO		NO		NO		NO		NO	5.00E-01	NO	1.30E+00	NO	
Eu-152		NO		NO		NO		NO		NO		NO		NO		NO	
Eu-154		NO		NO		NO		NO		NO		NO	1.00E-01	NO	1.00E-01	NO	
Eu-155		NO		NO		NO		NO		NO		NO	1.60E+00	NO		NO	
H-3		NO		NO		NO		NO		NO		NO	2.10E+05	YES	3.80E+03	YES	YES
K-40		NO		NO		NO		NO		NO		NO		NO		NO	
Na-22		NO		NO		NO		NO		NO		NO		NO		NO	
Ni-63		NO		NO		NO		NO		NO		NO		NO		NO	
Pu-238		NO		NO		NO		NO		NO		NO		NO		NO	
Pu-239/240		NO		NO		NO		NO		NO		NO		NO		NO	
Ra-226		NO		NO		NO		NO		NO		NO		NO		NO	
Sr-90		NO		NO		NO		NO		NO		NO	1.93E+01	NO	1.30E-01	NO	
Tc-99		NO		NO		NO		NO		NO		NO		NO		NO	
Th-228		NO		NO		NO		NO		NO		NO		NO		NO	
Th-232		NO		NO		NO		NO		NO		NO		NO		NO	
U-233/234		NO		NO		NO		NO		NO		NO		NO		NO	
U-235		NO		NO		NO		NO		NO		NO		NO		NO	
U-238 (k)		NO		NO		NO		NO		NO		NO	3.10E-01	NO	1.10E-01	NO	
INORGANICS (mg/kg)																	
Antimony		NO		NO		NO		NO		NO		NO		NO		NO	
Arsenic		NO		NO		NO		NO		NO		NO		NO		NO	
Barium		NO		NO		NO		NO		NO		NO		NO		NO	
Cadmium		NO		NO		NO		NO		NO		NO		NO		NO	
Chromium VI		NO		NO		NO		NO		NO		NO		NO		NO	
Lead		NO		NO		NO		NO		NO		NO		NO		NO	
Manganese		NO		NO		NO		NO		NO		NO		NO		NO	
Mercury		NO		NO		NO		NO		NO		NO		NO		NO	
Zinc		NO		NO		NO		NO		NO		NO		NO		NO	
ORGANICS (mg/kg)																	
Aroclor 1260 (PCB)		NO		NO		NO		NO		NO		NO		NO		NO	
Benzo(a)pyrene		NO		NO		NO		NO		NO		NO		NO		NO	
Chrysene		NO		NO		NO		NO		NO		NO		NO		NO	
Pentachlorophenol		NO		NO		NO		NO		NO		NO		NO		NO	

* Maximum concentrations (1992 values) are screened against the PRG (preliminary remediation goal). "Yes" if the value exceeds the PRG. "No" if the value is below the PRG.
The COPC (contaminants of potential concern) are refined based on the soil concentration and the PRG.
A blank under "Max" means either no information is available or the constituent was not detected.

(a) PRGs are established to be protective of groundwater, human and ecological receptors.
(b) PRGs are established to be protective of groundwater.
Source:
Dorian and Richards (Table 3.4-10, 1978) data, as decayed in the LFI (Attachment K1)

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Table K2-5. 116-KW-1 Condensate Crib Refined Contaminants of Potential Concern Based on Occasional Land Use Scenario and Protection of Groundwater

	Zone 1 (a)						Zone 2 (b)										Refined
116-DR-9	0 - 3 ft		3 - 6 ft		6 - 10 ft		10 - 15 ft		15 - 20 ft		20 - 25 ft		25 - 30 ft		30 - 35 ft		COPC
	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Summary
RADIONUCLIDES (pCi/g)																	
Am-241		NO		NO		NO		NO		NO		NO		NO		NO	
C-14		NO		NO		NO		NO		NO		NO	3.90E+05	YES	3.60E+04	YES	YES
Cs-134		NO		NO		NO		NO		NO		NO	2.20E-02	NO	4.70E-04	NO	
Cs-137		NO		NO		NO		NO		NO		NO	2.20E-02	NO	7.10E+00	NO	
Co-60		NO		NO		NO		NO		NO		NO	5.00E-01	NO	1.30E+00	NO	
Eu-152		NO		NO		NO		NO		NO		NO		NO		NO	
Eu-154		NO		NO		NO		NO		NO		NO	1.00E-01	NO	1.00E-01	NO	
Eu-155		NO		NO		NO		NO		NO		NO	1.60E+00	NO		NO	
H-3		NO		NO		NO		NO		NO		NO	2.10E+05	YES	3.80E+03	YES	YES
K-40		NO		NO		NO		NO		NO		NO		NO		NO	
Na-22		NO		NO		NO		NO		NO		NO		NO		NO	
Ni-63		NO		NO		NO		NO		NO		NO		NO		NO	
Pu-238		NO		NO		NO		NO		NO		NO		NO		NO	
Pu-239/240		NO		NO		NO		NO		NO		NO		NO		NO	
Ra-226		NO		NO		NO		NO		NO		NO		NO		NO	
Sr-90		NO		NO		NO		NO		NO		NO	1.93E+01	NO	1.30E-01	NO	
Tc-99		NO		NO		NO		NO		NO		NO		NO		NO	
Th-228		NO		NO		NO		NO		NO		NO		NO		NO	
Th-232		NO		NO		NO		NO		NO		NO		NO		NO	
U-233/234		NO		NO		NO		NO		NO		NO		NO		NO	
U-235		NO		NO		NO		NO		NO		NO		NO		NO	
U-238 (k)		NO		NO		NO		NO		NO		NO	3.10E-01	NO	1.10E-01	NO	
INORGANICS (mg/kg)																	
Antimony		NO		NO		NO		NO		NO		NO		NO		NO	
Arsenic		NO		NO		NO		NO		NO		NO		NO		NO	
Barium		NO		NO		NO		NO		NO		NO		NO		NO	
Cadmium		NO		NO		NO		NO		NO		NO		NO		NO	
Chromium VI		NO		NO		NO		NO		NO		NO		NO		NO	
Lead		NO		NO		NO		NO		NO		NO		NO		NO	
Manganese		NO		NO		NO		NO		NO		NO		NO		NO	
Mercury		NO		NO		NO		NO		NO		NO		NO		NO	
Zinc		NO		NO		NO		NO		NO		NO		NO		NO	
ORGANICS (mg/kg)																	
Aroclor 1260 (PCB)		NO		NO		NO		NO		NO		NO		NO		NO	
Benzo(a)pyrene		NO		NO		NO		NO		NO		NO		NO		NO	
Chrysene		NO		NO		NO		NO		NO		NO		NO		NO	
Pentachlorophenol		NO		NO		NO		NO		NO		NO		NO		NO	

* Maximum concentrations (1992 values) are screened against the PRG (preliminary remediation goal). "Yes" if the value exceeds the PRG. "No" if the value is below the PRG.
The COPC (contaminants of potential concern) are refined based on the soil concentration and the PRG.
A blank under "Max" means either no information is available or the constituent was not detected.

(a) PRGs are established to be protective of groundwater, human and ecological receptors.
(b) PRGs are established to be protective of groundwater.
Source:
Dorian and Richards (Table 3.4-10, 1978) data, as decayed in the LFI (Attachment K1)

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Table K2-6. 116-KE-2 Crib Refined Contaminants of Potential Concern Based on Occasional Land Use Scenario and Protection of Groundwater.

	Zone 1 (a)						Zone 2 (b)										Refined
116-KE-2	0 - 3 ft		3 - 6 ft		6 - 10 ft		10 - 15 ft		15 - 20 ft		20 - 25 ft		25 - 40 ft		> 40 ft		COPC
	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Summary
RADIONUCLIDES (nCi/g)																	
Am-241		NO		NO		NO		NO		NO		NO		NO		NO	
C-14		NO		NO		NO		NO		NO		NO		NO	1.40E-01	NO	
Cs-134		NO		NO		NO		NO		NO		NO		NO		NO	
Cs-137		NO		NO		NO		NO		NO		NO		NO	1.59E+02	NO	
Co-60		NO		NO		NO		NO		NO		NO		NO	1.54E+03	YES	YES
Eu-152		NO		NO		NO		NO		NO		NO		NO	5.40E-01	NO	
Eu-154		NO		NO		NO		NO		NO		NO		NO	3.10E+01	NO	
Eu-155		NO		NO		NO		NO		NO		NO		NO	1.80E+00	NO	
H-3		NO		NO		NO		NO		NO		NO		NO	6.80E+01	NO	
K-40		NO		NO		NO		NO		NO		NO		NO		NO	
Na-22		NO		NO		NO		NO		NO		NO		NO		NO	
Ni-63		NO		NO		NO		NO		NO		NO		NO		NO	
Pu-238		NO		NO		NO		NO		NO		NO		NO		NO	
Pu-239/240		NO		NO		NO		NO		NO		NO		NO	6.10E+00	YES	YES
Ra-226		NO		NO		NO		NO		NO		NO		NO		NO	
Sr-90		NO		NO		NO		NO		NO		NO		NO	4.91E+02	YES	YES
Tc-99		NO		NO		NO		NO		NO		NO		NO		NO	
Th-228		NO		NO		NO		NO		NO		NO		NO		NO	
Th-232		NO		NO		NO		NO		NO		NO		NO		NO	
U-233/234		NO		NO		NO		NO		NO		NO		NO		NO	
U-235		NO		NO		NO		NO		NO		NO		NO		NO	
U-238 (k)		NO		NO		NO		NO		NO		NO		NO	2.40E-01	NO	
INORGANICS (mg/kg)																	
Antimony		NO		NO		NO		NO		NO		NO		NO		NO	
Arsenic		NO		NO		NO		NO		NO		NO		NO		NO	
Barium		NO		NO		NO		NO		NO		NO		NO		NO	
Cadmium		NO		NO		NO		NO		NO		NO		NO		NO	
Chromium VI		NO		NO		NO		NO		NO		NO		NO		NO	
Lead		NO		NO		NO		NO		NO		NO		NO		NO	
Manganese		NO		NO		NO		NO		NO		NO		NO		NO	
Mercury		NO		NO		NO		NO		NO		NO		NO		NO	
Zinc		NO		NO		NO		NO		NO		NO		NO		NO	
ORGANICS (mg/kg)																	
Aroclor 1260 (PCB)		NO		NO		NO		NO		NO		NO		NO		NO	
Benzo(a)pyrene		NO		NO		NO		NO		NO		NO		NO		NO	
Chrysene		NO		NO		NO		NO		NO		NO		NO		NO	
Pentachlorophenol		NO		NO		NO		NO		NO		NO		NO		NO	

* Maximum concentrations are screened against the PRG (preliminary remediation goal). "Yes" if the value exceeds the PRG. "No" if the value is below the PRG.
The COPC (contaminants of potential concern) are refined based on the soil concentration and the PRG.
A blank under "Max" means either no information is available or the constituent was not detected.

(a) PRGs are established to be protective of groundwater, human and ecological receptors.
(b) PRGs are established to be protective of groundwater.
Source:
Dorian and Richards (Table 3.4-10, 1978) data. as decayed in the LFI (Attachment K1)

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Table K2-6. 116-KE-2 Crib Refined Contaminants of Potential Concern Based on Occasional Land Use Scenario and Protection of Groundwater.

	Zone 1 (a)						Zone 2 (b)										Refined
116-KE-2	0 - 3 ft		3 - 6 ft		6 - 10 ft		10 - 15 ft		15 - 20 ft		20 - 25 ft		25 - 40 ft		> 40 ft		COPC
	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Summary
RADIONUCLIDES (pCi/g)																	
Am-241		NO		NO		NO		NO		NO		NO		NO		NO	
C-14		NO		NO		NO		NO		NO		NO		NO	1.40E-01	NO	
Cs-134		NO		NO		NO		NO		NO		NO		NO		NO	
Cs-137		NO		NO		NO		NO		NO		NO		NO	1.59E+02	NO	
Co-60		NO		NO		NO		NO		NO		NO		NO	1.54E+03	YES	YES
Eu-152		NO		NO		NO		NO		NO		NO		NO	5.40E-01	NO	
Eu-154		NO		NO		NO		NO		NO		NO		NO	3.10E+01	NO	
Eu-155		NO		NO		NO		NO		NO		NO		NO	1.80E+00	NO	
H-3		NO		NO		NO		NO		NO		NO		NO	6.80E+01	NO	
K-40		NO		NO		NO		NO		NO		NO		NO		NO	
Na-22		NO		NO		NO		NO		NO		NO		NO		NO	
Ni-63		NO		NO		NO		NO		NO		NO		NO		NO	
Pu-238		NO		NO		NO		NO		NO		NO		NO		NO	
Pu-239/240		NO		NO		NO		NO		NO		NO		NO	6.10E+00	YES	YES
Ra-226		NO		NO		NO		NO		NO		NO		NO		NO	
Sr-90		NO		NO		NO		NO		NO		NO		NO	4.91E+02	YES	YES
Tc-99		NO		NO		NO		NO		NO		NO		NO		NO	
Th-228		NO		NO		NO		NO		NO		NO		NO		NO	
Th-232		NO		NO		NO		NO		NO		NO		NO		NO	
U-233/234		NO		NO		NO		NO		NO		NO		NO		NO	
U-235		NO		NO		NO		NO		NO		NO		NO		NO	
U-238 (k)		NO		NO		NO		NO		NO		NO		NO	2.40E-01	NO	
INORGANICS (mg/kg)																	
Antimony		NO		NO		NO		NO		NO		NO		NO		NO	
Arsenic		NO		NO		NO		NO		NO		NO		NO		NO	
Barium		NO		NO		NO		NO		NO		NO		NO		NO	
Cadmium		NO		NO		NO		NO		NO		NO		NO		NO	
Chromium VI		NO		NO		NO		NO		NO		NO		NO		NO	
Lead		NO		NO		NO		NO		NO		NO		NO		NO	
Manganese		NO		NO		NO		NO		NO		NO		NO		NO	
Mercury		NO		NO		NO		NO		NO		NO		NO		NO	
Zinc		NO		NO		NO		NO		NO		NO		NO		NO	
ORGANICS (mg/kg)																	
Aroclor 1260 (PCB)		NO		NO		NO		NO		NO		NO		NO		NO	
Benzo(a)pyrene		NO		NO		NO		NO		NO		NO		NO		NO	
Chrysene		NO		NO		NO		NO		NO		NO		NO		NO	
Pentachlorophenol		NO		NO		NO		NO		NO		NO		NO		NO	

* Maximum concentrations are screened against the PRG (preliminary remediation goal). "Yes" if the value exceeds the PRG. "No" if the value is below the PRG.
The COPC (contaminants of potential concern) are refined based on the soil concentration and the PRG.
A blank under "Max" means either no information is available or the constituent was not detected.

(a) PRGs are established to be protective of groundwater, human and ecological receptors.
(b) PRGs are established to be protective of groundwater.
Source:
Dorian and Richards (Table 3.4-10, 1978) data, as decayed in the LFI (Attachment K1)

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Table K2-7. 100-KR-2 Waste Site Profile. (Page 1 of 2)

Waste Site (group)	Extent of Contamination					Media/ Material	Refined COPC	Maximum Concentration Detected (a)	Are Reduced Infiltration Concentrations Exceeded?
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Depth (Thickness) (m)				
116-KE-1 Condensate Crib	106.6	5 diameter	NA	20	5.33	Soil Concrete	Radionuclides ^{3}H	pCi/g(b) 2.1E3	Yes
116-KW-1 Condensate Crib	106.6	5 diameter	NA	20	5.33	Soil	Radionuclides ^{14}C ^{3}H	pCi/g 3.9E5 2.1E5	Yes Yes
116-KE-2 Crib	583.6	9.14	9.14	83.5	7	soil, wood	239/240 Pu ^{90}Sr ^{60}Co	pCi/g 6.1E0 4.91E2 1.54E3	No
116-KE-3 French Drain	667	7.6 diameter	7.6 diameter	45.6	14.6	soil	Assume radionuclides and concentrations from Process Group		No(c)
116-KW-2 French Drain	667	7.6 diameter	7.6 diameter	45.6	14.6	soil	Assume radionuclides and concentrations from Process Document		No(c)

Table K2-7. 100-KR-2 Waste Site Profile. (Page 2 of 2)

Waste Site (group)	Extent of Contamination					Media/ Material	Refined COPC	Maximum Concentration Detected (a)	Are Reduced Infiltration Concentrations Exceeded?
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Depth (Thickness) (m)				
118-K-2 Sludge Trench	5,689.5	53.3	18	1,531.27	3.35	Soil	Assume contaminants and concentrations from Process group		No[c]
120-KE-2 French Drain	37.5	3.96 diam.	3.96 diam.	12.3	3	Soil	Hg	(d)	Unknown, assume Yes
120-KW-2 French Drain	37.5	3.96 diam.	3.96 diam.	12.3	3	Soil	Hg	(d)	Unknown, assume Yes
119-KW French Drain	0.24	0©dia m.	0.3 diam.	0.07	3.05	Soil	Assume radionuclides and concentrations from Process group		No[c]
118-K-1 Burial Ground	283,153	241	136	43,857	7.62	Misc. solid waste	Assume radionuclides and concentrations from Process group		No: Assume that the burial ground contains immobile forms of waste

(a) Where concentration exceeds preliminary remediation goals.
(b) See 116-KW-1 for analogous data.
(c) Based on group data.
(d) An estimated 700 lbs of Hg disposed to crib, no concentrations known
COPC = contaminants of potential concern
NA = not applicable

Table K2-8. Allowable Soil Concentration - Reduced Infiltration Scenario.

Analyte	Soil Concentration
RADIONUCLIDES	**pCi/g**
^{241}Am	$5.01E^{3}$
^{14}C	$2.92E^{3}$
^{134}Cs	$8.35E^{4}$
^{137}Cs	$1.25E^{5}$
^{60}Co	$2.09E^{5}$
^{152}Eu	$3.34E^{6}$
^{154}Eu	$3.34E^{6}$
^{155}Eu	$1.67E^{7}$
^{3}H	$8.35E^{4}$
^{40}K	$2.34E^{4}$
^{22}Na	$3.34E^{4}$
^{63}Ni	$7.52E^{6}$
^{238}Pu	$8.35E^{2}$
$^{239/240}Pu$	$6.27E^{2}$
^{226}Ra	$4.00E^{0}$
^{90}Sr	$2.09E^{4}$
^{99}Tc	$4.18E^{3}$
^{228}Th	$1.67E^{1}$
^{232}Th	$2.09E^{0}$
$^{233/234}U$	$8.35E^{2}$
^{235}U	$1.00E^{3}$
^{238}U	$1.00E^{3}$
INORGANICS	**mg/kg**
Antimony	$2.51E^{-1}$
Arsenic	$2.09E^{0}$
Barium	$4.18E^{4}$
Cadmium	$1.25E^{2}$
Chromium (VI)	$4.18E^{0}$
Lead	$1.25E^{3}$
Manganese	$2.09E^{3}$
Mercury	$5.01E^{1}$
Zinc	$1.25E^{5}$
ORGANICS	**mg/kg**
Aroclor 1260	$2.21E^{2}$
Benzo(a)pyrene	$9.19E^{2}$
Chrysene	$2.00E^{0}$
Pentachlorophenol	$4.40E^{1}$

3.0 RESULTS OF THE PLUG-IN APPROACH

This section provides the "plug-in" (Section 1.4 of the Process Document) approach, as applied to the IRM candidate sites in the 100-KR-2 Operable Unit. The plug-in approach requires identification of the waste site group to which a waste site belongs and an evaluation of the alternate applicable criteria. All 10 IRM candidates in the 100-KR-2 Operable Unit fit into Process Groups presented in DOE-RL (1995a).

Identifying the waste site group, to which each waste site belongs, is accomplished by using the waste site descriptions defined in Section 2.0 and fitting the site into the appropriate waste site group in Figure 1-4 of the Process Document. It is also necessary to refer to the group descriptions defined in Section 3.0 of the Process Document. The appropriate groups for these sites are identified in Table K3-1.

Table K3-1 presents the evaluation of the alternative applicability criteria for the IRM waste sites. The evaluation represents step 6 of the plug-in approach (Section 1.4 of the Process Document) and identifies which alternatives and enhancements apply to each site. Any deviation from alternatives developed for the appropriate group in the Process Document are identified by footnote. Sites with deviations will be developed further in subsequent sections; however, the general analysis of alternatives in the Process Document (Section 5.0) will be used for sites without deviations.

The deviations indicated in Table K3-1 are as follows:

- French Drains 116-KE-3 and 116-KW-2 have contamination >5.8-m (19-ft) thick; therefore, In Situ Vitrification does not apply.

- Crib 116-KE-2 has contamination that is >5.8-m (19-ft) thick; therefore, In Situ Vitrification does not apply. However, the contaminants are below reduced infiltration concentrations, so containment would be a viable alternative for the site in its Process Group.

- French Drains 120-KE-2 and 120-KW-2 are assumed to have mercury at levels above the reduced infiltration concentrations. Thus, containment is not an alternative.

- Condensate Cribs 116-KE-1 and 116-KW-1 have contamination that is >5.8-m (19-ft) thick; therefore, In Situ Vitrification does not apply.

3.1 EXAMPLE APPLICATION OF THE PLUG-IN APPROACH

To further understand the plug-in approach (Section 1.4 of the Process Document), an example of its application has been developed. The example waste site will be evaluated, as

dictated by the plug-in approach. The waste site profile has been defined in Section 2.0 (completing step 4 of the approach). Steps 5 and 6 of the approach are completed below.

3.1.1 Identification of Appropriate Group

Waste site 116-KE-2 is assessed against the elements of Figure 1-4 of the Process Document (DOE-RL 1995a) to ensure that the appropriate group is identified.

Table K2-2 indicates that the site received liquid wastes from test loops, cleanup columns, and contaminated cooling water. Table K2-2 also indicates that the site is constructed of wooden timbers 1.5 by 1.5 m^2 (16 by 16 ft^2) forming a cobble-filled crib in a 9.8-m (32-ft) deep pit, and is penetrated by a perforated well extending 3.6 m (12 ft) below the crib bottom. While this site is larger than the typical Pluto Crib, it is similar enough in construction and operation to be included under this waste group, with the deviations noted in Table K3-1.

3.1.2 Evaluation of the Alternative Applicability Criteria

An evaluation of the alternative applicability criteria is based on the description and profile developed for waste site 116-KE-2, presented in Section 2.0. The evaluation of each alternative is presented below.

No Action - There are data indicating contamination present at the site that warrants an interim action. Therefore, no action is not an appropriate alternative.

Institutional Controls - Refined COPC are identified for waste site 116-KE-2 in Table K2-5 indicating that a contaminant is present that exceeds PRGs. Therefore, institutional controls are not considered for the site.

Containment - Because no contaminants exceed reduced infiltration concentrations at the site, containment is applicable.

Removal/Disposal - Because contaminants exceed PRGs, this alternative is applicable.

In Situ Treatment - While contaminants exceed PRGs, the contaminated lens is >5.8 m (19 ft). Thus, the In Situ treatment option is not applicable.

Removal/Treatment/Disposal - Because contaminants exceed PRGs, this alternative is applicable. Thermal desorption enhancement is not applicable because organic contaminants are not known to be present at the site. For cost purposes, it was assumed that the percentage of contaminated soil that can be effectively treated by soil washing is 100% of the waste site. This percentage was based on the depth, distribution, and concentration of contaminants at the waste site. This does not affect the application of the alternative, but does impact the magnitude of volume reduction realized at the site.

This evaluation identified applicable alternatives. These results are compared to the results of the group analysis presented in Table 5-1 of the Process Document to identify deviations:

	Alternatives	Group Alternatives
Applicable	Removal/Disposal	Removal/Disposal
	Containment	Removal/Treatment/Disposal
	Removal/Treatment/Disposal	In Situ Treatment
Not Applicable	No Action	No Action
	Institutional Controls	Institutional Controls
	In Situ Treatment	Containment

Table K3-1. Comparison of Waste Sites to Potential Remedial Alternatives. (page 1 of 2)

100-KR-2 Waste Site		116-KE-3 116-KW-2	120-KE-2 120-KW-2	119-KW	118-K-1	118-K-2	116-KE-1 116-KW-1	116-KE-2
Waste Site Group		French Drains	French Drains	French Drains	Burial Grounds	Sludge Trench	Pluto Cribs	Pluto Crib
Alternative	**Applicability Criteria and Enhancements**	**Are Applicability Criteria and Enhancements Met?**						
No Action								
SS-1 SW-2	Criterion: • Has site been effectively addressed in the past?	No	No	No	No	No	No	No
Institutional Controls								
SS-2 SW-2	Criterion: • Contaminants < PRG	No	No	No	No	No	No	No
Containment								
SS-3 SW-3	Criteria: • Contaminants > PRG	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	• Contaminants < reduced infiltration concentrations	Yes	No(a)	Yes	Yes	No	No	Yes (a)
Removal/Disposal								
SS-4 SW-4	Criterion: • Contaminants > PRG	Yes	Yes	Yes	Yes	Yes	Yes	Yes
In Situ Treatment								
SS-8A	Criteria: • Contaminants > PRG	Yes	Yes	Yes	NA	Yes	Yes	Yes
	• Contamination < 5.8 m (19 ft) in depth	No (a)	Yes	Yes	NA	Yes	No(a)	No (a)
SS-8B	Criteria: • Contaminants > PRG	NA	NA	NA	NA	NA	NA	NA
	• Contaminants < reduced infiltration concentrations	NA	NA	NA	NA	NA	NA	NA

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Table K3-1. Comparison of Waste Sites to Potential Remedial Alternatives. (page 2 of 2)

100-KR-2 Waste Site		116-KE-3 116-KW-2	120-KE-2 120-KW-2	119-KW	118-K-1	118-K-2	116-KE-1 116-KW-1	116-KE-2
Waste Site Group		French Drains	French Drains	French Drains	Burial Ground	Sludge Trench	Cribs	Pluto Crib
Alternative	**Applicability Criteria and Enhancements**	**Are Applicability Criteria and Enhancements Met?**						
SW-7	Criteria: • Contaminants > PRG	NA	NA	NA	Yes	NA	NA	NA
	• Contaminants < reduced infiltration concentrations	NA	NA	NA	Yes	NA	NA	NA
Removal/Treatment/Disposal								
SS-10	Criterion: • Contaminants > PRG	Yes	Yes	Yes	NA	Yes	Yes	Yes
	Enhancements: • Organic contaminants (if yes, thermal desorption must be included in the treatment system)	No	No	No	NA	No	No	No
	• Percentage of contaminated volume less than twice the PRG for cesium-137.	100%	NA	100%	NA	100%	100%	100%
SW-9	Criterion: • Contaminants > PRG	NA	NA	NA	Yes	NA	NA	NA
	Enhancement: • Organic contaminants	NA	NA	NA	NA	NA	NA	NA

(a) - deviation from waste site group
PRG - preliminary remediation goals
NA - not applicable
NOTE: Shading highlights "Yes" blocks

4.0 ALTERNATIVE DEVELOPMENT

This section describes the alternative enhancement and site-specific alternative development for waste sites that do not align with the Process Document group profiles.

Alternatives do not require further development if the site plugs directly into the group profiles (Process Document, Section 1.4, step 6a).

The sites that do not plug in directly (Process Document, Section 1.4, step 6b) can be divided into two groups. The first group contains those sites that require enhancements to an alternative or an inclusion or dismissal of an alternative as originally proposed. These sites and deviations are discussed in Section 3.0. However, the enhancements do not need development for these sites, because the Process Document incorporates the appropriate enhancements in Section 1.4.

The second group of sites, which do not plug in, are those sites that require a significant modification to an alternative, such as changes in the excavation process or disposal options. Alternatives for sites included in this second set will require additional development. None of the sites within the 100-KR-2 Operable Unit fit into this second set; therefore, additional alternative development is not required.

5.0 DETAILED ANALYSIS OF ALTERNATIVES

This section presents the detailed analysis of the potential alternatives applicable to the individual waste sites within the 100-KR-2 Operable Unit. In the detailed analysis, each alternative is assessed against the evaluation criteria described in Section 5.1 of the Process Document. The detailed analysis for the sites within the 100-KR-2 Operable Unit are presented in the following manner:

- The detailed analyses for those individual waste sites that do not deviate from the waste site groups are referenced to the group discussion presented in the Process Document.

- The detailed analyses for those individual waste sites that deviate from the waste site groups are discussed in Section 5.2.

5.1 SITE-SPECIFIC DETAILED ANALYSIS

Based on the comparison presented in Table K3-1, most of the individual waste sites within the 100-KR-2 Operable Unit plug into the waste site group alternatives; therefore, the common evaluation considerations for these individual waste sites can be found in the Process Document. These sites are the 120-KE-2 and 120-KW-2 French drains, 119-KW French drain, 118-K-1 Burial Ground, and the 118-K-2 Sludge Trench.

The common evaluation considerations for the remaining waste sites (116-KE-1 and 116-KW-1 Condensate Cribs, 116-KE-3 and 116-KW-2 French drains, and the 116-KE-2 Crib) are discussed in the following sections. Each deviation of a Process Document alternative for these waste sites is analyzed for impacts to transportation, air quality, ecological, cultural, socioeconomic, noise, and visual resources. In addition to identifying those potential impacts, irretrievable and irreversible commitment of resources, indirect and cumulative impacts, and compliance with Executive Order 12898 (Environmental Justice) are also discussed. Table K5-2 presents the remediation durations associated with all waste sites.

5.1.1 116-KE-3 and 116-KW-2 French Drains

This section evaluates the alternatives that deviate from the Process Document for French drains 116-KE-3 and 116-KW-2. Alternatives SS-3, SS-4, and SS-10 are applicable to these sites. However, Alternative SS-8A in the Process Document is applicable to this waste group, but not these sites because the depth of contamination is greater than 5.8 m (19 ft), making In Situ vitrification inapplicable. Therefore, this alternative will not be considered. Because the deviation for these sites is an omission of an alternative rather than an addition, no additional evaluation is required.

5.1.2 116-KE-1 and 116-KW-1 Condensate Cribs

This section evaluates the alternatives that deviate from the Process Document for Condensate Cribs 116-KE-1 and 116-KW-1. These sites have been plugged into the pluto crib process group. Alternatives SS-4, SS-8, and SS-10 are applicable to this group. However, Alternative SS-8A is not applicable to these sites because the depth of contamination is greater than 5.8 m (19 ft), making In Situ vitrification inapplicable. Therefore, this alternative will not be considered. Because the deviation for these sites is an omission of an alternative, no evaluation is required.

5.1.3 116-KE-2 Crib

This section evaluates the alternatives that deviate from the Process Document for the 116-KE-2 Crib, which has been plugged into the pluto crib process group. Alternatives SS-4, SS-8A, and SS-10 are applicable to this group. However, Alternative SS-3 is applicable to these 100-KR-2 waste sites, because the contaminants are below reduced infiltration concentrations. This deviation from the process group alternatives will be evaluated.

Alternative SS-8A is not applicable to this site because the depth of contamination is greater than 5.8 m (19 ft), making In Situ vitrification inappropriate. Therefore, this alternative will not be considered. Because this deviation is an omission of an alternative rather than an addition, no additional evaluation is required.

Alternative SS-3, which is containment, would affect transportation. This alternative would require the transport of equipment and clean fill by trucks. The commuter traffic flow for this alternative is not expected to cause a noticeable effect at the Hanford Site.

Air quality would not be affected because contaminated soil would not be disturbed. Ecological resources would not be affected; instead, revegetation and restoration efforts would benefit natural resources in the long run. Because this area has already been heavily disturbed, no positive or negative effects to cultural resources are expected.

The socioeconomic impact of this alternative would be insignificant. The number of employees involved and the income gained would be insignificant when compared with the total Tri-Cities area employment. Workers would likely come from the regional labor force. Consistent with overall employment, income and effects on housing would be insignificant.

This alternative would create minor short-term impacts to noise and visual resources during the treatment process. Noise mitigation would be provided should noise levels become a problem. To mitigate potential impacts to visual resources, dust controls would be implemented when needed.

Resources, such as federal funds, soil cover, and consumables such as fuel, electricity, chemicals, and personal protective equipment, would be irreversibly committed.

The indirect impact of this alternative would be an enhancement of the natural resources through revegetation. This alternative could add to the cumulative impact on transportation and cultural, noise and visual resources from Hanford Site remediation.

As stated in the Process Document, this alternative would comply with Executive Order 12898, Environmental Justice, because it would not disproportionately affect any group of the population more than another.

Table K5-1. Waste Site Remedial Alternatives and Technologies. (1 of 2)

100-KR-2 IRM Candidate Sites			116-KE-3 116-KW-2	120-KE-2 120-KW-2	119-KW
Waste-Site Group			French Drains	French Drains	French Drains
Alternatives		Technologies Included			
No Action	SS-1 SW-1	None	--	--	--
Institutional Controls	SS-2 SW-2	Deed Restrictions	--	--	--
		Groundwater Monitoring	--	--	--
Containment	SS-3 SW-3	Surface Water Controls	P	--	P
		Hanford Barrier	P	--	P
		Deed Restrictions	P	--	P
		Groundwater Monitoring	P	--	P
Removal/Disposal	SS-4 SW-4	Removal	P	P	P
		Disposal	P	P	P
In Situ Treatment	SS-8A	Surface Water Controls	O	P	P
		In Situ Vitrification	O	P	P
		Groundwater Monitoring	O	P	P
		Deed Restrictions	O	P	P
	SS-8B	Void Grouting	--	--	--
		Hanford Barrier	--	--	--
		Surface Water Controls	--	--	--
		Deed Restrictions	--	--	--
		Groundwater Monitoring	--	--	--
	SW-7	Dynamic Compaction	--	--	--
		Hanford Barrier	--	--	--
		Surface Water Controls	--	--	--
		Deed Restrictions	--	--	--
		Groundwater Monitoring	--	--	--
Removal/Treatment/ Disposal	SS-10	Removal	P	P	P
		Thermal Desorption	--	--	--
		Soil Washing	P	P	P
		Disposal	P	P	P
	SW-9	Removal	--	--	--
		Thermal Desorption	--	--	--
		Compaction	--	--	--
		ERDF Disposal	--	--	--

P Indicates the applicable detailed analysis is provided in the Process Document.
O Indicates the applicable detailed analysis is provided in this report.
-- Technology does not apply to this waste-site group.

Table K5-1. Waste Site Remedial Alternatives and Technologies. (2 of 2)

100-KR-2 IRM Candidate Sites			118-K-1	118-K-2	116-KE-1 116-KW-1	116-KE-2
Waste-Site Group			Burial Ground	Sludge Trench	Cribs	Cribs
Alternatives		Technologies Included				
No Action	SS-1 SW-1	None	--	--	--	--
Institutional Controls	SS-2 SW-2	Deed Restrictions	--	--	--	--
		Groundwater Monitoring	--	--	--	--
Containment	SS-3 SW-3	Surface Water Controls	P	--	--	O
		Hanford Barrier	P	--	--	O
		Deed Restrictions	P	--	--	O
		Groundwater Monitoring	P	--	--	O
Removal/Disposal	SS-4 SW-4	Removal	P	P	P	P
		Disposal	P	P	P	P
In Situ Treatment	SS-8A	Surface Water Controls	--	P	--	O
		In Situ Vitrification	--	P	--	O
		Groundwater Monitoring	--	P	--	O
		Deed Restrictions	--	P	--	O
	SS-8B	Void Grouting	--	--	--	--
		Hanford Barrier	--	--	--	--
		Surface Water Controls	--	--	--	--
		Deed Restrictions	--	--	--	--
		Groundwater Monitoring	--	--	--	--
	SW-7	Dynamic Compaction	P	--	--	--
		Hanford Barrier	P	--	--	--
		Surface Water Controls	P	--	--	--
		Deed Restrictions	P	--	--	--
		Groundwater Monitoring	P	--	--	--
Removal/Treatment/ Disposal	SS-10	Removal	--	P	P	P
		Thermal Desorption	--	--	--	--
		Soil Washing	--	P	P	P
		Disposal	--	P	P	P
	SW-9	Removal	P	--	--	--
		Thermal Desorption	--	--	--	--
		Compaction	P	--	--	--
		ERDF Disposal	P	--	--	--

P Indicates the applicable detailed analysis, which is provided in the Process Document.
O Indicates the applicable detailed analysis, which is provided in this report.
-- Technology does not apply to this waste-site group.

Table K5-2. 100-KR-2 Waste Site-Specific Remedial Alternative Durations.

IRM Candidate Site	Containment	Removal/ Disposal	In Situ Treatment	Removal/ Treatment/ Disposal
	Duration (yr)	Duration (yr)	Duration (yr)	Duration (yr)
116-KE-3 French Drain	0.1	0.03	--	0.03
116-KW-2 French Drain	0.1	0.03	--	0.03
120-KE-2 French Drain	--	0.1	0.1	0.1
120-KW-2 French Drain	--	0.1	0.1	0.1
119-KW French Drain	0.1	0.1	0.1	0.1
118-K-1 Burial Ground	1.2 (1.5 with Compaction)	3.6	--	3.6
118-K-2 Sludge Trench	--	0.1	0.1	0.2
116-KE-1 Condensate Crib	--	0.1	--	0.1
116-KW-1 Condensate Crib	--	0.1	--	0.1
116-KE-2 Crib	0.1	0.1	--	0.2

Double dash (--) = Not applicable.

6.0 COMPARATIVE ANALYSIS FOR THE REVISED SCENARIO

As discussed in the introduction of this Appendix, the detailed and comparative analyses performed in Sections 5.0 and 6.0 of the Process Document (DOE-RL 1995a) were based on meeting human health risk-based goals. The analyses assume occasional use of the land and remediation of the soil to support frequent use of groundwater. This scenario is referred to as the baseline scenario. While the public has provided input to DOE on the future land use of the 100 Area through various forms, including the Hanford Future Site Uses Working Group, the final land use for the 100 Area has not been established. For this FFS, Ecology, EPA, and DOE have agreed to cleanup goals that to the extent practical, would not limit any future uses of the 100 Area land because of contaminants resulting from Hanford Site operations. Based on this, the Tri-Party signatory agencies have established cleanup goals based on three laws and the draft legislation listed below.

- State of Washington *Model Toxics Control Act* for organic and inorganic chemical constituents in soil to support unrestricted (residential) use.

- Draft EPA and Nuclear Regulatory Commission guidance proposal of a human health standard of 15 mrem/yr above background for radionuclides in soils.

- Protection of groundwater, such that contaminants remaining in the soil after remediation do not result in an impact to groundwater that could exceed Maximum Contaminant Levels under the *Safe Drinking Water Act*. (This applies to waste sites where groundwater has not been impacted.)

- Protection of the Columbia River, such that contaminants remaining in the soil after remediation do not result in an impact to groundwater and, therefore, the Columbia River that could exceed the Ambient Water Quality Criteria under the *Clean Water Act* (for protection of fish. This applies to sites where groundwater has already been impacted.)

For deep sites where contamination begins 4.5 m (15 ft) below ground surface, the extent of remediation may be balanced against several factors including reduction of risk by decay of radionuclides, protection of human health and the environment, costs, sizing of the Environmental Restoration Disposal Facility (ERDF), worker safety, presence of ecological and cultural resources, the use of institutional controls, and long-term monitoring costs. A full description of the nine evaluation criteria used to evaluate remedies at all sites is in Section 5.1 of the Process Document. However, the process of determining cleanup goals, considering all the criteria, cannot be done quantitatively in this FFS. Additional information from the Expedited Response Action at the 100-BC-1 Operable Unit and other activities will allow cleanup goals to be established during the Record of Decision (ROD) development or during remedial design.

The analysis of alternatives presented here reflects the change in cleanup goals from the baseline scenario to a scenario that would not limit any potential future use. Remedial Action

objectives and cleanup goals may be revisited if final land use and groundwater use determinations are inconsistent with the goals presented in this FFS.

In a cleanup scenario that would not limit any future uses, In Situ Treatment and Containment are no longer appropriate for interim actions because these alternatives would leave contaminants above cleanup goals at the Hanford Site. The presence of these contaminants, even vitrified or under a barrier, would preclude some potential future uses. Also, the cleanup goals agreed to by the Tri-Parties potentially requires less excavation than the baseline scenario originally developed in Sections 5.0 and 6.0 of the Process Document. This reduced excavation is because the protection of groundwater component in the revised scenario is based on less stringent criteria (that is, the Summers Model parameters have been updated; see Table D2-1 in the Sensitivity Analysis, Appendix D, of DOE-RL 1995a), whereas the groundwater scenario in the baseline scenario considered more conservative parameters for frequent use of the groundwater, under a recreational land use.

The alternatives considered for waste sites in the 100-KR-2 Operable Unit are Removal/Disposal and Removal/Treatment/Disposal. Treatment would be conducted as appropriate for cost-effective operations; for example, to reduce the size of the ERDF, or to reduce overall costs. Treatment by soil washing could reduce the volume of contaminated soil for disposal. The application of soil washing to a waste site will depend on several factors, including soil conditions, contaminant-specific cleanup goals, and the level of contaminants present. Soil washing is a desirable treatment only when the contaminated volume can be significantly reduced, and only when such volume reduction is cost-effective. The greatest cost benefit would be achieved at large-volume sites with low levels of contaminants. Treatability studies are in progress to evaluate the effectiveness of soil washing at 100-Area sites.

Treatment would also be conducted as appropriate to meet Land Disposal Restrictions (LDR) before disposal of any wastes that exceed concentration limits specified in the regulations. Based on the information currently available, LDR treatment will be required for a limited number of contaminants of concern. Because of the uncertainties associated with the LDR treatment volumes, a detailed analysis of costs could not be performed as part of this FFS.

6.1 INFLUENCE OF THE REVISED CLEANUP GOALS ON THE 100-KR-2 FFS

The development of the Remedial Alternatives in the 100 Area Feasibility Study Phases 1 and 2 (DOE-RL 1993a) and the Process Document (DOE/RL 1995a) are not influenced by the change in cleanup goals, so the number and types of Remedial Alternatives stay the same. Likewise, the plug-in approach is still directly applicable for either the baseline or the revised scenarios.

The detailed analysis of the Removal/Disposal and Removal/Treatment/Disposal Alternatives in the Process Document (Section 5.0) is influenced only slightly by the change in cleanup goals (less excavation is required by the revised scenario); therefore, there is no change in the assessment of these alternatives with regards to the CERCLA evaluation criteria and NEPA issues. The potential adverse effects of the Removal/ Disposal and Removal/Treatment/

Disposal Alternatives on workers, future site uses, and the environment are also much the same under the revised scenario as they are under the baseline scenario. Therefore, the detailed analysis of alternatives in the Process Document and this 100-KR-2 FFS Appendix remain valid.

6.2 REVISED SCENARIO QUALITATIVE COMPARISON OF REMEDIAL ALTERNATIVES

Significant uncertainties remain in treatment options, future land use, actual contamination present at each site, and the mechanics of remediation activities on an operable unit scale. Thus, only a qualitative evaluation has been made in weighing the cleanup alternatives against the ranking criteria, using professional judgement and consensus among the Tri-Parties. In addition, the final decision on remedial alternative may include additional criteria, such as modifications based on public concerns reflected in state and local community comments.

A qualitative comparative analysis of the alternative for these IRM sites ranks the Removal/Treatment/Disposal Alternative slightly ahead of the Removal/Disposal Alternative. Removal/Disposal would rank higher in short-term effectiveness and implementability, because there would be less risk to workers, cultural resources, and natural resources from remedial activities. This alternative would also be easier to implement. However, Removal/Treatment/Disposal would score higher in reduction of volume because the volume of soil and other material needed to be disposed of would be reduced through treatment. This reduction in volume would also reduce the amount of clean fill required from borrow areas to regrade the sites, and reduce the total size of the disposal site, making the treatment alternative score higher in long-term effectiveness. For some IRM sites (e.g., 119-KW), the small amount of contaminated material might preclude volume reduction, and treatment might be suitable only to meet LDR. Because of current uncertainties in disposal costs, transportation, and treatment, the costs for either alternative are assumed to be about equal.

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ATTACHMENT 1

100-KR-2 LIMITED FIELD INVESTIGATION/ QUALITATIVE RISK ASSESSMENT

ATTACHMENT 1

100-KR-2 LIMITED FIELD INVESTIGATION/ QUALITATIVE RISK ASSESSMENT

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1.0 INTRODUCTION

This attachment to the 100-KR-2 Focused Feasibility Study (FFS) summarizes the results of the LFI completed for the 100-KR-2 Operable Unit. A complete list of potential waste sites was presented in the *Approach and Plan for Cleanup Actions in the 100-KR-2 Operable Unit of the Hanford Site* (DOE-RL 1994a), along with proposed dispositions of all sites as Interim Remedial Measure (IRM) candidates, low-priority sites, nonwaste sites, facilities for decontamination and decommissioning, or "to be determined" sites. The IRMs are intended to achieve remedies that are likely to lead to a final record of decision. The final decision to conduct an IRM will rely on many factors, including applicable or relevant and appropriate requirements (ARAR), future land use, point of compliance, time of compliance, a bias for action, and the threat to human health and the environment. This LFI/Qualitative Risk Assessment (QRA) report summarizes the evaluations of IRMs and presents the QRAs for these sites. In addition, this LFI recommends dispositions of sites designated as "to be determined" (those that needed further evaluation) in the Focus Package (DOE-RL 1994a).

The *Hanford Past-Practice Strategy* (HPPS) (DOE-RL 1991) was developed to expedite cleanup by initiating and completing waste site cleanup through interim actions. The strategy focuses on reaching early decisions to initiate and complete cleanup projects, maximizing the use of existing data, coupled with focused short-term investigations, where necessary.

Implementation of the HPPS (DOE-RL 1991) at the 100-KR-2 Operable Unit began with the Focus Package (DOE-RL 1994a), a streamlined version of a work plan. Table KA1-1 shows the current IRM candidates and low-priority sites. Figure KA1-1 shows the locations of the IRM candidate sites.

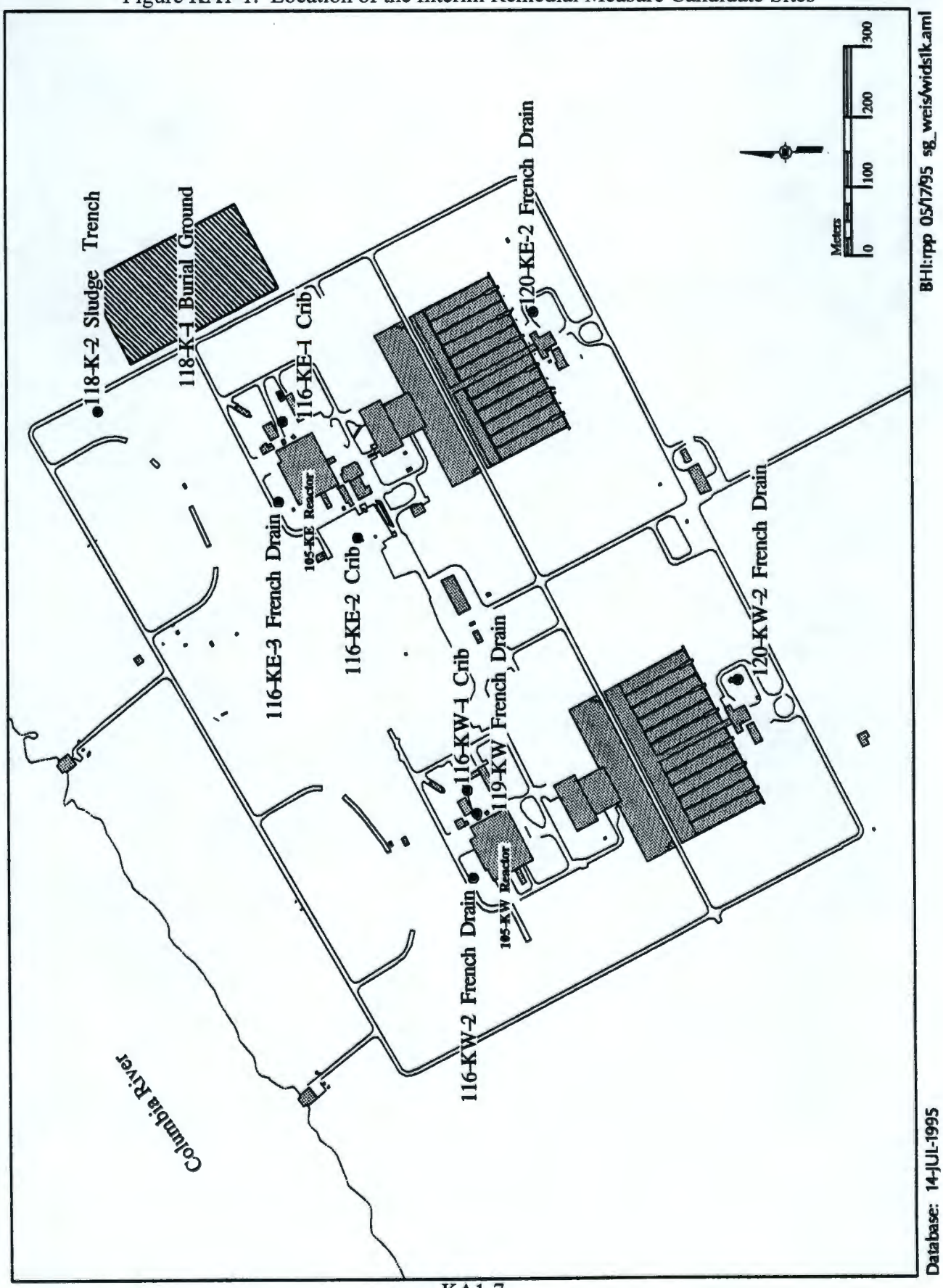
The Focus Package (DOE-RL 1994a) proposed limited nonintrusive investigations for the LFI. In preparation for determining Data Quality Objectives (DQO) for the LFI, additional historical record searches and cultural resource surveys were completed. Some of the sites initially targeted for IRM or landlord cleanup (not involving hazardous waste) were reassessed on the basis of the new information. Sites initially designated "to be determined" were assigned to the appropriate category (see Section 3.2 of this attachment).

The *Guidance for the Data Quality Objectives Process* (EPA 1994) was followed for the proposed LFI. As a result, nonintrusive investigations at the 100-KR-2 Operable Unit were conducted on two sites. This work consisted of geophysical surveys at two sludge disposal sites, 118-K-2 and 120-KE-3 (Bergstrom et al. 1995).

Table KA1-1. Interim Remedial Measure Candidate and Low-Priority Sites
(from DOE/RL 1994a)

IRM Candidate Site	Low-Priority Site
116-KE-1 Condensate Crib	116-KE-5 Heat Recovery Facility Junction Box
116-KE-2 Waste Crib	126-K-1 (100-K Gravel Pit)
116-KE-3 French Drain	1607-K6 Septic Tank
116-KW-1 Condensate Crib	118-KE & KW-2 French Drains
116-KW-2 French Drain	130-KW-1 Diesel Fuel Tank
118-K-2 Sludge Burial Ground	128-K-1 Burning Pit
French Drain South of 119-KW Building	128-K-2 Construction Dump
118-K-1 Burial Ground	1607-K1 Septic Tank
120-KE-2 French Drain	1607-K2 Septic Tank
120-KW-2 French Drain	1607-K3 Septic Tank
	1607-K4 Septic Tank
	1607-K5 Septic Tank
	600-55 Solid Waste Site
	120-KE-3 Trench
	600-29 Construction Laydown Area
	100-K-37 French Drain
	100-K-5 French Drain

Figure KA1-1. Location of the Interim Remedial Measure Candidate Sites



2.0 INVESTIGATIVE AND EVALUATION PHASE

No intrusive field sampling was done at any of the 100-KR-2 waste sites as part of this LFI. Instead, data were compiled from several different sources. The investigative activities consisted of nonintrusive investigations, review of analogous site information, evaluation of historical data, and examination of process knowledge. The investigation approach taken at each IRM candidate site is summarized in Table KA1-2. A QRA has been completed for each waste site considered an IRM candidate.

Table KA1-2. Investigation Approach for 100-KR-2 Interim Remedial Measure Candidates

IRM Candidate Site	Comments	Investigation Approach
116-KE-1 Condensate Crib	Location and historical sampling in Site drawings and Dorian and Richards (1978)	Historical sampling and process knowledge
116-KE-2 Crib	Wooden crib	Historical sampling
116-KE-3 French Drain	Adjacent to reactor	Recent well sampling
116-KW-1 Condensate Crib	Location and historical sampling in Site drawings and Dorian and Richards (1978)	Historical sampling
116-KW-2 French Drain	Adjacent to reactor	Recent well sampling
118-K-2 Sludge Trench	Existence and location uncertain	Ground penetrating radar; analogous sampling
French Drain south of 119-KW Building	Adjacent to reactor; received floor drainage from 119-KW	Not required
118-K-1 Burial Ground	Similar site, 118-B-1, excavated in 1994	Analogous sampling
120-KE-2 French Drain	Nonradioactive sludge, contains mercury	Process knowledge
120-KW-2 French Drain	Nonradioactive sludge, contains mercury	Process knowledge

2.1 HISTORICAL AND CULTURAL RESOURCES INFORMATION

Historical information includes operations records and reports, engineering drawings, photographs, interviews with current or former operations personnel, and data from sampling and analysis of facilities and the local environment. Recent reviews of historical information on 100-KR-2 waste sites are attached (Appendix K, Attachment 2, Part 2); in addition, an overview of historical information for the entire 100-K Area is provided in Carpenter and Cote (1994).

Various cultural resource-related investigations have been conducted in the 100-K Area over the last few decades. These investigations have resulted in the identification of several archaeological and ethnohistorical sites in and around the 100-KR-2 Operable Unit, ranging from 9,000 years ago to the mid-nineteenth century.

Evaluation of the archaeological sites and ethnohistorical information indicates that the cultural resources in the 100-K Area are significant. Beyond the potential for sites to yield important scientific information, additional significance is ascribed to the sites in the area because of potential associations with events related to Smohalla, Prophet of the Wanapum people. It was along the rapids adjacent to the 100-K Area that Smohalla held the first *washat*, the dance ceremony that has become central to the Seven Drums or Dreamer religion (Relander 1986).

For these reasons and because a Wanapum cemetery exists in the 100-K Area, the cultural sensitivity of the 100-KR-2 Operable Unit could be considered high. However, considering the distance of the operable unit from the river and areas of extensive disturbance that would have destroyed any cultural material, only the northwest corner of the site is considered to have high and moderately high cultural resource potential. The remainder of the 100-KR-2 Operable Unit is considered to have low potential for cultural resources, but it should be noted that the possibility still exists, especially because sections of this area are undisturbed.

Assessments of possible impacts on cultural resources from 100-KR-2 waste site remediation have indicated that no Waste Information Data System (WIDS)-listed sites are located in areas of extremely high cultural sensitivity. However, the following four 100-KR-2 sites listed in WIDS were found to be in areas of moderately high cultural sensitivity:

- 116-KW-4 Heat Recovery Station
- 118-K-1 Burial Ground
- 118-K-2 Sludge Trench
- 126-K-1 Gravel Pit.

2.2 INTRUSIVE FIELD INVESTIGATIONS

While no intrusive field investigations were completed for this LFI, several of the radionuclide waste sites were sampled for radionuclides in 1976 by Dorian and Richards (1978) (sites 116-KE-1, 116-KE-2, 116-KW-1, 116-KW-2, and 118-K-1), or by Williams (1994) (sites 116-KE-3, 116-KW-2). Where applicable, either directly or analogously, these results are included in this report, and the radionuclides are decayed to 1995.

2.3 NONINTRUSIVE FIELD INVESTIGATIONS

The nonintrusive field investigations in the 100-KR-2 Operable Unit conducted for this LFI were ground-penetrating radar surveys of the 118-K-2 Sludge Burial Ground and the

120-KE-3 filter water facility trench, both to help determine site locations. The survey results are summarized with the rest of the individual site data in Chapter 3.0 of this attachment. The complete surveys are reported in Bergstrom et al. (1995).

2.4 ANALOGOUS SITES

The information from the characterization and remediation of other 100 Area analogous sites can be applied toward 100-KR-2 waste sites. Table KA1-3 lists 100 Area analogous waste sites applicable to the 100-KR-2 Operable Unit. Soil-gas data collected from the 128-H-1 burn pit have been used to evaluate the 128-K-1 burn pit. Dorian and Richards' (1978) data on the 107-B Sludge Trench have been used for the 100-K-2 sludge burial trench, and their data for the 118-B-1 Burial Ground have been used for the 118-K-1 site.

Table KA1-3. 100 Area Analogous Sites Applicable to the 100-KR-2 Operable Unit

100-KR-2 Area	100-D/DR Area	100-H Area	100-B/C Area	100-F Area
118-K-1 Burial Ground	118-D-1 118-D-2 118-D-3 118-D-4A[a]	118-H-1	118-B-1 118-C-1	118-F-1 118-F-2
118-K-2 Sludge Trench	107-D #2 Sludge Trench[a]	107-H Sludge Trench	107-B Sludge Trench	None

[a]118-D-4A and 107-D #2 have been selected as waste group representatives in DOE-RL (1994c).

2.5 GROUNDWATER INVESTIGATIONS

The LFI for the 100-KR-4 Groundwater Operable Unit reported the following contaminants of potential concern (COPC) for QRA analysis: aluminum, arsenic, cadmium, chloride, chloroform, chromium, iron, lead, manganese, nickel, nitrate, silver, trichloroethane, tritium, uranium (-233/234, -238, and total), vanadium, zinc, carbon-14, strontium-90, and technetium-99.

The results of the QRA for 100-KR-4 show that for 100-K groundwater, arsenic, tritium, and carbon-14 have low carcinogenic risk under the occasional-use scenario and medium risk under the frequent-use scenario. Arsenic, chromium, and nitrate/nitrite have hazard quotients less than 1 under the occasional-use scenario but greater than 1 under the frequent-use scenario. An ecological risk (environmental hazard quotient greater than 1) was calculated for chromium, iron, lead, silver, zinc, and carbon-14 (DOE-RL 1993). Groundwater contamination concentrations downgradient of a waste site that are elevated above upgradient concentrations indicate probable effects from the waste site. However, because of the proximity of waste sites

to each other and uncertainties with groundwater flow direction and movement, it is often not possible to definitively identify which waste sites are affecting groundwater. Additional recent information on the groundwater and geology of the 100-K Area can be found in Lindberg (1995).

2.6 DATA UNCERTAINTY

Data uncertainty in the LFI/QRA is related to the data acquisition and evaluation process. The quality of data is intended as a qualitative evaluation of its dependability in making decisions on the waste sites. The ratings low, medium, and high are based on professional judgement and depend on the data origin and validation. For example, the data reported in Dorian and Richards (1978) were analyzed following routine laboratory protocols but have not been validated; therefore, the quality of the data is medium. Data from the 128-H-1 burn pit are considered of low quality for evaluation of 100-K sites because they are analogous. The contaminants and concentrations are not necessarily representative of the soil within the waste sites. The maximum detected concentrations of the COPC might be an under- or overestimate of the maximum concentration. Contaminants other than those reported may be present. Contamination identification uncertainty is considered to be high for waste sites evaluated using only historical or analogous data.

2.7 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The Washington State *Model Toxics Control Act* (MTCA) Cleanup Regulation Method B concentrations are potential ARAR for soil contamination, as discussed in the *100 Area Feasibility Study, Phases 1 and 2* (DOE-RL 1994b). The MTCA Method B limits are evaluated because they are a conservative, standardized approach for source units. Currently, MTCA has not defined specific levels for radionuclides; however, MTCA is based on waste risk of 1×10^{-5} for a residential use. Additional soil limits to be considered for radionuclides are in DOE Order 5400.5, which establishes radiation protection standards for the public and environment. For example, DOE Order 5400.5, Chapter II, Section 1a, directs that the exposure of the public to radiation sources as a consequence of all routine DOE activities shall not cause, in a year, an effective dose equivalent greater than 100 mrem from all exposure pathways, except under specified circumstances. In addition, the U.S. Environmental Protection Agency (EPA) has proposed a radionuclide cleanup standard of 15 mrem above background.

2.8 QUALITATIVE RISK ASSESSMENT APPROACH

The QRA presented available site information developed in the LFI to help evaluate IRM candidate sites. The QRA provides one piece of the total information used to determine if a site should remain on the IRM pathway. The approach to the QRA was developed from the guidance presented in Chapter 5 of the *Hanford Site Risk Assessment Methodology* (HSRAM) (DOE-RL 1995b).

The approach to the QRA included the following elements:

- Evaluate site features, including presence/absence of surrounding vegetation, site size and depth, source characteristics, and sampling and analytical data. Where appropriate, information was obtained from analogous sites.

- If sampling and analytical data were available, comparisons were made to risk-based concentrations.

- If no sampling and analytical data were available, a qualitative evaluation of the site risks was prepared.

- Uncertainties in the available information were evaluated.

- Each site was characterized with a qualitative risk ranking, either high, medium, or low risk. Each site was ranked in terms of (1) human health and ecological risks, (2) the potential for contaminant migration to groundwater, and (3) data uncertainty. The presence of "high" or "medium" data uncertainties could increase the risk ranking for a site.

2.8.1 Data Evaluation and Contaminant Identification

The LFI data were reviewed to identify radionuclides and inorganic contaminants in the soil at each site. In general, the available information consisted of sampling and analytical data from Dorian and Richards (1978), process knowledge, and analogous information. Sampling and analytical data were not available for inorganic contaminants.

2.8.2 Human Health Evaluation

The potential for human exposure or health risks associated with contaminants at 100-KR-2 sites is low, under current site conditions. The sites are covered with gravel or cobbles and access by the general public is restricted. However, for purposes of developing qualitative risk rankings, a hypothetical exposure scenario was developed that assumed future residential use of the sites. This scenario is applicable only for developing risk rankings within this QRA. The exposure pathways considered in this exposure scenario were developed in cooperation with the 100 Area Tri-Party Agreement unit managers (DOE-RL 1995b). These exposure pathways were soil ingestion, inhalation of fugitive dust, and external exposure to radiation. The exposure scenario assumed that humans could potentially become exposed through these pathways to contaminants detected within the top 4.5 m (15 ft) of soil at a site. Pathways of exposure were assumed to not be complete to contaminants detected deeper than 4.5 m (15 ft) in soil.

Neither ingestion of groundwater nor agricultural crops potentially grown on the sites in the future were included in the human health evaluation. However, risks to groundwater have been addressed in terms of the potential for contaminant migration to groundwater, as discussed below.

The human exposure scenario was used to develop risk-based concentrations in soil. The risk-based concentrations for radionuclides were based on an increased cancer risk of 10^{-6} and were developed using assumptions presented in HSRAM (DOE-RL 1995b, Appendix A). These concentrations were compared with Hanford Site background and analytical quantitation limits. Background or quantitation limits were used for comparison with contaminant concentrations in cases where the risk-based concentrations were below background or quantitation limits. These concentrations are presented in Table KA1-4. Calculations and assumptions used to develop the risk-based concentrations are presented in Appendix K, Attachment 2, Part 1.

2.8.3 Ecological Evaluation

The ecological evaluation is based on a simplified conceptual model described in HSRAM (DOE-RL 1995b). This conceptual model is based on the Great Basin pocket mouse as a receptor for exposure to contaminant concentrations in soil and operates on a waste site-by-waste site basis, assuming that each waste site approximates the size of the pocket mouse home range. Potential pathways of exposure are ingestion of contaminants accumulated into vegetation from soil and external whole-body doses.

Table KA1-4. Risk-Based Concentrations in Soil.

Radionuclides (pCi/g)	TR = 1E-06 (Radionuclides)[a]	Groundwater Protection[b]	Background[c]	CRQL/CRDL[d]	Risk-Based Concentrations[e]	
					<=15 feet in Soil[f]	>15 feet in Soil[g]
Am-241	1.1	20	N/C	1	1.1	20
C-14	77	13	N/C	50	50.0	50
Cs-134	1.9	338	N/C	0.1	1.9	338
Cs-137	0.03	507	1.8	0.1	1.8	507
Co-60	0.04	844	N/C	0.05	0.1	844
Eu-152	0.02	13,510	N/C	0.1	0.1	13,510
Eu-154	0.03	13,510	N/C	0.1	0.1	13,510
Eu-155	7.0	67,551	N/C	0.1	7.0	67,551
H-3	27,158	358	N/C	400	400	400
K-40	0.1	95	19.7	4	19.7	95
Na-22	0.4	135	N/C	4	4.0	135
Ni-63	1,545	30,398	N/C	30	1,545	30,398
Pu-238	1.7	27	N/C	1	1.7	27
Pu-239/Pu-240	1.4	20	0.035	1	1.4	20
Ra-226	0.006	34	0.98	0.1	1.0	34
Sr-90	20	84	0.36	1	20	84
Tc-99	536	18	N/C	15	18	18
Th-228	2.8	270	N/C	1	2.8	270
Th-232	3.9	34	N/C	1	3.9	34
U-233/U-234	4.7	3	1.1	1	3.4	3
U-235	0.2	4	N/C	1	1	4
U-238	0.7	4	1.04	1	1	4

CRQL/CRDL = Contract Required Quantitation Limit/Contract Required Detection Limit
TR = Target Risk
[a]Release date for radionuclide remediation goals - 2018 from a start date of 1994 (24 years)
[b]Calculated from Maximum Contaminant Levels (MCLs) or 1/25th Derived Concentration Guides (DCG) using the Summers Model
[c]Radionuclide bacckground from Hanford Site Background: Evaluation of Existing Soil Radionuclide Data (DOE/RL-95-55), June 1995
[d]CRQL/CRDL values obtained from Quality Assurance Project Plan (QAPP) for 100-BC-5 Operable Unit Work Plan.
[e]Target volumes in soil contain concentrations exceeding values in these columns.
[f]Risk-based concentrationsn for protection of human health and the environment (including groundwater).
[g]Risk-based concentrations for protection of groundwater.

KR2_RBC.XLS

Risk-based concentrations for radionuclides were not calculated for environmental receptors. National and international radiation protection advisory committees have concluded that levels protecting human health should be sufficient to protect the environment as well. The National Academy of Science (as cited in EPA 1993), for example, states:

> "The principal potential impact of radioactive effluents on the biosphere is the induction of deleterious health effects in [people]. Comparable levels of impact undoubtedly exist in other biota, but there is no present evidence that there is any biological species whose sensitivity is sufficiently high to warrant a greater level of protection than that adequate for [people]."

Based on these findings, EPA has concluded that there may be a technical basis for focusing on human health risks in the development and implementation of the radiation site cleanup regulations (EPA 1993). In terms of the QRA, this means that a qualitative risk ranking based on human health risk considerations is not likely to understate ecological risks for radionuclides in soil. However, for nonradioactive contaminants, there may be instances where adverse environmental effects may occur at or below levels that are protective of public health (EPA 1993). The lack of sampling and analytical data for nonradioactive contaminants represents an uncertainty in the evaluation of ecological risks potentially associated with these sites.

2.8.4 Groundwater Evaluation

Contaminants in soil deeper than 4.5 m (15 ft) are not likely to be associated with direct potential exposures or health risks to humans or ecological receptors. However, these contaminants could potentially migrate to groundwater. A conceptual model has been developed for the QRA in which the potential for contaminant migration to groundwater is associated with the migration of moisture through the vadose zone to groundwater and the retardation of contaminants in soil. Retardation in soil is related to the soil-water distribution coefficient (K_d) for each contaminant. Concentrations in soil corresponding to radionuclide groundwater protection criteria were calculated using the Summers model (DOE-RL 1995b). The radionuclide groundwater protection criteria of 4 mrem/yr (this corresponds to the federal maximum contaminate level) was converted to concentration in picocuries per liter by multiplying derived concentration guides (DCGs) (DOE Order 5400.5) by a factor of 0.04, or 1/25th (DCGs correspond to a dose rate of 100 mrem/yr). Assumptions and calculations used in the Summers model to calculate concentrations in soil corresponding to 1/25th of the DCG are presented in Appendix K, Attachment 2, Part 1. The concentrations in soil protective of groundwater are presented in Table KA1-4.

3.0 SITE EVALUATIONS

3.1 IRM CANDIDATES

3.1.1 116-KE-1 Condensate Crib

3.1.1.1 Background. The 116-KE-1 (115-KE) Condensate Crib is an inactive low-level liquid waste site that received 800,000 liters (211,200 gallons) of condensate and other waste from reactor gas purification systems. It operated from 1955 to 1971. The site is about 12.2 m (40 ft) north of the 115-KE Building at coordinates NK4525.00 KE4376.50 (100-K coordinate system). The 7.9 m (26-ft) deep crib is about 1.8 m (6 ft) diameter at the bottom, with the inlet pipe at a depth of about 17 ft and 15 ft of backfill to a 12.2-m (40-ft) diameter top (Figure KA1-2). Currently, the crib lies under gravel and asphalt east of the 105-KE Reactor.

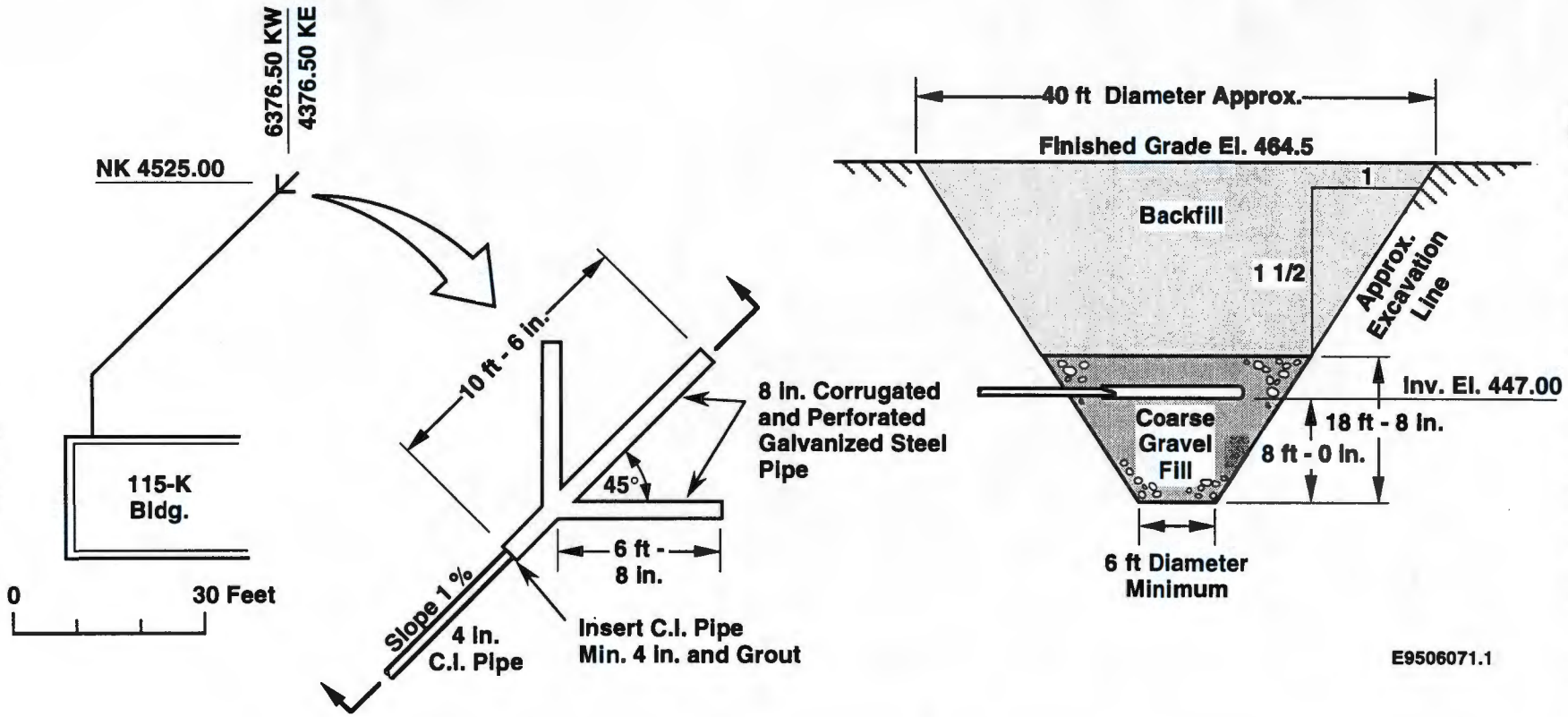
Dorian and Richards (1978) drilled a sample hole into the crib and estimated a radioactive inventory of less than 240 Ci, with only tritium concentrations provided, at 4,700 pCi/g (2,133 pCi/g decayed to 1992). Stenner et al. (1988) reported that 800,000 liters (211,200 gallons) of condensate and other liquid waste were disposed, with the following inventory:

Radionuclide	Total Curies decayed to		
	1986	1992	2018
Carbon-14	110	110	110
Tritium	56.5	40	9.3
Beta	0.974	Not available	Not available

3.1.1.2 Qualitative Risk Assessment. Limited data are available for performing a qualitative assessment of health risks potentially associated with this site. Nonradioactive contaminants have not been characterized in soil at this site. There is limited information on the depth of contamination in soil, although tritium is reportedly detected at 9.2 m (30 ft) below grade. The potential for exposure to humans or ecological receptors from contaminants in soil is not certain. There is no habitat or vegetation near the site that would support commonly considered ecological receptors (such as the Great Basin pocket mouse), reducing the potential for ecological risks associated with this site.

Tritium and carbon-14 have soil-water K_d values of zero and are not retarded in soil (these contaminants will migrate along with water in the vadose zone). Thus, compared with other radionuclides detected in soil, tritium and carbon-14 are mobile in soil. However, while natural recharge rates to groundwater are small at the Hanford Site, the potential for migration of these contaminants to groundwater under existing conditions is uncertain.

9513360.1805



Plan at El. 447.0 of 115 Building Drier Condensate Disposal System
Reference Drawing H-1-23207

Figure KA1-2. 116-KE-1 and 116-KW-1 Condensate Cribs.

The decayed tritium concentration in soil (2,133 pCi/g) is well below the human health preliminary remediation goal of 35,928 pCi/g and below the concentration corresponding to 0.04 of the DCG in groundwater (2,655 pCi/g). Contaminant concentration data are not available for carbon-14; carbon-14 is associated with a relatively higher cancer risk than tritium, has a lower DCG, and forms a larger part of the radionuclide inventory at this site. An analogous site is the 116-KW-1 Condensate Crib (see Section 3.1.4).

The data uncertainty is judged to be medium, since the assessment is based on Dorian and Richards (1978) data and the analogous 116-KW-1 Condensate Crib. The potential human health or ecological risk is judged to be low; the potential for contaminant migration to groundwater is judged to be high. Overall, the site risk associated with the 116-KE-1 Condensate Crib is judged to be medium.

3.1.2 116-KE-2 Crib

3.1.2.1 Background. The 116-KE-2 (1706-KER) Crib is an inactive liquid waste site about 54.9 m (180 ft) west of the 1706-KE Building at 100-K coordinates NK4405 WK5055. It operated from 1955 to 1971. About 3M liters (792,000 gallons) of liquid wastes from test loops and cleanup columns in the 1706-KER loop went to the crib; it was also designed to receive contaminated cooling water from fuel ruptures at the KE reactor, on an emergency basis.

Carpenter and Cote (1994) report this wooden crib to be 4.9 by 4.9 by 9.8 m (16 by 16 by 32 ft) deep, resting about 1 m (3 ft) above the excavation bottom. A 10.1-cm (4-in.) thick concrete slab covers the crib. Several pipes extend above grade level. Dorian and Richards (1978) report a contaminated volume of 1.3×10^5 ft^3, with a mass of 8.8×10^9 g. The crib is under a gravel lot, free of vegetation. A distribution pipe enters the crib at 7 m (23 ft) below grade.

The radionuclide inventory is mostly from depleted ion exchange resins. Dorian and Richards (1978) report a Geiger-Mueller reading of 15,000 c/m in a sample from 12.8 m (42 ft) below grade, but a reading of 500 c/m in the sample from 14.6 m (47.5 ft) below grade. Their results, decayed to 1992 and 2018, are presented in Table KA1-5. Most of the radionuclide inventory is from cobalt-60 (5.2 curies were left in 1992). The hazardous chemicals disposed to the crib include 100,000 kg (220,500 lb) of sodium hydroxide, which becomes sodium carbonate with contact to moisture, and 100,000 kg (220,500 lb) of sulfuric acid, which also becomes neutralized in the environment. These two chemicals combine in the environment to form sodium sulfate.

Table KA1-5. Radionuclide Inventory in the 116-KE-2 Crib
(data from Dorian and Richards 1978)

Radionuclide	Average pCi/g decayed to		
	1978	1992	2018
Carbon-14	14	14	14
Cesium-137	91	66	36
Cobalt-60	3,800	603	19.7
Europium-152	0.45	0.22	0.07
Europium-154	38	12.6	1.6
Europium-155	5.4	0.76	0.02
Plutonium-239/240	2.1	2.1	2.1
Strontium-90	290	207	104.8
Tritium	77	35	8
Uranium	0.24	0.24	0.24
Radionuclide	**Maximum pCi/g decayed to**		
	1978	**1992**	**2018**
Carbon-14	14	14	14
Cesium-137	220	159	88
Cobalt-60	9,700	1,539	50
Europium-152	1.1	0.54	0.14
Europium-154	92	31	4
Europium-155	13	1.8	0.05
Plutonium-239/240	6.1	6.1	6.1
Strontium-90	690	491	262
Tritium	150	68	15.7
Uranium	0.24	0.24	0.24
Radionuclide	**Total Curies**		
	1978	**1992**	**2018**
Carbon-14	0.12	0.12	0.12
Cesium-137	0.8	0.6	0.3
Cobalt-60	33	5.2	0.17
Europium-152	0.004	0.002	0.0005
Europium-154	0.33	0.11	0.01
Europium-155	0.048	0.007	0.0002
Plutonium-239/240	0.019	0.019	0.019
Strontium-90	2.6	1.85	0.98
Tritium	0.68	0.31	0.71
Uranium	0.0021	0.0021	0.0021

3.1.2.2 Qualitative Risk Assessment. Radionuclides have been detected in soil at depths ranging from 12.2 to 14.5 m (40 to 47.5 ft) below grade at this site. Based on the available information, it is possible that the site is overlain with clean fill, although this represents a data uncertainty because shallow soil samples have not been collected from this site. Considering these uncertainties, significant potential for exposures to humans or ecological receptors from contaminants in soil at this site is unlikely. There is no habitat or vegetation near the site that would support commonly considered ecological receptors (such as the Great Basin pocket mouse), which further reduces the potential for ecological risks associated with this site. The contaminants detected in soil (except for tritium and carbon-14) are retarded in soil to various degrees. The reported concentrations in soil, decayed to 1992, are less than the concentrations corresponding to 0.04 of the DCG in groundwater except for Co-60 and Sr-90 (Table KA1-6).

Table KA1-6. Contaminants in 116-KE-2 Crib Compared to Groundwater Protection Levels

Radionuclide	Maximum Concentration in Soil (pCi/g)	Groundwater Protection Level in Soil (pCi/g)
Carbon-14	14	50
Cesium-137	159	507
Cobalt-60	1,539	844
Europium-152	0.54	13,510
Europium-154	31	13,510
Europium-155	1.8	67,511
Tritium	68	400
Plutonium-239/240	6.1	20
Strontium-90	491	84
Uranium	0.24	3

An analogous site with numerical QRA results is not available for this site. The data uncertainty is judged to be medium, since this assessment is based on Dorian and Richards (1978) data. The potential human health or ecological risk is judged to be low, and the potential for contaminant migration to groundwater is judged to be medium, because the large quantities of liquids that may have driven contaminants deeper than those detected. Overall, the site risk associated with the 116-KE-2 crib is judged to be low.

3.1.3 116-KE-3 French Drain

3.1.3.1 Background. The 116-KE-3 (105-KE Storage Basin French Drain, 105-KE Reverse Well) French drain, an inactive low-level liquid waste site, was an overflow weir for subdrainage

from the 105-KE storage basin. It is about 22.8 m (75 ft) north of the 105-KE Reactor at 100-K coordinates NK4691 WK4756. Carpenter and Cote (1994) describe the site as a drain field with an 20.3-cm (8-in.) steel well casing extending downward to 3 m (10 ft) below the mean water table. The bottom 6.1 m (20 ft) of the well casing is perforated and embedded in gravel at a depth of 8.8 m (29 ft). A 10.1-cm (4-in.) steel test hole pipe formerly extended from the surface to the drain field, but is no longer visible on the surface. Carpenter and Cote (1994) report the dimensions of the site to be 6.1 m (20 ft) in diameter by 23.8 m (78 ft) deep, with a mound installed over the site in 1977 and 1978. The site is graveled, free of vegetation, and posted with "Underground Radioactive Material" signs.

Recent groundwater well drilling adjacent to the site included a gamma log of the borehole, every 0.15 m (0.5 ft) from ground level to 27.5 m (90 ft). Cesium-137 decay activity was observed at 7.6 to 9.5 m (25 to 31 ft), with a maximum activity estimated at less than 20 pCi/g. No other manmade radionuclides were detected (Williams 1994). Because the well was drilled near (not on) the site and was intended to sample groundwater rather than characterize the vadose zone, the results may not be representative of actual contamination at the site. No analogous sites exist.

3.1.3.2 Qualitative Risk Assessment. No data on radionuclide concentrations in soil have been reported for the 116-KE-3 site. The concentration of cesium-137 reported in soil from a nearby boring could indicate a plume of contamination in soil at this site. This concentration is at a depth where there is not likely to be exposure to humans or ecological receptors (>4.5 m [15 ft]). The estimated concentration of cesium-137 is less than the cesium-137 concentration in soil corresponding to groundwater protection standards. However, there could be higher concentrations of contaminants within the site. The potential for human health and ecological risks and the potential for contaminant migration to groundwater are judged to be low, but uncertainties in the data are judged to be high. Considering the data uncertainty associated with this site, the overall site risk is judged to be medium.

3.1.4 116-KW-1 Condensate Crib

3.1.4.1 Background. The 116-KW-1 (115-KW) Condensate Crib is an inactive low-level liquid waste site that received 800,000 liters (211,200 gallons) of condensate and other waste from reactor gas purification systems. The site is about 21.3 m (70 ft) north of the 115-KW Building at coordinates NK4525.00 WK6376.5. The 7.9-m (26-ft) deep crib is about 1.8 m (6 ft) in diameter at the bottom, with the inlet pipe at a depth of about 17 ft and 15 ft of backfill to a 12.2-m (40-ft) diameter top (see Figure KA1-2). The crib lies under gravel and asphalt outside the 105-KW Reactor.

Stenner et al. (1988) reported that 800,000 liters (211,200 gallons) of condensate and other liquid waste were disposed to the crib. Dorian and Richards (1978) drilled a sample hole into the crib and estimated a radioactive inventory of 240 Ci. Table KA1-7 shows the reported radionuclides, with total curies, average and maximum concentrations for 1978, 1992, and 2018.

Table KA1-7. Radionuclides in the 116-KW-1 Condensate Crib

Radionuclide	Total Curies		
	1978	1992	2018
Carbon-14	110	110	110
Cesium-134	6.5 E-4	5.9 E-5	0.0
Cesium-137	4.4 E-3	3.2 E-3	1.8 E-3
Cobalt-60	3.0 E-3	4.8 E-4	1.6 E-5
Europium-154	1.6 E-4	5.3 E-5	6.8 E-6
Europium-155	3.0 E-3	4.2 E-4	1.1 E-5
Strontium-90	7.6 E-3	5.4 E-3	1.0 E-3
Tritium	130	59	13.6
Uranium-238	1.1 E-4	1.1 E-4	1.1 E-4
Radionuclide	**Average Concentration (pCi/g)**		
	1978	**1992**	**2018**
Carbon-14	2.1 E+5	2.1 E+5	2.1 E+5
Cesium-134	1.2	1.0 E-2	0.0
Cesium-137	8.1	5.9	3.2
Cobalt-60	5.6	0.9	0.03
Europium-154	0.29	0.1	0.01
Europium-155	5.5	0.8	0.02
Strontium-90	14	10	5.3
Tritium	2.4 E+5	1.1 E+5	2.5 E+4
Uranium-238	0.21	0.21	0.21
Radionuclide	**Maximum Concentration (pCi/g)**		
	1978	**1992**	**2018**
Carbon-14	3.9 E+5	3.9 E+5	3.9 E+5
Cesium-134	2.4	2.2 E-2	3.5 E-6
Cesium-137	9.8	7.1	3.9
Cobalt-60	7.9	1.3	0.04
Europium-154	0.33	0.1	0.01
Europium-155	11	1.6	0.04
Strontium-90	27	19.3	10
Tritium	4.7 E+5	2.1 E+5	4.9 E+4
Uranium-238	0.31	0.31	0.31

3.1.4.1 Qualitative Risk Assessment. Sampling and analytical data reported by Dorian and Richards (1978) indicate that radionuclides are detected between 7.6 and 8.3 m (25 and 27.5 ft) below grade at this site. The site is currently partially paved with asphalt, and contaminants have not been reported within the top 4.5 m (15 ft) of soil. Therefore, it is unlikely that there would be exposures to humans or ecological receptors at this site. The maximum concentrations detected in deep soil (decayed to 1992) are compared to the concentrations in soil corresponding to groundwater protection standards, as shown in Table KA1-8.

Table KA1-8. Soil Concentrations Compared to Groundwater Protection Standards in the 116-KW-1 Condensate Crib

Radionuclide	Concentration in Soil (pCi/g)	Concentration in Soil Corresponding to Groundwater Protection Standard (pCi/g)
Carbon-14	390,000	50
Cesium-134	0.02	338
Cesium-137	7.1	507
Cobalt-60	1.3	844
Europium-154	0.1	13,510
Europium-155	1.6	67,551
Tritium	210,000	400
Strontium-90	19.3	84
Uranium	0.31	4

The risks to human health and ecological receptors is judged to be low. Based on the above comparison, the potential for contaminant migration to groundwater is judged to be high. The data uncertainty is judged to be medium. The overall site risk is judged to be medium.

3.1.5 116-KW-2 French Drain

3.1.5.1 Background. The 116-KW-2 Storage Basin French drain, also known as the 105-KW Basin Reverse Well, is located about 22.8 m (75 ft) north of the KW Reactor, It was used as an overflow weir for subdrainage from the fuels storage basin. The drain is an 20.3-cm (8-in.) well casing that extends to 3 m (10 ft) below the mean water table, with the bottom 6.1 m (20 ft) of the casing being perforated. A drain field is 8.8 m (29 ft) below grade. In the 1950s, a concrete sump 2.3 by 1.4 by 3.6 m (7.5 by 4.6 by 12 ft) deep allowed the drainage to be routed to the French drain, the process sewer, a 76,000 liters (20,000-gal) tank, or the 116-KW-1 Condensate Crib. The site appears as a gravel, vegetation-free area and mound with assorted pipes, valves, and vents extending above the surface.

Stenner et al. (1988) report that the radionuclide and hazardous waste inventory is unknown. Recent drilling (Williams 1994) for the 199-K-107A well, adjacent to the 116-KW-2 drain, included gamma-ray logging. The survey report identifies cesium-137 at the 3.8-m (12.5-ft) level, at an activity of less than 2 pCi/g; cobalt-60 at 14.1 m (46.5 ft), at an activity of less than 1 pCi/g; europium-152 from 14 to 14.5 m (46 to 47.5 ft) at an activity of less than 2 pCi/g; and europium-154 at the 14.1-m (46.5-ft) level, at an activity of less than 1 pCi/g. Because the well was drilled near (not on) the site and was intended to sample groundwater rather than characterize the vadose zone, the results are not representative of actual contamination at the site.

3.1.5.2 Qualitative Risk Assessment. Sampling and analysis data have not been reported for this site. The site is free of vegetation and covered with cobbles. Samples from a nearby boring for a monitoring well detected 2 pCi/g of cesium-137 at a depth of 3.8 m (12.5 ft) (compared with the risk-based concentration of 0.03 pCi/g). Concentrations of cobalt-60, europium-152, and europium-154 detected at 14 to 14.3 m (46 to 47.5 ft) below grade are well below their respective concentrations corresponding to groundwater protection standards. Risks to human health and ecological receptors and the potential for contaminant migration to groundwater are judged to be low. The data uncertainty is judged to be high, and the overall site risk is judged to be medium.

3.1.6 118-K-2 Sludge Trench

3.1.6.1 Background. A burial ground for radioactive sludge from the 116-KE-4 retention basins has been reported to be in several locations east of the basins. Recent interviews with former employees also indicate that the sludge may have been barreled and disposed of in the 200 Areas (Appendix K, Attachment 2, Part 3). In addition, Dorian and Richards (1978) report that no sludge trenches are documented for the 107-C, 107-F, 107-KE, and 107-KW retention basins.

However, assuming that the site exists, geophysical investigations (Bergstrom et al. 1995) have established a possible location for the site as shown in Figure KA1-3 (areas surveyed) and Figure KA1-4 (survey results). The approximate size of the trench, estimated from the geophysical report, is 18.3 by 53.3 by 4.5 m (60 ft by 175 ft by 15 ft) deep, with an average 1.2 m (4 ft) of fill covering it (the approximate depth given is likely based on other sludge burial grounds, but there are no data indicating depth). While the geophysical survey stopped at the perimeter fence, it is unlikely that sludge would continue under the road and fence, because the removal of established roadways to dispose of sludge was not practiced at any other reaction site at Hanford. The ground-penetrating radar survey results may be indicative of an irrigation canal that once ran through the site, rather than a burial trench (Appendix K, Attachment 2, Part 2).

The surface over the possible trench is gravel and vegetation free. This site has been assigned a moderately high cultural sensitivity.

Figure KA1-3. Areas Surveyed with Ground Penetrating Radar at the 118-K-2 and 120-KE-3 Sites

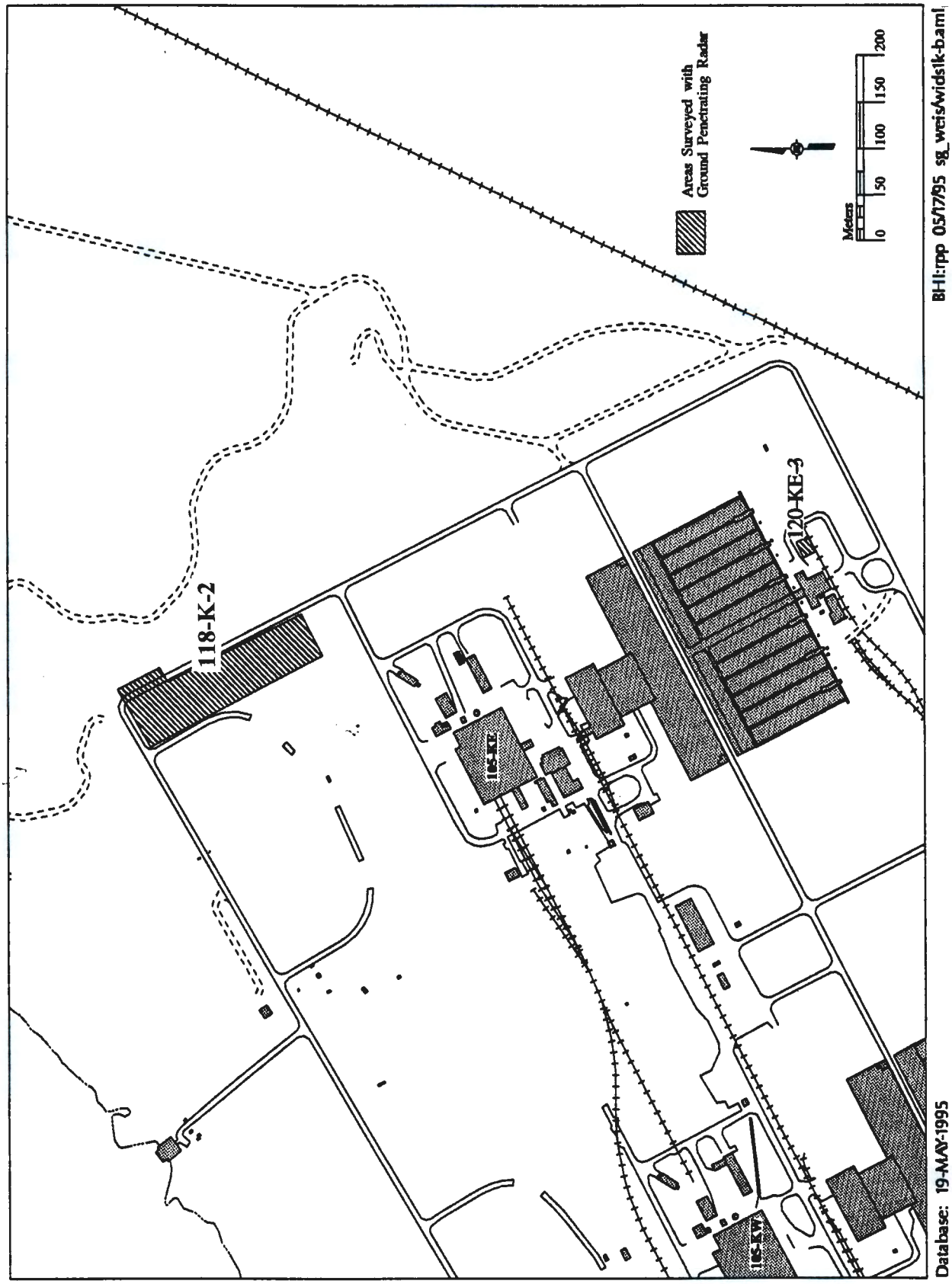
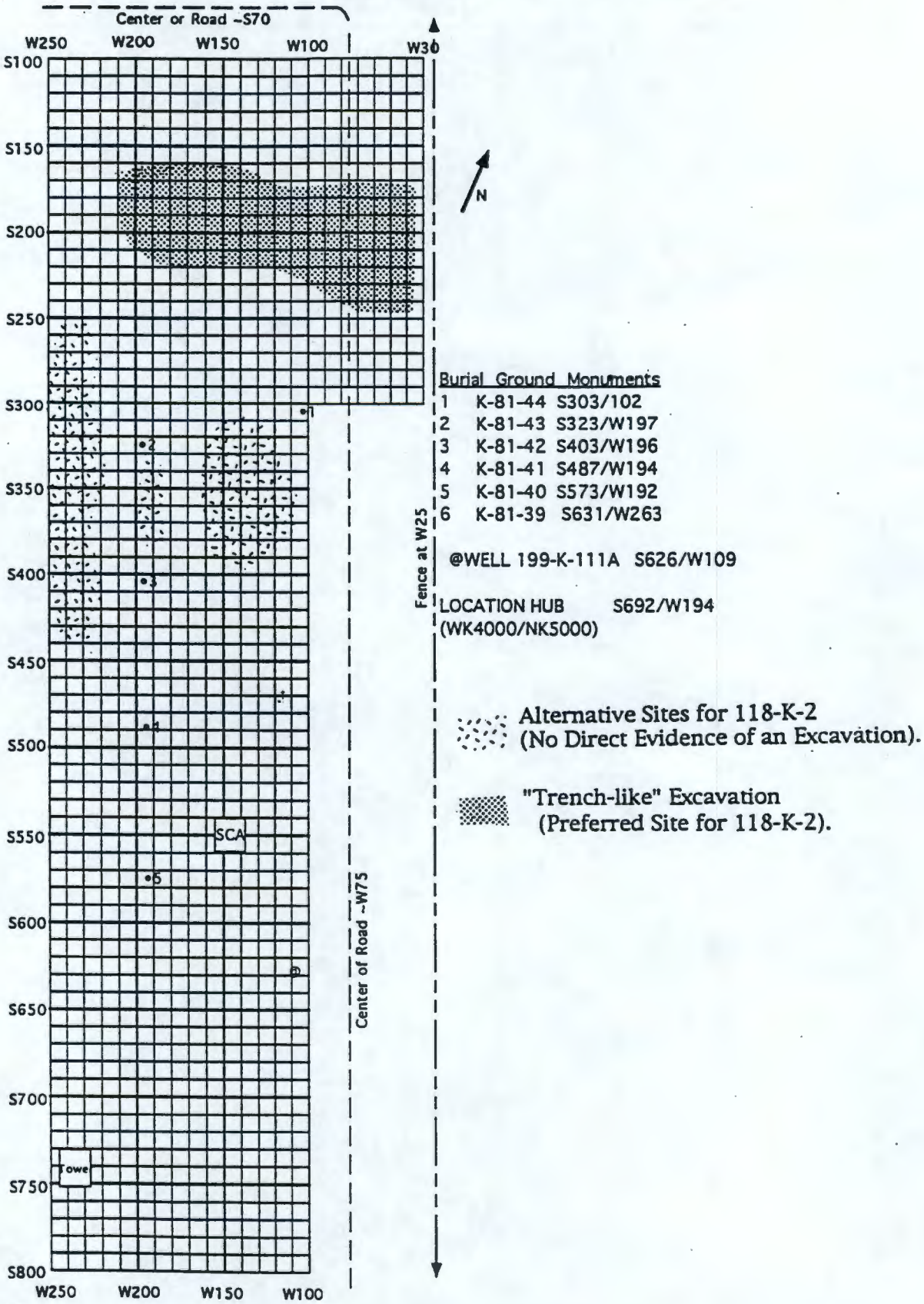


Figure KA1-4. Summary Interpretation of 118-K-2 Investigations



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The radionuclide inventory for the 118-K-2 Sludge Trench is unknown. However, an analogous sludge trench, for 107-B retention basin sludge, contained 0.8 Ci in 1978, including a maximum plutonium-239/240 concentration of 2.2 pCi/g (average 0.7 pCi/g), with 680 pCi/g maximum and 240 pCi/g average beta-gamma concentrations (Dorian and Richards 1978). The radionuclides expected to contribute to this are predominately europium-152, europium-154, europium-155, cobalt-60, cesium-137, strontium-90, and nickel-63 (Dorian and Richards 1978).

3.1.6.2 Qualitative Risk Assessment. Contaminants in this trench have a higher likelihood of coming into contact with humans or ecological receptors compared with liquid waste disposal sites. However, past flooding of this area increases the likelihood of migration to groundwater compared to other sludge burial trenches. The reported maximum concentration of plutonium-239/240 (2.2 pCi/g) in the analogous 107-B Area sludge trench slightly exceeds the risk-based concentration of 1.4 pCi/g. The human health and ecological risks associated with this site are judged to be low, while data uncertainty and potential for contaminant migration to groundwater are judged to be medium. The overall site risk is judged to be low, evaluating both risks and the uncertainty of the site's existence.

3.1.7 French Drain South of 119-KW Building

3.1.7.1 Background. This French drain is about 9.1 m (33 ft) east of the 105-KW Reactor building, between the exhaust stack and the 119-KW exhaust air sample building at K-Area coordinates NK 4522 WK6484 Hanford Site drawing (H-1-19808) . The 0.3-m (1-ft) diameter drain received effluent from the 119-KW floor drain, evaporative cooling system, and heat exchange in detection equipment. As such, the total quantity of fluids drained and the amount of contaminants are expected to be low. The contamination should be a depth of less than 3 m (10 ft) in the soil. "Surface Contamination" and "Confined Space" warning signs are posted on the metal cover, but there is no information on the radionuclide inventory. The ground surface is gravel and clear of vegetation.

3.1.7.2 Qualitative Risk Assessment. Based on information for other drains and cribs, contaminants that may be at this site would be at depths >4.5 m (15 ft) in soil, where exposures to humans or ecological receptors would be unlikely. Risk to humans or ecological receptors is judged to be low. The potential for contaminant migration to groundwater is judged to be low or medium; however, data uncertainty is judged to be high. The overall site risk is judged to be medium.

3.1.8 118-K-1 Burial Ground

3.1.8.1 Background. This solid waste burial ground, which operated from 1953 to 1973, received radioactive solid waste from the K and N Reactors. The site is 366 m (1,200 ft) long, 183 m (600 ft) wide, and up to 7.6 m (25 ft) deep (approximate volume of 407,762 m^3); with an estimated 10,000 m^3 (353,150 ft^3) of solid waste. It is located east of the K Area perimeter fence, with corner coordinates of N77375 W66991, N77375 W67286, N77330 W67183, and N77323 W66955. The surface is gravel and free of vegetation. A moderately high cultural sensitivity has been assigned to this site.

The burial ground was constructed with numerous trenches and pits of various sizes to accommodate material being disposed. Six vertical silos, 3 m (10 ft) in diameter and 7.6 m (25 ft) deep, were used to hold small reactor hardware that had high dose rates. Figure KA1-5 shows the approximate as-built locations of the trenches within the burial ground. The 118-K-1 Burial Ground also contained a waste incinerator that was built in 1968 over an ash pit in the burial ground. It was dismantled and buried in 1971 (Dorian and Richards 1978).
The following are metallic wastes reported to be in the 118-K-1 Burial Ground by Stenner et al. (1988):

Material	kg
Aluminum tubes	46,266
Aluminum spacers	145,149
Lead-cadmium slugs	
Lead	41,235
Cadmium	17,145
Graphite	146
Desiccant	33
Aluminum slugs	9,616
Boron poison splines	1,360
Lead	41,730
Miscellaneous	2,267

Dorian and Richards reported 14,000 Ci of radionuclides with >1 yr half-life through 1971. Almost all of this inventory is cobalt-60 (with a 5.3-yr half-life) contained in the solid metal reactor pieces. Stenner et al. (1988) reported the radionuclide inventory shown in Table KA1-9, decayed to 1995 and 2018.

Table KA1-9. Total Curies Reported to be in the 118-K-1 Burial Ground

Radionuclide	Total Curies		
	1986	1992	2018
Antimony-125	25	5.6	8.3 E-3
Carbon-14	1.56	1.56	1.56
Cesium-137	7.6	6.6	3.6
Cobalt-60	2,289	1,040	34
Europium-152	47.2	34.8	9.2
Europium-154	84.6	52.7	6.8
Nickel-63	376	361	301
Plutonium-239	0.216	0.216	0.216
Plutonium-240	0.0138	0.0138	0.0138
Strontium-90	7.6	6.6	3.5
Tritium	7	5	1.1

Figure KA1-5. Schematic of Trenches in the 118-K-1 Burial Ground

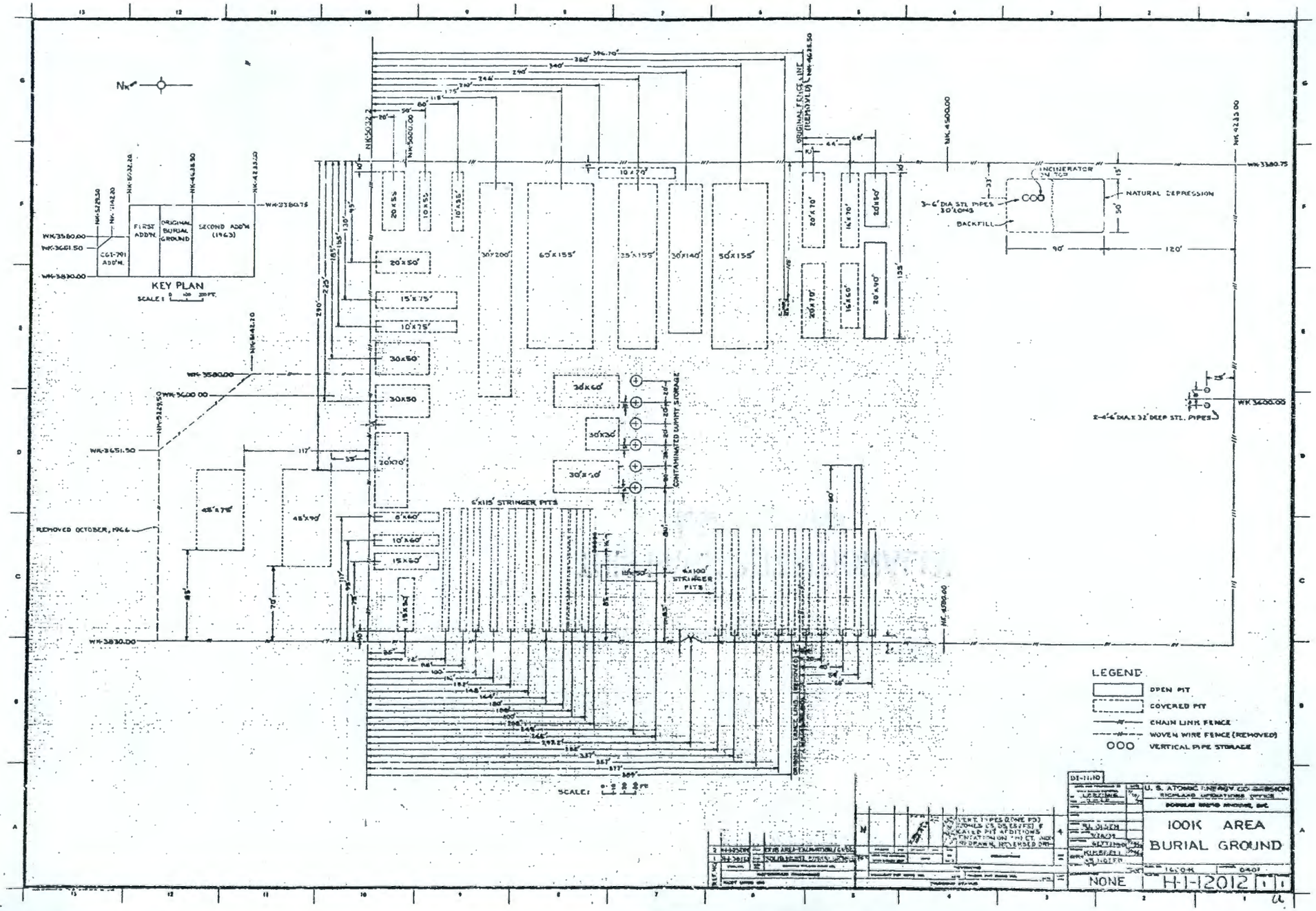

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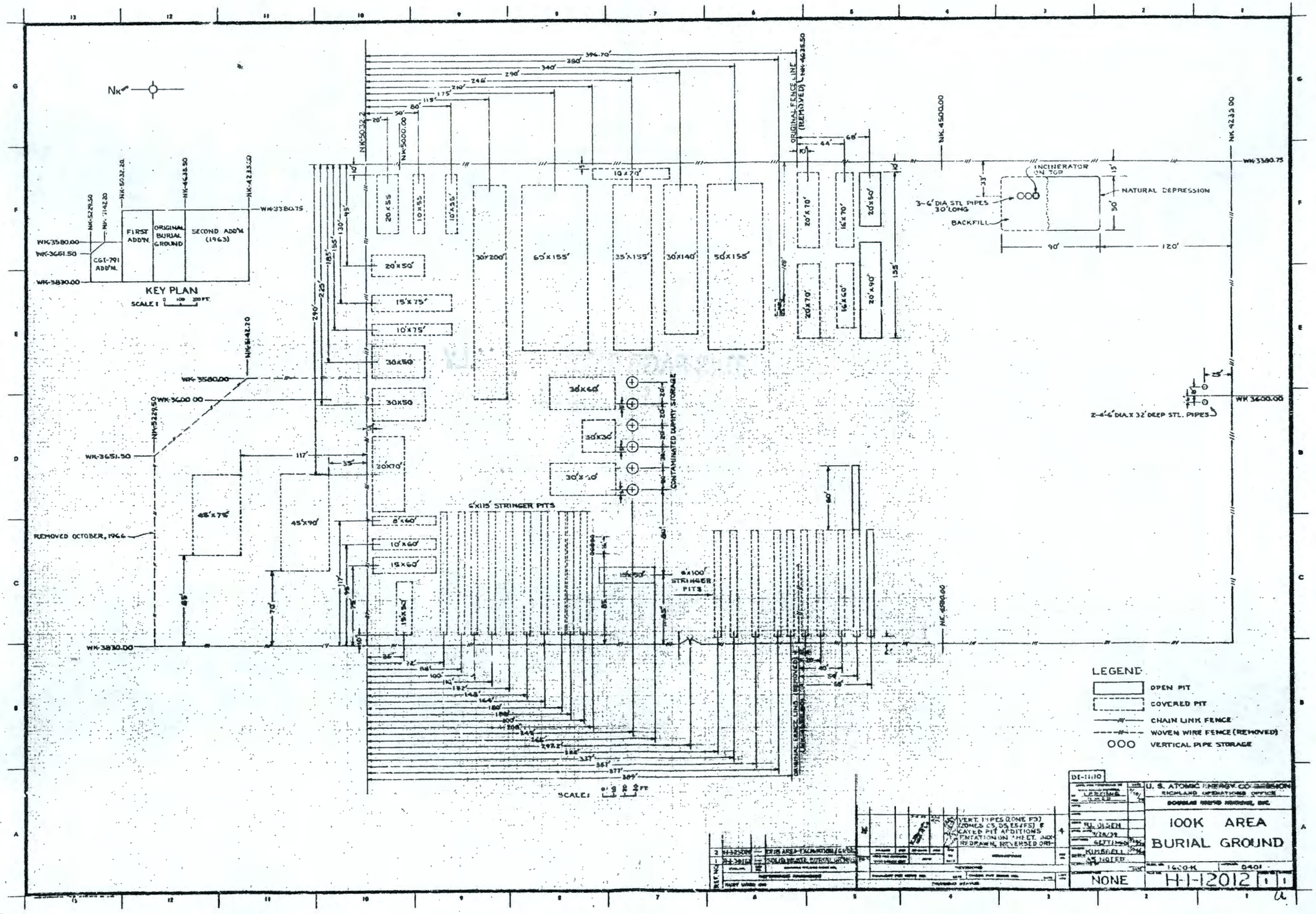
Figure KA1-5. Schematic of Trenches in the 118-K-1 Burial Ground



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The excavation treatability test report (DOE-RL 1995a) for the 118-B-1 solid waste burial ground can be used analogously for insight into the 118-K-1 Burial Ground (Appendix K, Attachment 2, Part 1).

3.1.8.2 Qualitative Risk Assessment. The site is considered analogous to the 118-B-1 burial ground, for which there are historical sampling and analytical data (Dorian and Richards 1978). Contaminants of potential concern at the 118-B-1 site include Eu-152, Co-60, Eu-154. and Cs-137. The highest concentrations of these contaminants occur in 118-B-1 at depths ranging from 6.1 to 9.1 m (20 to 30 ft) below grade. The highest concentrations of these contaminants, decayed from 1978 to 1992 and to 2018, are summarized below:

Summary of Highest Concentrations of Contaminants of Potential Concern in 118-B-1 (Analogous Site to 118-K-1)

Radionuclide	Maximum Concentration in Soil (pCi/g)		
	1978	Decayed to 1992	Decayed to 2018
Eu-152	4,500	2,205	586
Co-60	170,000	26,971	883
Eu-154	2,700	896	116
Cs-137	2,700	1,957	1,077

These concentrations exceed the risk-based concentrations for human health, but are less than the concentrations corresponding to groundwater protection criteria except for Co-60 and Cs-137, as shown below:

Radionuclide	Concentration in Soil (pCi/g)		Risk-based Concentrations in Soil (pCi/g)	
	1992	2018	Human Health	Groundwater Criteria
Eu-152	2,205	586	0.1	13,510
Co-60	26,971	883	0.1	844
Eu-154	896	116	0.1	13,510
Cs-137	1,957	1,077	0.1	507

Radiation screening of buried objects excavated during the 118-B-1 excavation treatability study reported dose rates ranging from 0.3 to 30 mR/hr, with one reading of 2,000 mR/hr.

It is not certain as to what is the potential for exposure to humans or ecological receptors from contaminants in soil. There is no habitat or vegetation near the site for supporting commonly considered ecological receptors (such as the Great Basin pocket mouse), reducing the potential for ecological risks associated with this site. Under current conditions, potential risks to human health are low, since radionuclides in the site are underneath fill and cobbles. However, should the cover on this site be disturbed, human health risks could be high. A stated goal for 100 Area IRMs is that they do not restrict future uses of the sites; consistent with this goal, it should be assumed that the contaminants in this site could be disturbed in the future. Therefore, human health risks potentially associated with this site are judged to be high. The potential for contaminant migration to groundwater is judged to be low. The contaminants detected at this site are not considered to have significant mobility in soil under ambient groundwater recharge conditions.

Data uncertainty is judged to be high. There are no sampling and analytical data for this site, though data for an analogous site are available. Uncertainty in the historical data for the analogous site is judged to be high. The overall risk for this site is judged to be high.

3.1.9 120-KE-2 French Drain

3.1.9.1 Background. The 120-KE-2 French drain is a nonradioactive liquid waste site that operated from 1955 to 1971 to receive sulfuric acid sludge from the acid storage tanks. Located next to the sulfuric acid tanks (100-K coordinates NK3131.5 WK4814), the site is a 1-m (3-ft) diameter, 1.8-m (6-ft) long vitrified clay pipe placed in a 3.9-m (13-ft) diameter, 3.3-m (11-ft) deep excavation. The bottom of the excavation is filled with coarse rock. A sand-covered mound marks the location and is surrounded by gravel in a vegetation-free area (Carpenter and Cote 1994). Stenner et al. (1988) report the waste inventory to be 200 kg (441 lb) of mercury, remaining from the sulfuric acid sludge. The MTCA Method B standard for mercury is 24 ppm. The concentration of mercury in the 120-KE-2 French drain is unknown but is expected to exceed the MTCA standard.

3.1.9.2 Qualitative Risk Assessment. As with other drains and cribs, contaminants are likely to be inaccessible for exposure to humans or ecological receptors. The potential for contaminant migration to groundwater (from mercury) is judged to be medium, while data uncertainty is judged to be high. The overall site risk is judged to be medium.

3.1.10 120-KW-2 French Drain

3.1.10.1 Background. Nonradioactive sludge, containing mercury, from the KW sulfuric acid tanks was disposed to the 120-KW-2 French drain, at 100-K coordinates NK3131.5 WK6522 (near the sulfuric acid storage tanks). Carpenter and Cote (1994) report the site to be a 1-m (3-ft) diameter, 1.8-m (6-ft) long clay pipe in a 3.9-m (13-ft) wide, 3.3-m (11-ft) deep excavation, with about 1.8-m (6 in.) of pipe extending above grade. The surface is gravel and free of vegetation. Stenner et al. (1988) report 200 kg (441 lb) of mercury, contained in the acid tank sludge,

remains at the site. The concentration of mercury in the 120-KW-2 French drain is unknown, but is expected to exceed the MTCA standard.

3.1.10.2 Qualitative Risk Assessment. As with other drains and cribs, contaminants are likely to be inaccessible for exposure to humans or ecological receptors. The potential for contaminant migration to groundwater (from mercury) is judged to be medium, while data uncertainty is judged to be high. The overall site risk is judged to be medium.

3.2 OTHER CHANGES FROM FOCUS PACKAGE

The following site discussions (which have been incorporated into Table KA1-1) include changes in proposed dispositions from the Focus Package (DOE-RL 1994a), new proposed dispositions for sites originally categorized as "To Be Determined," and changes in proposed LFIs.

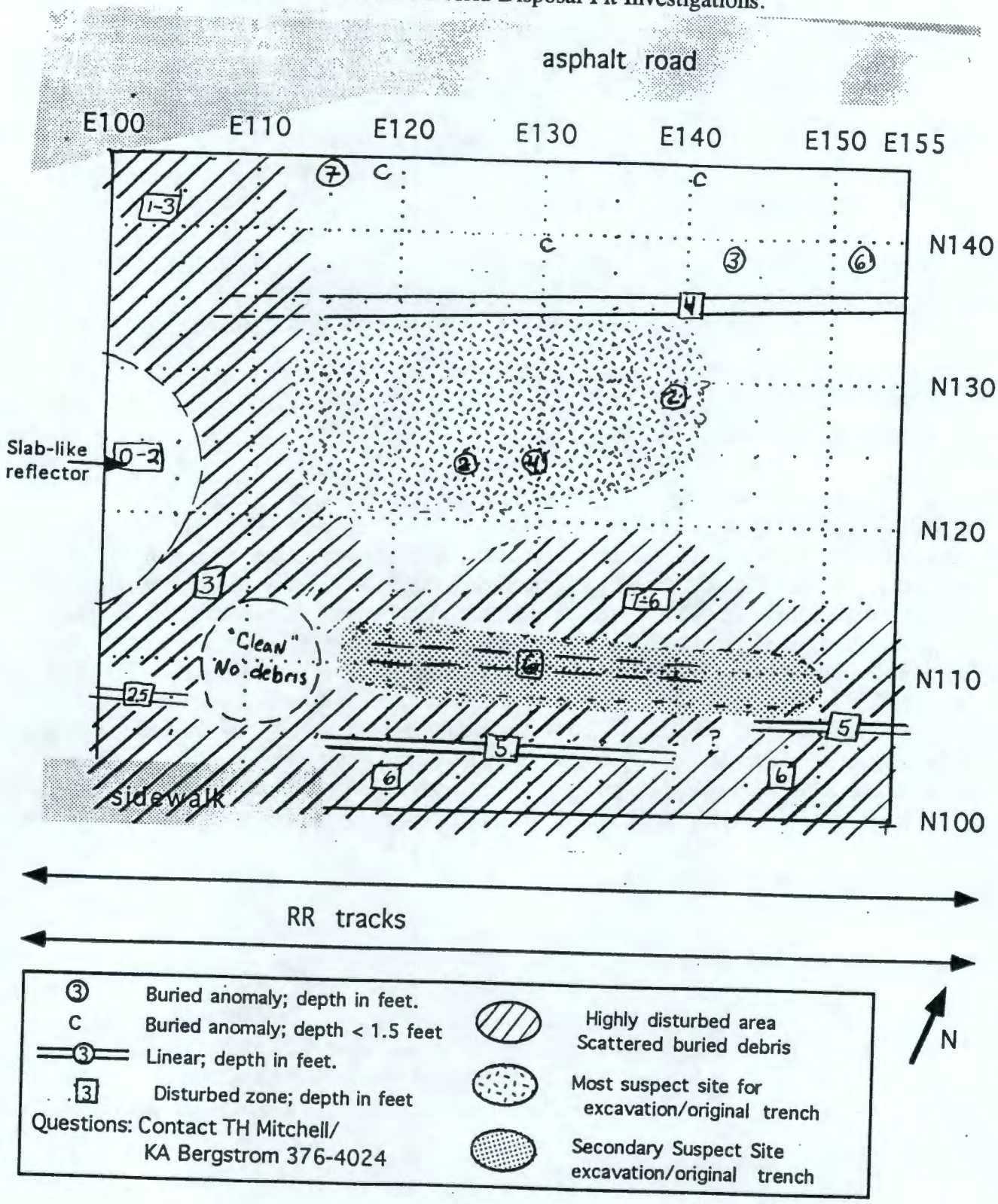
3.2.1 120-KE-3 Filter Water Facility Trench

Nonradioactive sludge from the KE sulfuric acid tanks was also disposed of to the 120-KE-3 Filter Water Facility Trench. This site was 12.2 by 1 by 1 cm (40 by 3 by 3 ft) and lined with sand so the acid sludge slurry would drain. When the site was decommissioned, the remaining material, which had a mercury content of 700 kg (1,544 lb), was removed by a salvage contractor and the trench backfilled with clean fill material. Because the precise location of the site was not known, geophysical surveys were conducted (Bergstrom et al. 1995); the probable location is shown in Figure K1-3 (areas surveyed) and Figure KA1-6 (survey results). The site is gravel and free of vegetation. It is not known if the entire amount of mercury-contaminated sludge was removed. The MTCA Method B standard for mercury is 24 ppm. The concentration of mercury remaining in the 120-KE-3 trench is unknown, but is not expected to be high. This site would have been considered a high priority if the sludge had not been removed. This decision to consider it a low-priority site was reached through DQO discussions with the regulatory agencies and reflects the past removal actions, stable situation, and unlikely potential for surface and groundwater impacts.

3.2.2 120-KW-1 French Drain

The 120-KW-1 French Drain was identified as an IRM candidate in the Focus Package (DOE-RL 1995a, Table 2). Further evaluation by Carpenter (Appendix K, Attachment 2, Part 2) indicates that this site does not exist. Instead, any material intended for disposal at this site went to 100-K-17, an undocumented acid neutralization pit described in Section 6.26 of Carpenter and Cote (1994).

Figure KA1-6. Interpretations of Ground Penetrating Radar Data from the 120-KE-3 Sulfuric Acid Disposal Pit Investigations.



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3.2.3 100-K-37 (1706-KE) French Drain

The 100-K-37 French drain is on the east side of the 1706-KE Building, at the chemical storage facility that stores sodium hydroxide and sulfuric acids. These chemicals were used to regenerate ion exchange columns within the 1706 Building. The French drain, which is buried to depth below the chemical storage tanks, is 45.7 cm (18 in.) in diameter and filled to grade with crushed limestone. Overflow and drain pipes from the tanks end just above the limestone.

Because of uncertainties in the disposal practices at this site, the Focus Package did not make a recommendation and listed this site as a TBD. Further evaluation as part of the LFI concluded that this site should be "low priority." Carpenter (Appendix K, Attachment 2, Part 2) examined historical records on this facility and reports that large volumes of sodium hydroxide have been disposed to the drain and may have leaked to a tunnel leading to the 105-KE Reactor. Sodium hydroxide neutralizes to sodium carbonate on contact with atmospheric or soil moisture. No radionuclides are suspected to have been disposed of to the drain. However, there is the potential for other contaminants to have been in the chemicals stored in the tanks and leaked to the drain (e.g., mercury in the sulfuric acid).

3.2.4 100-K-13 Undocumented Liquid Waste Site

This French drain is about 1.2 m (4 ft) in diameter and is filled with coarse gravel. It is located on a small rise west of the 166-KW oil storage tank facility, across the access road. Because of the uncertainties in the disposal practices at this site, the Focus Package did not make a recommendation and listed the site as TBD. Further evaluation as part of the LFI concluded that this site should be "low priority." Carpenter (Appendix K, Attachment 2, Part 2) reports that the drain was likely used for sanitary wastes generated by the adjacent construction facilities while the KW Reactor was being built. No radioactive or hazardous wastes are suspected to have been disposed of to this site.

3.2.5 118-K-3 Filter Crib

Because of the uncertainty of the existence of this site, the Focus Package did not make a recommendation and listed this site as TBD. According to Carpenter (Appendix K, Attachment 2, Part 2) and Carpenter and Cote (1994), the location for this site is a fenced electrical station; the wastes thought to have been disposed of to this crib were actually disposed of in the 116-KE-2 Crib, which is significantly closer to the reactor. While DOE-RL (1992) describes this site (at the location of the electrical station), no other documentation has been found to verify its existence.

The 118-K-3 Filter Crib is no longer considered a waste site for purposes of this investigation.

3.2.6 Facility Pipelines

Because of uncertainties associated with pipeline leaks, the Focus Package did not make a recommendation for the pipelines and listed them as TBD. Further evaluation of the pipeline leakages at the 100-K Area (Appendix K, Attachment 2, Part 2) indicates past leaks at the retention basins, 116-K-1 Crib, and river discharge lines, are all in the 100-KR-1 Operable Unit. In the 100-KR-2 Operable Unit, the ethylene glycol plant heating system may have leaked at the 100-KE storage tanks. This potential leak has already been addressed in the Focus Package (DOE-RL 1994a) as a low-priority site (the 116-KE-5 Heat Recovery Facility Junction Box).

The facility pipelines are no longer considered a part of the 100-KR-2 LFI except as noted for 116-KE-5.

3.2.7 100-K-5 (1705-KE) French Drain

This facility, located at Hanford Site coordinates W4703.3 N4190.75 (north of the 1705-KE facility), is a 88.9 cm (35-in.) diameter vertical vitrified clay pipe buried to a depth of about 9 ft. Because of the limited information available at the time the Focus Package was prepared, no recommendation was made for this site and it was listed as TBD. Further evaluation by Carpenter (Appendix K, Attachment 2, Part 2) has uncovered site drawings of this facility. The floor drains inside the 1705-KE Building, which was used only for process cooling water makeup, empty into the 100-K-5 French Drain. Thus, the chemicals likely to have been disposed of to this drain are sodium hydroxide, sulfuric acid, chlorine, separan, and/or alum.

Through the DQO process and evaluation of the historical information, DOE, EPA, and Ecology decided that radiation surveys were not needed and that the site should be categorized as a low-priority site.

3.2.8 120-KE-1 French Drain

Because of the uncertainty of the existence of this site, the Focus Package did not make a recommendation and listed the site as TBD. Carpenter (Appendix K, Attachment 2, Part 2) indicates that this site, as with the 120-KW-1 drain, does not exist. Instead, any material disposed went to 100-K-18, an undocumented acid neutralization pit described in Section 6.26 of Carpenter and Cote (1994). The 120-KE-1 site is no longer to be considered a waste site for purposes of this LFI.

3.2.9 118-KE and 118-KW-2 French Drains Associated with Rod Caves

The Focus Package (DOE-RL 1994a) recommended subsurface radiation surveys of the French drains associated with the rod caves. Subsequently, however, facility drawings showed that the drains did not receive water from the areas storing the radioactive rods. Therefore,

through the DQO process DOE, EPA, and Ecology decided that an evaluation for radionuclide contamination in the drains when D&D of the rod caves was done would be the most efficient alternative.

3.2.10 128-K-1 Burning Pit

The Focus Package (DOE-RL 1994a) for the 100-KR-2 Operable Unit proposed screening for organics at the 128-K-1 Burning Pit. Since then, 1993 soil-gas survey data from an analogous waste site, the 128-H-1 Burning Pit, have been presented (Appendix K, Attachment 2, Part 5). These data demonstrated that the 128-H-1 Burning Pit was a low-priority site. Thus, because of the analogous data, DOE, EPA, and Ecology decided that additional soil-gas screening would not be needed at this burning pit.

3.2.11 600-29 Construction Laydown Area

This site was identified in the Focus Packages as a non-*Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) landlord site and was not expected to be addressed as a waste site. Reanalysis of the available information on the 600-29 construction laydown area indicates that the area should be reclassified as a low-priority site, as defined in the HPPS (DOE-RL 1991), instead of a non-CERCLA/landlord cleanup site. The presence of the discolored soil sites provides sufficient justification to consider this a low-priority site. Thus, because questions do not remain as to site disposition, DOE, EPA, and Ecology decided that additional soil-gas screening would not be needed at this site.

3.2.12 116-KW-1 and KE-1 Condensate Cribs

The Focus Package proposed an LFI for these sites because of confusion as to their location; signs placed in the field did not agree with locations shown on existing maps. Geophysics was proposed to resolve the discrepancy. Supporting information in the technical baseline report (Carpenter and Cote 1994) and the sampling report (Dorian and Richards 1978), however, describe the actual locations and the field signs are in error. The DOE, EPA, and Ecology decided that the original questions as to site locations, caused by the misplaced signs, have been answered.

4.0 SUMMARY

Ten waste sites have been considered in this LFI/QRA for continued IRM candidacy. Table KA1-10 evaluates each of these sites against evaluation criteria to decide if the site should continue as an IRM candidate in the FFS. A waste site was retained as an IRM candidate if the site was considered, using professional judgement, to pose at least a medium incremental cancer

risk to humans under the occasional-use scenario, or there was at least a medium potential for impacting groundwater. See Figure KA1-1 for the location of each site. These evaluations are almost all (except for the 120-KE-2 and 120-KW-2 French Drains) based only on radionuclide data. Other contaminants, if present, will be addressed through the observational approach during remediation.

Table KA1-10. Summary of Interim Remedial Measure Sites and Evaluation Against Criteria

Site	Human Health Risk Priority	Eco Risk Priority	Overall Risk[a]	Probable Current Impact on Groundwater	Potential for Natural Attenuation by 2018	IRM Candidate
116-KE-1 Condensate Crib	Low	Low	Medium	High	Low	Yes
116-KE-2 Crib	Low	Low	Low	Medium	Low	Yes
116-KE-3 French Drain	Low	Low	Medium	Low	Unknown	Yes
116-KW-1 Condensate Crib	Low	Low	Medium	High	Low	Yes
116-KW-2 French Drain	Low	Low	Medium	Low	Unknown	Yes
118-K-2 Sludge Trench	Low	Low	Low	Medium	Low (if present)	Yes
French Drain South of 119-KW Building	Low	Low	Medium	Medium	Unknown	Yes
118-K-1 Burial Ground	High	Medium	High	Low	Low	Yes
120-KE-2 French Drain	Low	Low	Medium	Medium	Not applicable	Yes
120-KW-2 French Drain	Low	Low	Medium	Medium	Not applicable	Yes

[a]Included uncertainties; qualitative evaluation of risk based on previous evaluations of other operable units and professional judgement.

Three of these sites are adjacent to the reactors. Sites 116-KE-3 and 116-KW-2 are reverse wells adjacent to the KE and KW Reactors. While the potential risks have been judged to be low, the uncertainties associated with the sites are high, with an overall medium risk potential. While they are still recommended as IRM candidates, because of the proximity of these sites to the reactors, they may be most efficiently remediated with the reactor buildings. This decision will be made in the proposed plan.

The French drain south of the 119-KW Building has an estimated low potential for human health or ecological risk, but has a high uncertainty and a medium overall risk. This site is also still recommended as an IRM candidate, but because the site is adjacent to the reactor building, it may be most efficiently remediated with the reactor building. This decision will be made in the proposed plan.

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ATTACHMENT 2

BACKGROUND INFORMATION FOR THE 100-KR-2 OPERABLE UNIT

ATTACHMENT 2

BACKGROUND INFORMATION FOR THE 100-KR-2 OPERABLE UNIT

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PART 1

BACKGROUND INFORMATION FOR THE 100-KR-2 OPERABLE UNIT

DEVELOPMENT OF RISK-BASED CONCENTRATIONS IN SOIL FOR THE 100-KR-2 LIMITED FIELD INVESTIGATION/ QUALITATIVE RISK ASSESSMENT

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1.0 INTRODUCTION

This attachment presents the calculations used to develop risk-based concentrations in soil for the 100-KR-2 Limited Field Investigation/Qualitative Risk Assessment (LFI/QRA). These concentrations are used to provide a preliminary indication of the extent of contamination in soil and, for sites with limited sampling and analytical data, support the development of a qualitative, relative ranking of health risks potentially associated with a site. The following sections present the conceptual model used to identify receptors and exposure pathways, the exposure assumptions, and the risk equations used in calculation of risk-based concentrations.

2.0 RECEPTORS AND EXPOSURE PATHWAYS

This chapter presents the conceptual exposure model which, in turn, defines the receptors, exposure pathways, and points of exposure potentially associated with the 100-KR-2 sites.

2.1 CONCEPTUAL MODEL

The conceptual model for the 100-KR-2 source Operable Unit describes the potential sources of contaminants in soil, the hypothetical receptors that potentially could come into contact with those contaminants, and the exposure pathways through which this contact could occur. The conceptual model is based on an assumption of unrestricted land use; consistent with this assumption, risk-based concentrations have been developed to correspond to a residential land-use scenario. The other potential receptors are likely to be terrestrial biota; one single organism, the Great Basin pocket mouse, was selected to represent terrestrial biota. Note that risk-based concentrations specifically addressing terrestrial organisms were not calculated, as is discussed in Section 2.3 I.of this attachment.

The pathways of exposure to humans considered in the conceptual model are soil ingestion, inhalation of suspended dust, and external exposure (radionuclides).

2.2 EXPOSURE POINTS

Human receptors are assumed to be able to come into direct contact with soil to a depth of 5 m (15 ft). The pathways of exposure to humans for soils within the top 5 m are soil ingestion, inhalation of suspended dust, and external exposure. The rationale for this assumption is that basements or other subsurface structures could be constructed within the site, resulting in subsurface soils becoming accessible to human contact. Beyond 5 m in soil, it is reasonable that soils would be undisturbed by most human activities. Contaminants located at depths from >5 m to the water table could potentially migrate to groundwater. Risk-based concentrations that address groundwater protection have been developed for contaminants >5 m in soil.

2.3 SPECIFIC PATHWAYS AND RECEPTORS USED FOR RISK-BASED CONCENTRATION DEVELOPMENT

The exposure pathways used to develop risk-based concentrations in soil are those identified for use in the guidance for preparing QRAs presented in the *Hanford Site Risk Assessment Methodology* (HSRAM) (DOE-RL 1995). These pathways were soil ingestion, inhalation of resuspended dust, and external exposure. Risk-based concentrations were developed to address human receptors, and for contaminants in deep soils, to address potential migration to groundwater. Risk-based concentrations in soil for protection of groundwater underlying a site were calculated from groundwater protection criteria using a simple model, as described in Appendix K, Attachment 1, Section 2.8.

As discussed in the LFI/QRA, risk-based concentrations addressing terrestrial biota were not calculated. These concentrations were not calculated because (1) they would be applicable only to single organisms, not populations or communities, and could potentially misstate the nature of ecological impact associated with contaminants in soil and (2) terrestrial biota generally are considered less sensitive to exposure to radionuclides compared with humans (nonradionuclide contaminants of potential concern have been identified for only some 100-KR-2 IRM sites, e.g., 118-K-1, 120-KE-2, and 120-KW-2, but with no concentrations known).

3.0 CALCULATION OF RISK-BASED CONCENTRATIONS

Risk-based concentrations of radionuclides for human receptors were calculated from a target increased cancer risk of 1×10^{-6}. This risk level, which is at the lower end of the U.S. Environmental Protection Agency's (EPA) 10^{-4} to 10^{-6} acceptable risk range for remediation, was selected to ensure that all contaminants of potential concerns (COPC) were addressed. This target risk is highly conservative and will include as COPCs several contaminants that are not significant contributors to site risks. Also note that these risk-based concentrations should not be considered remediation goals. The risk-based concentrations in soil for human receptors first were back-calculated from the target risk, then compared with background concentrations and analytical quantitation limits. If the concentrations calculated from target risks were lower than background or quantitation limits, then either background or the quantitation limit were used as the risk-based concentration.

Risk-based concentrations in soil for groundwater protection were based on the maximum contaminant limit (MCL) or 1/25 of the DCG, with the point of exposure assumed to be underlying the site. The corresponding concentration in soil was then calculated using a simple compartment model referred to as the Summers model (DOE-RL 1995).

3.1 HUMAN RECEPTORS

Risk-based concentrations for radionuclide (carcinogenic) contaminants are estimated from a target increased cancer risk levels using equations presented in HSRAM (DOE-RL 1995) and intake factors and assumptions that correspond to a residential land-use scenario. An increased cancer risk level of 1×10^{-6} has been selected as a point of departure for calculating concentrations for individual contaminants. For radionuclides, the concentration corresponding to 1×10^{-6} is based on occupancy of a site in the year 2018; radioactive decay occurring from 1994 to 2018 is considered in developing the risk-based concentration for radionuclides.

The target risk of 1×10^{-6} is the sum of the risks from the following exposure pathways: soil ingestion, inhalation of fugitive dust, and external exposure to radionuclides. Therefore, the

$$TR = Risk_{si} + Risk_{inh} + Risk_{ext} \quad (1)$$

target risk is the sum of the risks from these three exposure pathways, as follows:
where

TR	=	Target risk, or 1×10^{-6}
$Risk_{si}$	=	Increased cancer risk from soil ingestion
$Risk_{inh}$	=	Increased cancer risk from inhalation
$Risk_{ext}$	=	Increased cancer risk from external exposure.

Increased cancer risk is calculated as the product of contaminant intake and a slope factor; therefore, the target risk can be calculated as:

$$TR = \Sigma (Intake \times SF)_i \quad (2)$$

where

I	=	ingestion, inhalation, or external exposure pathways
Intake	=	Contaminant intake (pCi)
SF	=	Carcinogenic slope factor $(pCi)^{-1}$ (EPA 1993).

Contaminant intake is calculated as the product of contaminant concentration in soil and an intake factor; the intake factor represents assumptions concerning rate of contact with the contaminated media, exposure frequency, duration, body weight, and other assumptions. Intake factors used in developing risk-based concentrations for carcinogenic contaminants were obtained from HSRAM (DOE-RL 1995, Appendix A). These are summarized in Table KA2-1.

Table KA2-1. Hanford Site Risk Assessment Methodology
Intake Factors (Residential Exposure Scenario) (units in pCi/g).

Exposure Pathway	Noncarcinogens	Carcinogens	Radionuclides
Soil Ingestion	1.30 E-05	1.60 E-06	1.30 E+03
Inhalation	6.30 E-01	1.20 E-01	2.20 E+05
External Exposure			2.40 E+01

Using the contaminant concentration in soil and intake factors, target risk can be calculated as:

$$TR = \Sigma\,(IF \times SC \times SF)_i \qquad (3)$$

where SC is the concentration in soil (pCi/g). Because SC is the same for all pathways, it can be brought out of the summation, as follows:

$$TR = SC \times \Sigma\,(IF \times SF)_i \qquad (4)$$

Equation (4) can be rearranged to solve for concentration in soil:

$$SC = \frac{TR}{\Sigma\,(IF \times SF)_i} \qquad (5)$$

Equation (5) is used to calculate concentrations for chemical contaminants (i.e., not radionuclides). For radionuclides, a relationship is defined between the concentration in soil corresponding to 1×10^{-6} in the year 2018 (the year when sites may be released as described previously), and the concentration in soil in 1994, which is used to estimate volumes of contaminated soil requiring remedial action. This relationship is defined as follows:

$$SC_t = SC_o \times DF \qquad (6)$$

where

SC_t = Concentration in soil at time *t* (nominally 2018)
SC_o = Concentration in soil at time 0 (assumed to be 1994)
DF = Decay factor = 0.5^{β}
β = Calculated as $(time_t - time_0)/T_{0.5}$
$T_{0.5}$ = Radionuclide-specific half-life (EPA 1993).

Equation (5) can then be rearranged to incorporate radioactive decay as follows:

$$SC_0 = \frac{TR}{[0.5^{\beta} \times \Sigma\,(IF \times SF)_i]} \qquad (7)$$

Equation (7) can then be used to calculate the concentration in soil in 1994 that achieves the target increased cancer risk level in the year 2018. These concentrations are presented in Chapter 4.0 of this attachment.

3.2 GROUNDWATER PROTECTION

Development of risk-based concentration corresponding to groundwater protection criteria is based on the Summers method, which is described in EPA (1989). A summary of the model description is also first presented in the Focused Feasibility Study (FFS) document for the 100 Area (DOE-RL 1994a). Some revisions to the parameters (recharge rate to groundwater and distribution coefficients (K_d) for some contaminants) have been revised since original presentation of the method. A summary of this method is presented below.

Allowable constituent concentrations in soil for groundwater protection are calculated using the Summers model, which is rearranged to solve for concentration in soil from concentration in groundwater. The rearranged model is presented below:

$$C_p = \frac{C_{gw}(Q_p + Q_{gw}) - Q_{gw}C_i}{Q_p} \qquad \textbf{(8)}$$

where

C_{gw}	=	Allowable concentration in groundwater (pCi/L or µg/L)
Q_p	=	Volumetric flow rate to groundwater (ft^3/day), calculated as A_p x q
A_p	=	Horizontal area of contamination (ft^2)
q	=	Recharge rate (ft/day)
Q_{gw}	=	Groundwater flow rate (ft^3/day), calculated as V x h x w
V	=	Darcy velocity in groundwater (ft/day), calculated as K x I
K	=	Hydraulic conductivity of aquifer (ft/day)
I	=	Hydraulic gradient in aquifer (ft/ft)
h	=	Thickness of zone of mixing in aquifer (ft)
w	=	Width of zone of mixing in aquifer (site width) (ft)
C_i	=	Initial concentration in groundwater (assumed to be zero) (pCi/L or mg/L).

Concentration in soil is calculated from C_p (leachate concentration) as follows:

$$C_s = K_d C_p \qquad \textbf{(9)}$$

where

C_s	=	Concentration in soil (pCi/g or µg/g)
C_p	=	Concentration in leachate (pCi/mL or µg/mL)
K_d	=	Distribution coefficient (mL/g).

For contaminants where the K_d value is zero, concentrations in soil are calculated as follows:

$$C_s = C_p\left(\frac{m}{d}\right) \quad \textbf{(10)}$$

where m is volumetric moisture content (unitless) and d is dry soil density (g/mL).

The K_d for radionuclides and inorganics are estimated from a review of the literature (presented in Section 3.2.1 of this attachment). The K_d for organics are estimated as follows:

$$K_d = K_{oc} f_{oc} \quad \textbf{(11)}$$

where K_{oc} is soil organic carbon constant (mL/g) and f_{oc} is fraction of organic carbon in soil.

The K_{oc} values were unchanged from the FFS. The value for f_{oc} was assumed to be 0.1% (f_{oc} = 0.001), which was unchanged from the FFS.

Parameters used in the Summers method are summarized in Table KA2-2.

Table KA2-2. Summary of Parameters in Summers Method.

Parameter	Symbol	Value	Source
Allowable concentration in groundwater	C_{gw}	Contaminant specific	MCLs for nonradioactive contaminants; 1/25th of DCGs for radionuclides
Volumetric flow to groundwater	Q_p	11.5 ft^3/day	A_p x q; A_p = 640,000 ft^2 (see below), q = 1.8 x 10^{-5} ft/day (see below)
Horizontal area of contamination	A_p	640,000 ft^2	Assumed surface area of 116-C-5 retention basin, based on dimensions of 800 ft by 800 ft
Recharge rate	q	1.8 x 10^{-5} ft/day	Varies from site to site. Assumed value of 0.2 cm/yr (Routson and Johnson 1990)
Groundwater flow rate	Q_{gw}	7,200 ft^3/day	V x h x w; V = 0.3 ft/day (see below); h = 30 ft (see below); w = 800 ft (see below)
Darcy velocity in groundwater	V	0.3 ft/day	K x I; K = 100 ft/day (see below); I = 0.003 ft/ft (see below)
Hydraulic conductivity of the aquifer	K	100 ft/day	Hydraulic conductivity of the Ringold Formation (DOE-RL 1993)
Hydraulic gradient of the aquifer	I	0.003 ft/ft	DOE-RL (1993)

Table KA2-2. Summary of Parameters in Summers Method.

Thickness of the mixing zone in the aquifer	h	30 ft	N Area Report
Width of the mixing zone	w	800 ft	Assumed to be the site width (value for 116-C-5 retention basin)
Volumetric moisture content	m	0.09	Soil moistures average 5% (w/w), or 9% by volume (DOE-RL 1994b)
Dry soil density	d	1.7 g/mL	Based on value of approximately 110 lb/ft^3

3.2.1 Distribution Coefficients for Inorganic Constituents

The K_d is an empirical parameter that represents the tendency for a chemical substance to adsorb to soil. Typically, it is measured in the laboratory as the ratio of concentration in soil (C_s) to concentration in water (C_w), at equilibrium, as shown below:

$$K_d = \frac{C_s}{C_w} \tag{12}$$

The greater the extent of adsorption in soil, the greater the value of K_d.

Values for K_d can then be used in models to quantify the amount of contaminant in soil that can leach to groundwater. The K_d values measured for an individual substance can vary substantially based on differences in soil properties. For example, the range of K_d values for plutonium and zinc, measured in different soils can span four orders of magnitude (Dragun 1988; Baes and Sharp 1983). The variables affecting K_d include the relative abundance of different cations and anions in soil, soil pH, redox potential, cation exchange capacity, and organic matter content (Dragun 1988; Barney 1978).

Ideally, the K_d value to be used to model leaching potential in Hanford Site soils should be based on site-specific measurements. However, sole reliance on site-specific measurements generally is not feasible. An alternate approach to develop K_d values for modeling is (1) identify the range of K_d values measured in Hanford Site soils, or under conditions similar to those encountered in Hanford Site soils and (2) select a value that provides a conservatively reasonable estimate of contaminant leaching to groundwater. These selected values then can be used to develop preliminary remediation goals in soil.

3.2.1.1 Methodology. Several studies have compiled K_d values for a variety of soil, sediment, and leachate conditions at the Hanford Site. These values generally span a range depending on

soil and leachate (liquid waste stream) conditions. These conditions include varying combinations in soils and leachate of:

- High or low salt concentrations
- High or low organic matter concentrations
- Acid (low pH) or neutral/basic (moderate to high pH) conditions.

The approach for selecting conservatively reasonable values for K_d involved evaluating the characteristics of Hanford Site soils and identifying the K_d value corresponding most closely to those characteristics. The hierarchy of data used to select K_d values was to use Hanford Site-specific data in preference to more general compilations of K_d values in the literature. The selected values were compared with the range of general literature values. Finally, uncertainties in the data were discussed to support the selected K_d value.

3.2.1.2 Hanford Site Soil Characteristics. For purposes of selecting K_d values from the literature, most Hanford Site soils are characterized as low salt, low organic matter content with neutral to basic pH (Serne and Wood 1990). Hanford Site soils typically are sandy with very little organic carbon content (Ames and Serne 1991). Soil pH measured in 100 Area soils ranges from 6.5 to 7.66. Total organic carbon concentrations range from 600 to 1,640 ppm (DOE-RL 1994b).

3.2.1.3 Distribution Coefficient Data Sources. The principal sources of information on Hanford Site-specific K_d values consulted in this analysis were Ames and Serne (1991) and Serne and Wood (1990). These references provided information on most of the radionuclide and nonradioactive inorganic contaminants in soil in the 100 Areas. Ames and Serne (1991) provided ranges of K_d values for different waste stream characteristics (high/low dissolved solids; high/low organic content; low/neutral to high pH), these parameters being more variable than soil characteristics at the Hanford Site. Ames and Serne (1991) also recommended conservative estimates of K_d values for use in modeling contaminant leaching (WHC 1990). Ames and Serne (1991) recommended K_d values for all of the contaminants of potential concern, except for carbon, arsenic, antimony, thorium, and radium. Serne and Wood (1990) summarized available information on K_d values and identified changes in K_d values with changing conditions in soil. These references did not reveal information on K_d values for thorium and arsenic. Information on these two contaminants in soil was developed from the range of K_d values compiled by Baes and Sharp (1983). Baes and Sharp (1983) presented ranges of K_d values for 222 agricultural soils and clays between pH 4.5 and 9. The K_d values presented in these sources are summarized in Table KA2-3.

Table KA2-3. Summary of Revised Distribution Coefficient Values for Summers Model used in the 100 Area Focused Feasibility Study.

Contaminants of Potential Concern	Kds in the FFS	Revised Kd value	Source for Revised Kd value	Ames and Serne, 1991 (a)		Baes and Sharp, 1983 (c)	
				Recommended Value	Range	Geometric mean	Observed Range
Am-241	200	200	Ames and Serne, 1991	200	100-500	810	1.0-47,230
C-14	**0.05**	**0**	Serne and Woods, 1990				
Cs-134	50	50	Ames and Serne, 1991	50	50-3,000	1,110	10-52,000
Cs-137	50	50	Ames and Serne, 1991	50	50-3,000	1,110	10-52,000
Co-60	50	50	Ames and Serne, 1991	50	10-3,000	55	0.2-3,800
Eu-152	200	200	Ames and Serne, 1991	200	100-500		
Eu-154	200	200	Ames and Serne, 1991	200	100-500		
Eu-155	200	200	Ames and Serne, 1991	200	100-500		
H-3	**0.05**	**0**	Serne and Woods, 1990				
K-40	4	4	Ames and Serne, 1991			5.5	2.0-9.0
Na-22	4	4	Ames and Serne, 1991	4	1-30		
Ni-63	30	30	Ames and Serne, 1991	4	1-30		
Pu-238	**25**	**200**	Serne and Woods, 1990	25	100-2,000	1,800	11-300,000
Pu-239/240	**25**	**200**	Serne and Woods, 1990	25	100-2,000	1,800	11-300,000
Ra-226	**0.05**	**100**	Ames and Rai, 1978				
Sr-90	25	25	Ames and Serne, 1991	25	20-200	27	0.15-3,300
Tc-99	**0.05**	**0**	Serne and Woods, 1990	0	0		
Th-228	**0.05**	**200**	Ames and Rai, 1978			60,000	2,000-510,000
Th-232	**0.05**	**200**	Ames and Rai, 1978			60,000	2,000-510,000
U-233/234	2	2	Serne and Woods, 1990	2	2-2,000	45	10.5-4,400
U-235	2	2	Serne and Woods, 1990	2	2-2,000	45	10.5-4,400
U-238	2	2	Serne and Woods, 1990	2	2-2,000	45	10.5-4,400
Antimony	**0.05**	**1**	Ames and Rai, 1978	0	0-40		
Arsenic	**0.05**	**3**	Baes and Sharp, 1983			3.3 (As III); 6.7 (As V)	1.0-8.3 (As III); 1.9-18 (As V)
Barium	25	25	Ames and Serne, 1991	25	20-200		
Cadmium	30	30	Ames and Serne, 1991	30	100-200	6.7	1.26-26.8
Chromium	**0.05**	**200**	Ames and Serne, 1991; Thorton et al., 1994	0 (Cr VI)	0 (Cr VI) (b)	37	1.2-1,800
Lead	30	30	Ames and Serne, 1991	30	100-200	99	4.5-7,640
Manganese	50	50	Ames and Serne, 1991	50	10-3,000	150	0.2-10,000
Mercury	30	30	Ames and Serne, 1991	30	100-200		
Zinc	30	30	Ames and Serne, 1991	30	100-200	16	0.1-8,000
Aroclor 1260 (PCB)	530	530	EPA, 1986				
Benzo(a)pyrene	5500	5500	EPA, 1986				
Chrysene	200	200	EPA, 1986				
Pentachlorophenol	53	53	EPA, 1986				

(a) Recommended conservative value for liquid waste streams with low dissolved solids concentrations (<0.01 M), low organic concentration (<2 ppm), and pH>6).

(b) Recommended conservative Kd for Cr(III) was 200, with a range from 100-500

(c) Values for most elements are geometric means of population of values in agricultural soils and clays of pH 4.5 to 9.

3.2.1.4 Selected Distribution Coefficient Values. The K_d values selected for modeling contaminant concentrations leaching to groundwater are summarized in Table 2. Uncertainties in the data for selected contaminants are discussed below.

3.2.1.4.1 Cesium. Ames and Serne (1991) recommended a K_d of 50 from values ranging from 50 to 3,000. Baes and Sharp (1983) cite a range from 10 to 52,000, with a geometric mean of 1,100. According to Serne and Wood (1990), the available data indicate that a minimum value of 200 is reasonable for ambient conditions in soil at the Hanford Site (near neutral pH, low dissolved solids concentrations, and low organic matter content); the value of 200 was selected as a K_d for cesium based on data evaluated by Serne and Wood (1990).

3.2.1.4.2 Plutonium. Ames and Serne (1991) recommended a K_d of 25, with a range from 100 to 2,000. Baes and Sharp (1983) cite a range from 11 to 300,000, with a geometric mean of 1,800. Serne and Wood (1990) cite studies in which plutonium sorption in a pH range from 4 to 8.5 was high, with K_d >1,980. Based on the available data, Serne and Wood (1990) recommended a range of K_d values from approximately 100 to 1,000 for ambient soil conditions at the Hanford Site. Data reviewed by Serne and Wood (1990) appear to show similarities in the behavior of plutonium and americium in soil, while Ames and Serne (1991) recommend a K_d of 200 for americium. Based on this range of information, a K_d of 200 was selected for plutonium.

3.2.1.4.3 Uranium. Ames and Serne (1991) recommend a K_d of 2 for uranium from a range from 2 to 2,000. Baes and Sharp (1983) cite a range from 10.5 to 4,400, with a geometric mean of 45. Serne and Wood (1990) suggest that uranium would sorb poorly to soil under neutral and basic conditions and concluded that additional data were required to support a recommended K_d value. Uranium has been detected in groundwater at 100 Area sites, suggesting that it has some mobility in soil. While it is likely that K_d values are higher, a K_d of 2 was selected for modeling contaminant leaching.

3.2.1.4.4 Thorium. There have been no estimates of K_d developed for thorium at the Hanford Site. The range of literature values cited by Baes and Sharp (1983) is from 2,000 to 510,000. Values for K_d at a pH of 8.15 in medium sands (40 to 130) and very fine sands (310 to 470) (Yu et al. 1993) are likely to be appropriate for soil conditions at the Hanford Site. The higher K_d values appear to be associated more with silty-clay soils (Ames and Rai 1978). K_d values for thorium are lower with low soil pH. A conservative estimate of 100 was selected as a K_d for thorium in Hanford Site soils.

3.2.1.4.5 Radium. There have been no estimates of K_d developed for radium at the Hanford Site, and no data were cited in Baes and Sharp (1983). Yu et al. (1993) compiled data indicating K_d values at acidic pHs (2 to 6) ranging from 0 to 60 and K_d values at neutral/basic pHs (7 to 7.7) ranging from 100 to 2,400. Data summarized in Ames and Rai (1978) indicate K_d values at neutral/basic pHs ranging from 214 to 354. A conservative estimate of 200 was selected as a K_d for radium in Hanford Site soils.

3.2.1.4.6 Arsenic. There have been no estimates of K_d developed for arsenic at the Hanford Site. The range of values cited in the literature are 1 to 8.3 for As III (geometric mean of 3.3)

and 1.9 to 18 for As V (geometric mean of 6.7) (Baes and Sharp 1983). A value of 3 was selected as a K_d for arsenic in Hanford Site soils.

3.2.1.4.7 Antimony. Estimates of K_d for antimony at the Hanford Site range from 0 to 40 (Ames and Serne 1991). Studies of the soil chemistry and observed mobility of antimony-containing wastes have resulted in K_d values ranging from <1 to >1,000 (Ames and Rai 1978). A value of 1 was selected as a K_d for antimony in Hanford Site soils.

3.2.1.4.8 Chromium. The mobility of chromium in soil will vary greatly with valence. The Cr VI is highly mobile in soil and has been estimated to have a K_d of zero (Ames and Serne 1991). However, Cr VI is readily reduced in soil to Cr III by the presence of ferrous ion and organic matter. A minor amount of Cr III can be oxidized to Cr VI through the presence of manganese oxides in soils and sediments (Thornton et al. 1994). A suggested K_d value for Cr III = 200 mL/g.

4.0 SUMMARY OF RISK-BASED CONCENTRATIONS

The risk-based concentrations used in the LFI/QRA are summarized in Table KA2-4.

Table KA2-4. Summary of Risk-Based Concentrations in Soil (100-KR-2 Limited Field Investigations/Qualitative Risk Assessment).

Radionuclides (pCi/g)	TR = 1E-06 (Radionuclides)	Groundwater Protection	Background	CRQL/CRDL	Human Health and Ecological Receptors (<15 ft)	Protection of Groundwater (>15 feet)
Am-241	1.3	150	N/C	1	1.3	150
C-14	856	93	N/C	50	93	93
Cs-134	2.2	2,507	N/C	0.1	2.2	2,507
Cs-137	0.03	3,761	1.8	0.1	1.8	3,761
Co-60	0.04	6,268	N/C	0.05	0.1	6,268
Eu-152	0.03	100,287	N/C	0.1	0.1	100,287
Eu-154	0.04	100,287	N/C	0.1	0.1	100,287
Eu-155	7.2	501,434	N/C	0.1	7.2	501,434
H-3	35,928	2,655	N/C	400	2,655	2,655
K-40	0.1	702	19.7	4	19.7	702
Na-22	0.5	1,003	N/C	4	4.0	1,003
Ni-63	3,382	225,645	N/C	30	3,382	225,645
Pu-238	1.6	201	N/C	1	1.6	201
Pu-239/Pu-240	1.4	150	0.035	1	1.4	150
Ra-226	0.007	251	0.98	0.1	1.0	251
Sr-90	32	627	0.36	1	31.5	627
Tc-99	557	133	N/C	15	133	133
Th-228	3.1	2,006	N/C	1	3.1	2,006
Th-232	3.1	251	N/C	1	3.1	251
U-233/U-234	3.1	25	1.1	1	3.1	25
U-235	0.2	30	N/C	1	1.0	30
U-238	0.7	30	1.04	1	1.0	30

Notes:

Release Date for Radionuclide Risk-based Concentrations:

Starting: 1994

Ending: 2018

Duration (years): 24

Target Risk for Carcinogens: 1.00E-06

Groundwater protection values calculated from MCLs or 1/25 DCG using the Summers model.

TR - Target Risk

CRQL/CRDL - Contract Required Quantitation Limits/Contract Required Detection Limits

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PART 2

BACKGROUND INFORMATION FOR THE 100-KR-2 OPERABLE UNIT

100-K AREA SITE-SPECIFIC INVESTIGATIONS

9513360.1829 010728

DOE/RL-94-61
Draft A

Environmental Restoration Contractor **ERC Team**

Interoffice Memorandum

Job No. 22192
Written Response Required? N0
Closes CCN: N/A
OU: 100 KR 1 & 2
TSD: N/A
ERA: N/A
Subject Code: 8000

TO: S. G. Weiss H4-90

DATE: February 27, 1995

COPIES: Below

FROM: R. W. Carpenter RWCarpenter
Natural Resources
H6-03 372-3702

SUBJECT: **100-K AREA SITE SPECIFIC INVESTIGATIONS**

The attached report documents my investigation of several specific 100-K Area waste sites per your request.

If you have any questions or need additional information, you may contact me on 372-3702.

RWC:ds

Attachment: 100-K Area Site Specific Investigations Report

Distribution

W. L. Pamplin, w/a H4-86
R. P. Prosser, w/a H6-07
RWC: Letter book H6-03
BHI Document Control H4-79, w/a

DOE/RL-94-61
Draft A

010728

100-K AREA SITE SPECIFIC INVESTIGATIONS

R. W. CARPENTER

FEBRUARY 2, 1995

KA2-24

100-K Area Site Specific Investigations

At the request of Steve Weiss of Environmental Sciences, the Waste Site and Facility Research Office has conducted the following review of specific 100-K Area Waste sites and suspect waste sites.

120-KW-1 (183-KW FILTER WATER FACILITY DRY WELL)

The 120-KW-1, commonly known as the 183-KW Filter Water Facility Dry Well, does not exist as described in the Bechtel Hanford, Inc. (BHI) Waste Information Data System (WIDS) database. Field surveillance activities performed for the *100-K Area Technical Baseline Report* (WHC-SD-EN-TI-239, Rev. 0), and additional research conducted in November 1994, determined that, most likely, the "dry well" was actually a neutralization box located near the sulfuric acid storage tanks.

This neutralization box, located at 183-KW and at Hanford coordinates NK3131 WK6548, is likely to be the 120-KW-1 dry well described in WIDS. This brick-lined concrete box is 8-ft 4-in. long, 6-ft 4-in. wide, and 3-ft deep. It drains to the 100-K Area Process Sewer System. The box is divided into three sections. A below-ground drain pipe enters the box on the northeast side about 18 in. below grade. Effluent released to this system were held up in a small brick weir, then channeled to a second brick weir, which then emptied into a larger chamber that drained to the 100-K Area Process Sewer.

When the wooden cover to this neutralization box was opened, it was discovered that a sludge-like material nearly fills the first two chambers.

A duplicate of this system can be found at the 183-KE complex. It is at Hanford coordinates NK3131 WK4751.5 and appears to have been used in the same fashion as the system at 183-KW.

Additionally, a french drain is located at each of the two 183-K Facilities. The drains are identified as 120-KW-2 (the 183-KW Filter Water Facility French Drain) and 120-KE-2 (the 183-KE Filter Water Facility French Drain). These two french drains are known to have been used to dispose of acid sludge wastes. The drain at the 183-KE Facility is covered by soils and is not apparent on the surface. However, the wooden lid to the drain lays nearby on the ground surface. The drain at 183-KW appears as it did during operations. It is full, to within 6 in. of its wooden cover, with what appears to be acid sludge.

Two additional neutralization boxes are located in the vicinity of the acid storage system. It is unlikely that these two neutralization boxes were used for the disposal of acid sludge. Each neutralization box is located adjacent to its 183-KW area's caustic storage tank, which was just north of the rail spur to the 183 Buildings and opposite the sulfuric acid storage tanks.

The neutralization box at 183-KE has been backfilled with fill material and cannot be visually identified, except at times of very high humidity (see attached photo #1). Limited intrusive work, conducted for safety reasons, was performed at the site in 1994 to determine whether or not the box's wooden cover had been removed before the box was covered with clean soil. It was determined that the wooden cover was no longer in place.

The box at 183-KW appears as it did during operations. Opening of its wooden cover reveals that it is relatively clean of debris, which tends to confirm the idea that these boxes were not used for acid sludge

disposals.

Finally, there is an acid neutralization box at each of the two 183-K Facilities that was used for neutralization of waste materials associated with an elevated day use acid tank. In both cases these boxes are located adjacent to the facilities' west side. These boxes are partly filled with crushed limestone and do not appear to have been used for the disposal of acid sludge associated with the larger acid storage tanks located at each facility.

120-KE-3 (183-KE Filter Water Facility Trench)

This 40-ft long, 3-ft wide,and 3-ft deep trench was used for the disposal of sulfuric acid sludge. The trench was lined with sand to allow for filtration of the sludge-bearing solution by percolation to the soil, trapping the sludge materials in the sand. According to documents found, the trench was located just west of the 183-KE brine pit and east of the caustic neutralization box (see attached photo #1).

The trench was used for sludge disposal because of mercury contamination in the sludge. When the trench was decommissioned, the sand and sludge material was removed by a salvage contractor and the trench was backfilled with clean fill material (Dorian 1985).

118-K-3 (118-K-3 Filter Crib)

It is doubtful that this crib ever existed. However, the site is identified by maps included in the *Remedial Investigation/Feasibility Study Work Plan for the 100-KR-1 Operable Unit, Hanford Site, Richland, Washington* (DOE-RL 1992).

Field investigation reveals that the site described as a crib by these maps is actually a fenced electrical station. Interviews conducted with numerous current and former Hanford Site employees indicated that the wastes thought to have been disposed of in this crib were actually disposed of in the 1706-KER Crib (116-KE-2).

Undocumented French Drain - West of 166-KW

The 3-ft-diameter french drain described in Section 5.33 of the *100-K Area Technical Baseline Report* (WHC-SD-EN-TI-239, Rev. 0) could not be positively identified from documents, drawings, photographs, and oral history interviews. However, it is likely that the drain was installed and used as a disposal site of sanitary type wastes generated in several Temporary Construction (TC) facilities that were located very near to the site during construction of the KW Reactor.

These facilities can be seen in an aerial photograph taken in June 1953. Another aerial photograph, taken in January 1955 shows that the TC facilities have been removed and the french drain is visible at the location. See attached photos #2 and #3.

To the knowledge of numerous current employees and former employees no other facilities have been located at this site, nor could any be seen in aerial photographs taken over time.

Underground Piping System Leaks

The retention basins associated with each of the 100-K Area Reactors are known to have leaked as much as 10,000 to 20,000 gallons per minute. This leakage caused ponding around the basins and on the ground surface north of the basins to the river shoreline (DOE-RL 1992).

Additionally, during the first use of the 116-K-1 Crib, effluent water washed out under the northwest corner of its earthen berm, causing the ponding of effluent water on the ground surface directly north of the KE Retention Basins.

The valves designed to cycle the effluent through the retention basin system worked very poorly. Leak-by of these valves was so bad that, in the case of the 116-K-1 Crib, the flow of effluent water to this system could not be stopped. However, this leakage was not external to the piping system; it was leakage through the valves. It is not known if the piping systems leaked externally.
Additionally, right after the initial startup of the 100-K Area Reactors, an incident occurred in which the effluent discharge lines to the river floated and damaged the effluent discharge system.

Several systems were put into place to help alleviate the problems described above. A leach trench was installed near the effluent basins to collect leakage to a 24-in. corrugated pipe that ran under the perimeter road and drained to a ditch to the river shoreline. Likewise, a leach trench was installed around the 116-K-1 Crib; it also drained via a cobble-filled trench to the river shoreline. The outfall flume trench was deepened to collect groundwater and route it to the shoreline. Another trench was dug on the west side of the effluent lines, and a perforated corrugated pipe was installed to collect groundwater and to discharge it at the shoreline.

One significant reactor system that may have leaked is the Ethylene Glycol Plant Heating System.

A heat exchanger system utilized ethylene glycol to remove heat from the reactor effluent discharge system and used the heated ethylene glycol to heat facilities located in the 100-K Area.

The system is not known to have leaked. However, it was rumored that some product ethylene glycol had been spilled on the ground at the 100-KE storage tanks that are located adjacent to the north side of the 165-KE Building.

Horizontal Control Rod Storage Cave French Drains at 105-KE and 105-KW

Two identical french drains, 24 in. in diameter, are located adjacent to each Horizontal Control Rod Storage Cave. Each drain is connected to a drain located between the two cave sections of the storage facility via a 3-in. drain pipe.

The cave sections consist of a 24-in. pipe sectioned lengthwise and bolted to a concrete pad, the interface of which was grouted. Earth was then added to provide shielding. Two drains were provided beneath the earth cover between the cave sections to remove excess precipitation from the earth cover. Because the cave sections were grouted, it is unlikely that any radionuclide contamination reached these drains (Hanford Site Drawing H-1-23250).

1705-KE French Drain (Dry Well)

The 1705-KE french drain, located at Hanford coordinates W4703.3 N4190.75, consists of a 35 in. diameter vitrified clay pipe buried vertically in a round excavation with a minimum base diameter of 8 ft. The excavation bottom consists of coarse quarry-run basalt stone 1 ft deep. Centered in the excavation are two pipe sections stacked vertically. The bottom section is about 5 ft long and the top section is 4 ft in length. The lower section has a 6-in. spur located near the top of the section that allows for a 4-in. vitrified clay drain pipe to drain into the "dry well." The two sections are filled with crushed limestone. The wooden cover is made of laminated fir planks that have been treated with pentachlorophenol as a preservative.

The 4 in. vitrified clay pipe drain pipe connects to a 3 in. duriron drain pipe that in turn connects to all of the floor drains located within the 1705-KE facility. These floor drains are located one each in the four rooms that comprise the facility and are as follows; control room, dry chemical storage room, chlorine room, acid storage room (Hanford Drawings H-1-33100 and H-1-33101).

The purpose of the facility was to provide an experimental facility for the control of makeup water to process tubes controlled and supplied from the 1706-KE laboratory facility.

Since the facility was only used for process cooling water makeup, the chemicals used at the site are the identical to chemicals used in the 183-K Area Water Treatment facilities ie; sodium hydroxide, sulfuric acid, chlorine, separan and/or alum. It is highly unlikely that there was or is any radionuclide contamination in this french drain.

1706-KE French Drain, East Side Storage Tanks

An outside Chemical Storage Facility was added to the 1706-KE Building in 1962-63 to store product sodium hydroxide and sulfuric acid. The french drain was added as part of this storage facility.

The drain consists of an 18 in. diameter vitrified clay pipe that is 4 ft long and buried vertically in the ground. It is filled with crushed limestone. Overflow and drain pipes from the storage tanks terminate just above the top of the drain.

Current and former Hanford Site employees report that there were several small spills of sodium hydroxide and sulfuric acid product that occurred during filling operations of the storage tanks that discharged to this drain (Carpenter and Cote 1994). The drain was also used to receive rinsate generated by rinsing of the hoses that were used to fill the storage tanks.

The tanks that comprise the storage facility were excess material transferred to the 1706-KE Building from the 200-Areas. In 1989 radioactive surface contamination was found on the bolt heads that secure the tank top lids. However, there is no record of radioactive contamination on or in any other part of the storage facility, and the tanks were fully surveyed for contamination when they were received from the 200-Areas. Former employees report that the tanks have never been used for the storage of radioactive materials. It is highly unlikely that any radioactive contamination was ever released to the french drain.

Paved Area West of the 100-K Area

A paved area located west of the 100-K Area can be seen in a 1982 aerial photograph. This paved area is not apparent in a 1955 aerial photograph, and no clear, early aerials of the area could be found.

A visit to the site in early 1995 revealed that the paved area is not on level ground; the site slopes up in a southward direction. The site may have been a temporary staging area for asphalt material, as one row of asphalt material remains at the western edge of the site, and there are rows of loosely compacted materials over the remainder of the site.

No documentation could be found to indicate the purpose of the materials or how they came to be located at the site.

The roadway extends to the east and goes directly to the 100-K Area.

There appears to have been several disruptions of the soil nearby to the east and adjacent to the canal roadway. These disruptions appear to be vegetation free in a 1982 aerial photograph. Field surveillance of the these disruptions indicates that portions of the sites were apparently barrow pits. The remaining portions of the site are littered with wooden, metallic, and asphalt debris.
During initial construction of the 100-K Area facilities, a barrow pit was excavated on the north side of the roadway, between the road and the irrigation ditch. The barrow pit and a section of the irrigation ditch were later used to dispose of construction debris. The area is posted with asbestos warning signs, and burning is apparent on the ground surface (smoke can be seen in this area in one construction photograph).

There is ample evidence of farming north of the irrigation ditch, and extending to the river shoreline. Furrowed rows can still be seen, and domestic debris litters the ground along the terrace edge. Debris could be found from a point just west of the Allard Pumping Station to the west fence line of the 100-K Area. Two building foundations are located in the area just west of the Allard Pumping Station and on top of the terrace that forms the river shoreline.

Early photographs also show a farm that was located on the flat, just northwest of the 100-K Area between the terrace edge and the shoreline. The homestead site can be seen just west of the 181 Pumphouse that supported the 100-KW Reactor. Early photographs indicate that this farm extended nearly to the elevated roadway to the 181-KE Pumphouse that supported the 100-KE Reactor.

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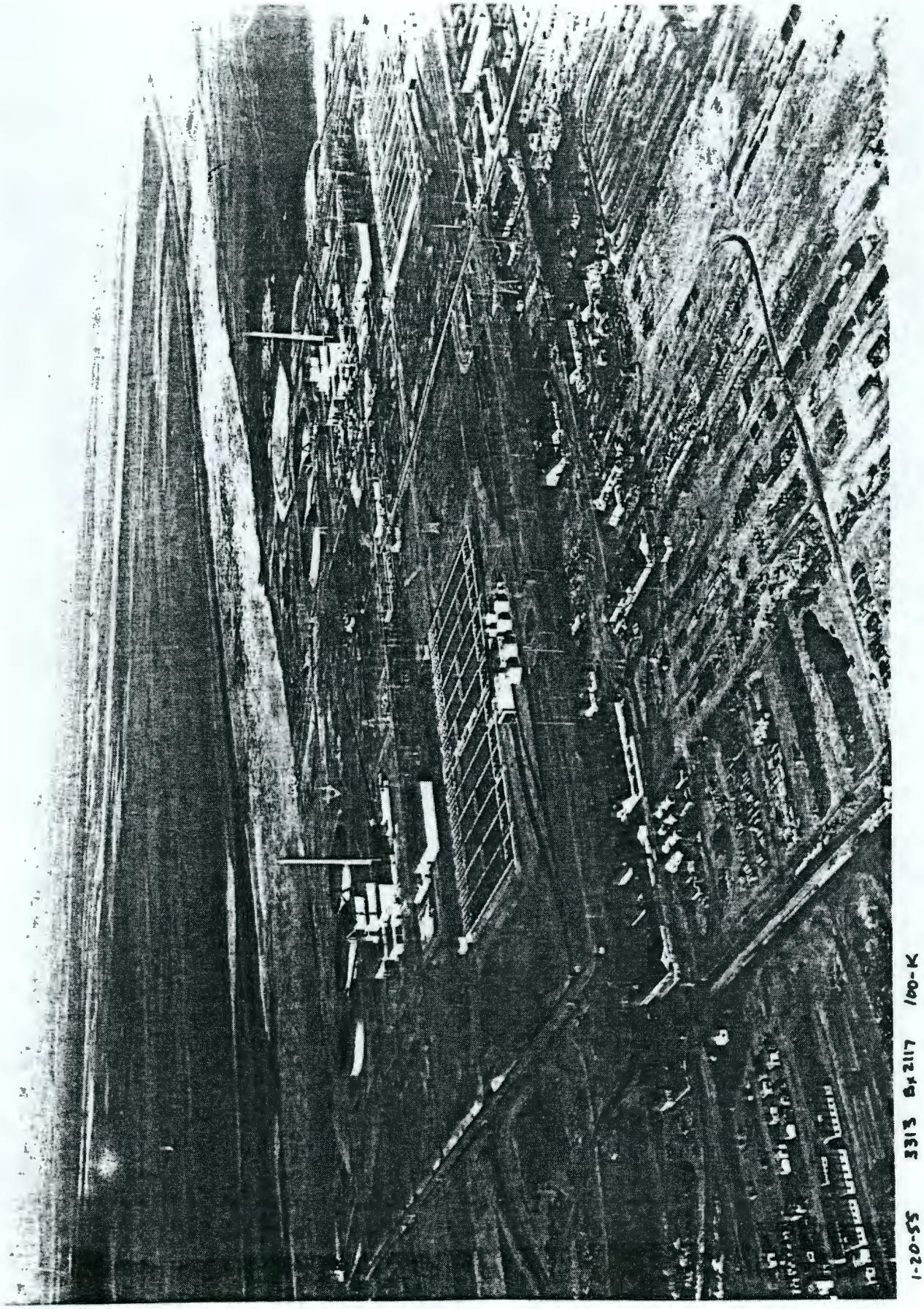
Photographs:

GSVFEK-C 2-58, U.S. Department of the Interior Geological Survey 7-1982, Hanford Site.
AAR-13A-21 7-15-1941, 100-K Area.
3373 Hanford Photograph 6-6-1955, 100-K Area.
1781 Hanford Photograph 6-5-1953, 100-K Area.
3313 Hanford Photograph 1-20-1955, 100-K Area.

Drawings:

H-1-23250, **Horizontal Rod Cave Plan and Details.**
H-1-23211-KE, **Area Layout - Roads, Railroads and Walkways.**
H-1-23215-KE, **105-KE Area Outside Pipelines, Sewers, Roads, and Railroads.**
H-1-33100, **Plot Plan and Drawing Index Water Treatment Pilot Plant.**
H-1-33101, **Architectural Head House and Basin Plan and Details.**
H-1-33419, **Chemical Storage Facility Structural Plan and Details.**


1-20-55
3313 Bx2117
100-K

9513360.1835

PART 3

BACKGROUND INFORMATION FOR THE 100-KR-2 OPERABLE UNIT

100-K SLUDGE BURIAL

Environmental Restoration Contractor **ERC Team**

Interoffice Memorandum

Job No. 22192
Written Response Required: NO
CCN:
OU: 100-KR-1
TSD: N/A
ERA: N/A
Subject Code: 8000

Environmental Restoration Contractor

Interoffice Memorandum

TO: Stephen G Weiss
T3-01

DATE: 05-01-95

COPIES: LW Pamplin/H6-07

FROM: RW Carpenter
Waste Site amd Facility Research
Office/Natural Resources
H6-03/372-9369

SUBJECT: **100-K AREA SLUDGE BURIAL**

During an oral history interview with a retired Hanford employee, Jack Goodenow, the topic of sludge disposal at 100-K Area came up. The following is an excerpt of that interview.

Jack: "We had to clean those out on occasion."

Interviewer: "The basins, about how often did you do that?"

Jack: "About every two years."

Interviewer: "At 100-K, what did you do with the sludge? Do you know where it is buried?"

Jack: "No, or yea I know it's buried, we put (it) in a large tank and hauled (it) over to the 200 Area. I had to get special equipped tanks to haul it over."

Interviewer: "Ok, so sludge from the K Basins went to the 200 Area Burial Grounds?"

Jack: "Right."

Interviewer: (looking at a 100-K Area aerial photograph) "Someone thought that there was a sludge burial trench right over here on the east end (just east of the 100-KE Retention Basins)."

Jack: "I don't think so."

Based on other recollections and information provided in this interview, I feel that the information is most likely accurate for this waste site. In researching the area earlier for the technical baseline report (WHC-SD-EN-TI-239) the only reference made that a sludge burial trench was located at the site was on pictorial type map of the 100-K Area. No documentation could be found to indicate that any sludge had been buried near the 100-K Area Retention Basins. The artist may have depicted a planned disposal site.

The area suspected of being a sludge disposal trench is in line with an irrigation ditch that once ran through the 100-K Area prior to the reactors location at the site. Because the irrigation ditch was there, one would expect to find a linear anomaly using Ground Penetrating Radar (GPR). This technology could mistakenly identify the anomaly as a suspect disposal site.

RWC

PART 4

BACKGROUND INFORMATION WITH 100-KR-2 OPERABLE UNIT

LIMITED FIELD INVESTIGATION RESULTS FROM THE 118-B-1 BURIAL GROUND (ANALOG TO 118-K-1)

From:

DOE-RL, 1994, *Limited Field Investigation Report for the 100-BC-2 Operable Unit*, DOE/RL-94-42, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

3.3.1 118-B-1 Burial Ground

3.3.1.1 Site Description. The 118-B-1 burial ground is located 914 m (3,000 ft) west of the 105-C Reactor building (Figure 1-2). The site boundaries are permanently marked with concrete posts numbered B-81-1 through B-81-31. The dimensions of the burial ground are approximately 305 x 98 m (1,000 x 321 ft) with a depth of approximately 6.1 m (20 ft). The site consists of a series of trenches, running generally east-west, perforated burials (excavations shored with railroad ties), and spline silos. Relative trench locations for the 118-B-1 burial ground are shown on Figure 3-8.

The first trench in the 118-B-1 burial ground was excavated in 1944 and the site received waste until 1973. Stenner et al. (1988) estimates that 10,000 m^3 (353,100 ft^3) of waste has been buried at this site. Trenches received general reactor wastes from the 100 B and 100 N Reactors that included aluminum tubes, irradiated facilities, thermocouples, vertical and horizontal aluminum thimbles, stainless-steel gun barrels, and expendables consisting of plastic, wood, and cardboard (Dorian and Richards 1978). Spline silos received metallic wastes (Stenner et al. 1988).

A second burial site was started in early 1950 south and adjacent to the 118-B-1 burial trenches. This area was called the 108-B solid waste burial ground and has now been incorporated into the 118-B-1 burial ground. Solid tritium wastes and high-level liquid tritium wastes sealed in 8 cm (3 in) diameter iron pipes were buried here. This site was used to dispose of contaminated tritium pots and irradiated process tubing in 1952. Another trench, in this second burial area, contains contaminated perfs. Heid (1956) discusses three trenches at this site which were covered with 1.8 m (6 ft) of soil.

A 61 x 15.2 m (200 x 50 ft) extension was added adjacent to and at the middle of the west 118-B-1 boundary in the spring of 1956. Contaminated yokes from the 105-B Reactor building were buried in the extension (Heid 1956).

Based on Miller and Wahlen (1987), the estimated decayed inventory is as follows:

Radionuclide	Quantity in curies (decayed through 7-1-93)
tritium	2,500
carbon-14	0.66
calcium-41	0.01
nickel-59	0.3
nickel-63	246
cobalt-60	127
strontium-90	0.3
silver-108m	8.6
barium-133	0.3
cesium-137	0.3
europium-152	1.6
europium-154	0.92

Estimates of metallic and other wastes for the 118-B-1 burial ground are as follows (Miller and Wahlen 1987).

Material	Amount (Tons)
Aluminum[1]	135.2
Boron[2]	1.4
Lead	30
Lead/Cadmium	201.2/8.4
Graphite	0.08
Mercury	1.0
Other[3]	527

1 Includes aluminum cans on lead/cadmium pieces, spacers, and aluminum contained in splines.

2 Includes boron from splines, vertical safety rods (VSR), and horizontal control rods (HCR).

3 Includes soft waste, desiccant, and miscellaneous materials.

3.3.1.2 Geophysical Surveys. Surface based reconnaissance GPR and EMI surveys were completed at the 118-B-1 burial ground (Bergstrom 1993). Twenty-two areas representing trenches, silos, and other large features were identified in the survey by areas of high anomaly concentration. Numerous other smaller features of unknown origin were also identified. Bergstrom (1993) presents an interpretation map of the 118-B-1 burial ground showing the 22 zones and other detected features. The report also presents an estimated depth to detected features of 0.6 to 4.3 m (2 to 14 ft) based on GPR results.

The survey indicates no buried debris occurs outside of the permanent burial ground markers, and that good definition of buried waste can be achieved using these methods.

Electro-magnetic induction was effective at locating concentrations of metallic debris possibly up to 5.5 m (18 ft) deep. Ground-penetrating radar was effective at locating objects between 0.6 and 4.3 m (2 and 14 ft) deep.

3.3.1.3 Historical Data. Historical data available for the 118-B-1 burial ground is limited to process knowledge and limited sampling conducted in 1976 (Dorian and Richards 1978). Boreholes were drilled into individual waste trenches and samples collected. The waste trenches sampled were used between the early 1940's to after 1966. The following discussion presents the results of this sampling effort.

Six borings (A - F, Figure 3-8) were drilled in trenches used between 1944 and 1956. Samples collected showed very little radioactivity. In situ GM probe readings taken in the sample holes showed background levels. The results of the in situ GM probe survey are presented on Table 3-14. Pieces of cadmium and lead with aluminum jackets were found in some samples (Dorian and Richards 1978). One sample was collected from boring A at 6.1 m (20 ft) bls for radiological analysis. The results are presented in Appendix B. The results decayed to July 1993 (17 years, 90 days) are reported on Table 3-15.

Boring G (Figure 3-8) was drilled into a trench used between 1958 and 1960. Low level contamination was first detected at 4.6 m (15 ft) bls. Geiger-Mueller counts for this sample were <100 cpm. Pieces of reactor poison were recovered from 6.1 to 6.2 m (20 to 20.5 ft) depth. A small piece of aluminum was recovered from 6.7 m (22 ft) bls that caused a GM reading of 15,000 cpm. Samples were collected from 7.6 and 9.1 m (25 and 30 ft) bls with no detectable contamination (Dorian and Richards 1978). In situ GM probe readings were taken from this boring and are reported on Table 3-14. Radiological analysis was performed on three samples. The results are presented in Appendix B. The results decayed to July 1993 (17 years, 90 days) are reported on Table 3-15.

> Borings H, I and J were drilled into trench number 13 (Figure 3-8). This trench is the southern most trench in the burial ground and is approximately 9.1 m (30 ft) wide (Dorian and Richards 1978). In boring H the first detectable radiation was 28,000 cpm at 3.7 m (12 ft) bls. The GM readings went off the scale at 5.2 m (17 ft) bls. The GM probe was changed to a low-range totem pole (LTP) probe. The maximum LTP reading was 30 mR/hr at 6.1 m (20 ft) bls. In situ GM readings for boring H are reported on Table 3-14. Results from samples collected for radiological analysis from boring H are listed in Appendix B. The results decayed to July 1993 (17 years, 90 days) are reported on Table 3-15.

Boring I showed no detectable contamination using the handheld GM probe (Table 3-14). Only one in situ GM probe result was reported in Dorian and Richards (1978). At 6.1 m (20 ft) bls the count rate was 600 cpm.

Boring J was drilled 1.8 m (6 ft) south of boring I to a depth of 9.8 m (32 ft) bls (Figure 3-8). Between 3.05 and 7.6 m (10 and 25 ft) depth, 1/2-in diameter steel tubing was encountered. Dorian and Richards (1978) reported that this tubing may have been from N Area steam generator repair. Low level contamination, <100 cpm, was first detected by a handheld GM probe at 7.6 m (25 ft) bls. At 9.3 m (30.5 ft) bls, the count rate was

600 cpm, then dropped to below 100 cpm. In situ GM probe readings are listed on Table 3-14. Results from samples collected for radiological analysis are listed in Appendix B. The results decayed to July 1993 (17 years, 90 days) are reported on Table 3-15.

No detectable radioactivity was measured from borings K and L.

Boring M samples had background handheld GM readings down to 6.1 m (20 ft) bls. Below 6.1 m (20 ft) activity levels increased to a maximum of 7,000 cpm at 7.01 and 7.6 m (23 and 25 ft) bls. In situ GM probe readings are listed on Table 3-14. Pieces of wood, plastic, sheet cadmium, concrete and other debris was recovered from this boring. Radiological sample analysis results are listed in Appendix B. The results decayed to July 1993 (17 years, 90 days) are reported on Table 3-15.

Handheld GM readings from boring N were all at background levels. In situ GM probe counts however do show contamination in the vicinity of the boring. The in situ GM probe results are presented on Table 3-14.

3.3.1.4 Analogous Sites. Sites within the 100 Areas which are analogous to the 118-B-1 burial ground are listed on Table 1-2. However, there have not been any investigations completed on analogous burial grounds.

3.3.1.5 Groundwater Impact. Only one well, 199-B8-6, is near 118-B-1 burial ground (Table 3-6). Based on water table maps for the 100-BC-5 Operable Unit LFI (DOE-RL 1993b), it is uncertain whether this well is downgradient or crossgradient from the burial ground. There are no nearby upgradient groundwater monitoring wells. The 100-BC-5 Operable Unit LFI (DOE-RL 1993b) reported that carbon-14 was detected in one round of sampling, however the following two rounds were nondetect. Tritium and technetium-99 were also detected in low concentrations (Table 3-16); however, higher concentrations of these two contaminants have been detected in wells further downgradient. Based on these data, it does not appear that the 118-B-1 burial ground is a contributing source to the groundwater.

3.3.1.6 LFI Results. No intrusive investigations were completed at the 118-B-1 burial ground as part of this LFI. Surface based reconnaissance GPR and EMI surveys were completed to locate the heaviest concentration of buried debris. The geophysical surveys indicate that buried waste is not found outside of the permanent burial ground markers and good definition of the burial trenches was achieved. The EMI method is effective at locating metallic objects possibly up to 5.5 m (18 ft) in depth and GPR is effective at locating objects between 0.61 and 4.3 m (2 and 14 ft) deep.

Based on historical radiological analysis of soil samples from borings (Dorian and Richards 1978), radionuclide contamination is present in the soils within the 118-B-1 burial ground. The migration of these contaminants within the subsurface appears to be limited. This is less certain near trenches H and J because the vertical extent of contamination is not characterized. There are no observable impacts to groundwater.

3.3.1.7 Human Health Risk Characterization. The human health risk characterization is based on Dorian and Richards (1978) historical sampling data using maximum soil concentrations detected from a depth 0 to 4.6 m (0 to 15 ft). The maximum analyte concentration at this site was detected at a depth of 4.6 m (15 ft). Maximum soil analyte concentrations and the sampling depth ranges are summarized in Table 2-7. Risks estimated for the frequent-use and occasional-use scenarios at the 118-B-1 burial ground are summarized in Table 3-17.

No COPC are estimated to represent ICR >1E-06 from ingestion or inhalation exposure pathways in the frequent-use scenario. Cobalt-60, cesium-137, europium-152, and europium-154 represent ICR >1E-06 from the external exposure pathway in the frequent-use scenario. In the occasional-use scenario cobalt-60 represents ICR >1E-06 from the external exposure pathway.

The total estimated lifetime ICR to humans was considered "medium" in the frequent-use scenario and "low" in the occasional-use scenario. The external radiation exposure is considered to be the primary pathway contributing to ICR. Cobalt-60 is considered to be the greatest contributor in both scenarios.

The total ICR anticipated, if the onset of the frequent-use scenario exposures is delayed until 2018, is 4E-05 for the frequent-use scenario and 3E-07 for the occasional-use scenario (Table 3-18). The primary pathway contributing to risk would remain the external radiation pathway and the qualitative risk classification is reduced to a "low" for the frequent-use scenario at this site (Table 3-19).

Process knowledge information indicates that this burial ground received the bulk of solid waste from the operation of 105-B Reactor as well as waste from the tritium separation program gas line (108-B building). No soil sampling data of the solid waste is available at this time, therefore no assessment of risk from this source is provided.

3.3.1.8 Human Health Risk Characterization Uncertainty Analysis. General uncertainties attributed to the methodology used in this QRA are discussed in Section 2.6.4. Uncertainties inherent in the quality of the data used in the human health risk characterization are discussed in Section 2.6.2. Moderate uncertainty is associated with the historical data used to characterize this site. Exposure uncertainty for external exposure is considered high for the 1.8 to 4.6 m (6 to 15 ft) interval in the occasional-use scenario. High uncertainty for external exposure is associated with the frequent-use scenario in the 0 to 4.6 m (0 to 15 ft) interval because future land-use has not been identified and frequent-use does not currently occur at this site. General toxicity assessment uncertainty is discussed in Section 2.6.4.2 and is considered moderate to high at this site. Table 4-1 summarizes data and exposure uncertainty.

3.3.1.9 Ecological Risk Characterization. The total calculated dose rates to the Great Basin pocket mouse from radionuclides in the burial ground soil are listed on Table 3-20 and summarized on Table 3-13. The total dose rate from radionuclides in soils 1.8 to 4.6 m (6 to 15 ft) does not exceed the EHQ (1 rad/day).

3.3.1.10 Ecological Risk Characterization Uncertainty Analysis. The uncertainty associated with the approach used in the qualitative ecological characterization is described in Section 2.5.6. Presently, the site is maintained free of vegetation, therefore leading to a reduced pocket mouse population. There is uncertainty about what vegetation would result if revegetation were allowed. The dose models assume that pocket mice are present and that a food source is growing. Therefore, the highest dose is used to assess qualitative risk, although the actual dose may be lower than this estimate. It is uncertain whether pocket mice would actually burrow to the depth of the waste or that plant roots would reach the waste since the contaminants are buried at soil depths >1.8 m (6 ft).

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PART 5

BACKGROUND INFORMATION IN THE 100-KR-2 OPERABLE UNIT

SOIL-GAS SURVEY AT THE 128-H-1 BURN PIT (ANALOG TO 128-K-1)

From:

DOE-RL, 1994, *Limited Field Investigation Report for the 100-HR-2 Operable Unit*, DOE/RL-94-53, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Westinghouse Hanford Company — **Internal Memo**

From: Site Remediation Management Section — 81353-94-002
Phone: 372-3314 H6-04
Date: January 14, 1994
Subject: SOIL-GAS SURVEY AT THE 128-H-1 BURN PIT

To: N. A. Homan H6-02

cc: I. D. Jacques H6-04
R. P. Henckel H6-02
R. C. Roos H6-04
R. G. McCain H6-04
RBK File/LB

The Site Remediation Management Section, Soil Gas Survey Team, has completed the requested soil-gas investigation at the 128-H-1 Burn Pit. The results of that investigation are detailed in the attached report.

If you have any questions or require any further information, please feel free to contact me at 372-3314 or I. D. Jacques at 376-3306.

Richard Kerkow

R. B. Kerkow, Engineer
Site Remediation
Management Section

kla

Attachment

SOIL-GAS SURVEY AT THE 128-H-1 BURN PIT
January 14, 1994

INTRODUCTION

This document reports the results of a soil-gas survey conducted by the Site Remediation Management, Soil-gas Investigation Team, in a burn pit located in the eastern portion of 128-H-1, which is in the 100-HR-2 Operable Unit. The soil-gas survey was conducted in support of the investigative strategy established for low priority waste sites as discussed in the 100-HR-2 work plan (DOE, 1993), and in the scoping meeting minutes for development of the work plan.

The soil-gas survey was requested to determine if significant quantities of volatile organic compounds (VOCs) or landfill gases (LFGs) could be detected in the vadose zone associated with the burn pit. The investigation consisted of installing 18 soil-gas probes into the region of the vadose zone 4 to 6 feet below the surface. Soil-gas vapors were field screened using two total-organic-vapor monitoring instruments, and an infrared landfill gas analyzer. Soil-gas samples were also collected and analyzed using two portable gas chromatographs (GCs). No VOC contaminants were detected by the total-vapor instruments or by the portable GCs, and the landfill gas analyzer LFG readings were at or near ambient levels.

SITE DESCRIPTION

The investigation was performed in the eastern portion of 128-H-1 (Figure 1). The site is an area approximately 50 feet wide and 450 feet long which has been excavated to a depth of about 10 feet below grade. The location is known to have been used as a burn pit and is suspected of containing residue from painting materials and paint solvents. The surface of the burn pit is comprised of a thin layer of fly-ash (less than 1-inch thick). Under the fly ash layer is river rock cobble (approximately 2-inch to 6-inch diameter river rock). The river rock cobble is characteristic of the vadose zone in the 100 Areas and has been described geologically as - the gravel with intercalated sand and silt layer of the Hanford Formation (DOE, 1993). Depth to ground water in this vicinity is estimated to be 25 to 30 feet based on existing ground water wells located in the 100 H Area.

PROBE INSTALLATION

Eighteen soil-gas probes were installed in the study area at depths of 4 to 6 feet (Figure 2). The probes were installed in accordance with Environmental Investigations Instruction (EII) 5.9, "Soil-Gas Sampling", (WHC 1988). Each probe consists of a dedicated, perforated stainless-steel point connected to an 8-foot section of ¼-inch outside diameter (OD) Teflon (a trade-mark of E. I. du Pont de Nemours & Company) tubing. The exposed end of the tubing was capped with a plastic cap prior to installation, and the soil around the tubing was firmly packed to minimize the annular space after installation. The location and depth of each probe was documented, at the time of installation, in field logbook EFL-1117, (WHC 1993b). Probe location coordinates correspond to the coordinate grid used for the Ground Penetrating Radar (GPR) Survey, conducted by the Surface Geophysics Team of WHC Geophysics on November 5, 1993, (WHC 1993c).

FIELD SCREENING INSTRUMENTS AND METHODOLOGY

Initial field screening was performed on November 29 and 30, 1993. Each probe was screened for total-VOC levels using three field screening instruments: a total-vapor photo-ionization detector (PID), a total-vapor flame ionization detector (FID), and an infrared landfill gas analyzer (IRGA). The total-vapor PID instrument is a MicroTip HL-2000 (a trademark of Photovac International, Inc.) Photoionization Detector equipped with a 10.6-eV lamp. The total-vapor FID is an OVA 128 Organic Vapor Analyzer (a trademark of Foxboro Company) Flame Ionization Detector. The IRGA is a Geo Group, Model GA-90, Infrared Gas Analyzer (a trademark of the Geotechnical Instrument Company).

The field screening instruments were calibrated, before use (daily), as follows:

- The PID was zeroed using a laboratory grade zero air standard. The instrument span was set using a standard calibration mixture of 101 ppm isobutylene (C_4H_8) in air, and the instrument response was verified using a standard calibration mixture of 9.51 ppm isobutylene in air.

- The FID was zeroed using a laboratory grade zero air standard, and the preset factory calibration was checked using standard calibration mixtures of 9 ppm and 95 ppm methane (CH_4) in air.

- The IRGA was set to the preset factory calibration settings and the instrument response was checked using a standard calibration mixture of 4.24% methane (CH_4), 5.40% carbon dioxide (CO_2), and 9.55% oxygen (O_2) in nitrogen.

Instrument readings were obtained by connecting each instrument directly to the soil-gas probe, teflon tube, using a 1-inch section of Tygon (a trademark of the Norton Company) tubing. The following methodology was used for collecting field-screening measurements:

- First, the IRGA instrument was connected to the probe and allowed to pump for 60 seconds. This time was sufficient to draw about 500 mL of soil-gas vapor thereby providing a purge volume of approximately 6 tube-volumes. The IRGA instrument reading was then recorded.

- Second, the PID instrument was attached to the probe and allowed to pump for 15 seconds. The PID instrument response was then recorded.

- Finally, the FID instrument was attached to the probe. The FID instrument response was noted for 5 seconds and then recorded. One probe (probe #6 - N380 E140) did not allow sufficient flow of oxygen to support the FID flame. In this case, the instrument was disconnected from the probe before the flame was extinguished, and the response was recorded as "No flow".

GAS CHROMATOGRAPHY INSTRUMENTS AND METHODOLOGY

On December 7 and 8, 1993, soil-gas samples were collected and analyzed using two portable Gas Chromatographs (GCs). Vapor samples of approximately 500 mL volume were collected in 1-L tedlar bags. The samples were collected via the outlet port of an Organic Vapor Monitor (OVM) (a trademark of Thermo Environmental). The battery powered pump on this device provides a flow rate of approximately 500 mL per minute. Each soil-gas probe was purged for a minimum of 60 seconds before the bag sample was drawn.

The samples were transported to the 300 area for GC analysis. One GC used is a Photovac 10S Plus (a trademark of Photovac International, Inc.) portable gas chromatograph (10S Plus). The 10S Plus is a self-contained, battery-powered portable gas chromatograph that incorporates a 10-meter, non-polar, wide-bore, capillary column and a photoionization detector (PID) which utilizes a 10.6 eV lamp. The PID is a broad-spectrum detector that is particularly sensitive to aromatic compounds, and is also able to detect many ketones and chlorinated compounds. Each sample aliquot was drawn directly from the sample bag for 10-seconds, transferring a volume of 500 uL via the sample loop to the GC column. The 10S Plus was operated at an isothermal column temperature of 40 °C and using ultra high-purity air carrier gas at a flow rate of 8 mL/min.

The 10S Plus makes qualitative identification of compounds by comparing observed retention times with an established method library of VOC compounds. Quantification is based on peak area, as adjusted by appropriate response factors for each compound of interest. Three-point calibration curves have been developed for a wide variety of VOC contaminants commonly detected at hazardous waste sites. At the beginning of each sampling day, the 10S Plus was calibrated using a gas calibration standard containing 1 ppm each of benzene, toluene, ethyl benzene and o-xylene. The acceptable calibration tolerance is ± 10% (ASTM 1993).

The other GC used is a Sentex Scentograph (a trademark of Sentex Systems Incorporated) portable gas chromatograph. The Scentograph is a self-contained, battery-powered portable gas chromatograph that incorporates a 30-meter, non-polar, wide-bore, capillary column and an argon ionization detector (AID). The AID is a broad-spectrum detector with an effective ionization potential of 11.7 eV. Each sample aliquot is drawn into the Scentograph from the sample bag by an on-board pump. The sample is routed via a tenax trap preconcentrator then desorbed at high temperature into the GC column for separation. The Scentograph was operated using an isothermal column temperature of 60 °C and using high-purity argon carrier gas at a flow rate of 9.4 mL/min.

The Sentograph makes qualitative identification of compounds by comparing observed retention times with an established method library of VOC compounds. Quantification of compounds is based on comparison of an observed peak area and a peak of known concentration in the method library. A calibration standard containing carbon tetrachloride (CCl_4), chloroform (TCM), trichloroethylene (TCE), 1,1,1-trichloroethane (111-TCA), 1,1,2-trichloroethane (112-TCA), and tetrachloroethylene (PCE) was prepared each sampling day by adding headspace vapor above laboratory-grade pure chemical standards to a tedlar bag containing 1.5 L high-purity air. The calibration standard was analyzed to establish the method library.

RESULTS AND DISCUSSION

Probe Installation

Eighteen probes were installed in the investigation. All probes were driven beyond the minimum depth of 4-feet, and eight of the eighteen probes were driven beyond a depth of 5-feet. The deepest probe is probe #9 at 5.5 feet. One probe, probe #6, appears to be completely plugged, as it would not allow enough flow to permit sampling by the FID or IRGA. Several attempts to unplug probe #6 were unsuccessful indicating that the probe tip may have been damaged during installation causing the inlet to become irreversibly plugged. Replacement of probe #6 was contemplated, but was not considered cost effective or necessary based on data from surrounding probes. Another probe, probe #17, was found to be partially plugged, with silt, when it was first sampled. This probe was successfully unplugged and most of the silt was removed with suction. The remaining sixteen probes provided normal flow, when sampled, and appear to be functioning normally.

Field Screening Results

No significant levels of VOCs or LFGs were detected during the initial field screening phase of the investigation. Field Screening results are summarized on Table 1-1. The total-vapor PID readings of up to 0.3 ppm are not considered significant because they are not supported by any of the FID or GC data. Additionally, the PID readings were discounted because the PID detector is known to be affected by high moisture conditions (weather conditions at the time of field screening consisted of low clouds, fog and light drizzle with humidity at or near 100%). FID readings were reported as "negative-response" (N-R) because the instrument gauge moved from an arbitrary ambient setting of 3.0 ppm to a reading of approximately 1.5 ppm when connected to the probe tubing (a net change of negative 1.5 ppm). IRGA readings indicated no LFG levels of concern. No methane gas was detected at any of the probes and the oxygen level readings were at or near ambient conditions. Carbon dioxide readings showed slightly elevated levels at probes 5, 7, 8, 9 and 10, with probe 9 showing the highest level at 1.3% (v/v). Carbon dioxide gas, in the vadose zone, is generally produced as a by product of microbial decomposition of organic materials. The carbon dioxide readings observed in this investigation may indicate some microbial activity in this region of the burn pit, but are not considered significant enough to warrant further study.

Gas Chromatography Results

No VOC contaminants were detected by gas chromatograph, in excess of the minimum detection levels established for the GCs used in this survey. Minimum GC detection levels for a number of VOCs commonly associated with hazardous waste sites are identified on Table 1-2, *Soil-Gas Analytes for the 128-H-1 Burn Pit Investigation*. Minimum detection levels were established for each contaminant by ensuring that reported values are greater than at least twice the baseline noise level on the instrument (ASTM 1993).

Quality control samples for the GC analysis included: equipment blanks, ambient air samples, field duplicate samples, and calibration standards.

REFERENCES

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DOE, 1993, RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-HR-2 Operable Unit, DOE/RL-93-20 Draft A-1, November, 1993, United States Department of Energy, Richland, Washington.

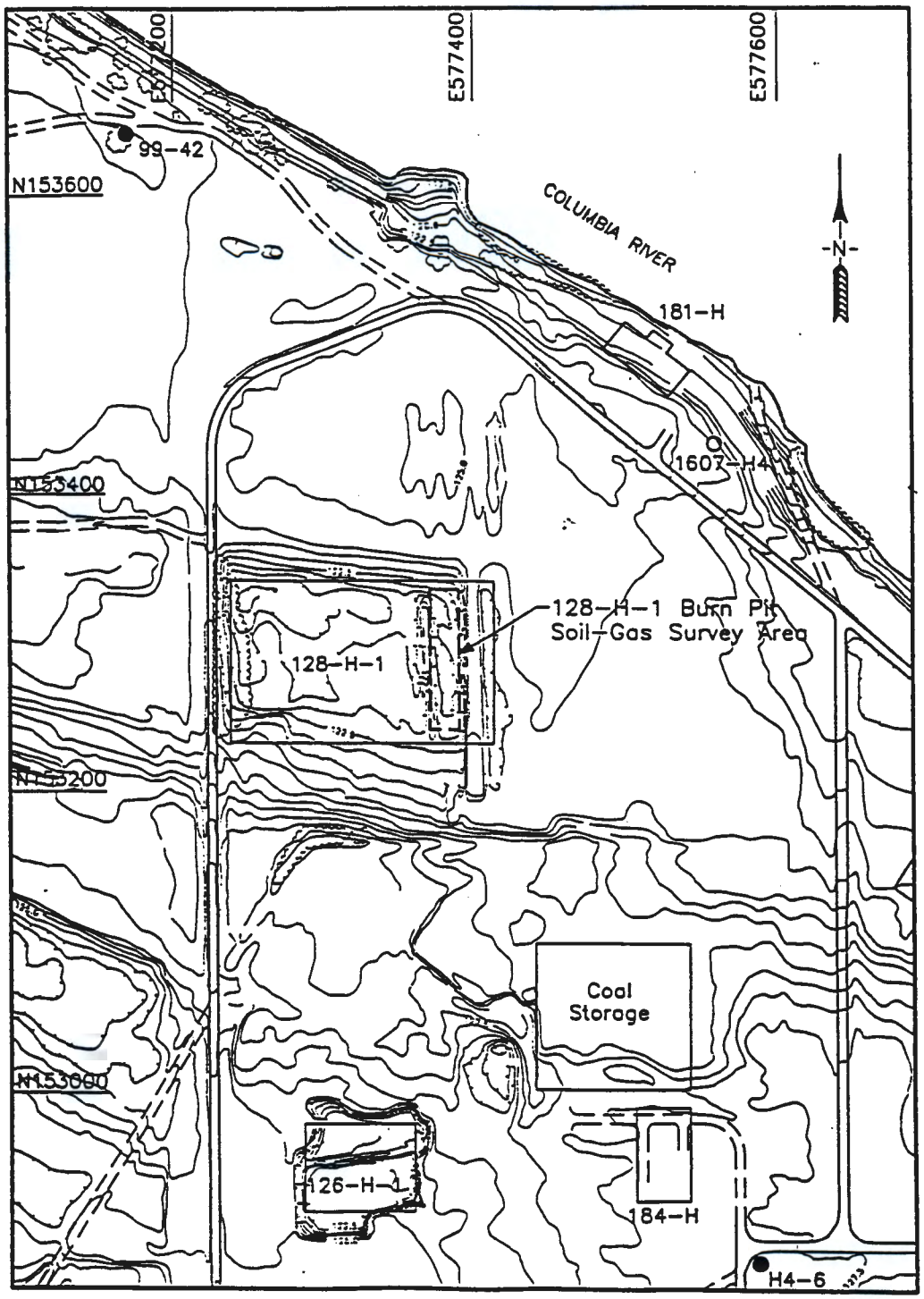
WHC, 1993a, WHC Internal Memo 81353-93-053, I. D. Jacques to N. A. Homan, Subject: *128-H-1 BURN PIT SOIL-GAS SURVEY*, November 5, 1993, Westinghouse Hanford Company, Richland, Washington.

WHC, 1993b, *128-H-1 Investigation Field Logbook*, EFL-1117, Westinghouse Hanford Company, Richland, Washington.

WHC, 1993c, *128-H-1 Burn Pit Ground Penetrating Radar (GPR) Report* WHC-SD-EN-TI-217, December, 1993, Westinghouse Hanford Company, Richland, Washington.

WHC, 1988, *Environmental Investigations and Site Characterization Manual* WHC-CM-7-7, Westinghouse Hanford Company, Richland, Washington.

Figure A-3 Location of the 128-H-1 Burn Pit



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SOIL-GAS SURVEY AT THE 128-H-1 BURN PIT
January 14, 1994

Figure A-4 Soil-Gas Probe Locations in the 128-H-1 Burn Pit

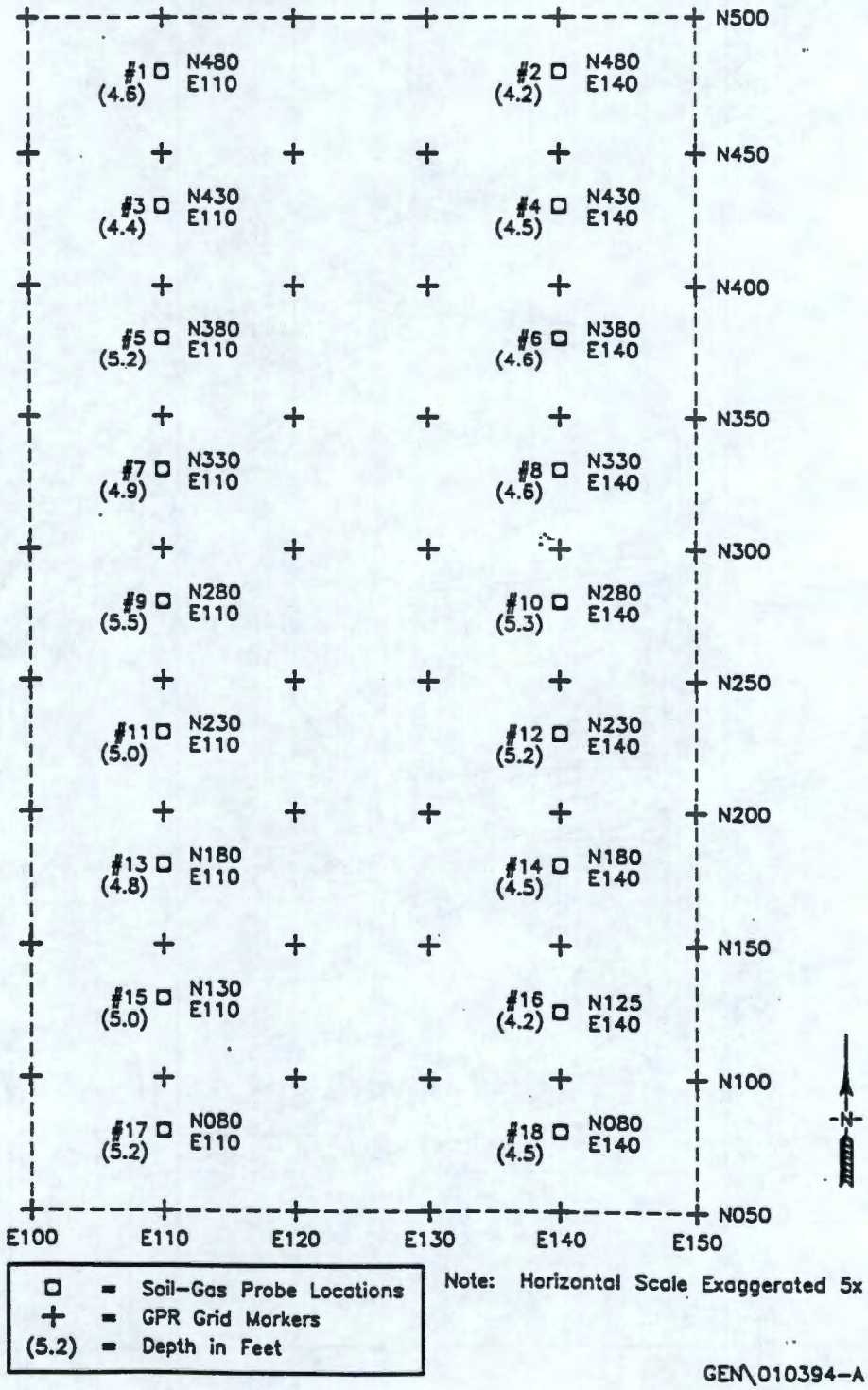

Table A-2. Field Screening Results for the 128-H-1 Burn Pit Investigation

Probe #	GPR Coordinates		Depth (feet)	Micro-Tip PID (ppm)	OVA-128 FID (ppm)	GEO TECH - IRGA CH4 (%)	CO2 (%)	02 (%)
1	N480	E110	4.6	0.1	N-R	0.0	0.2	21.5
2	N480	E140	4.2	0.0	N-R	0.0	0.2	21.5
3	N430	E110	4.4	0.0	N-R	0.0	0.1	21.6
4	N430	E140	4.5	0.0	N-R	0.0	0.1	21.6
5	N380	E110	5.2	0.1	N-R	0.0	0.3	21.6
6	N380	E140	4.6	0.0	No flow	NA	NA	NA
7	N330	E110	4.9	0.3	N-R	0.0	0.5	21.3
8	N330	E140	4.6	0.0	N-R	0.0	0.4	21.3
9	N280	E110	5.5	0.0	N-R	0.0	1.3	20.9
10	N280	E140	5.3	0.3	N-R	0.0	0.4	21.3
11	N230	E110	5.0	0.2	N-R	0.0	0.2	21.3
12	N230	E140	5.2	0.3	N-R	0.0	0.2	21.3
13	N180	E110	4.8	0.1	N-R	0.0	0.2	21.3
14	N180	E140	4.5	0.2	N-R	0.0	0.0	21.4
15	N130	E110	5.0	0.1	N-R	0.0	0.1	21.3
16	N125	E140	4.2	0.0	N-R	0.0	0.1	21.4
17	N080	E110	5.2	0.0	N-R	0.0	0.1	21.4
18	N080	E140	4.5	0.0	N-R	0.0	0.1	21.4

NOTES: N-R = Negative response on FID (indicator needle moved from 3 ppm to 1.5ppm when attached to soil-gas tubing)

NA = Not available (the pump meter on the Geo Tech - IRGA switched OFF automatically due to lack of flow)

Table A-3. Soil-Gas Analytes for the 128-H-1 Burn Pit Investigation

Analyte	CAS Number	Chemical Formula	Molecular Weight	I.P. (eV)	Minimum Detection
Acetone	67-64-1	CH_3COCH_3	58.08[1]	9.69[2]	50 ppb [p]
Benzene	71-43-2	C_6H_6	78.11[2]	9.24[3]	50 ppb [p]
Carbon tetrachloride	56-23-5	CCl_4	153.82[2]	11.47[2]	150 ppb [s]
Chloroform	67-66-3	$CHCl_3$	119.38[2]	11.42[2]	200 ppb [s]
1,2-dichloroethane	107-06-2	$ClCH_2CH_2Cl$	98.96[2]	11.05[2]	200 ppb [p]
cis-1,2-dichloroethylene	540-59-0	$ClCH=CHCl$	96.94[2]	9.65[3]	50 ppb [p]
dichloromethane (methylene chloride)	75-09-2	CH_2Cl_2	84.93[2]	11.35[2]	50 ppb [p]
Ethylbenzene	100-41-4	$C_6H_5CH_2CH_3$	106.2[2]	8.76[2]	50 ppb [p]
Methyl Ethyl Ketone	78-93-3	$CH_3COCH_2CH_3$	72.1[1]	9.54[2]	50 ppb [p]
Methyl Isobutyl Ketone	108-10-1	$CH_3COCH_2CH(CH_3)_2$	100.2[1]	9.30[2]	50 ppb [p]
1,1,2,2-Tetrachloroethane	79-34-5	$CHCl_2CHCl_2$	167.9[2]	11.10[3]	250 ppb [s]
Tetrachloroethylene	127-18-4	$Cl_2C=CCl_2$	165.83[2]	9.32[3]	50 ppb [s]
Toluene	108-88-3	$C_6H_5CH_3$	92.11[2]	8.82[2]	50 ppb [p]
1,1,1-Trichloroethane	71-55-6	CH_3CCl_3	133.40[2]	11.00[3]	100 ppb [s]
1,1,2-Trichloroethane	79-00-5	$CHCl_2CH_2Cl$	133.40[2]	11.00[3]	50 ppb [s]
Trichloroethylene	79-01-6	$ClCH=CCl_2$	131.39[2]	9.45[3]	50 ppb [s]
m-xylene	1330-20-7	$C_6H_4(CH_3)_2$	106.2[2]	8.56[2]	50 ppb [p]
o-xylene	1330-20-7	$C_6H_4(CH_3)_2$	106.2[2]	8.56[2]	50 ppb [p]

ppb [p] = Photovac 10s Plus, portable GC with PID (10.6 eV lamp) and 10 meter capillary column
ppb [s] = Sentex Sentograph, portable GC with AID and 30 meter capillary column

1. Montgomery, J.H., and L.M. Welkom, 1989, Groundwater Chemicals Desk Reference, Lewis Publishers, Inc., Chelsea, Michigan.

2. Verschueren, K., 1983, Handbook of Environmental Data on Organic Chemicals, Second Edition, Van Nostrand Reinhold, New York.

3. NIOSH, 1990, Pocket Guide to Chemical Hazards, National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, Washington, D.C.

Table A-4. 128-H-1 Burn Pit Soil Gas Sampling Data.

Analyte	Minimum Detection Limit (ppb)**
	Sampled December 1993
Acetone	50 (a)
Benzene	50 (a)
Carbon tetrachloride	150 (b)
Chloroform	200 (b)
1,2-dichloroethane	200 (a)
cis-1,2-dichloroethylene	50 (a)
dichlormethane	50 (a)
Ethylbenzene	50 (a)
Methyl Ethyl Ketone	50 (a)
Methyl Isobutyl Ketone	50 (a)
1,1,2,2-Tetrachloroethane	250 (b)
Tetrachloroethylene	50 (b)
Toluene	50 (a)
1,1,1 - Trichlorethane	100 (b)
1,1,2-Trichloroethane	50 (b)
Trichloroethylene	50 (b)
m-xylene	50 (a)
o-xylene	50 (a)

**No analyte measured above minimum detection limits

(a) = Photovac 10s Plus (a trademark of Photovac International Inc), portable GC with PID (10.6 eV lamp) and 10 meter capillary column

(b) = Sentex Sentograph (a trademark of Sentex System Inc), portable GC with AID and 30 meter capillary column

ATTACHMENT 3

100-KR-2 OPERABLE UNIT WASTE SITE VOLUME ESTIMATES

Volume Estimate
100-KR-2 Operable Unit

OBJECTIVE

Provide estimates of the following:

- The volume of contaminated materials within selected waste sites in the 100-KR-2 Operable Unit.
- The volume of materials that will need to be excavated to remove the contaminated materials.
- The areal extent of contamination.

Estimates are provided for the following waste sites:

IRM Candidate Site Number and Name	Page
116-KE-3 Storage Basin French Drain	KA1-5
116-KW-2 Storage Basin French Drain	KA1-6
120-KE-2 Filter Water Facility French	KA1-7
120-KW-2 Filter Water Facility French	KA1-8
119-KW French Drain	KA1-9
118-K-1 Burial Ground	KA1-10
118-K-2 Sludge Trench	KA1-11
116-KE-1 Condensate Crib	KA1-12
116-KW-1 Condensate Crib	KA1-13
116-KE-2 Waste Crib	KA1-14

Volume Estimate
100-KR-2 Operable Unit

METHOD

The following steps are used to calculate volumes and areas for each waste site:

- Estimate the dimensions of each waste site.
- Estimate the location of the site.
- Estimate the extent of contamination present at each site.
- Estimate the extent of the excavation necessary to remove the contamination present.
- Calculate the volume of contamination present, the volume of material to be removed, and the areal extent of contamination.

Waste Site Dimensions

Dimensions of the waste site are derived from all pertinent references.

Waste Site Location

Location of the waste site is derived from pertinent references, confirmed by field visits. The specific reference or method used to locate each site is discussed in a separate brief. Coordinates for each waste site are converted to Washington State coordinates. Resulting Washington State coordinates are presented herein.

Contaminated Volume Dimensions

The extent of contamination present at the waste site is estimated from analytical data that exists for the site. The data used, assumptions made, and method for estimating extent is discussed in a separate brief. Dimensions are summarized herein.

Excavated Volume Dimensions

The extent of the excavation necessary to remove the contamination is based on a 1.5 H : 1.0 V excavation slope with the extent of contamination at depth serving as the bottom of the excavation.

Volume and Area Calculations

The above information is used to construct a digital terrain model of each site within the computer program AutoCad[1]. The computer program Softdesk[2] is then used to calculate volumes and areas for the waste site.

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[1]Autocad is a tradename of Autodesk, Inc.

[2]Softdesk is a tradename of Softdesk, Inc.

Volume Estimate
100-KR-2 Operable Unit

ASSUMPTIONS

The following assumptions were used to locate and/or provide dimensions for a waste site if no other data exist. Assumptions concerning extent of contamination are provided in Carpenter and Cote (1994), and Dorian and Richards (1978).

Burial Grounds

- Burial grounds were completely filled.

Liquid Waste Sites

- Trenches were built with 1.0 H : 1.0 V side slopes.

The following assumptions were used to calculate volumes and areas:

- No site interferences or overlaps are considered; volumes and areas are calculated for each waste site separately.

- All depths are belowgrade unless otherwise noted.

REFERENCES

Carpenter, R. W., and S. L. Cote, 1994, *100-K Area Technical Baseline Report*, WHC-SD-EN-TI-239, Westinghouse Hanford Company, Richland, Washington.

DOE-RL, 1994a, *Annual Report for RCRA Groundwater Monitoring*, DOE/RL-94-136, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1994b, *Hanford Site Waste Information Data System* (WIDS), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-DR-2 Operable Unit, Hanford Site, Richland, Washington*, DOE/RL-93-46, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Dorian, J. J. and V. R. Richards, 1978, *Radiological Characterization of the Retired 100 Areas*, UNI-946, United Nuclear Industries, Richland, Washington.

Volume Estimate
100-KR-2 Operable Unit

Site Number: 116-KE-3
Site Name: 105-KE Storage Basin French Drain

Waste Site Dimensions
Diameter: 18.3 m (60 ft) surface diameter, 6.1 m (20 ft) diameter at the structure about 8.84 m (29 ft) below grade, 3 m (10 ft) diameter bottom dimension
Depth/Height: 23.8 m (78 ft) below grade (in ground water)

Contaminated Volume Dimensions (rounded to nearest ft)
Overburden about 6.10 m (20 ft) deep, slope of 18.3 m (1 to 1.5 ft, 60 ft) to 6.1 m (20 ft) diameter
Diameter: 7.6 m (25 ft)
Depth/Height: 14.6 m (48 ft)

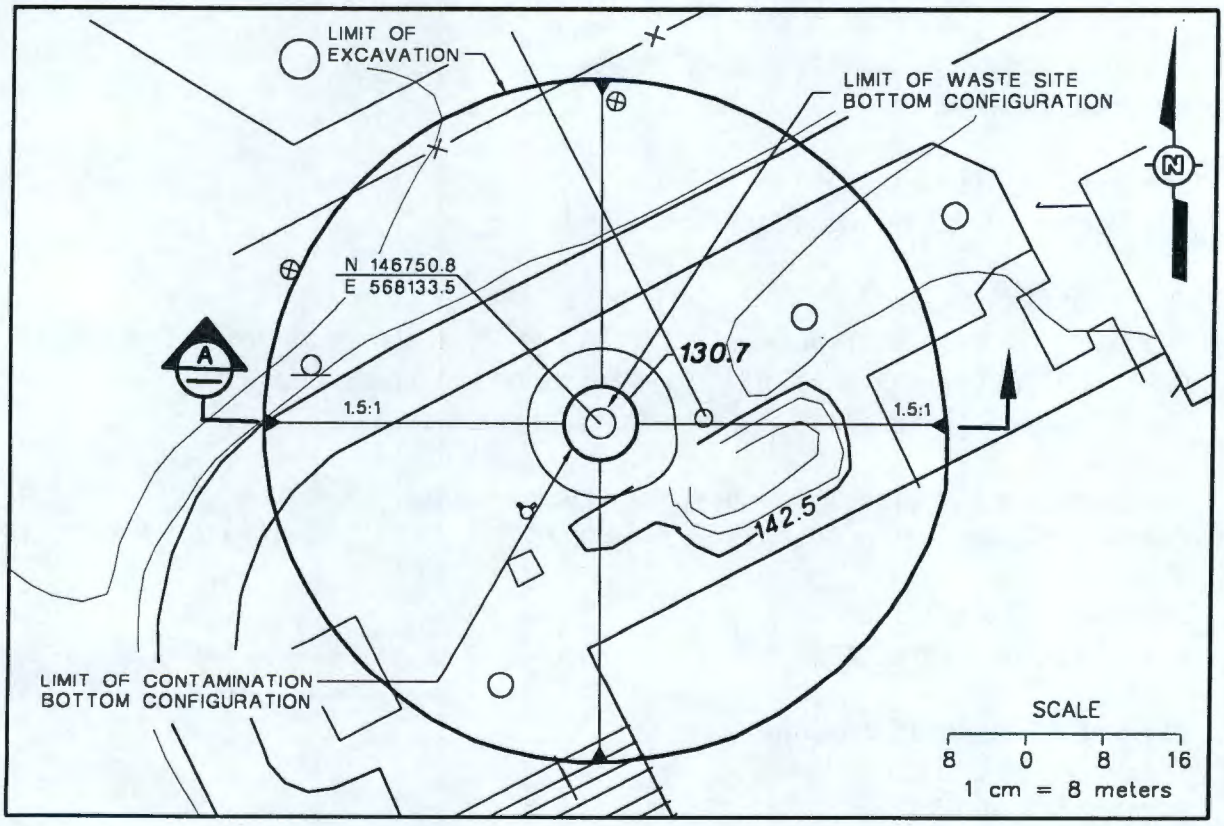
Excavated Volume Dimensions
Diameter: 71.6 m (234.7 ft)
Depth: 20.7 m (68 ft)

Waste Site Location
E: 568133.53
N: 146750.81
Reference: WCS83S (Arcview)

Elevations
Surface: 141.6 m MSL (464.5 ft MSL)
Reference: H-1-23207
Groundwater: 20.73 m (68 ft) below grade

Assumptions: assumes that site is identical (size and contamination) to 116-KW-2

116-KE-3



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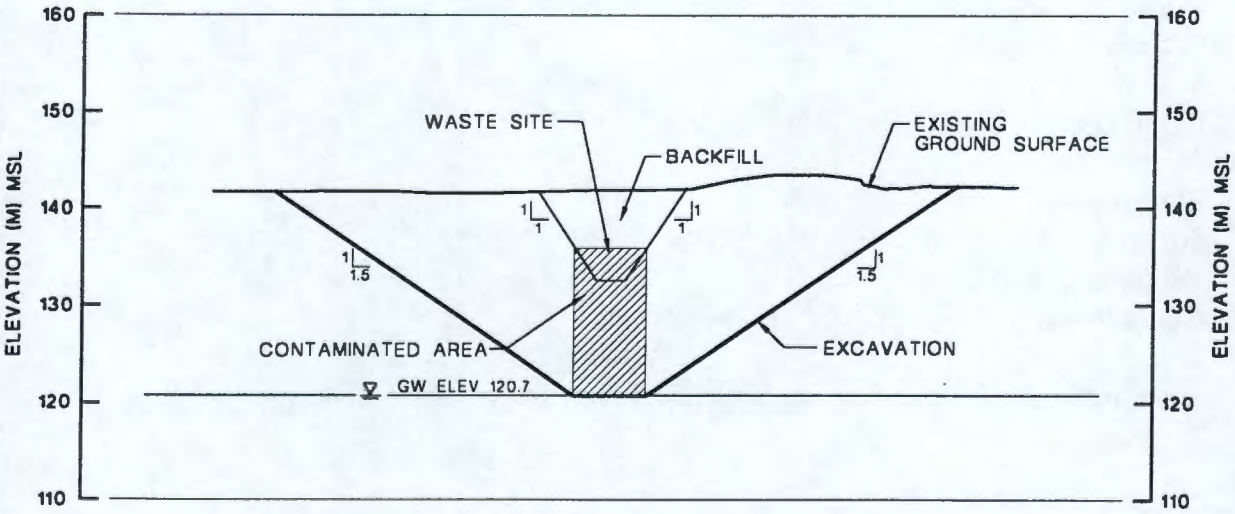


VERTICAL EXAGGERATION : 1x

A SECTION

EXTENT OF CONTAMINATION

SURFACE AREA : 45.6 sq. meters
VOLUME : 667 cu. meters

EXTENT OF EXCAVATION

SURFACE AREA : 4,022 sq. meters
VOLUME : 31,383 cu. meters

116KE3

CHECKPRINT NO. 1 DATE 6/7/95
PROJECT 100 KR2 PPS
CHECKED BY _____ DATE _____

Volume Estimate
100-KR-2 Operable Unit

Site Number: 116-KW-2
Site Name: 105-KW Storage Basin French Drain

Waste Site Dimensions
Diameter: 18.3 m (60 ft) surface diameter, 6.1 m (20 ft) diameter at the structure about 8.84 m (29 ft) below grade; 3 m (10 ft) diameter bottom dimension
Depth/Height: 23.8 m (78 ft) below grade (in groundwater)

Contaminated Dimensions (rounded to nearest ft)
Overburden about 6.10 m (20 ft) deep, slope of 18.3 m (1 to 1.5 ft, 60 ft) to 6.1 m (20 ft) diameter
Diameter: 7.6 m (25 ft)
Depth/Height: 14.6 m (48 ft) below grade

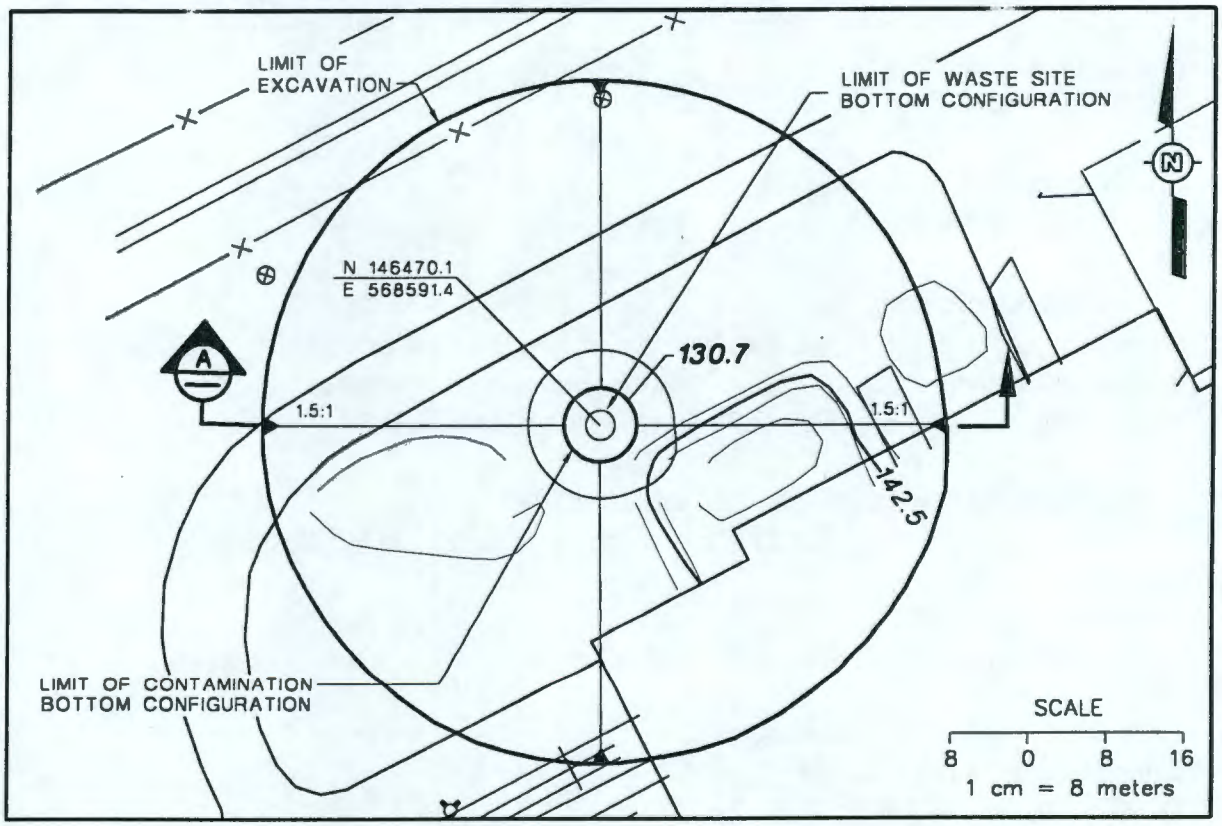
Excavated Volume Dimensions
Diameter: 71.6 m (234.7 ft)
Depth: 20.7 m (68 ft)

Waste Site Location
E: 568591.4
N: 146470.1
Reference: WCS83S (Arcview)

Elevations
Surface: 141.6 m MSL) 464.5 ft MSL
Reference: H-1-23207
Groundwater: 20.73 m (68 ft) below grade

Assumptions: assumes that site is identical (size and contamination) to 116-KE-3.

116-KW-2



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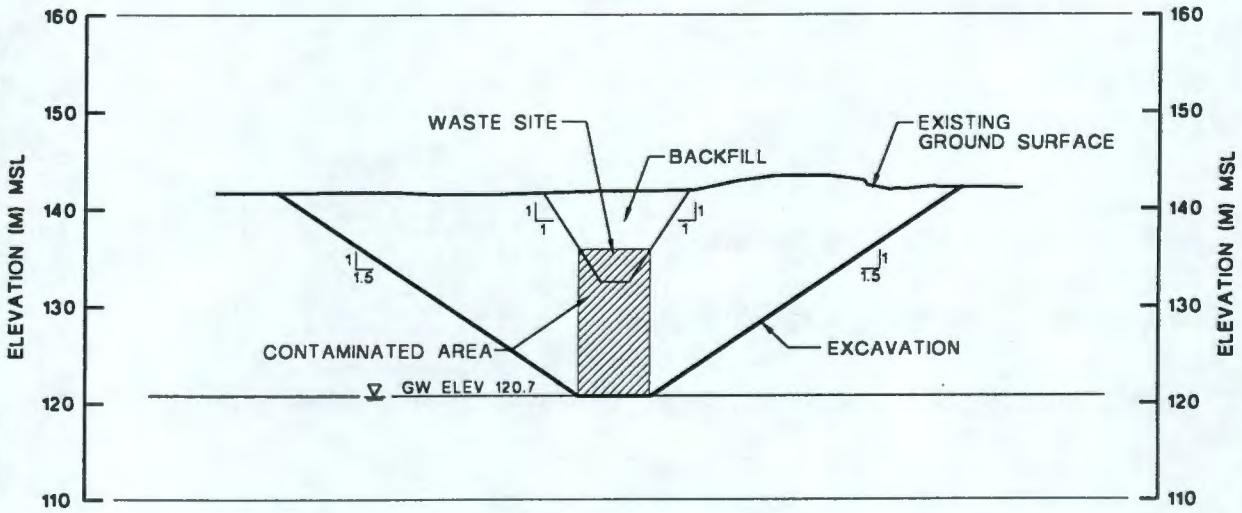


VERTICAL EXAGGERATION : 1x

A SECTION

EXTENT OF CONTAMINATION

SURFACE AREA : 45.6 sq. meters
VOLUME : 667 cu. meters

EXTENT OF EXCAVATION

SURFACE AREA : 4,022 sq. meters
VOLUME : 31,383 cu. meters

116KW2

CHECKPRINT NO. 1 DATE 6/7/95
PROJECT 100KR2 FFS
CHECKED BY _____ DATE _____

Volume Estimate
100-KR-2 Operable Unit

Site Number: 120-KE-2
Site Name: 183-KE Filter Water Facility French Drain
(Technical Baseline Report, WHC-SD-EN-TI-239, Rev. 0 erroneously identifies it as the 183-KE Filter Waste Facility French drain, "Waste" should have been Water.)

Waste Site Dimensions
Diameter: 0.91 m (3 ft) diameter
Depth/Height: 3.35 m (11 ft) below grade

Contaminated Volume Dimensions
Overburden 1.52 m (5 ft) deep, 3.96 m (13 ft) diameter
Diameter: 3.96 m (13 ft)
Depth/Height: 3 m (10 ft)
Volume: 37.5 m^3 (1324 ft^3)

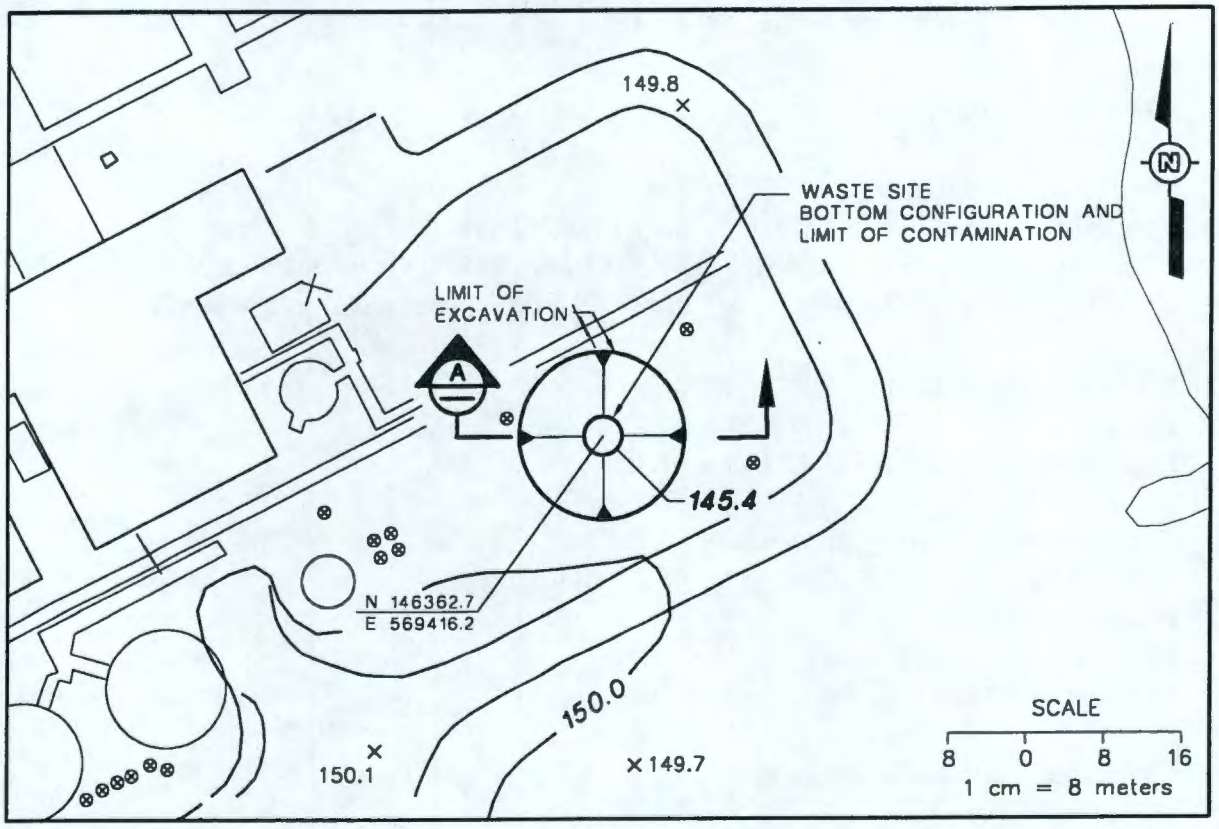
Excavated Volume Dimensions
Diameter: 17 m (56 ft)
Depth: 4.57 m (15 ft)
Volume: 442 m^3) 14,283 ft^3

Waste Site Location
E: 569416.21
N: 146362.69
Reference: WCS83S (Arcview)

Elevation
Surface: 150 m MSL (492.5 ft MSL)
Reference: WIDS
Groundwater: 20.73 m (68 ft) below grade

Assumptions: assumes that site is identical (size and contamination) to 120-KW-2

120-KE-2



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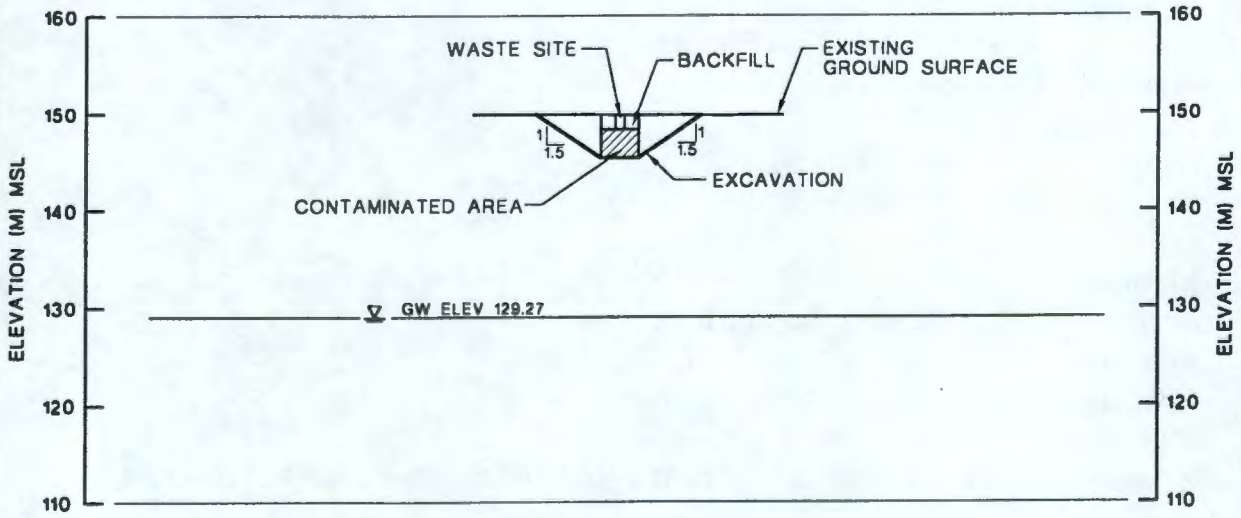


VERTICAL
EXAGGERATION : 1x

A SECTION

EXTENT OF CONTAMINATION

SURFACE AREA : 12.3 sq. meters
VOLUME : 37.5 cu. meters

EXTENT OF EXCAVATION

SURFACE AREA : 230 sq. meters
VOLUME : 442 cu. meters

120KE2

CHECKPRINT NO. 1 DATE 5/24/95
PROJECT 100 KR2 FFS
CHECKED BY _____ DATE _____

Volume Estimate
100-KR-2 Operable Unit

Site Number: 120-KW-2
Site Name: 183-KW Filter Water Facility French Drain

Waste Site Dimensions
Diameter: 0.91 m (3 ft) diameter; original excavation 3.96 m (13 ft) diameter
Depth/Height: 3.35 m (11 ft) below grade

Contaminated Volume Dimensions
Overburden 1.52 m (5 ft) deep, 3.96 m (13 ft) diameter
Diameter: 3.96 m (13 ft)
Depth/Height: 3 m (10 ft)
Volume: 37.5 m^3 (1324 ft^3)

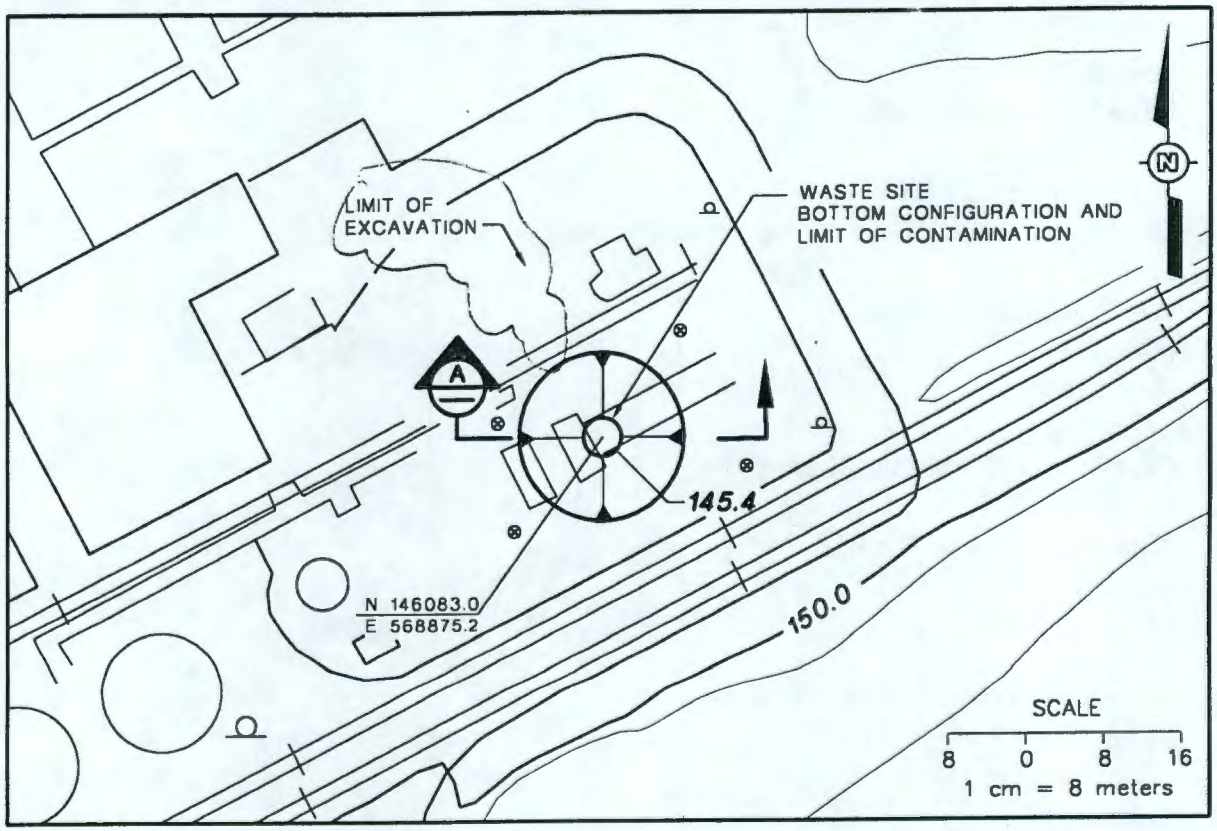
Excavated Volume Dimensions
Diameter: 17 m (56 ft)
Depth: 4.57 m (15 ft)
Volume: 442 m^3 (14,283 ft^3)

Waste Site Location
E: 568875
N: 146083
Reference: WCS83S (Arcview)

Elevations
Surface: 141.43 m MSL (464 ft MSL)
Reference: WIDS
Groundwater: 20.73 m (68 ft) below grade

Assumptions: assumes that site is identical (size and contamination) to 120-KE-2

120-KW-2



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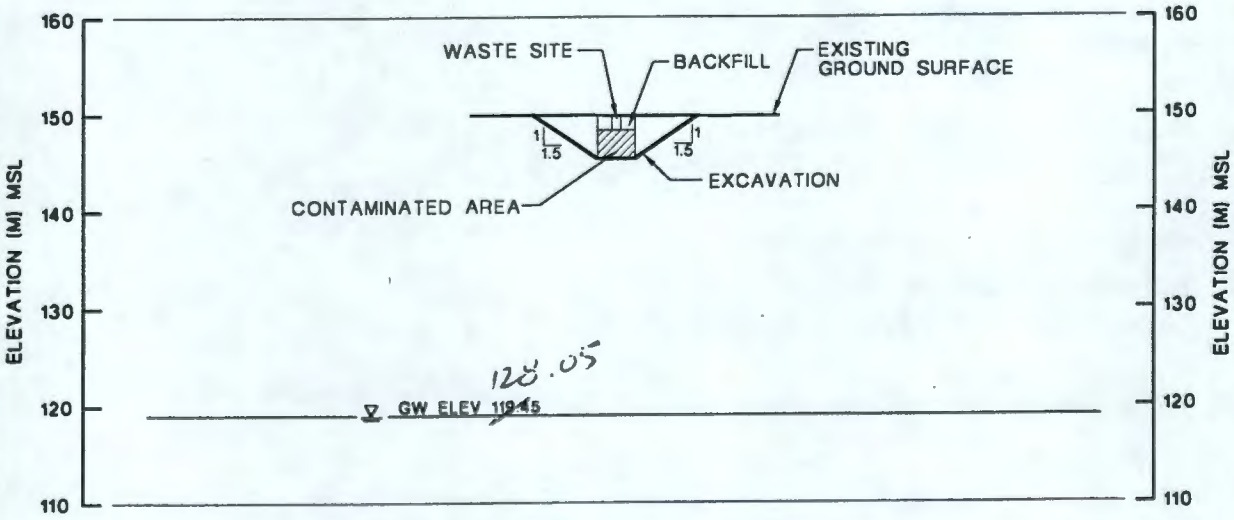


VERTICAL EXAGGERATION : 1x

A SECTION

EXTENT OF CONTAMINATION

SURFACE AREA : 12.3 sq. meters
VOLUME : 37.5 cu. meters

EXTENT OF EXCAVATION

SURFACE AREA : 230 sq. meters
VOLUME : 442 cu. meters

120KW2

CHECKPRINT NO. 1 DATE 5/25/95
PROJECT 100KR2 PFS
CHECKED BY _____ DATE _____

Volume Estimate
100-KR-2 Operable Unit

Site Number: 119-KW French Drain
Site Name: 119-KW French Drain

Waste Site Dimensions
Diameter: 0.30 m (1 ft) surface diameter
Depth/Height: 3 m (10 ft) below grade

Contaminated Dimensions (rounded to nearest ft)
Diameter: 0.30 m (1 ft) surface diameter
Depth/Height: 3 m (10 ft)

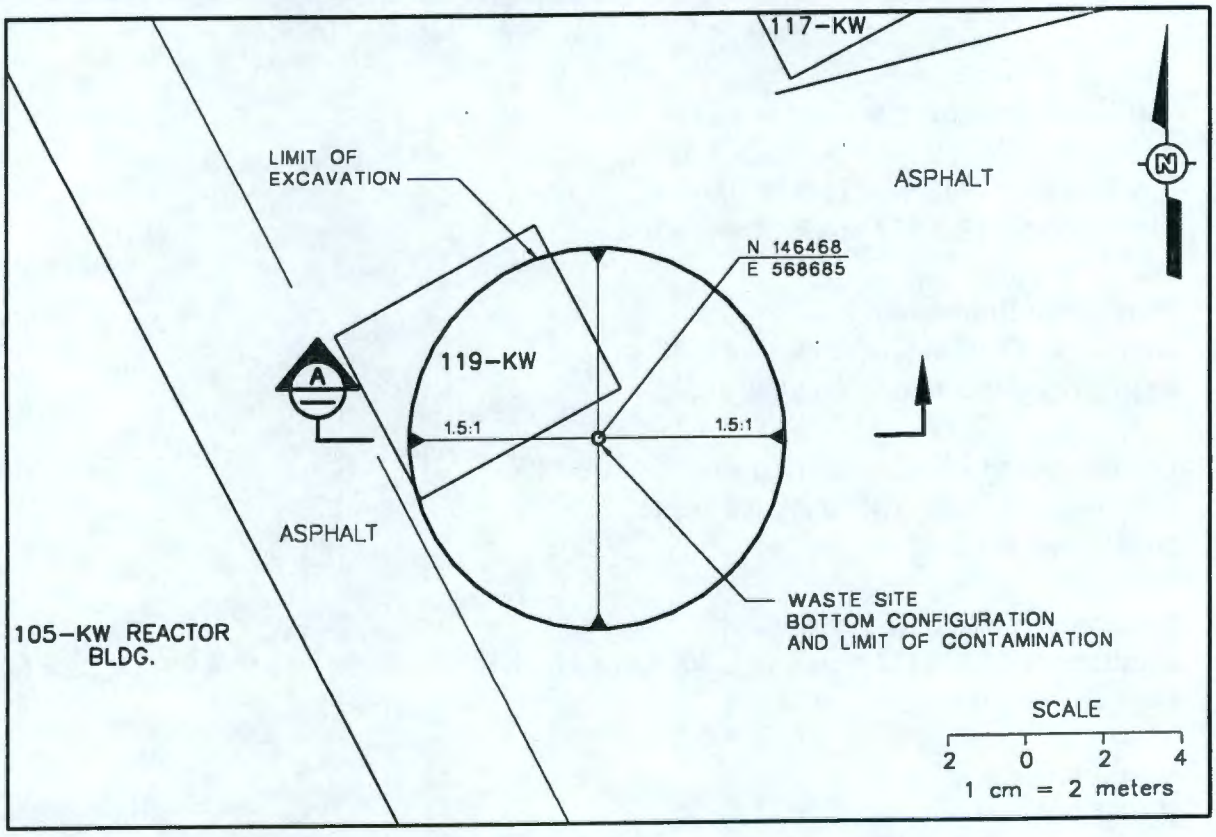
Excavated Volume Dimensions
Diameter: 9.83 m (32.5 ft) top; 0.30 m (1 ft) bottom
Depth: 3 m (10 ft)

Waste Site Location
E: 568685
N: 146468
Reference: WCS83S (Arcview)

Elevations
Surface: 141.7 m MSL (465 ft MSL)
Groundwater: 20.7 m (68 ft) below grade

Assumptions: This site is not known to have received radionuclide or chemical contamination; however, it is posted with surface contamination warning signs.

119-KW



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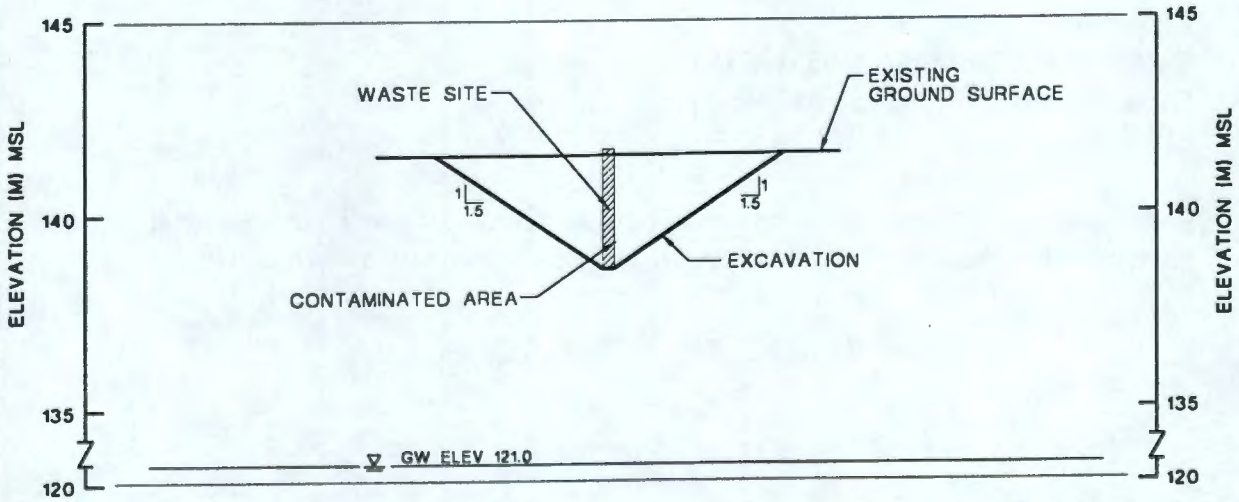


VERTICAL EXAGGERATION = 1x

A SECTION

EXTENT OF CONTAMINATION

SURFACE AREA = 0.071 sq. meters
VOLUME = 0.21 cu. meters

EXTENT OF EXCAVATION

SURFACE AREA = 76 sq. meters
VOLUME = 116 cu. meters

119KWFD

5/22/95
100KR2 FFS

Volume Estimate
100-KR-2 Operable Unit

Site Number: 118-K-1
Site Name: 100-K Burial Ground

Waste Site Dimensions
Length: 241 m (790 ft)
Width: 136 m (446 ft)
Depth/Height: Trenches 6.1 m (20 ft) Silos 7.62 m (25 ft) below grade

Contaminated Volume Dimensions
Overburden 1.22 to 1.83 m (4 to 6 ft)
Length: 241 m (790 ft), slope 1 to 1.5 ft
Width: 136 m (446 ft)
Depth/Height: 7.62 m (25 ft)

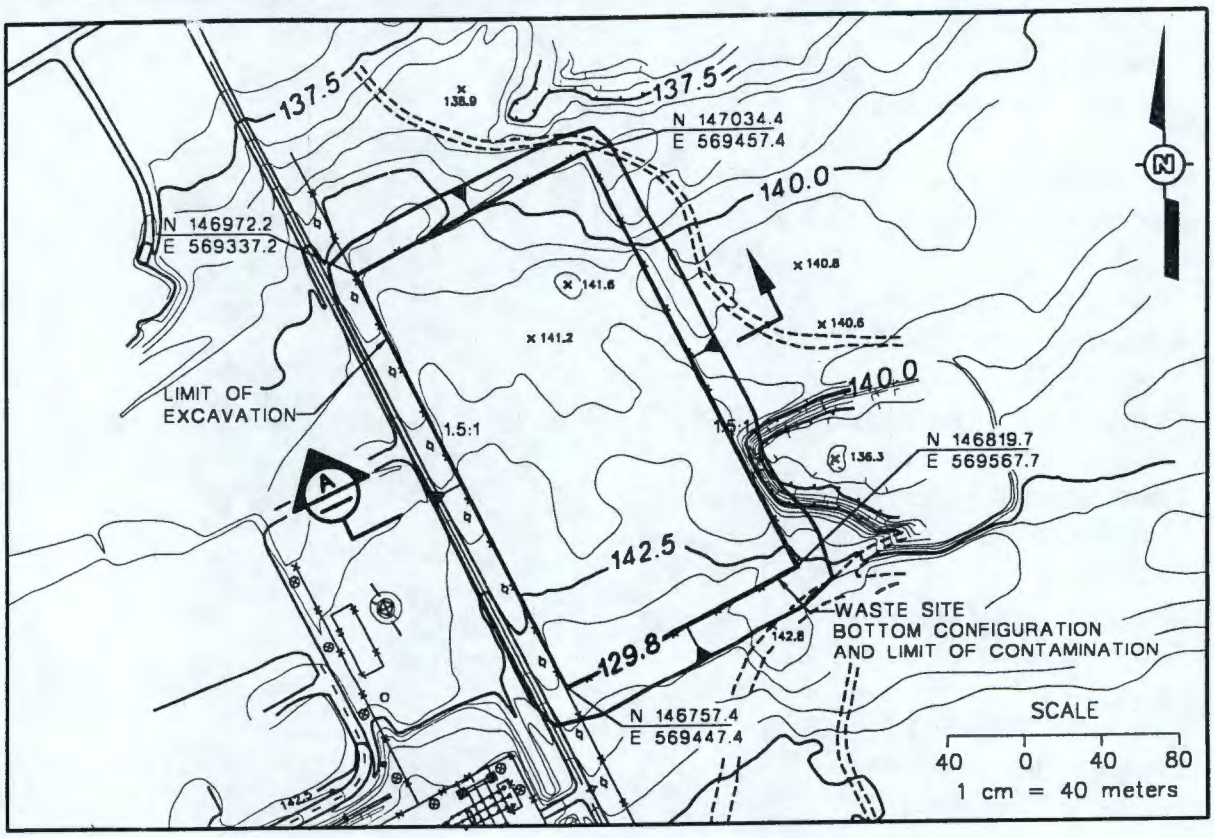
Excavated Volume Dimensions
Length: 280 m (918 ft)
Width: 170 m (558 ft)
Depth: 7.6 m (25 ft)

Waste Site Location
(approximate center)
E: 569452 (NE corner E569457.4 N147034.4, NW corner E569337.2 N146972.2)
N: 146898 (SE corner E569567.7 N146819.7, SW corner E569447.4 N146757.4)
Reference: WCS83S (Arcview)

Elevations
Surface: 139.0 m MSL
Reference: WIDS
Groundwater: 16.46 m (54 ft) below grade

Assumptions: Contaminated dimensions assume that entire area is filled with debris and that individual trenches are not to be remediated independently.

118-K-1



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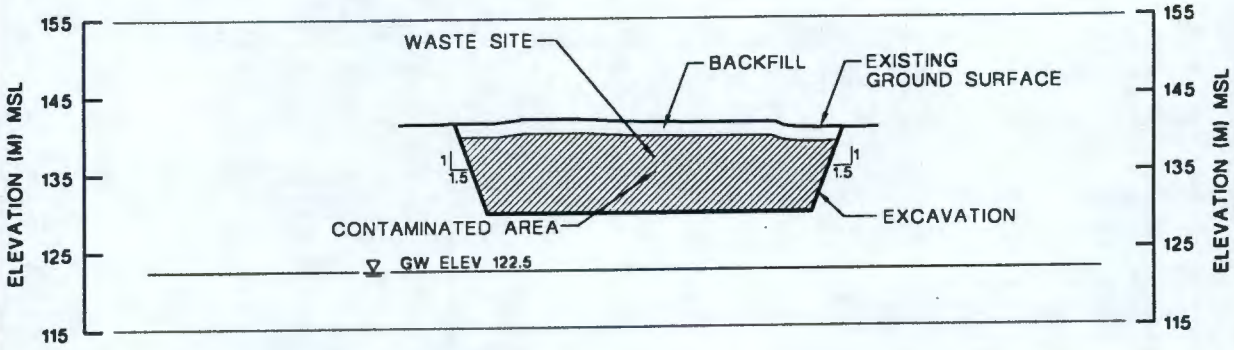


VERTICAL
EXAGGERATION : 4x

A SECTION

EXTENT OF CONTAMINATION

SURFACE AREA : 43,851 sq. meters
VOLUME : 283,153 cu. meters

EXTENT OF EXCAVATION

SURFACE AREA : 46,000 sq. meters
VOLUME : 364,254 cu. meters

118K1

CHECKPRINT NO. 2 DATE 6/1/95
PROJECT 100KR2 FFS
CHECKED BY _____ DATE _____

Volume Estimate
100-KR-2 Operable Unit

Site Number: 118-K-2
Site Name: Sludge Burial Ground (Trench)

Waste Site Dimensions
Length: 53.3 m (175 ft)
Width: 18 m (60 ft)
Depth/Height: 3.05 to 4.57 m below grade

Contaminated Volume Dimensions
Overburden about 1.22 m (4 ft) deep, slope of 1 to 1 ft
Length: 53.3 m (175 ft)
Width: 18 m (60 ft)
Depth/Height: 3.35 m (11 ft)

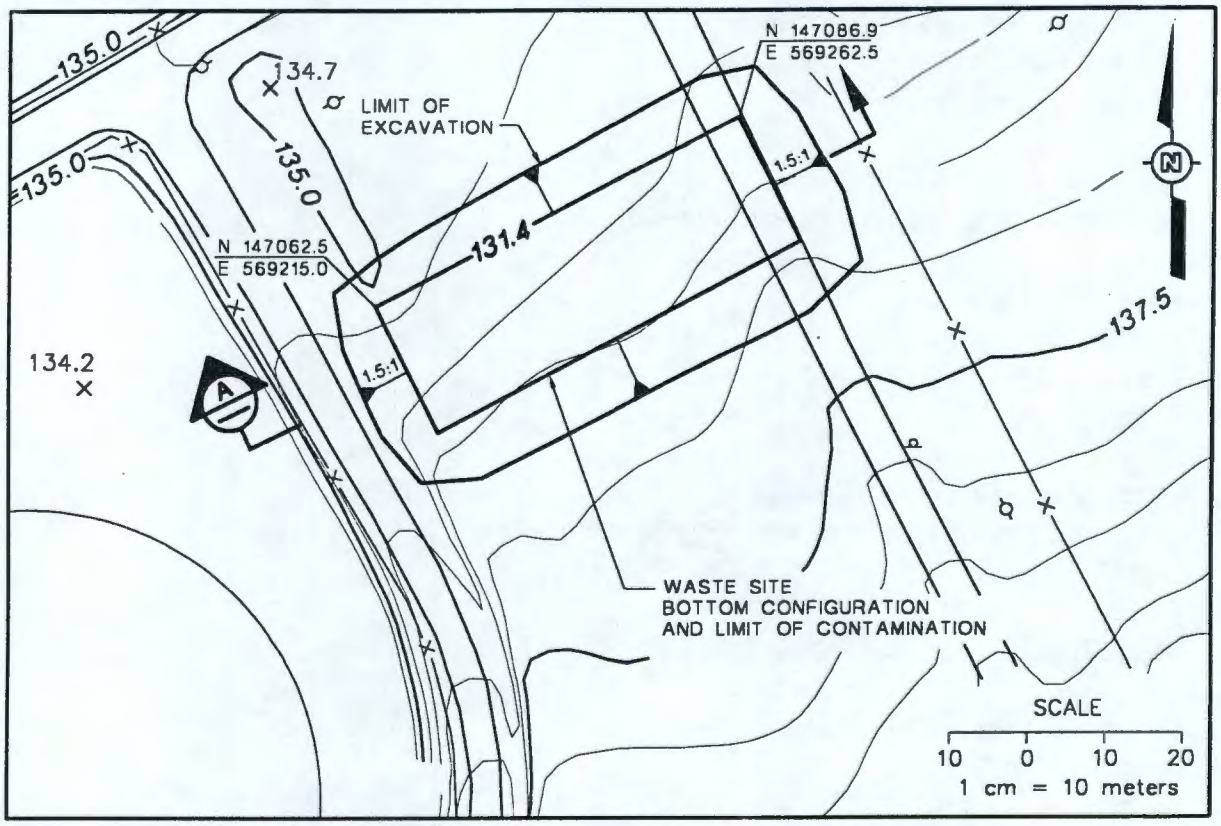
Excavated Volume Dimensions
Length: 67 m (219 ft)
Width: 31.5 m (103.3 ft)
Depth: 4.57 m (15 ft)

Waste Site Location
approximate center
E: 569243.88
N: 147045.88
Reference: WCS83S (Arcview)

Elevations
Surface: 136.5 m MSL
Reference: H-1-71798
Groundwater: About 15.24 m (50 ft) below grade

Assumptions: Assumes that sludge was buried at the site, but it is possible that no sludge burials occurred at the 100-K Area (see Attachment K2, Part 3).

118-K-2



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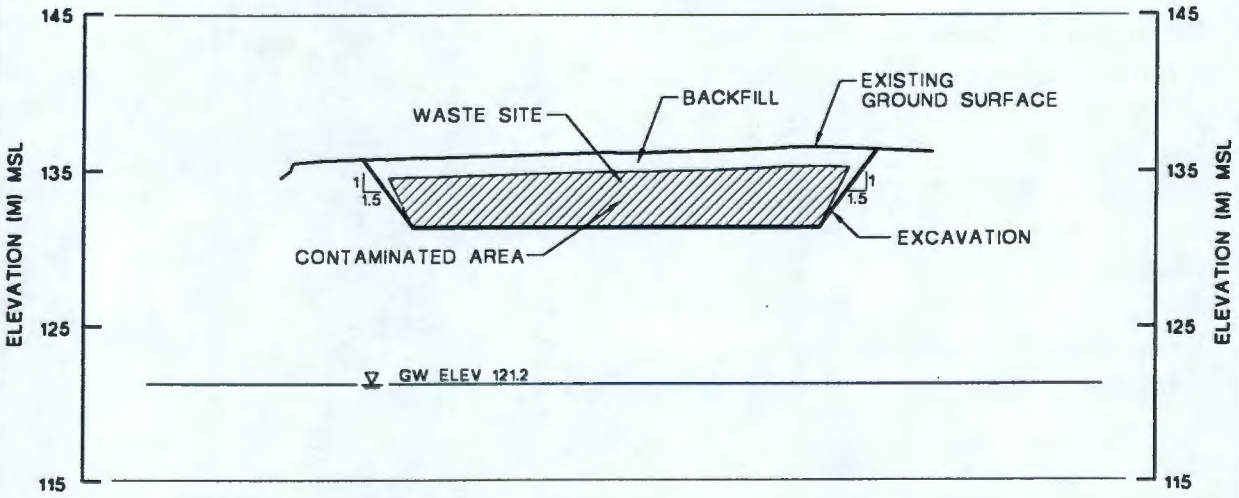


VERTICAL EXAGGERATION : 2x

A SECTION

EXTENT OF CONTAMINATION

SURFACE AREA : 1,531 sq. meters
VOLUME : 5,689.5 cu. meters

EXTENT OF EXCAVATION

SURFACE AREA : 2,100 sq. meters
VOLUME : 7,173 cu. meters

118K2

CHECKPRINT NO. 2 DATE 6/7/95
PROJECT 200KR2 HS
CHECKED BY _____ DATE _____

Volume Estimate
100-KR-2 Operable Unit

Site Number: 116-KE-1
Site Name: 115-KE Condensate Crib

Waste Site Dimensions
Diameter: 12.9 m (40 ft) surface diameter
Depth/Height: 7.77 m (25.5 ft) below grade

Contaminated Volume Dimensions
Top and Bottom: 5 m (16.5 ft) diameter
Depth/Height: 5.33 m (17.5 ft)

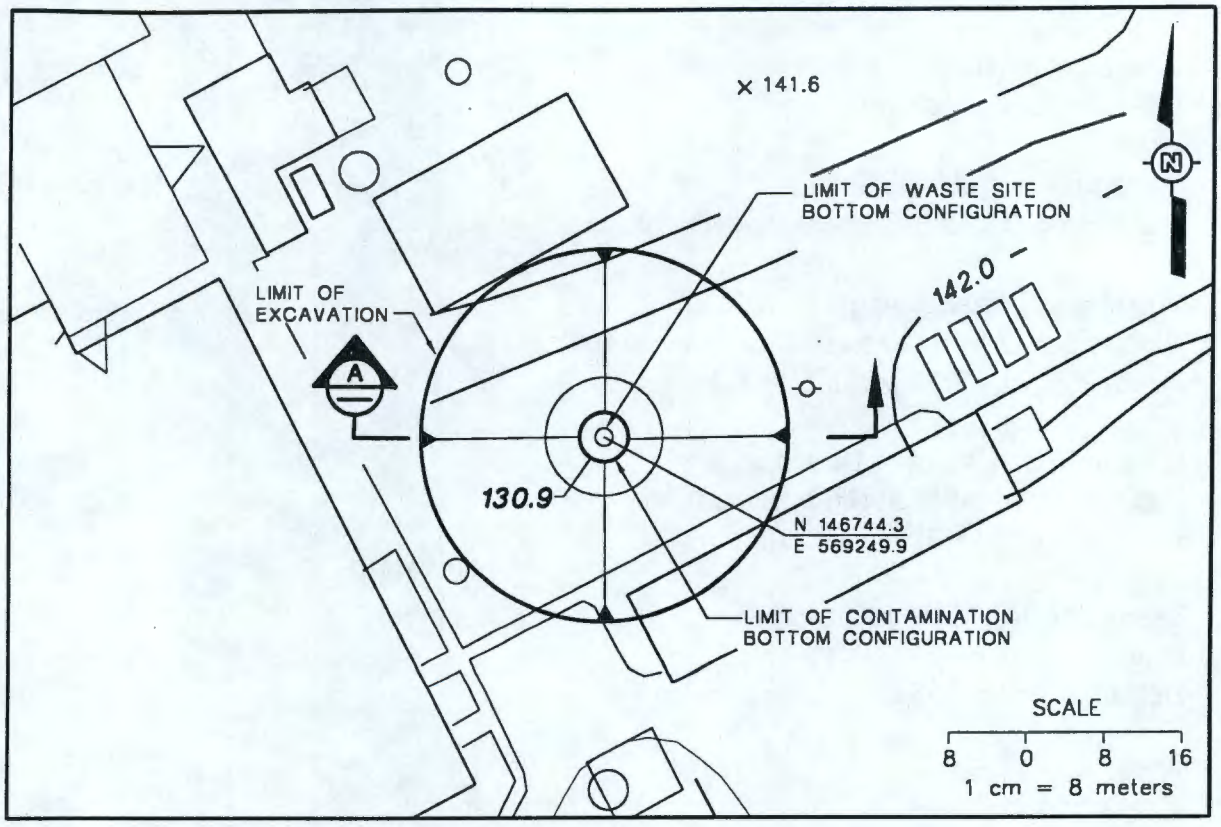
Excavated Volume Dimensions
Diameter: 38 m (124.6 ft)
Depth: 10.67 m (35 ft)

Waste Site Location
E: 569249.9
N: 146744.3
Reference: WCS83S (Arcview)

Elevations
Surface: 141.6 m MSL (464.5 ft MSL)
Reference: H-1-23207
Groundwater: 20.7 m (68 ft) below grade

Assumptions: Assumes site is identical (size and contamination) to 116-KW-1

116-KE-1



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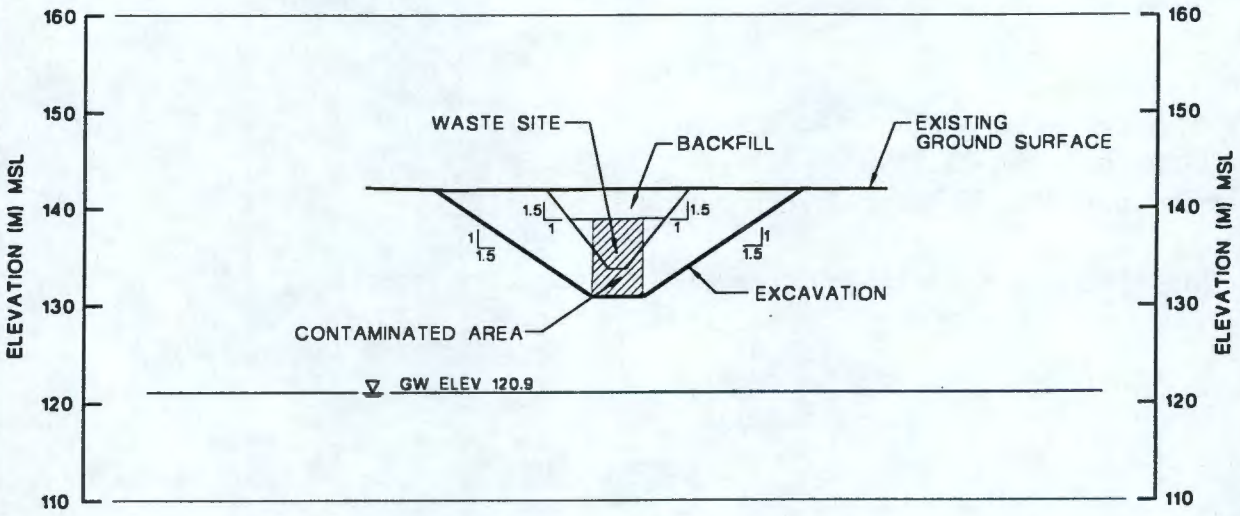


VERTICAL
EXAGGERATION : 1x

A SECTION

EXTENT OF CONTAMINATION

SURFACE AREA : 20.0 sq. meters
VOLUME : 106.6 cu. meters

EXTENT OF EXCAVATION

SURFACE AREA : 1,155 sq. meters
VOLUME : 3,131 cu. meters

116KE1

CHECKPRINT NO. 2 DATE 6/7/95
PROJECT 100KR2 FFS
CHECKED BY _____ DATE _____

Volume Estimate
100-KR-2 Operable Unit

Site Number: 116-KW-1
Site Name: 115-KW Condensate Crib

Waste Site Dimensions
Diameter: 12.9 m (40 ft) surface diameter
Depth/Height: 7.77 m (25.5 ft) below grade

Contaminated Volume Dimensions
Top and Bottom: 5 m (16.5 ft)
Depth/Height: 5.33 m (17.5 ft)

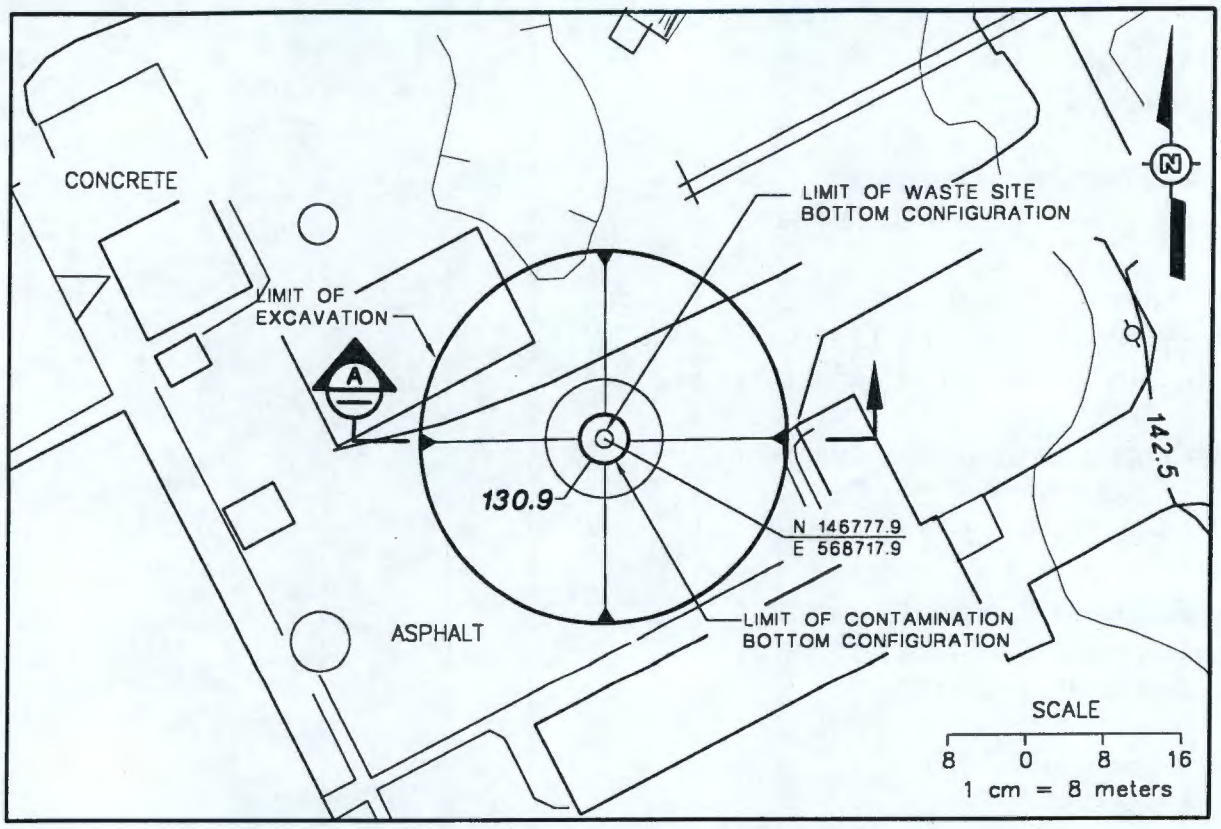
Excavated Volume Dimensions
Diameter: 38 m (124.6 ft)
Depth: 10.67 m (35 ft)

Waste Site Location
E: 568717.9
N: 146777.9
Reference: WCS83S (Arcview)

Elevations
Surface: 464.5 ft MSL (141.6 m MSL)
Reference: H-1-23207
Groundwater: 20.7 m (68 ft) below grade

Assumptions: Assumes that site is identical (size and contamination) to 116-KE-1.

116-KW-1



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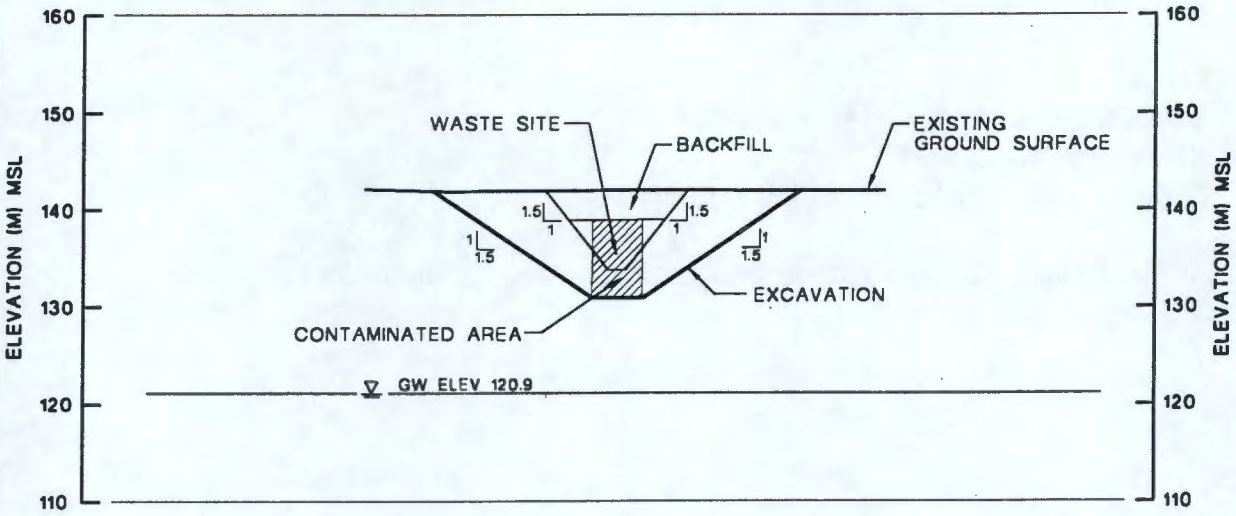

VERTICAL EXAGGERATION = 1x

A SECTION

EXTENT OF CONTAMINATION

SURFACE AREA = 20.0 sq. meters
VOLUME = 106.6 cu. meters

EXTENT OF EXCAVATION

SURFACE AREA = 1,155 sq. meters
VOLUME = 3,131 cu. meters

116KW1

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Volume Estimate
100-KR-2 Operable Unit

Site Number: 116-KE-2
Site Name: 1706-KER Waste Crib

Waste Site Dimensions
Length: 4.9 m (16 ft)
Width: 4.9 m (16 ft)
Depth/Height: 9.8 m (32 ft) below grade

Contaminated Dimensions
Overburden about 6.71 m (22 ft) deep, slope of 1 to 1 ft
Length: 9.14 m (30 ft) (H-1-20380-KE)
Width: 9.14 m (30 ft) (H-1-20380-KE)
Depth/Height: 7 m (23 ft)
Contaminated Dimensions reference Dorian and Richards (1987), UNI-946

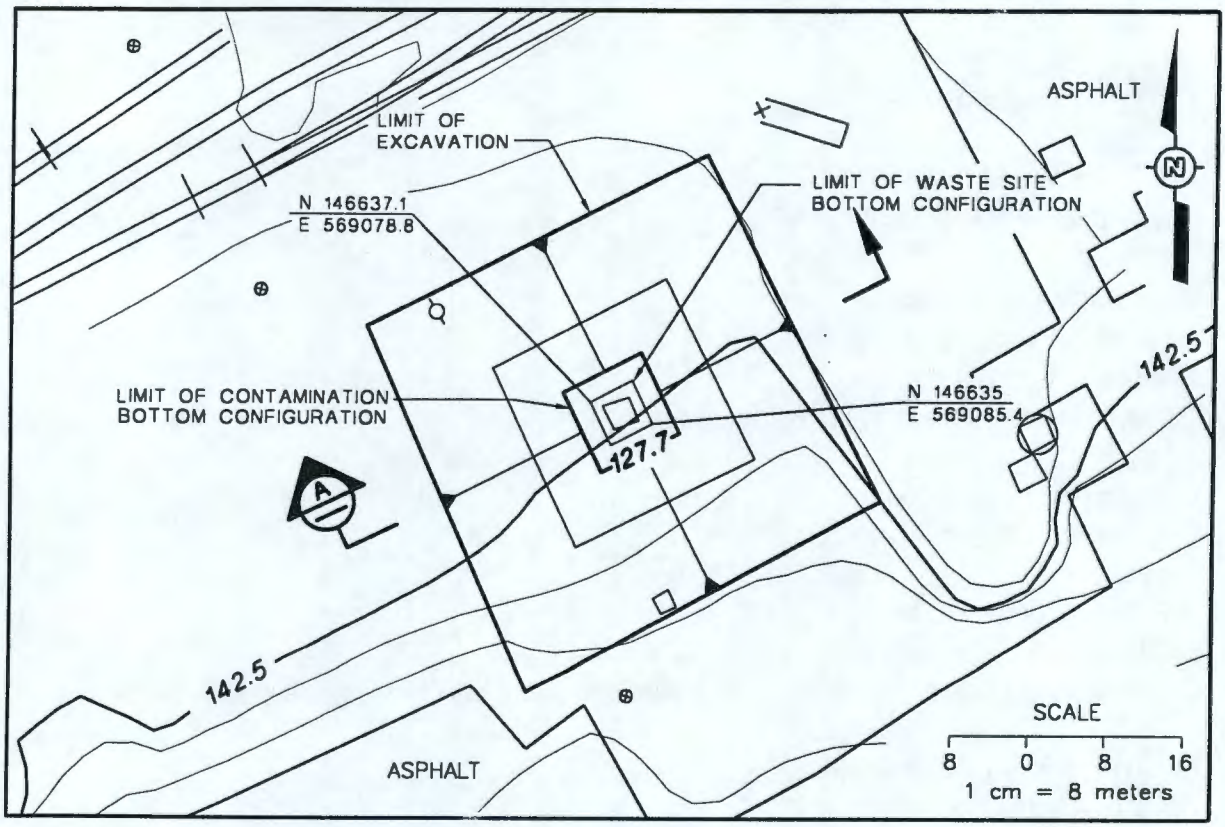
Excavated Volume Dimensions
Length: 41 m (134.5 ft)
Width: 41 m (134.5 ft)
Depth: 13.7 m (45 ft)

Waste Site Location
E: 569081.75
N: 146635.99
Reference: WCS83S (Arcview)

Elevations
Surface: 141.4 m MSL (464 ft MSL)
Reference: H-1-20380-KE
Groundwater: 20.73 m (68 ft) below grade

Assumptions: Lateral extent of contamination is likely to be less than 24.38 m (80 ft) estimated by Dorian and Richards (1978) and closer to the original dimensions of the site, or about 6.10 to 9.14 m (20 to 30 ft).

116-KE-2



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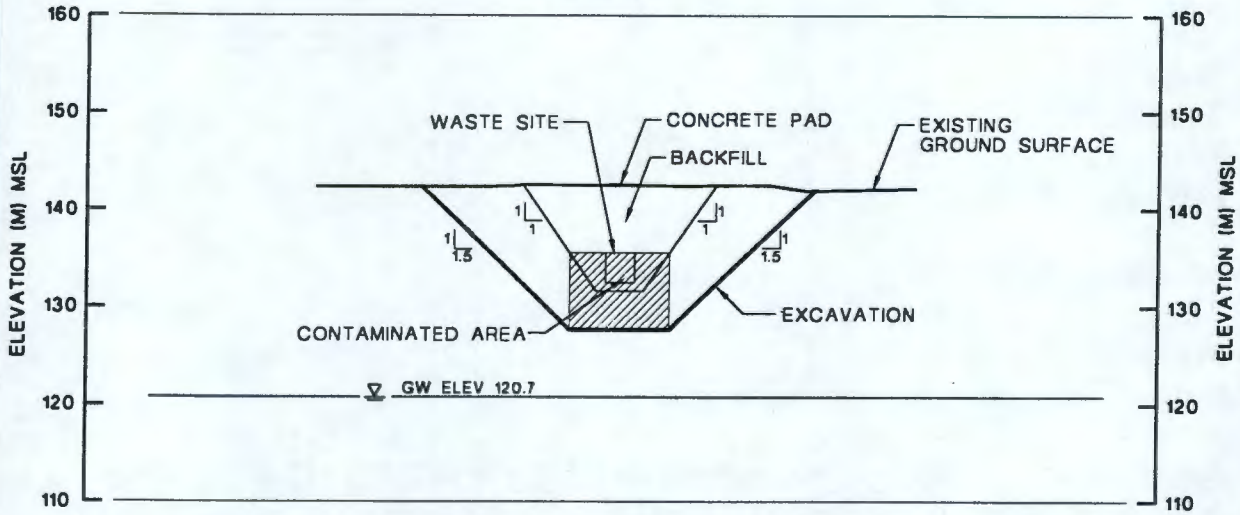

VERTICAL EXAGGERATION : 1x

A SECTION

EXTENT OF CONTAMINATION

SURFACE AREA : 83.5 sq. meters
VOLUME : 583.6 cu. meters

EXTENT OF EXCAVATION

SURFACE AREA : 1,657 sq. meters
VOLUME : 12,922 cu. meters

116KE2

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ATTACHMENT 4

100-KR-2 OPERABLE UNIT WASTE SITE COST ESTIMATES

1.0 COST ESTIMATE SUMMARIES

This attachment describes the cost models developed to support the source operable unit FFS reports. This attachment also documents the cost estimates developed for each waste site using the cost models.

1.1 DESCRIPTION OF COST MODELS

A cost model defines the remedial alternative activities and provides a method in which to estimate the associated cost. Each cost model is developed using the Micro Computer Aided Cost Estimating System (MCACES) software package.

The FFS cost models are based on the environmental restoration cost models used to develop the fiscal year planning baselines. The environmental restoration cost models were modified for the source operable unit FFSs to include all costs associated with the remedial alternatives. Project time and Cost, Inc., supported both the baseline and FFS cost estimating activities. The fourteen cost models associated with the source operable unit FFSs are presented in the *100 Area Source Operable Unit Focused Feasibility Study Cost Models* (WHC 1994).

All cost models were developed based on a common work breakdown structure. There are three main elements within the structure: Offsite Analytical Services (ANA), Fixed Price Contractor (SUB), and the Environmental Restoration contractor (ERC). The cost model terminology has not been updated to reflect the current change in the environmental restoration primary contractor. Each element is defined further by additional levels. Appendix B of the Process Document describes each element and level of a cost model. The work breakdown structure discussion is applicable for each cost model.

1.2 WASTE SITE COST ESTIMATES

Cost estimates were developed for each waste site addressed by the FFS based on the applicable cost model. The present worth for each estimate is based on a 5% discount rate and a disposal fee of \$70/yd^3. Because of current uncertainty as to the actual disposal fee, a Sensitivity Analysis is presented based on \$700/yd^3 and \$7,000/yd^3 besides \$70/yd^3. A matrix of the waste site, cost estimate, and cost comparison is presented in Tables B-1 through B-8 of Appendix B of the Process Document.

Table KA2-1. Cost Model Work Breakdown Structure Discussion. (page 1 of 2)

Elements and Levels	Description
SUB:21 Demobilization	This level includes the demobilization of temporary facilities. NOTE: Because multiple sites will be cleaned up within an operable unit and a cost for mobilization between sites is already included, no allowance for demobilization is made. Only the cost for removal of temporary utilities, fencing, and decontamination facilities is included.
ERC: Environmental Restoration Contractor	This element represents activities performed by the prime contractor.
ERC:02 Onsite lab	This level includes mobile laboratory support, quality assurance/safety oversight, and health physics support. Ninety percent of routine soil and solid waste samples were assumed to be analyzed using level 3 analysis. Routine sampling was assumed to occur at one sample per every 24.5 m^3 (32 yd^3) removed (one per container.)
ERC:08 Solids collection and containment	This level includes personnel protection services including equipment, maintenance, and laundry services.
Subcontractor material procurement rate	The materials procurement rate reflects the activities associated with procurement or direct materials, inventories, and subcontracts.
Project management/construction management	This cost accounts for project management, construction management, and office support personnel.
General and administrative/common support pool	The general and administrative costs consist of indirect costs of activities that benefit the company and cannot be identified to a specific end-cost objective. The common support pool provides for sitewide services of which Bechtel Hanford, Inc. pays a proportional share.

Elements and Levels	Description
Contingency	A contingency value is calculated for the various waste site groups based on an evaluation of the various levels, the relative importance of the factor to successful completion of the action, and the probability that the factor will change.
Total, capital, annual operations, and maintenance	The total represents the costs associated with the remedial action. The total cost includes capital and operations and maintenance of a cap. These costs are accounted for through the year 2018.
Present worth	Present worth is calculated using a 5% discount rate over the life of the activity.

Table KA2-2. Waste Site Cost Presentation Matrix.

Waste Site	Cost Summary Table	Cost Comparison Table
116-KE-3	Table KA2-3	Table K6-1
116-KW-2	Table KA2-4	Table K6-2
120-KE-2	Table KA2-5	Table K6-3
120-KW-2	Table KA2-6	Table K6-4
119-KW	Table KA2-7	Table K6-5
118-K-1	Table KA2-8	Table K6-6
118-K-2	Table KA2-9	Table K6-7
116-KE-1	Table KA2-10	Table K6-8
116-KW-1	Table KA2-11	Table K6-9
116-KE-2	Table KA2-12	Table K6-10

Table KA2-3. Cost Summary for 116-KE-3.

Cost Element		SW-3	SW-4	SW-9
ANA: Offsite Analytical Services				
ANA:02	Monitoring, sampling and analysis	--	46,310.00	92,620.00
SUB: Fixed price contractor				
SUB:01	Mobilization and preparatory	43,670.00	63,830.00	63,750.00
SUB:02	Monitoring, sampling and analysis	--	94,630.00	96,640.00
SUB:08	Solids collection and containment	287,460.00	131,210.00	169,600.00
SUB:13	Physical treatment	--	--	775,340.00
SUB:14	Thermal treatment	--	--	--
SUB:15	Stabilization/fixation	--	--	--
SUB:18	Disposal (other than commercial)	--	868,610.00	400,070.00
SUB:20	Site restoration	1,298,740.00	305,740.00	275,810.00
SUB:21	Demobilization	12,960.00	14,530.00	14,450.00
ERC: Environmental Restoration Contractor				
ERC:02	Monitoring, sampling and analysis	18,120.00	170,570.00	209,020.00
ERC:08	Solids collection and containment	250.00	16,600.00	20,050.00
Subcontractor materials procurement rate		119,930.00	107,930.00	131,080.00
Project management/construction management		267,170.00	266,050.00	323,370.00
General and administration/common support pool		522,320.00	520,130.00	632,190.00
Contingency		874,010.00	938,210.00	1,185,470.00
Total		3,444,630.00	3,544,350.00	4,389,460.00
Capital		3,444,630.00	3,544,350.00	3,774,030.00
Annual operations and maintenance		330,602.00	--	615,430.00
Present worth		3,467,393.00	3,378,677.00	4,183,556.00

SS-3/SW-3: Containment
SS-4/SW-4: Removal/disposal
SS-8A/SS-8B/SW-7: In situ treatment
SS-10/SW-9: Removal/treatment/disposal

Table KA2-4. Cost Summary for 116-KW-2.

Cost Element		SW-3	SW-4	SW-9
ANA: Offsite Analytical Services				
ANA:02	Monitoring, sampling and analysis	--	46,310.00	92,620.00
SUB: Fixed price contractor				
SUB:01	Mobilization and preparatory	43,670.00	63,830.00	63,750.00
SUB:02	Monitoring, sampling and analysis	--	94,630.00	96,640.00
SUB:08	Solids collection and containment	287,460.00	131,210.00	169,600.00
SUB:13	Physical treatment	--	--	775,340.00
SUB:14	Thermal treatment	--	--	--
SUB:15	Stabilization/fixation	--	--	--
SUB:18	Disposal (other than commercial)	--	868,610.00	400,070.00
SUB:20	Site restoration	1,298,740.00	305,740.00	275,810.00
SUB:21	Demobilization	12,960.00	14,530.00	14,450.00
ERC: Environmental Restoration Contractor				
ERC:02	Monitoring, sampling and analysis	18,120.00	170,570.00	209,020.00
ERC:08	Solids collection and containment	250.00	16,600.00	20,050.00
Subcontractor materials procurement rate		119,930.00	107,930.00	131,080.00
Project management/construction management		267,170.00	266,050.00	323,370.00
General and administration/common support pool		522,320.00	520,130.00	632,190.00
Contingency		874,010.00	938,210.00	1,185,470.00
Total		3,444,630.00	3,544,350.00	4,389,460.00
Capital		3,444,630.00	3,544,350.00	3,774,030.00
Annual operations and maintenance		330,602.00	--	615,430.00
Present worth		3,467,393.00	3,378,677.00	4,183,556.00

SS-3/SW-3: Containment
SS-4/SW-4: Removal/disposal
SS-8A/SS-8B/SW-7: In situ treatment
SS-10/SW-9: Removal/treatment/disposal

Table KA2-5. Cost Summary for 120-KE-2 .

Cost Element		SW-4	SW-7	SW-9
ANA: Offsite Analytical Services				
ANA:02	Monitoring, sampling and analysis	16,840.00	--	29,470.00
SUB: Fixed price contractor				
SUB:01	Mobilization and preparatory	52,610.00	44,390.00	52,580.00
SUB:02	Monitoring, sampling and analysis	12,480.00	880.00	1,920.00
SUB:08	Solids collection and containment	20,050.00	5,420.00	6,120.00
SUB:13	Physical treatment	--	--	172,400.00
SUB:14	Thermal treatment	--	--	--
SUB:15	Stabilization/fixation	--	241,720.00	--
SUB:18	Disposal (other than commercial)	106,790.00	--	7,740.00
SUB:20	Site restoration	41,520.00	14,720.00	15,150.00
SUB:21	Demobilization	12,930.00	12,900.00	12,900.00
ERC: Environmental Restoration Contractor				
ERC:02	Monitoring, sampling and analysis	28,900.00	22,750.00	43,810.00
ERC:08	Solids collection and containment	2,250.00	1,690.00	3,870.00
Subcontractor materials procurement rate		17,980.00	23,360.00	19,620.00
Project management/construction management		44,330.00	55,170.00	50,420.00
General and administration/common support pool		86,660.00	107,870.00	98,560.00
Contingency		159,600.00	180,500.00	190,390.00
Total		602,940.00	711,370.00	704,950.00
Capital		602,940.00	604,020.00	693,200.00
Annual operations and maintenance		--	107,350.00	11,750.00
Present worth		576,744.00	679,622.00	673,897.00

SS-3/SW-3: Containment
SS-4/SW-4: Removal/disposal
SS-8A/SS-8B/SW-7: In situ treatment
SS-10/SW-9: Removal/treatment/disposal

Table KA2-6. Cost Summary for 120-KW-2 .

Cost Element		SW-4	SW-7	SW-9
ANA: Offsite Analytical Services				
ANA:02	Monitoring, sampling and analysis	16,840.00	--	29,470.00
SUB: Fixed price contractor				
SUB:01	Mobilization and preparatory	52,610.00	44,390.00	52,580.00
SUB:02	Monitoring, sampling and analysis	12,480.00	880.00	1,920.00
SUB:08	Solids collection and containment	20,050.00	5,420.00	6,120.00
SUB:13	Physical treatment	--	--	172,400.00
SUB:14	Thermal treatment	--	--	--
SUB:15	Stabilization/fixation	--	241,720.00	--
SUB:18	Disposal (other than commercial)	106,790.00	--	7,740.00
SUB:20	Site restoration	41,520.00	14,720.00	15,150.00
SUB:21	Demobilization	12,930.00	12,900.00	12,900.00
ERC: Environmental Restoration Contractor				
ERC:02	Monitoring, sampling and analysis	28,900.00	22,750.00	43,810.00
ERC:08	Solids collection and containment	2,250.00	1,690.00	3,870.00
Subcontractor materials procurement rate		17,980.00	23,360.00	19,620.00
Project management/construction management		44,330.00	55,170.00	50,420.00
General and administration/common support pool		86,660.00	107,870.00	98,560.00
Contingency		159,600.00	180,500.00	190,390.00
Total		602,940.00	711,370.00	704,950.00
Capital		602,940.00	604,020.00	693,200.00
Annual operations and maintenance		--	107,350.00	11,750.00
Present worth		576,744.00	679,622.00	673,897.00

SS-3/SW-3: Containment
SS-4/SW-4: Removal/disposal
SS-8A/SS-8B/SW-7: In situ treatment
SS-10/SW-9: Removal/treatment/disposal

Table KA2-7. Cost Summary for 119-KW French Drain.

Cost Element		SW-3	SW-4	SW-7	SW-9
ANA: Offsite Analytical Services					
ANA:02	Monitoring, sampling and analysis	--	16,840.00	--	29,470.00
SUB: Fixed price contractor					
SUB:01	Mobilization and preparatory	42,160.00	51,110.00	42,880.00	51,070.00
SUB:02	Monitoring, sampling and analysis	--	520.00	250.00	610.00
SUB:08	Solids collection and containment	176,350.00	4,010.00	4,070.00	4,290.00
SUB:13	Physical treatment	--	--	--	163,010.00
SUB:14	Thermal treatment	--	--	--	--
SUB:15	Stabilization/fixation	--	--	182,310.00	--
SUB:18	Disposal (other than commercial)	--	3,200.00	--	1,590.00
SUB:20	Site restoration	1,295,200.00	8,640.00	8,460.00	8,540.00
SUB:21	Demobilization	12,750.00	12,710.00	12,690.00	12,690.00
ERC: Environmental Restoration Contractor					
ERC:02	Monitoring, sampling and analysis	15,210.00	8,640.00	18,400.00	40,030.00
ERC:08	Solids collection and containment	250.00	280.00	980.00	3,870.00
Subcontractor materials procurement rate		111,430.00	5,850.00	18,300.00	17,650.00
Project management/construction management		248,000.00	14,240.00	43,250.00	45,500.00
General and administration/common support pool		484,840.00	27,850.00	84,560.00	88,950.00
Contingency		811,310.00	55,400.00	141,490.00	172,890.00
Total		3,197,500.00	209,290.00	557,640.00	640,160.00
Capital		3,197,500.00	209,290.00	509,790.00	637,800.00
Annual operations and maintenance		202,814.00	--	47,850.00	2,360.00
Present worth		3,160,582.00	201,761.00	533,137.00	612,119.00

SS-3/SW-3: Containment
SS-4/SW-4: Removal/disposal
SS-8A/SS-8B/SW-7: In situ treatment
SS-10/SW-9: Removal/treatment/disposal

Table KA2-8. Cost Summary for 118-K-1.

Cost Element		SW-3	SW-4	SW-7	SW-9
ANA: Offsite Analytical Services					
ANA:02	Monitoring, sampling and analysis	--	837,790.00	--	837,790.00
SUB: Fixed price contractor					
SUB:01	Mobilization and preparatory	80,320.00	86,460.00	105,690.00	93,140.00
SUB:02	Monitoring, sampling and analysis	--	1,509,460.00	--	1,509,450.00
SUB:08	Solids collection and containment	11,147,820.00	2,755,470.00	11,911,730.00	2,755,450.00
SUB:13	Physical treatment	--	--	--	2,842,320.00
SUB:14	Thermal treatment	--	--	--	--
SUB:15	Stabilization/fixation	--	--	--	--
SUB:18	Disposal (other than commercial)	--	46,147,890.00	--	44,807,890.00
SUB:20	Site restoration	1,678,610.00	5,729,340.00	1,682,310.00	5,666,950.00
SUB:21	Demobilization	18,030.00	18,310.00	18,070.00	18,310.00
ERC: Environmental Restoration Contractor					
ERC:02	Monitoring, sampling and analysis	383,110.00	2,254,040.00	669,210.00	2,862,150.00
ERC:08	Solids collection and containment	8,370.00	333,780.00	39,040.00	600,780.00
Subcontractor materials procurement rate		129,250.00	562,470.00	137,180.00	576,940.00
Project management/construction management		2,016,830.00	8,909,580.00	2,184,480.00	9,360,010.00
General and administration/common support pool		3,942,900.00	17,418,230.00	4,270,670.00	18,103,320.00
Contingency		6,597,780.00	32,028,250.00	7,146,250.00	33,275,760.00
Total		26,003,020.00	118,591,070.00	28,164,630.00	123,210,260.00
Capital		26,003,020.00	118,591,070.00	28,164,630.00	120,406,360.00
Annual operations and maintenance		12,262,602.00	--	13,102,914.00	2,803,900.00
Present worth		31,252,090.00	105,583,625.00	33,467,925.00	109,693,711.00

SS-3/SW-3: Containment
SS-4/SW-4: Removal/disposal
SS-8A/SS-8B/SW-7: In situ treatment (Barrier with Compaction)
SS-10/SW-9: Removal/treatment/disposal

Table KA2-9. Cost Summary for 118-K-2.

Cost Element		SW-4	SW-7	SW-9
ANA: Offsite Analytical Services				
ANA:02	Monitoring, sampling and analysis	58,940.00	--	109,460.00
SUB: Fixed price contractor				
SUB:01	Mobilization and preparatory	53,270.00	51,370.00	59,050.00
SUB:02	Monitoring, sampling and analysis	23,150.00	3,240.00	36,470.00
SUB:08	Solids collection and containment	39,530.00	12,500.00	46,960.00
SUB:13	Physical treatment	--	--	849,280.00
SUB:14	Thermal treatment	--	--	--
SUB:15	Stabilization/fixation	--	4,428,180.00	--
SUB:18	Disposal (other than commercial)	960,560.00	--	448,120.00
SUB:20	Site restoration	136,530.00	78,230.00	103,360.00
SUB:21	Demobilization	13,800.00	13,910.00	13,790.00
ERC: Environmental Restoration Contractor				
ERC:02	Monitoring, sampling and analysis	58,280.00	370,350.00	118,710.00
ERC:08	Solids collection and containment	4,220.00	59,790.00	11,260.00
Subcontractor materials procurement rate		89,560.00	334,880.00	113,660.00
Project management/construction management		206,840.00	802,870.00	270,100.00
General and administration/common support pool		404,360.00	1,569,610.00	528,040.00
Contingency		696,670.00	2,626,470.00	1,002,060.00
Total		2,745,710.00	10,351,400.00	3,710,320.00
Capital		2,745,710.00	6,056,700.00	3,020,840.00
Annual operations and maintenance		--	4,294,700.00	689,480.00
Present worth		2,617,550.00	9,861,119.00	3,536,520.00

SS-3/SW-3: Containment
SS-4/SW-4: Removal/disposal
SS-8A/SS-8B/SW-7: In situ treatment
SS-10/SW-9: Removal/treatment/disposal

Table KA2-10. Cost Summary for 116-KE-1.

Cost Element		SW-4	SW-9
ANA: Offsite Analytical Services			
ANA:02	Monitoring, sampling and analysis	21,050.00	33,680.00
SUB: Fixed price contractor			
SUB:01	Mobilization and preparatory	57,020.00	56,970.00
SUB:02	Monitoring, sampling and analysis	9,850.00	10,290.00
SUB:08	Solids collection and containment	16,710.00	20,660.00
SUB:13	Physical treatment	--	226,380.00
SUB:14	Thermal treatment	--	--
SUB:15	Stabilization/fixation	--	--
SUB:18	Disposal (other than commercial)	92,960.00	42,750.00
SUB:20	Site restoration	54,110.00	50,920.00
SUB:21	Demobilization	13,570.00	13,520.00
ERC: Environmental Restoration Contractor			
ERC:02	Monitoring, sampling and analysis	26,790.00	58,870.00
ERC:08	Solids collection and containment	1,690.00	5,280.00
Subcontractor materials procurement rate		17,830.00	30,770.00
Project management/construction management		43,580.00	77,460.00
General and administration/common support pool		85,200.00	151,440.00
Contingency		158,520.00	288,230.00
Total		598,880.00	1,067,220.00
Capital		598,880.00	1,001,440.00
Annual operations and maintenance		--	65,780.00
Present worth		573,087.00	1,019,132.00

SS-3/SW-3: Containment
SS-4/SW-4: Removal/disposal
SS-8A/SS-8B/SW-7: In situ treatment
SS-10/SW-9: Removal/treatment/disposal

Table KA2-11. Cost Summary for 116-KW-1.

Cost Element		SW-4	SW-9
ANA: Offsite Analytical Services			
ANA:02	Monitoring, sampling and analysis	21,050.00	33,680.00
SUB: Fixed price contractor			
SUB:01	Mobilization and preparatory	57,020.00	56,970.00
SUB:02	Monitoring, sampling and analysis	9,850.00	10,290.00
SUB:08	Solids collection and containment	16,710.00	20,660.00
SUB:13	Physical treatment	--	226,380.00
SUB:14	Thermal treatment	--	--
SUB:15	Stabilization/fixation	--	--
SUB:18	Disposal (other than commercial)	92,960.00	42,750.00
SUB:20	Site restoration	54,110.00	50,920.00
SUB:21	Demobilization	13,570.00	13,520.00
ERC: Environmental Restoration Contractor			
ERC:02	Monitoring, sampling and analysis	26,790.00	58,870.00
ERC:08	Solids collection and containment	1,690.00	5,280.00
Subcontractor materials procurement rate		17,830.00	30,770.00
Project management/construction management		43,580.00	77,460.00
General and administration/common support pool		85,200.00	151,440.00
Contingency		158,520.00	288,230.00
Total		598,880.00	1,067,220.00
Capital		598,880.00	1,001,440.00
Annual operations and maintenance		--	65,780.00
Present worth		573,087.00	1,019,132.00

SS-3/SW-3: Containment
SS-4/SW-4: Removal/disposal
SS-8A/SS-8B/SW-7: In situ treatment
SS-10/SW-9: Removal/treatment/disposal

Table KA2-12. Cost Summary for 116-KE-2.

Cost Element		SW-3	SW-4	SW-9
ANA: Offsite Analytical Services				
ANA:02	Monitoring, sampling and analysis	--	54,730.00	79,990.00
SUB: Fixed price contractor				
SUB:01	Mobilization and preparatory	43,820.00	57,530.00	57,460.00
SUB:02	Monitoring, sampling and analysis	--	40,750.00	42,230.00
SUB:08	Solids collection and containment	313,090.00	56,570.00	72,350.00
SUB:13	Physical treatment	--	--	444,820.00
SUB:14	Thermal treatment	--	--	--
SUB:15	Stabilization/fixation	--	--	--
SUB:18	Disposal (other than commercial)	--	401,800.00	185,080.00
SUB:20	Site restoration	1,294,760.00	130,440.00	116,620.00
SUB:21	Demobilization	12,950.00	13,630.00	13,580.00
ERC: Environmental Restoration Contractor				
ERC:02	Monitoring, sampling and analysis	19,280.00	89,530.00	123,750.00
ERC:08	Solids collection and containment	250.00	7,030.00	10,550.00
Subcontractor materials procurement rate		121,520.00	51,150.00	68,050.00
Project management/construction management		270,850.00	127,270.00	170,170.00
General and administration/common support pool		529,510.00	248,810.00	332,690.00
Contingency		886,050.00	460,530.00	635,410.00
Total		3,492,080.00	1,739,770.00	2,352,750.00
Capital		3,492,080.00	1,739,770.00	2,068,150.00
Annual operations and maintenance		360,065.00	--	284,600.00
Present worth		3,529,047.00	1,659,695.00	2,243,494.00

SS-3/SW-3: Containment
SS-4/SW-4: Removal/disposal
SS-8A/SS-8B/SW-7: In situ treatment
SS-10/SW-9: Removal/treatment/disposal

Table KA2-13. Summary Table for All Waste Sites.

IRM Candidate Site	Containment			Removal/Disposal			In Situ Vitrification			Removal/Treatment/Disposal		
	Capital ($ million)	O&M ($ million)	Present Worth ($ million)	Capital ($ million)	O&M ($ million)	Present Worth ($ million)	Capital ($ million)	O&M ($ million)	Present Worth ($ million)	Capital ($ million)	O&M ($ million)	Present Worth ($ million)
100-KR-2 OPERABLE UNIT												
116-KE-3 French Drain	3.44	0.33	3.47	3.54	--	3.38	--	--	--	3.77	0.62	4.18
116-KW-2 French Drain	3.44	0.33	3.47	3.54	--	3.38	--	--	--	3.77	0.62	4.18
120-KE-2 French Drain	--	--	--	0.60	--	0.58	0.60	0.11	0.68	0.69	0.01	0.67
120-KW-2 French Drain	--	--	--	0.60	--	0.58	0.60	0.11	0.68	0.69	0.01	0.67
119-KW French Drain	3.19	0.20	3.16	0.21	--	0.20	0.51	0.05	0.53	0.64	0.002	0.61
118-K-1 Burial Ground	26.00	12.26	31.25	118.59	--	105.58	--	--	--	120.41	2.80	109.69
(a)	28.16	13.10	33.47									
118-K-2 Sludge Trench	--	--	--	2.75	--	2.62	6.06	4.29	9.86	3.02	0.69	3.54
116-KE-1 Condensate Crib	--	--	--	0.60	--	0.57	--	--	--	1.00	0.07	1.02
116-KW-1 Condensate Crib	--	--	--	0.60	--	0.57	--	--	--	1.00	0.07	1.02
116-KE-2 Crib	3.49	0.36	3.53	1.74	--	1.66	--	--	--	2.07	0.28	2.24

NOTES:

- Costs are in millions of dollars
- Costs presented are preliminary, and are presented for comparison purposes only. It is expected that actual costs will be significantly lower, but the relative differences between alternatives is similar (see FFS Report for detailed cost analysis).
- Double Dash (--) = Not Applicable to the Waste Site (see FFS Report)
- O&M = Operation and Maintenance
- Containment = Hanford Barrier without Compaction

(a) Containment with Compaction (only applicable to 118-K-1 Burial Ground)